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# 16th ISPO World Congress

# 2017

# Abstract Book

# INTRODUCTION

The ISPO 2017 theme of "Assistive Technology for All" is a brave call to people who develop and research assistive technology, since "up to one billion people need equipment to stay alive, keep moving, or to communicate and participate in community life" (Wesley Pryor, 2016). The strong and innovative research presented at this year's World Congress should bring hope to people with disabilities since advances in prosthetics and orthotics are happening on a broad scale. This research also demonstrates the need for multidisciplinary participation in prosthetics and orthotics care and research, which is a founding principle of ISPO.

This congress program would not have been possible without the work and expertise of the World Congress Scientific Committee. I thank Pamela Gallagher, Kerstin Hagberg, Jaap Harlaar, Dick Plettenburg, and Mariette Schmidt for their excellent contributions and Giulia Miotto for her kind support. The comprehensive abstract review process would not have been possible without the timely and informative analysis from the 88 peer reviewers. These reviewers are acknowledged by name in this abstract book. This book contains abstracts that exceeded the combined review score criteria for publication.

I encourage you to read the abstracts from our 2017 World Congress, use the information in clinical practice, build on the knowledge by innovating further, and sharing your knowledge to ensure that appropriate assistive technology is available for all.

Edward Lemaire

Chair of the ISPO 16th World Congress Scientific Committee



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# ORAL PRESENTATIONS

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# EFFECTIVENESS OF PROSTHETIC REHABILITATION IN CHILDREN AND YOUNG ADULTS WITH UPPER LIMB ABSENCE... A SYSTEMATIC LITERATURE REVIEW

Nizar Akhtar[1]

[1]Pakistan Institute of Prosthetic and Orthotic Sciences

**BACKGROUND:**

Unlike their peers, children, adolescents and young adults with upper limb deficiencies and acquired amputation present limitations in daily life activities, subjected to the severity of deficiency or amputation. They are fitted with prostheses to make them able to perform daily activities and participate in social and leisure sports.

**OBJECTIVE:**

To view the impact of prosthetic rehabilitation on regaining an adequate level of functioning and participation in sports related activities by children, adolescents and young adults with upper limb absence

**DESIGN:**

A systematic search of relevant literature was performed and the quality of the studies was evaluated according to the checklist for review of general published articles. Ten studies were included in this review. Studies conducted on subjects; children and young adults (age 1-20) with upper limb absence, were considered eligible for inclusion.

**MAIN MEASURES:**

Functionality and participation in ADL and sports, early prosthetic fitting and later functional outcomes, ease of performance of prosthetic users compared to non-users

**RESULTS:**

Overall, seven studies did not find any significant difference on the domains of ADL and sports related activities compared with prosthesis users and non-users as well as the general population of children with acquired or congenital deficiency of upper extremities. Only three studies reported higher satisfactory results on behalf of prosthetic wearers as opposed to non-wearers. The results of this review indicated that most of the literature reported a tendency of greater compliance and better functional outcomes in youngsters; fitted with the 1st prosthetic device before the age of two years. Though, such results might be considered tendencies instead of evidences. Only on specific activities for which children with deficient upper limbs use the prosthesis, they performed those activities easier with the prosthesis than without. Non-wearers accomplished activities easier than prosthetic wearers. Additionally, prosthetic users accomplish the activities of daily life easier deprived of the prosthetic appliance compared with the appliance.

**CONCLUSIONS:**

Majority of the studies exhibited that congenital deficient children executed activities well both with and without the prosthesis. Also, children with ULRD had equal capability of performing tasks without their prosthesis similar to their able bodied peers. Early age fitting has no significant influence on the functional use of prosthesis compared with fitting after two years of age.

# PRELIMINARY RESULTS OF A PROSPERTIVE AIS COHORT TREATED WITH A GENSINGEN BRACE (GBW)

Weiss HR [1], Tournavitis N [2], Seibel S [1]

1Gesundheitsforum Nahetal, Alzeyer Str. 23, D-55457 Gensingen, Germany, [2]Scoliosis Best Practice Rehab Services, Aristotelous [5], GR 54624, Thessaloniki, Greece

## BACKGROUND

Brace treatment meanwhile is regarded an evidence based treatment which is the most important part of the management of patients with scoliosis1. Highest evidence (level I) has been gained for the Boston brace2, however, there is also high level evidence for the treatment of scoliosis patients with Chêneau derivates1. A prospective study with a cohort treated with the Gensingen brace (GBW)1 was started in 2011. Meanwhile we have 82 patients in the database complying with the SRS inclusion criteria2.

## AIM

Purpose of this paper was to analyze the first patients with a follow-up of at least 18 months.

## METHOD

35 patients (12.3 years; Risser 0.8; Cobb 33.6°; menarche 2.4 months) had a follow up of at least 18 months (24.9 months). Main Cobb angle and ATR angles at the last visit have been compared to the initial values. 11 /35 (31%) Patients were already weaned off the brace.

## RESULTS

15 Patients (42,9%) improved (>5°), 15 (42,9.2%) were unchanged and 4 (11.2%) had a progression (>5°). Cobb angle was reduced to 29.8° ($p < 0{,}01$), ATR has been reduced as well. Average brace wearing time as reported was 21 hrs. / day. The whole group of patients is clearly at the end of the descendent phase of the pubertal growth spurt indicating that progression now is much less likely than at the start of the observation period.

Figure 1. GBW for a major thoracic curve of a patient with AIS

## DISCUSSION & CONCLUSION

Compared to other cohorts complying with the SRS inclusion criteria2 rate of progression was less in this cohort although average Cobb angle was high due to the fact that we also included patients up to 45°. Loss of correction may happen until the end of the follow up and corrections may not be stable until the end. The preliminary success rate of > 88%, however is promising compared to the 72% from the BRAIST study by Weinstein et al.2. Preliminary results as achieved with the GBW seem promising.

## REFERENCES

1. Ng SY; 2016 Curr Pediatr Rev.
2. Weinstein SL;2013 N Engl J Med.

# A PROSPECTIVE AIS COHORT OF 40° AND MORE TREATED WITH A GENSINGEN BRACE (GBW)

Weiss HR [1], Tournavitis N [2], Seibel S [1]

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## BACKGROUND

Because there currently is no high quality evidence for spinal fusion surgery Ward and co-workers (2015)1 let their patients with curvatures beyond 40 degrees decide upon undergoing surgery by themselves. This evidence based change of paradigm demands to extend the conservative perspective of treatment also to patients with curvatures beyond 40 degrees2.

## AIM

Therefore, we have started a prospective cohort study with immature patients complying with the SRS inclusion criteria3 except the range of curvature being 40 degrees and more.

## METHOD

All female patients complying with the SRS inclusion criteria and with curves of 40 degrees and over treated with the Gensingen brace (GBW) have been followed up prospectively since 2012 (currently 42). 23 patients have been identified having a follow-up period of 18 months or more. The average curvature was 49,4 (40 – 71) degrees at the start (8 combined and 15 single patterns of curvature). Average age: 12,4 years; average Risser: 0,83; 13 / 23 being pre-menarchial. Average follow-up time was 28 months, average x-ray follow-up 21 months.

## RESULTS

Average Cobb angle after follow-up was 43,8 degrees with 2 patients progressing and 9 patients improving 6 degrees or more. ATR decreased from 12,8 to 9,7 degrees ($p < 0,01$).
Successful treatment of AIS curves of 40 degrees and more was possible in > 91% and cosmetic improvement of the deformity was possible as well when using the GBW.

**Figure 1.** Patient with a curve exceeding 50° with an obvious clinical (and radiological) correction.

## DISCUSSION & CONCLUSION

Successful treatment of AIS curves of 40 degrees and more was possible in > 91% of the cases which is better than the results as achieved with the Boston brace (72%) and curves between 20 and 40 degrees. Significant reduction of the ATR shows that an improvement of the deformity is possible as well.

## REFERENCES

1. Ward T; 2015 SRS Meeting.
2. Ng SY; 2016 Curr Pediatr Rev.
3. Weinstein SL;2013 N Engl J Med.

# JEWETT SPINAL ORTHOSIS EFFICACY ON OBESE WEARERS

Dr. Bashar Al Qaroot[1], Dr. Martin Twiste[2,3], Prof. David Howard[4], Prof. Peter Hogg[2]
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## BACKGROUND

Jewett orthosis is a spinal orthosis used for the treatment of stable vertebral fractures by means of hyper-extending the spine; this offloads the spine to allow healing. Jewett orthosis was found to be an effective treatment modality[1] and for obese wearers Jewett orthosis effectiveness may be reduced[2]. However, to date, there are no reports identifying the relation between obesity and Jewett orthosis effectiveness.

## AIM

Determine the effectiveness of Jewett orthoses in hyper-extending the spine when worn by obese people and to compare its effectiveness between obese and normal-body-weight wearers.

## METHOD

8 normal-body-weight and 8 obese male participants were recruited. Each participant underwent lateral spine x-rays under 3 different conditions (randomly selected) as follows:

1. Extension without Jewett
2. Flexion with Jewett
3. Standing with Jewett

Superimposition method was used to measure the following range-of-motions at each articulation between T9 to L3 (being the most susceptible for stable fracture):

A. Jewett Referenced-Flexion (using images 1&2)
B. Jewett Referenced-Standing (using images 1&3)

A&B measurements were used to assess Jewett's capability in retaining the spine in a hyperextension position whilst the wearer A) flexes his spine and B) stands. Obtained results were statistically analysed using mixed design ANOVA.

## RESULTS

Although statistically insignificant ($p=0.79$ for Jewett referenced flexion and $p=0.52$ for Jewett referenced standing), the efficacy of Jewett was generally higher in normal-body-weight group (see figure 1). For example, normal-body-weight group experienced higher efficacy at T11-T12 and L2-L3 by 490%* and 4% (for Jewett referenced standing) and 25% and 29% (for Jewett referenced flexion).

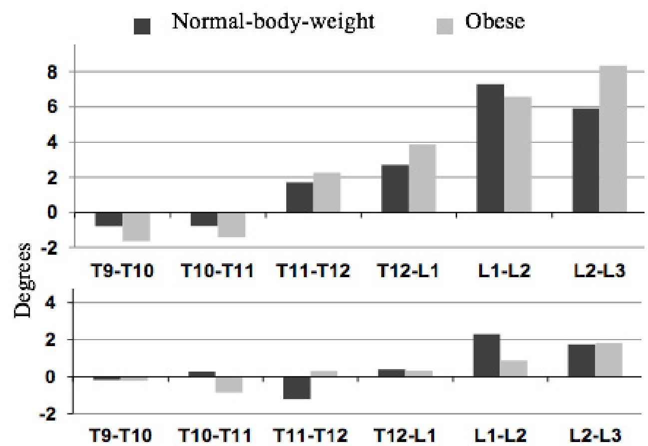


Figure 1. Jewett referenced flexion (top) and Jewett referenced standing (bottom). Zero line is the hyperextended position achievable without Jewett. Below Zero line is hyperextension and above is flexion

## DISCUSSION & CONCLUSION

Jewett orthosis efficacy in retaining the spine in the hyperextended position achievable without an orthosis (whilst the wearer stands and attempts to flex) is slightly better in normal-body-weight group (up to 2.42° difference at L2-L3).

Bearing in mind that generalisation is not possible due to the small sample size and in accordance with previous studies2, Jewett is likely to be a successful treatment for stable fractures in both normal-body-weight and obese people.

## REFERENCES

1. Patwardhan A; 1990 Spine
2. Tuong N; 1998 J Rehabil Res Dev

# DIABETIC FOOT IN INDIA

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*Sr. Prosthetist & Orthotist, Head of Artificial Limb Centre, St. Stephen's Hospital Delhi, India

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## BACKGROUND:

The clinical profile of diabetes differs across the world on account of difference in social, economical, and cultural factors. India is referred to as the capital of Type-2 diabetes. In India, the lack of awareness among patients and general medical practitioner is a key factor in foot care. Lack of resources, medical reimbursement and poor state funding for diabetes is a barrier to quality care, because the patient is unable to afford the high cost of treatment. This article on the clinical profile of the diabetic foot describes commonly observed problem in India. Certain atypical features and successful implementation of diabetic foot care project in St. Stephen's Hospital, New Delhi, India on reducing of foot ulcers and leg amputation.

## AIM:

To educate the diabetic patient and provide appropriate diabetic foot orthotic solution, prevent the foot from ulceration and amputation with the help of a full team approach.

## METHOD:

We developed a multidisciplinary diabetic foot care clinic in St. Stephen's hospital, where the team members ( Diabetologist, nurse, educator, Orthotist, Physiotherapist) are willing to work with great interest and dedication.

The sensory neuropathy can be tested by using monofilaments and biothesiometry. Testing and measuring the high planter pressure by simple inexpensive technique using an ink mat and also use PODIA scan with special software.

After the PODIA Scan and clinical assessment of 470 patients with diabetic foot we found in 59 patient with foot problem i.e. sensory loss ,corn and ulcers, the impression is made in foot impression box, positive mould is made rectifying the PODIA Scan and foot abnormalities. Then made customized soft total contact insoles for each and every diabetic foot patient. Some patients need special kind of orthotic devices and footwear, we also provided the same. At least two layers of different material be needed, the medium density crossed linked polyethylene to be the most suitable for the base of the orthotics. The top cover, which comes in contact with planter surface of the foot is made of plastozote foam as they provide cushioning and decrease friction and shear forces with using shear ban sheet. Then regular follow-up of the diabetic patient for recheck and reassess for further improvement. .

## RESULTS:

We are providing consistent patient education as well as preventive and acute care for diabetic foot, expected to bring gratifying results both in preventing as well as healing them. Lower limbs are salvaged and the quality of life of the diabetic patient also be improved.

## DISCUSSION & CONCLUSION:

India is rank second in the world with 65.1 million diabetic patients. The prevalence rate of diabetes in India is 2.4% in rural and the 12-17% in urban population. Foot ulcers are much feared complication of diabetes and recent studies have suggested that the risk of developing foot ulcer is as high as 25%.it has to be realized that the 85% of amputation are preceded by ulcer. If the ulcers are properly managed, majority of leg amputation would be preventable.

# ANALYSIS OF LEARNING CAPACITY OF STUDENTS AND VARIOUS REASONS FOR FAILURE IN ACADEMICS

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## BACKGROUND

After completing the school days, when the students get admissions in the professional course, most of them don't take their studies seriously and there are so many reasons for their unsatisfactory performance in their studies. Most of the reasons are largely within the control of the students itself whereas they are unable to identify their own problems about their failure/ unsuccessful studies.

## AIM

The only aim of this paper is to develop confidence among the students which will reflect in their professional career. It is the prime responsibility of the teacher to find out the reasons for poor performance, provide them proper guidance, advice and education.

## METHOD

107 undergraduate P&O students were individually interacted and based on the common problems faced by most of the students, a questionnaire consists of various questions with multiple answers related to their study plan and expectations has been prepared. The answers to each question were graphed and essay answers were entered into spreadsheets in an abbreviated form and shall also be highlighted in the presentation. Large number of students doesn't even know about their weakness and strength because of which they are unable to plan their studies. This paper will bring out their positive and negative qualities available with them and an initiation to eliminate the negative and improve the positive qualities has been taken.

## RESULTS

After getting all the relevant answers, 77% students maintain punctuality and similarly,33%students assured
of never missing their lectures.
45% of the students rarely ask questions with teachers and 66% agreed that their mobile phone disturbs their concentration. In contrast, only 4% of students revise the subjects daily and more than 50% study at least one hour in a day. 60% of students remain more attentive in the class despite their involvement in household activities. 60% of the students prefer to spend their reading time at home and around 45% of the students spend their leisure time in reading books and visiting library. Here it's the responsibility of the teacher to ascertain and resolve their negative factors and improving their quality of study by encouragement and support.

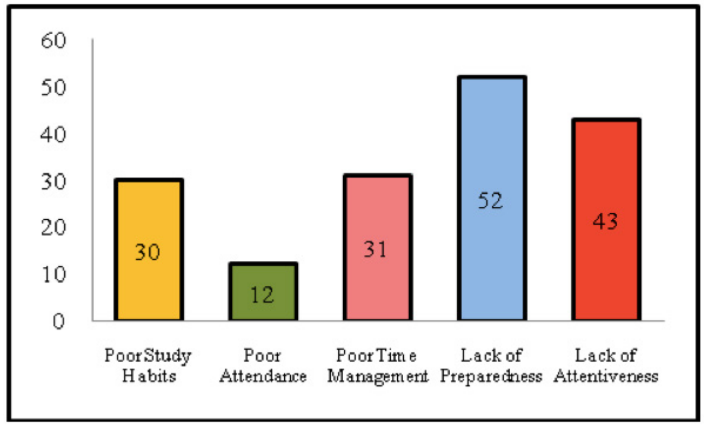


Figure 1. Factors affecting the Study Performance.

## DISCUSSION & CONCLUSION

To make a successful scholar, the teacher should know deeply about every student, their family set-up and difficulties including economic issues. This will help the teacher to overcome the difficulties in their study. The result outcome should be taken into consideration in positive approach and to adapt the changes and modifications which are required to establish successful quality of studies among the students who are the foundations of tomorrow's generation.

## REFERENCES

1. Why Do Students Fail? Faculty's Perspective. Abour H. Cherif, Gerald E. Adams, Farahnaz Movahedzadeh, Margaret A. Martyn, and Jeremy Dunning.

# EFFECT OF EXERCISE ON STATIC BALANCE AND COBB ANGLE DURING THE WEANING PHASE OF BRACE MANAGEMENT IN SPINAL DEFORMITIES

## BACKGROUND

Spinal deformities are inherently associated with balance disturbance [1-3]. furthermore, despite the positive effect of orthotic management, it may impact postural alignment and muscular performance by restricting spinal motion[4, 5]; therefore, a comprehensive and efficient treatment protocol for spinal deformities should consider body posture parameters and quality of standing stability. The effect of exercise doing in association with orthotic intervention, commonly used Blount and Moe protocol, on these parameters has not been considered until now.

## AIM

This study aimed to investigate the role of exercise (the Blount and Moe protocol) on static balance and Cobb angle in adolescents with spinal deformities during weaning from Milwaukee brace.

## METHOD

This is a cross-sectional study of 17 Milwaukee brace users allocated into 3 groups (good, moderate, and weak), according to their exercise quality and quantity. Static balance was evaluated on 4 conditions (standing on a platform/foam; with/without brace) using a force platform. Center of pressure displacement in the anteroposterior and mediolateral directions were compared among the 3 groups employing ANOVA and Kruskal-Wallis statistical tests. The mean Cobb angles of scoliosis and kyphosis at the beginning of brace use and at the start of the weaning phase were compared in general and among the 3 analogous groups using Wilcoxon and ANOVA tests.

## RESULTS

No significant difference was found in the static balance parameters and the scoliosis and kyphosis Cobb angles among the 3 groups, but wearing a Milwaukee brace significantly declined scoliosis and kyphosis ($P<.05$).

## DISCUSSION & CONCLUSION

Despite the claim of effectivity of exercise on natural history of spinal deformities[6, 7], the exercise quantity and quality (i.e. Blount and Moe protocol) in association with bracing, up to the weaning phase, has no effect on static balance and changes in scoliosis and kyphosis, but the curvature of scoliosis and kyphosis is reduced after wearing a Milwaukee brace.

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# SCHEUERMANN KYPHOSIS AND TREATMENT APPROACHES WITH A FOCUS ON NEW ORTHOTIC PROTOCOLS: A REVIEW OF LITERATURE

## BACKGROUND

Scheuermann's kyphosis, with prevalence of 0.4 -8.3%, is characterized by wedging of the anterior vertebral bodies caused by growth disturbance of the vertebral endplates, in late childhood (1).

## AIM

This study aimed to to investigate new findings in natural history, etiology and orthotic treatment approaches in Scheuermann kyphosis.

## METHOD

A database search was made between the years 1964 and 2016 under "Scheuermann kyphosis," "natural history," "etiology," "non-operative treatment," "orthotic treatment," "Milwaukee brace," "Thoraco-lumbo-sacral orthosis." Databases searched included: Cochrane Database, PubMed and Medline. Twenty seven journal articles were selected.

## RESULTS

The etiology of this disease is multifactorial including genetic and environmental factors as biomechanical factors that are the most probable source because of positive effect of bracing (2-4).

Pain complaint incidence is 20-60%, particularly in thoracolumbar curves, but it is not limitative. The likelihood of progression of a kyphotic curve is currently not known. Kyphosis more than 100° with upper thoracic apex impacts breathing (1, 5, 6).

Treatment embraces exercise, orthosis, serial casting followed by orthosis, and surgery (4, 7, 8). Orthotic management including Milwaukee and different types of TLSO is the preferred option for progressive curves between 50-80°with good flexibility and in loss of sagittal balance, in Risser 2 or lesser. Two major advantages of Milwaukee brace to others are controlling of the forward head posture and active correction mechanism that strengthens the thoracic spine extensors (7-10).

## DISCUSSION & CONCLUSION

The literature has confirmed long term efficacy of Milwaukee brace (11-14). But the articles related to the efficacy of TLSOs as Dupont, Boston, Maguelone and Kyphologic brace are low quality with no control group (15-21). Future research should focus on short- and long-term outcomes of TLSOs treatment. It is essential to plan randomized controlled trials to consider the efficacy of different types of orthoses and design new orthoses. Also it needs to do some researches related to natural history and etiology of the disease.

# INVESTIGATION OF PROSTHETICS AND ORTHOTICS EDUCATION IN JAPAN

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## BACKGROUND

In Japan, the first formal Prosthetics and Orthotics educational program began at the National Rehabilitation Center for Persons with Disabilities in 1982, and there have been ten P&O programme established until now. The Ministry of Health, Labor and Welfare has officially recognized all those P&O schools and allowed P&O graduates to enter the national P&O license exam. The author has been involved into P&O education, firstly as a student and then as a faculty as well as a board of P&O professional body (JAPO) for more than thirty years, and realize that there has been no significant change in P&O education in the country so far.

## AIM

The purpose of this study is to investigate P&O education provided in Japan by identifying its relationship to current P&O needs or trend in the country.

## METHOD

Two surveys were independently conducted. Investigation of current status of P&O education was done by sending questionnaire to ask head of each P&O program about their curriculum concept, allocation of P/O subject hours, and factors taken into account in curriculum development. Another survey was done to grasp the current P&O needs by sending questionnaire to all the JAPO members asking about their job in clinical practice. Statistical data provided by governmental organizations were also referred to know specific data regarding P&O provision in the country.

## RESULTS

Ten out of the ten P&O programme's heads responded and completed the questionnaire regarding education. Allocation of hours of P&O subjects at each school was identified. The average ratio of P/O subject hours in the ten programme is shown in Fig.1. Allocation of hours of patient contact or fabrication process in each P/O subject was also indicated. The data shows that, for example, approximately 70% of the total hours of Lower Limb Orthotics course are spent for fabrication process. Factors that faculties take into account in curriculum developing are shown in Fig.3.

The number of one thousand three hundred eighty five prosthetists and orthotists answered to the questionnaire regarding clinical practice. The average ratio of P/O devices they provided in the past one year is shown in Fig. 2. The result also shows that 63% of the P&Os have undertaken both device fitting and fabrication. According to statistics given by the Ministry, a total number of one hundred forty six thousand assistive devices were provided by Services and Supports for Persons with Disabilities Act in 2015, and Lower Limb Orthoses accounted for 20% while Lower Limb Prostheses accounted for only 3.3%. The data also shows that a number of wheelchair / seatings provision has increased in the past ten years.

## DISCUSSION & CONCLUSION

World Health Organization (WHO) describes in "Effective Teaching1)" that there are three factors must be taken into account in curriculum development of healthcare professional education, thus Research and Technology, Needs of the country, and Professional environment. This concept would be applied when investigating P&O education, and followings can be said from the results;

- Allocation of P/O subjects hours in curriculum doesn't reflect actual clinical needs, as shown in Fig.1 and Fig.2. This looks contradiction to what faculties answered "clinical P&O needs must be highly considered in curriculum development". (Fig. 3) There is currently lack of hours for students to learn about clinical skills. Although fabrication skill still looks important for Japanese P&Os, clinical competencies must be more focused on in education.
- Since demands of other assistive devices, such as wheelchairs, seatings, rehabilitation robots and so on, have increased in the country, P&Os are expected to contribute in those items fitting. P&O faculties also have to discuss and establish some educational program in this aspect.

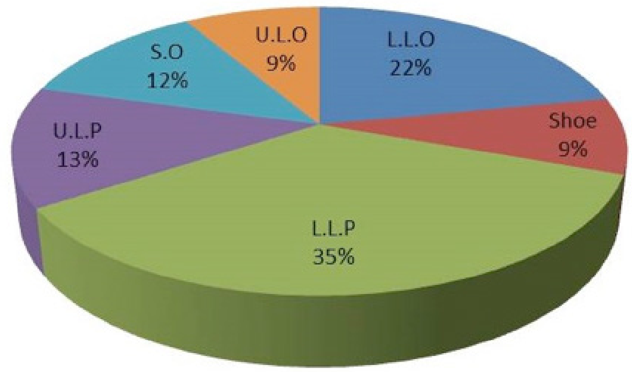


Figure 1. Ratio of P/O subjects

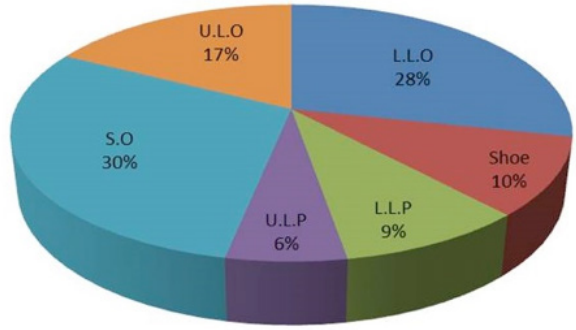


Figure 2. Ratio of P/O provision

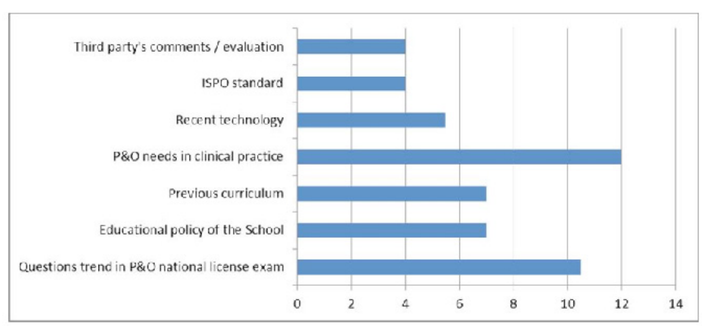


Figure 3. Factors taken into account in Curriculum Development

## REFERENCES

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2. Ministry of Health, Labor and Welfare Japan: Health Care and Welfare Measures for Persons with Disabilities, 2016

# SPECIAL NEEDS: DYNAMIC NEW PROXIMAL MASS KNEE (PMK) FOR SHORT-STUMP TRANS-FEMORAL AMPUTEES

## BACKGROUND

Knee joints must provide a safe stance, stumble recovery, stance yield, variable cadence and continuous availability of function to transfemoral amputees. Added function typically causes added mass to a knee joint, and amputees with short transfemoral residual limb (STF) suffer proportionally to the square of the distance of that mass to the mid-socket. This can cause these amputees to select a low function but light weight joint. There is a distinct special need for a high function proximal mass knee joint (PMK).

## AIM

To investigate the problems associated with short transfemoral amputation as a special needs sub-class of transfemoral amputation in general, and to review the medical benefits of a proposed solution.

## METHOD

The needs of an opportunity focus group of TF amputees with bone length 12cm or less, were reviewed: they needed a lightweight, high function knee joint.

Problem analysis predicted a requirement of proximal mass knee joint (PMK) for which a functional prototype was developed. Gait analysis was conducted with n=3 amputees, and subjective comments were included to evaluate the specification.

To improve the relevance and scope of the working model, it was peer reviewed by consultants and third party payers.

## RESULTS

STF amputees (n=10) found the PMK extremely light. The demands on the hydraulic control proved to be greater than in distal knees. Walking speed of 6.2 km/hr and stumble recovery were recorded. Reciprocating descent was found functional.

The three main results were:

1. The predicted significantly reduction of second moment of inertia to ¼ of that of an equivalent standard knee correlated with positive amputee experience, and allows STF amputees to reduce socket discomfort.
2. Theory that the spine needs (X), a matched-inertia prosthesis to benefit from body mass symmetry and the residual limb needs (Y), by priority, a low inertia prosthesis compatible with stump length and condition. The second order of inertia of the whole prosthesis about mid-socket length is proposed as a functional characteristic to correlate to outcome measures.

## DISCUSSION & CONCLUSION

The unprecedented proximal mass of the working model fluidic knee appears to offer direct medical benefits for the STF. Low inertia reduces stump forces and dynamic tissue deformation, supporting increase of proprioceptive awareness.

STF should be a specific subclass of TF due to the pseudo-articulating nature of the femur socket interface in an inverse proportional fashion to stump length. STF has not been identified before as a class of amputation that needs distinct healthcare provision.

# RESPONSES OF INDIVIDUALS WITH AN AMPUTATION TO ANTEROPOSTERIOR PLATFORM PERTURBATIONS DURING WALKING: INFLUENCE OF A MICROPROCESSOR-CONTROLLED PROSTHETIC KNEE

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## BACKGROUND

A survey conducted in 2001 indicated that over 66% of respondents with a transfemoral amputation fell at least once in the past year.[1] It is therefore of clinical importance to understand the responses of individuals with an amputation to balance perturbations and how interventions can affect these responses. One potential intervention is the use of microprocessor-controlled prosthetic knees (MPK) which has been associated with a reduced number of self-reported falls and stumbles.[2] A biomechanical explanation for this finding, however, is lacking.

## AIM

The aim of this study was to compare the use of a non-microprocessor-controlled prosthetic knee (NMPK) and a MPK (the Rheo Knee II) on responses to anteroposterior platform perturbations during walking.

## METHOD

Participants were measured twice: once with their own NMPK and once with the Rheo Knee II. Data were collected using a CAREN system consisting of an instrumented treadmill and a 12-camera VICON system. We measured perturbed and non-perturbed walking, both at preferred walking speed. A control group was included for reference purposes. Anteroposterior platform perturbations (magnitude 0.2m, speed 0.2 m/s) were applied during the single stance phase on the prosthetic leg and during the end of the swing phase of the prosthetic leg. The primary outcome measure was the backward margin of stability (BMoS), which is the distance between the extrapolated center of mass and the anteroposterior base of support.

## RESULTS

MPK vs NMPK condition: The BMoS of the steps after the stance phase perturbations in the Rheo Knee II condition was significantly increased when compared to NMPK condition. This is explained by a smaller foot forward placement and step length in the Rheo Knee II condition when compared to the NMPK condition. For the BMoS of the steps after the swing phase perturbations no differences were found.

Perturbed vs non-perturbed condition: In the Rheo Knee II condition, the BMoS of the steps after the stance phase perturbation was significantly increased when compared to non-perturbed walking. This was also seen in the controls. In the NMPK condition, the BMoS of perturbed walking was comparable to the BMoS of non-perturbed walking. In the Rheo Knee II condition participants decreased the step length and foot forward placement when compared to non-perturbed walking. Similar strategies were also used by controls.

## DISCUSSION & CONCLUSION

The Rheo Knee II led to an increased BMoS when compared to the use of a NMPK after stance phase perturbations. An increased BMoS is thought to be reflective of increased dynamic stability. The Rheo Knee II enabled the use of strategies that are also used by non-amputees where this was not the case for the NMPK condition. This study provides initial findings that might explain the decrease of self-reported falls and stumble while using a microprocessor-controlled prosthetic knee.

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# COMPARISON OF EFFECT OF CMAS ORTHOSIS, SOFT ANKLE SUPPORT AND CUSTOM MADE INSOLE ON POSTURAL CONTROL OF PATIENT WITH CHRONIC ANKLE INSTABILITY

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## BACKGROUND

Chronic ankle instability (CAI) is one of the most common problems after an ankle sprain. Depending on the type and severity of the initial injury, various combinations of ankle insufficiencies may be seen in CAI patients. The therapeutic approaches that were used for this population should consider different characteristic of them. Recently, CMAS orthosis introduced as effective device to improve postural control deficits in CAI patients. To date, no study comparison effect of this newly introduced orthosis with other usual ones.

## AIM

The purpose of current study is to compare CMAS orthosis, soft ankle support and custom made insole effects on postural control of patient with CAI.

## METHOD

Twenty patients with CAI and 20 healthy subjects participated in the study. Postural control was assessed on force platform in single limb stance with eyes-open. Both groups were evaluated while wearing no orthosis, custom made insole, CMAS and soft orthosis. The order of conditions was randomized. The center of pressure measures (COP) were derived from force platform signals for all 4 conditions in each group. The mean for the 3 trials of COP parameters in each condition was used for statistical analysis. To determine the main effects and interactions of the 2 factors, a separate 2×4 mixed model analysis of variance was used.

## RESULTS

Significant interaction between group and orthosis was found for all of the parameters extracted from COP data. There were no statistically significant differences between orthotics conditions in healthy subjects. In contrast, post hoc analysis revealed significant differences In CAI group between orthotics conditions. In all evaluated COP parameter CMAS significantly ($p < 0.05$) show lower value regarding other orthotics conditions..

## DISCUSSION & CONCLUSION

The results demonstrated that orthoses have no effect on postural sway of healthy participants. CMAS orthosis improved postural stability in patients with CAI but such effect did not find for soft ankle support and custom made insole. As the CMAS orthosis was designed to address mechanical and functional insufficiencies that are associated with CAI patients, it seems that this orthosis is more effective than two other investigated devices to improve COP parameter in CAI patients.

# PROBLEM BASED LEARNING IN PROSTHETICS AND ORTHOTICS CURRICULUM

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## BACKGROUND

Recently, problem-based-learning (PBL) became the dominant approach in clinical teaching were students are encouraged to find the answers to their questions rather than being stuffed with information from their teachers 1. Many researchers have documented the benefits that students could gain from PBL approach including improving their communication skills with other team members and improving their competence to interpret and understand knowledge 1,2.

## AIM

This study aims at documenting the benefits of integrating PBL in prosthetics-and-orthotics undergraduate curriculum as this has never been studied before despite being reported to be effective in other clinical fields.

## METHOD

Last year students underwent a newly developed course. The course was based on PBL. In particular, based on a search in the literature and evidence-based-practice, students had to choose and deliver a prosthetic or orthotic treatment for each of four patients. After that, students have to submit a case report for each of the patients he/she dealt with. The course was run under direct supervision and started by an induction week.
Upon completion, interviews with a randomly selected group were conducted to ask six questions (table1).
Recorded interviews were verbatim transcribed. Grounded theory was used to analyze the data. Open coding and axial coding were used to understand students' perspective of integrating PBL in their curriculum.

## RESULTS

Students were highly satisfied and optimistic about the implementation of PBL in this clinical practice. In particular, they have described it as an effective and self-enhancing method of education. “It was the best learning experience I have ever had” “The knowledge I gained through this course is equivalent to what I have gained over all previous terms (i.e. seven terms)” The students also mentioned that their clinical-practice has much improved after this course as they were exposed (from literature search) to cutting-edge technology in the field. “Literature review helped me to improve and broaden my clinical skills”
This is thought to be associated with the fact that students felt more confident about their prosthetic or orthotic choice as they read more about it in the literature.

1. What do you think of PBL integration in the curriculum?
2. Tell me things that helped you to learn using PBL.
3. Tell me if you have faced any obstacles during this course.
4. What did you gain during this course?
5. How will your experience with this course reflect on your clinical practice?
6. What and how have you benefited from your literature search involvement?

**Figure 1**. students' interview questions

## DISCUSSION & CONCLUSION

Overall, evidence from the current investigation suggests that integrating PBL into prosthetics-and-orthotics curriculum could improve students' learning experience and their clinical practice. In particular, students were keen to learn about different orthotic/prosthetic treatment modalities by themselves rather than by their lecturers.

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# THE INVESTIGATION ON RECYCLING PLASTER OF PARIS.

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## BACKGROUND

Plaster of Paris has been used in the manufacturing of positive models of body segments since the introduction of lamination and thermoforming in the prosthetic orthotic profession. Traditionally plaster of Paris has been used as a one off procedure, but this investigation looked at the possibility of recycling, re-using, used plaster of Paris positive/cast/models as an alternative. To achieve a sustainable and environmental friendly disposal, it is necessary to develop new waste gypsum recycling processes (Mihara et al., 2008)

## AIM

To investigate on recycled plaster of Paris positive cast models to be reused to produce positive cast models

## METHOD

The calcinations: i.e. thermal treatment process was utilized and determination on how many times plaster of Paris can be recycled while retaining the required compressive strength, setting time, and working characteristics. The plaster of Paris positive cast models were exposed to the sun light for two months to let them dry by evaporation thereafter they were broken into small pieces that can be grinded easily in pulverizing machine to get the powder form and thereafter heated inside the oven.

In this study, newly un-used, virgin plaster of Paris powder was used as a control and compared to the re-cycled material

## RESULTS

All recycled samples show the same setting time and compressive strength. The temperatures recorded were higher than virgin powder when mixed with powder to water at a ratio of 1:1 and 2:3 respectively. The six sample groups, each containing six cylinder models, were tested for compressive strength. The average strength of the recycled powder mixed in ratio 1:1 and 2:3 were 2,407 KN/M² and 1,028KN/M² respectively while for the virgin plaster of Paris were 1,807 KN/M² and 798 KN/M². The variations of the mixing ratio of 1:1 and 2:3 as well as the variation of the respective virgin sample was (1,028/2,407) 42.7% and (798/1,807), 44.2% respectively.

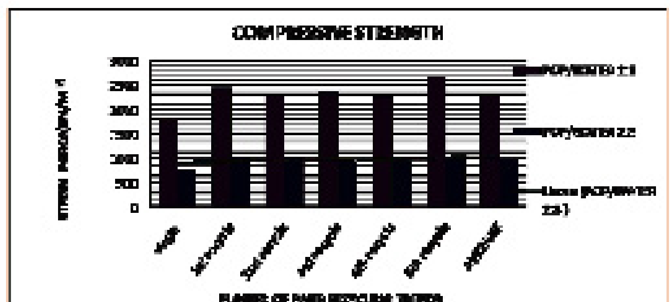


**Figure 1**.Compressive strength trend versus mixing ratio in weight, powder to water. The virgin poP is a control sample

## DISCUSSION & CONCLUSION

The results were such that, the transformation of calcium dihydrate ($CaSO_4 \cdot 2H_2O$) to calcium hemihydrates ($CaSO_4 \cdot \frac{1}{2}H_2O$) and vice versa is a reversible reaction Plaster of Paris can be produced by the heat treatment of discarded moulds under different conditions and the quality of the product thus obtained depends on the temperature and duration of burning (LOKULIYANA, 1987) The conclusion was that the process under controlled conditions of temperature, grinding and avoiding contamination and can be endless

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# PREDICTING FALL-RELATED INJURY AMONG PEOPLE WITH LOWER LIMB LOSS LIVING IN THE COMMUNITY: EXTERNAL VALIDATION OF A PRELIMINARY PREDICTIVE MODEL USING A MULTISTATE POPULATION

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## BACKGROUND

People with lower limb loss that live in the community fall at a rate of >50% per year [1], leading to an average fall-injury rate of 46.2/100,000 person-days that exceeds that of some other vulnerable populations such as hospitalized elderly people [2]. The predictive model derived from a one-state population found that female sex, non-White race, vascular amputation, and age predicted fall-related injury [2]. If externally validated, the predictive model can be used to identify and educate people at high risk for fall-related injury.

## AIM

The purpose of this study was to determine whether a predictive model for fall-related injury would be validated in a multistate American sample of people with lower limb loss.

## METHOD

This cohort study included community-dwelling people with lower limb loss participating in wellness-walking programs in 11 states within the United States. People of any age, sex, and race with lower limb amputations of any level and etiology were included. Subjects provided demographic information, amputation-related medical history, and self-report measures of balance confidence, prosthetic function, and fall history via questionnaire. Subjects also performed balance and gait speed assessments. Fall-related injury was considered injury sustained during a fall to the ground that required medical care by a doctor or emergency room staff, or required hospitalization or surgery. Descriptive analysis used Pearson's Chi-squared and student's t-test for categorical and continuous variables. A multivariable logistic regression model was created including significant variables in bivariate analysis. Odds ratios with 95% confidence intervals estimated the risk of fall-related injuries.

## RESULTS

Of 426 subject records, 257 had fall-related injury data for analysis. Age ranged from 8-83 years (mean=55.6±15.3), 68.9% were male, 83.8% were white, 53.6% had vascular amputations, 52.3% had transfemoral amputations, and 17.5% (n=45) reported fall-related injury. Injured subjects walked slower (p=0.003), and had more recurrent falls (p=0.047), transtibial amputations and lower balance confidence (p<0.001). The fall-related injury predictive model included sex, race, amputation etiology and level (Goodness of Fit Chi-square=2.95, p=0.889) without multicollinearity. Adjusting for other model variables, the likelihood of injury was three times more for females, almost five times more for non-White people, two times more for people with vascular amputations, and two times more for people with transtibial amputations.

| Multivariate Predictors | OR | 95%CI |
|---|---|---|
| Female vs Male Sex | 2.90 | 1.35–6.24 |
| Non-White vs White Race | 4.79 | 1.06–21.76 |
| Vascular vs Non-vascular Amputation Etiology | 2.22 | 1.04–4.73 |
| Transtibial vs Transfemoral Amputation Level | 2.32 | 1.01–4.89 |

Table: Multivariable Prediction Model for Fall-Related Injury

## DISCUSSION

The fall-related injury prediction model for this multistate sample included women, non-white race, vascular and transtibial amputations with each variable significantly adding to the odds of injury. While people with transtibial amputations achieve higher functional levels, they also engage in more activities that can lead to increased risk and more injurious falls [1]. The one-state preliminary model did not include amputation level, although 8/11 injured subjects had transtibial amputations, because of the small sample size [2]. The earlier model did include age, although not independently significant, as a covariate [2]. The relationship between age and falling may not be linear; falls increase with age until activity declines and people take fewer risks.

## CONCLUSION

Overall, the study results validate the earlier model and highlight the impact of female sex, non-white race, vascular and transtibial amputations on the risk of fall-related injury.

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# ANALYSIS OF HIP JOINT LOADING RESPONSE OF AMPUTEES USING UNILATERAL TRANS FEMORAL PROSTHESIS WITH CONSTANT FRICTION KNEE JOINT IN THEIR SELF SELECTED SPEED.

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## INTRODUCTION

Provision of appropriate Trans Femoral (TF) Prosthesis is the only way out in comprehensive management of challenging TF amputation. In India many amputees are still using TF Prosthesis with constant friction knee joint. Understanding the hip joint loading of unilateral TF amputees using those knee joint is indispensable for biomechanical consideration. It is essential to verify the impact of said Prosthesis related to hip joint loading to avoid other secondary health complications.
AIM :The study was conducted to measure the kinematic and kinetic parameters of TF Prosthesis users in their self selected speed to analyze the hip joint loading of sound limb and prosthetic limb.

## METHOD

Subjects with unilateral trans femoral amputation (N=30; 24 men, 6 female) with average age of 36.467±10.763 years, height of 1.629±0.073m, mass of 61.693±7.884 kg and Body Mass Index (BMI) of 23.217±2.430 kg/m2 and range,20-60 years. To obtain the net joint forces and moments, the inverse dynamics method was employed.Statistical methods was used to check the significant different between each comparisons in Statistical Package for the Social Sciences (SPSS) 20 and MS-Excel. Probability level of $\alpha=0.05$ was accepted as indicative of a statistically significant difference in the individual comparisons. Hip Joint loading of two limbs of amputee subjects was conducted using the paired t-test (parametric method).

## RESULTS

The hip joint loading calculated in loading response and terminal stance of the gait cycle in walking of trans femoral amputee in self selected speed. The hip joint loading at sound limb is 2.22 times than body weight and the net hip joint loading in prosthetic limb 1.7 times than body weight during loading response in stance phase (Fig.1). The loading pattern in sound limb is more than in prosthetic limb during loading response phase of the gait cycle ($p=0.0027$).The hip joint loading at sound limb is 6.13 times than body weight and the net hip joint loading in prosthetic limb 5.6 times than body weight during terminal stance in stance phase. The loading pattern in sound limb is more than in prosthetic limb during terminal stance phase of the gait cycle ($p=0.0038$).

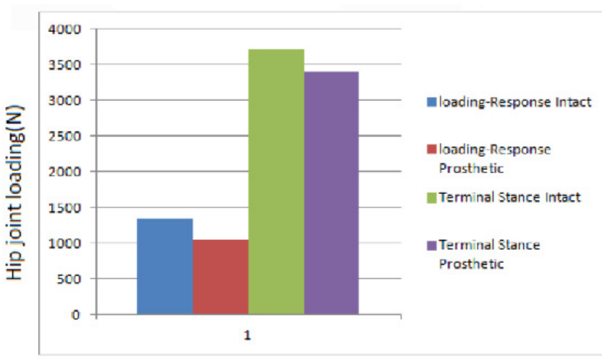


Fig.1.Hip Joint Loading Pattern

## DISCUSSION & CONCLUSION

After analyzing the result it is found that there is significant difference in hip joint loading between sound limb and prosthetic limb for the Trans femoral prosthesis users during walking in their self selected speed. Sound limb loading is more than the amputated limb. There was limitation in the study since the study was conducted with single force plate available at gait laboratory of the study place.

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# EFFECTS OF Q-ANGLE MANIPULATION IN CORRECTING GENU VALGUM DEFORMITY IN A PATIENT WITH POLIOMYELITIS USING KNEE-ANKLE-FOOT ORTHOSIS (KAFO): A CASE REPORT

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## BACKGROUND

Quadriceps femoris angle (Q-angle) is a scientific way tomeasure the angle between the hip, knee, and tibia. Literatures state that normal Q- angle for males is 14º and 17º for females. It is also a way of quantifying knee valgus deformity that is commonly observed in patients with poliomyelitis. KAFO is usually prescribed for patients who exhibit genuvalgum deformity. This study that quantifies effects of KAFO in manipulating the Q-angle can help guide clinicians in gauging the amount of corrective forces that can be administered within bounds of patient comfort.

## AIM

The aim is to quantify the effects of plastic KAFOs with varying Q-angle corrections on a patient with poliomyelitis exhibiting unilateral genu valgum deformity during walking in terms of frontal plane joint angles, joint moments, pressure and comfort.

## METHOD

Three Q-angle corrections were administered in random order using plastic KAFOs to a 56 y.o. patient diagnosed with poliomyelitis and has a unilateral flexible genu valgum deformity (Q-angle = 28O). The three corrections were set as: C20 (Q-angle reduced to 20O), C15 (reduced to 15O) and C10 (reduced to 10O ). A Vicon® motion analysis system was used to assess joint angles and moments while pressure was evaluated using the Force Sensitive Application (FSA) pressure mapping system version 4.0 by Vista model equipment. The subject was provided with a local (Thai) version of Visual A

## RESULTS

Hip and knee varus moments increased with increasing genuvalgum correction. The highest hip and knee varus moment was seen in C10. The trunk, pelvis and hip joint angles changed in varying amounts of genu valgum correction. C15 yielded the highest hip abduction across all conditions while maximum pelvic hike on the stance limb was seen in C20. Consequently, the highest ipsilateral trunk sway was observed in C20, followed by C15 and C10. C10 having the highest correction registered the highest pressure in FSA in comparison with C15 and C20. The highest VAS ratings resulted from C10 82% while C15 registered 16% and C20 14%. The subject reported discomfort at the medial heel of the affected limb during stance using the C10 device. (See figure 1 on the angle used in the study)

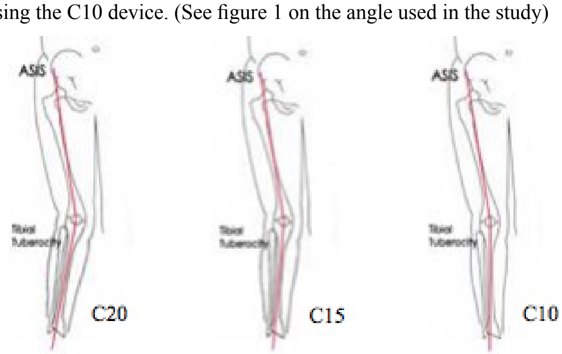


**Figure 1.** Different Q-angle used in the study

## DISCUSSION & CONCLUSION

Trunk hip and pelvic angles and moments along with pressure and comfort were altered variably in different scales of genuvalgum correction. However, it induced untoward effects on the hip, pelvis and spine angles specially when increasing correction beyond the sound side's Q-angle value. The result of this study suggests that C20 gives high rating in comfort but poor in joint control while C15 shows acceptable range in joint control along with acceptable comfort rating. However, C10 result suggests that it can give an excellent value in controlling the joints but beyond patient's comfort limit.

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# IS ANY WHEELCHAIR BETTER THAN NO WHEELCHAIR? A ZIMBABWEAN PERSPECTIVE.

Elsje Scheffler

## BACKGROUND

Within a rights-based paradigm, wheelchairs are essential in the promotion of user autonomy, dignity, freedom, inclusion and participation. Inappropriate wheelchairs and services may ultimately limit these aims and increase the risk for injury.

## AIM

This paper aims to describe a group of Zimbabwean wheelchair users' satisfaction with wheelchairs, wheelchair services and wheelchair function.

## METHOD

A mixed method, descriptive study was done. Quantitative data was collected from 94 consecutively sampled wheelchair users, who accessed wheelchair services at 16 clinics in five Zimbabwean provinces, between October 2013 and February 2014. The Quebec User Evaluation of Satisfaction with Assistive Technology for adults and children and Functioning Everyday with a Wheelchair questionnaire were used for quantitative data collection. Descriptive analyses were done. Qualitative data was collected through two focus group discussions (22 participants) and two case studies with participants purposively sampled from those who participated in the quantitative phase. Qualitative findings were used to inform and contextualise quantitative findings.

## RESULTS

The majority of wheelchair users (89%) used donated wheelchairs with a basic folding or non-folding design. More than 60% of participants were dissatisfied with the following wheelchair features: durability (78.6%), weight (75.6%), ease of adjustment (69.1%), effectiveness (69.0%), safety (66.7%), reliability (66.7%), and meeting user needs (60.6%). Users were not included as active participants in the wheelchair provision process. More than 66% of participants were dissatisfied with various services aspects: professional services (69.0%), follow-up (67.0%), and service delivery (68.3%). Although 60% of participants agreed that the wheelchair contributed to specific functions, more than 50% of participants indicated that the features of the wheelchair did not allow for satisfactory in- (53.2%) and outdoor (52.7%) mobility.

## DISCUSSION & CONCLUSION

The high levels of dissatisfaction with wheelchair features, services, and mobility may be related to the features of the wheelchairs commonly used and reflect inadequate training of service providers, both aspects often associated with charity model wheelchair distribution. It is recommended that policy and minimum service standards which incorporate evidence and good practice guidelines for wheelchair services and management of wheelchair donations are developed for Zimbabwe.

# MOBILITY AND PERCEIVED FUNCTIONAL CHANGES IN UNILATERAL TRANSFEMORAL AMPUTEES USING A NEW MICROPROCESSOR CONTROL KNEE

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## BACKGROUND

Microprocessor knees (MPK) have shown to increase quality of life (QoL)1, of which mobility is a major determinant2. Amputees‘ QoL also depend on satisfaction with their prosthesis3. Increased physical activity has shown to improve psychological, social and physical well being4, additional factors of QoL.
The purpose of this study was to measure the influence of a new MPK on mobility, functioning and satisfaction with unilateral transfemoral amputees.

## AIM

The primary hypothesis aimed to show improvements in functioning and satisfaction (PEQ MS 12/5) and mobility (6MWT) when using the new MPK; and secondary if these correlate to each other.

## METHOD

19 unilateral transfemoral subjects within the functional MFCL K3, K4 level were recruited in an IRB approved multi-center study. Participants were measured at baseline with their current MPK, at the initial fitting with the new design and after 3 weeks adaptation at which point in time 6MWT and PEQ MS 12/5 were performed. The cohort was stratified into two groups MPK1 and MPK2 according to the type of previous MPK to determine if either group would differ.

## RESULTS

17 (14 male) finished the study protocol and were included in the analysis 2 users dropped out. The average age of the sample was 41.7 (29-68) years (MPK1: 36.6 (32-44); MPK2: 44.5 (29-68)) and average weight was 79.47kg (56.7-104.3) (MPK: 76.1kg (56.7-87.5); MPK2: 81.3kg (59-104.3)). Although the MPK2 group was both heavier and older (including 2 users over 65) there was no statistical difference between the groups. Mobility improved statistically significant ($p>0.05$) for the entire group. The primary outcome, PEQ MS12/5, improved significantly ($p>0.05$) from 3, 10 at baseline to 3, 63 at 3 weeks follow up and users walked significantly ($p>0.05$) more 69.41m (447.94-517.35m) on average during the 6MWT.

No significantly different outcomes were observed in between the groups MPK1 and MPK2, neither at baseline, nor at 3 weeks follow up.

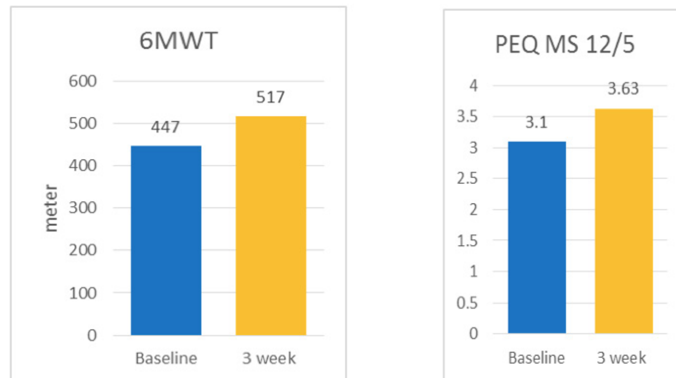


Figure 1. Statistical significant improvements (< 0.05) with the new MPK in 6MWT and PEQ MS 12/5 indicating a correlation of mobility to user satisfaction in functioning

## DISCUSSION & CONCLUSION

The typical 6MWT performance of transfemoral K4 Level amputees is 419.76 m and the minimal detectable change is 45m. The results indicate that the users step up to another performance level which is close to those of active duty service members of the US army. The PEQ MS 12/5 ratings show a significant improvement reaching close to the maximum of the score. Significant correlation with PEQ average in 3 weeks was found, indicating that increased mobility improves perceived functioning and satisfaction in the studied cohort. The new MPK significantly improved the mobility and satisfaction in prosthetic function for active unilateral transfemoral users.

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# A RANDOMIZED DOUBLE-BLIND CONTROLLED COMPARISON BETWEEN THREE TYPES OF PROSTHETIC FEET – A SINGLE-SUBJECT TRIAL

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BACKGROUND

There are over 200 different prosthetic feet on the market and the number is still increasing. Several articles report on properties and advantages of different prosthetic feet, but most of them are not randomized controlled trials. Those that are compare up to 20 different prosthetic feet available on the market or developed just for the purpose of a particular study [1-4]. For the majority of the parameters measured in these studies neither minimal detectable change nor minimal clinically important difference have been estimated.

**AIM**

The aim of our study was to find out whether clinicians can observe and reliably measure, and whether the patient can feel differences between three different prosthetic feet.

**METHOD**

The study was performed with a 43-year old active prosthetic foot user amputated at the trans-tibial level because of injury 17 years before the study who had no other medical problems. We put three different prosthetic feet (PT) in random order on his latest socket, which had a good fit. Each prosthetic foot was tried 6 times. The required number of trials with each prosthetic foot was statistically estimated based on previous results [5]. In each trial, the patient first walked on a designated path (comprising flat, uneven and sloped terrain and stairs). Three expert observers and the patient himself, all blind to the currently used prosthetic foot, rated the patient walking (-2 much worse, -1 slightly worse, 0 the same, 1 slightly better, 2 much better) in comparison with the patient's own prosthetic foot. After each trial we also performed one- leg standing test (with three repetitions) and 10-meter walking test.

**RESULTS**

The ratings differed significantly between the raters on each terrain and the ordering of the PT varied between the raters. The tested PF were rated as worse than the previous one. The patient gave lower ratings on average than the professionals, and recognised the order of the tested PF. Figure 1 present the results of the one-leg standing test (p=0.025 for testing the null hypothesis of no difference between prosthetic feet).

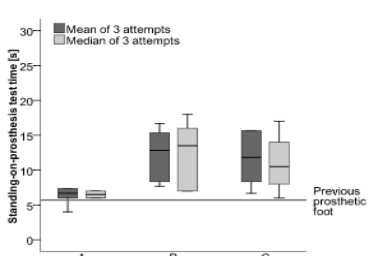


Figure 1. . Summary of results for one leg-standing test on prosthesis (A – Triton dynamic response foot, B – Dynamic Motion dynamic response foot, C – SACH foot)

**DISCUSSION & CONCLUSION**

Rehabilitation professionals, when blinded, cannot observe differences in walking on different surfaces with different prosthetic feet, whereas the patient may feel the differences, but those may not be the same as the manufacturers declare.

patients in need of a new prosthetic foot should not describe

(or even advertise) the characteristics of different prosthetic

feet to the patient, but just inform them that they will try

another one and then listen to the patient's opinion.

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# EFFECTIVENESS OF STANDARDIZED STUMP MANAGEMENT AND PROSTHETIC REHABILITATION PROGRAMME USING SILICONE LINERS FOR VASCULAR TRANSTIBIAL AMPUTATION

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Katsuhiro Konishi [2], Taichi Sano [2]

## BACKGROUND

Recently, the importance of preserving the knee joint when selecting the amputation level became widely known, with two thirds of the patients requiring major amputation due to peripheral arterial disease (PAD) being amputated at the transtibial level. Therefore, prosthetic rehabilitation for vascular transtibial amputees is very important. Our institution introduced a standardized stump management and prosthetic rehabilitation programme using silicone liners in a time-series framework after wound closure for transtibial amputation in 2006.

## AIM

To investigate the effect of our standardized silicone liner programme on the prosthetic rehabilitation period in patients who had undergone transtibial amputation caused by PAD by retrospectively evaluating the outcomes compared with those following an earlier soft dressing management programme.

## METHOD

Standardized silicone liner programme group consisted of the patients with PAD who had undergone unilateral transtibial amputation at local community hospitals and were then referred to our Centre for prosthetic rehabilitation between January 2006 and December 2014. The control group consisted of patients in the same conditions between January 2001 and December 2005. Control patients had received conventional soft dressing management and prosthetic rehabilitation. Standardized programme were as follows: 1) Two weeks compression treatment of the stump with a silicone liner. 2) Four weeks provisional prosthesis training, using cast sockets and silicone liners, with training in standing up between parallel bars and walking training using walking aids. 3) Two weeks intensive walking training using thermoplastic sockets with silicone liners. The ideal total duration of the programme was 8 weeks (Figure.1). Data of the patients (age, sex, and stump length) were retrieved from the medical records. The durations required for the silicone liner programme and the soft dressing programme were investigated. A retrospective comparison was conducted to evaluate the effects of the silicone liner programme on reducing the rehabilitation period compared with the soft dressing programme. Continuous variables (age, stump length and duration of training) were compared with Student's t-test and categorical variables (sex) with chi-square test. A P-value<0.05 was considered statistically significant.

## RESULTS

A total of 16 patients (13 males and three females) underwent unilateral transtibial amputations due to PAD and then underwent the standardized silicone liner programme. Their mean ± SD age was 62.1 ± 11.8 years. The control group consisted of 11 patients (nine males and two females) who had undergone unilateral transtibial amputation due to PAD that was followed by a soft dressing programme for stump management. Their mean ± SD age was 56.3 ± 12.6 years. There were no statistically significant differences in age, sex and stump length. The duration required for the completion of the prosthetic training programme was significantly shorter for the silicone liner programme compared with the soft dressing programme (77.3 days ± 13.4 versus 125.4 days ± 66.4 days, respectively; P<0.05). All patients in this study completed their prosthetic training programme without: (i) any interruptions from major complications, such as the need for wound debridement; and (ii) any internal complications that needed to be treated at another hospital during the rehabilitation period.

## DISCUSSION & CONCLUSION

The results in this present study showed that a standardized prosthetic rehabilitation programme using silicone liners for vascular transtibial amputees significantly reduced the rehabilitation period compared with a conventional soft dressing programme. These results suggest that a silicone liner programme may be a favourable method for postoperative stump management and prosthetic rehabilitation for transtibial amputation caused by PAD. This standardized silicone liner programme may be feasible in a community hospital setting that lacks a skilled prosthetic team. The numbers of elderly transtibial amputees due to PAD is expected to increase considerably in the future. Therefore, the establishment of an effective stump management protocol is important for both improving patient outcomes and managing the economics of healthcare.

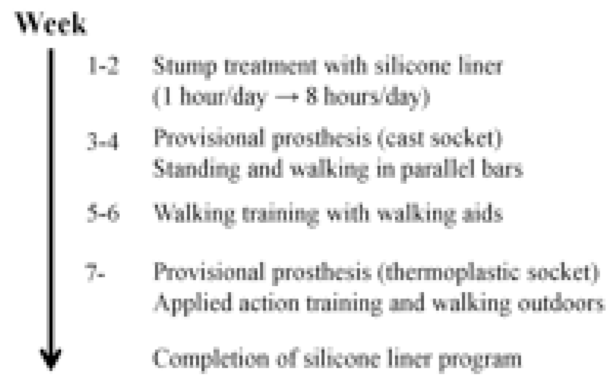


Figure 1. Schematic presentation of the protocol used for stump management using a standardized silicone liner programme.

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# IMPACT OF AN mHEALTH SKILLS TRAINING PROGRAM ON WHEELCHAIR MOBILITY OUTCOMES

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## BACKGROUND

Wheelchair mobility skills training is a core element in wheelchair service provision [1]. However, comprehensive skill training is often not provided, even in well-resourced countries like Canada. Therapists have limited time to address training needs and wheelchair users report issues with attending out-patient training because of cost, transportation and scheduling issues [2]. mHealth strategies address these barriers by providing rehabilitation services at home via a mobile device, such as a computer tablet [3].

## AIM

The purpose of this study was to evaluate the impact of an mHealth wheelchair training program on skill capacity and mobility-related outcomes of older adult manual wheelchair users.

## METHOD

Using a feasibility randomized control trial design, manual wheelchair (MWC) users over 50 years of age in two Canadian cities were assigned to one of 2 training programs: the mHealth intervention and a game-based control program. Each group received 2 in-person training sessions and 4 weeks of home training with a computer tablet. Participants were asked to practice 75-150 minutes/week (total of 300-600 minutes). Outcomes collected at baseline and immediately following intervention were analyzed using ANCOVA and □p2 effect size. The primary outcome was wheelchair skill capacity (WST-C); secondary outcomes included safety (WST-S, WWT), self-efficacy (WheelCon), participation (WhOM) in indoor and outdoor activities, mobility (LSA) and quality of life (HUI).

## RESULTS

Among the 18 Participants enrolled, 17 completed data collection (mHealth n=9; control n=8). Mean age was 65.4 ± 9.3 years. Mean total training time for the mHealth group was 734 ± 460 minutes; 7 participants achieved the minimum training threshold of 300 minutes, with 5 achieving 600 minutes or more. On the primary outcome, estimated marginal means for mHealth and control groups were 68.6 and 67.7, respectively (p=0.82; □p2=0.01). Skill capacity improvement was 5.3% and 4.7% respectively; 3.0% is considered clinically significant. WST-Safety (p=0.07; □p2=0.21), WheelCon (p=0.07; □p2=0.22), and WhOM outdoor (p=0.02; □p2=0.32) measures showed statistically significant improvements in the mHealth group. The remaining measures also favoured the mHealth group (n.s.) with small to medium effect sizes (□p2=0.05-0.13).

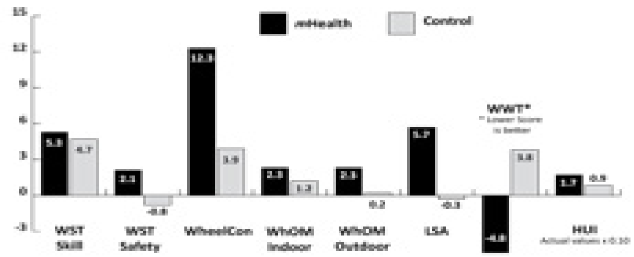


Figure 1. Change scores for mHealth and control groups

## DISCUSSION & CONCLUSION

Improvements were demonstrated in all wheelchair mobility outcomes measured, including significant differences in safety, confidence and participation compared with the control group. Adherence to the treatment was good. Both groups demonstrated a clinically important improvement in skill capacity. The small sample size may have muted statistically significant differences. This mHealth wheelchair training program shows promise as a method of delivering comprehensive skills training, particularly among those with limited access to rehabilitation professionals.

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# THREE-DIMENSIONAL MAGNETIC RESONANCE IMAGING RECONSTRUCTION OF HIP ABDUCTOR MUSCLE VOLUME IN A PATIENT WITH A TRANSFEMORAL BONE-ANCHORED PROSTHESIS: A FEASIBILITY STUDY

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## BACKGROUND

In persons with a lower extremity amputation severe muscle atrophy of the residual limb is present compared to the sound side. Bone-anchored prostheses are an alternative for conventional socket prostheses in persons suffering from socket-related problems. The effect of bone-anchored prostheses on tissue level is unknown. A potentially feasible method to evaluate this is magnetic resonance imaging (MRI)-based three-dimensional (3-D) muscle reconstruction.

## AIM

A) To examine the feasibility of a MRI-based 3-D muscle reconstruction technique in a person with a cobalt–chrome–molybdenum press-fit bone-anchored prosthesis. B) To describe the change of hip abductor muscle volume over time after implantation of a bone-anchored prosthesis.

## METHOD

In this single case one-year follow-up study we reconstructed the 3-D hip abductor muscle volumes semiautomatically from 1.5T MRI scans at baseline, six- and twelve-month follow-up using Mimics software (Materialise, Leuven, Belgium). The degree of adverse events, difficulties in accurate data analysis, time investment and participants' burden determined the level of feasibility.

## RESULTS

We included a man (70y) with a transfemoral amputation who received a bone-anchored prosthesis after 52 years of socket prosthesis use. No adverse events, such as heating of the metal parts, have occurred. Artifacts were mainly present in the most distal part of the residual limb, but caused no difficulties in the 3-D reconstruction of the hip abductor muscles (Figure 1). The accuracy of the reconstruction was potentially reduced by severe intra- and intermuscular adipose tissue. Data analysis was time-intensive (115 hours). Participants' burden was limited to 3-hour time investment. Severe muscle volume asymmetry was present at all assessments. The residual limb had 34-37% less total hip abductor muscle volume compared to the sound side (Figure 2). Compared to baseline, the total hip abductor volume of both the residual limb (six- month: 5.5%; twelve-month: 7.4%) and sound limb (six- month: 7.8%; twelve-month: 5.5%) increased.

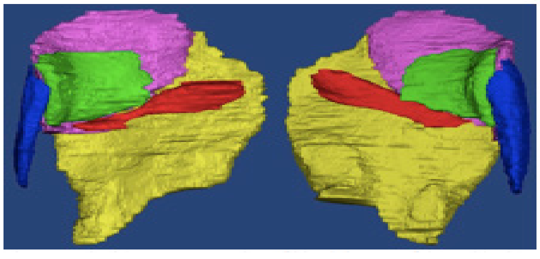

Figure 1: Final 3-D reconstruction of hip abductors of the residual limb (left) and sound limb (right). M. gluteus maximus (yellow), m. gluteus medius (purple), m. gluteus minimus (green), m. piriformis (red) and m. tensor fascia latae (blue.).

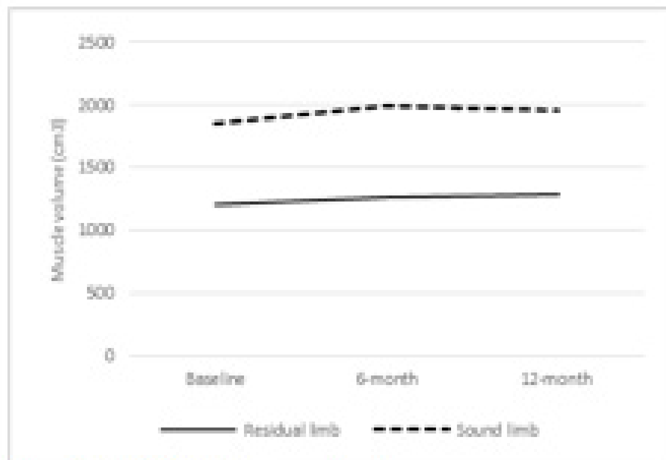


Figure 2: Total hip abductor muscle volume

## DISCUSSION & CONCLUSION

This study demonstrated that the MRI-based 3-D muscle reconstruction technique appears feasible to follow muscle volume changes over time in a person with a cobalt–chrome–molybdenum bone-anchored prosthesis in a scientific setting. Future research should focus on further automation of the 3-D reconstruction technique, analysis of the muscle tissue composition to quantify the level of intramuscular adipose tissue and the feasibility of this technique in other common bone-anchored prostheses, such as implants with a titanium alloy.

# ONE-YEAR FOLLOW-UP OUTCOMES FOLLOWING LOWER EXTREMITY PRESS-FIT BONE-ANCHORED PROSTHESIS SURGERY: A BEFORE-AFTER STUDY

Ruud A. Leijendekkers[1], Gerben van Hinte1, J. Bart Staal[2],[3], Jan Paul Frölke[4], Hendrik van de Meent[5], Maria W.G. Nijhuis-van der Sanden[1,2,5,] Thomas J. Hoogeboom[2]

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## BACKGROUND

Patients with lower extremity amputation frequently suffer from socket-related problems seriously limiting prosthesis use leading to limitations in the level of activity and health-related quality of life (HRQoL). Bone-anchored prostheses (BAPs) are a possible solution for socket-related problems. Knowledge concerning the level of function, activity and HRQoL after surgery is limited.1 No research has been done concerning the patients' level of satisfaction in regards to their prosthesis. This is remarkable, because BAP surgery is an invasive intervention aimed to overcome socket-related problems and associated problems in physical functioning.

## AIM

To describe the change in the level of function, activity, HRQoL and satisfaction in patients with a lower extremity amputation after receiving a press-fit BAP at six-month and one-year follow-up in comparison to baseline.

## METHOD

This is a prospective before-after study with follow-ups at six- and twelve-months after surgery and one baseline assessment. Adults with a lower extremity amputation suffering from socket-related problems who received a press-fit BAP between May 2014 and July 2015 were included. The outcome measures were: a) function-level defined as hip abductor strength and prosthetic use (Q-TFA prosthetic use score); b) activity-level defined as mobility level (Timed Up and Go (TUG)) and walking ability (6-Minute Walking Test (6MWT) and patient-reported estimation of the walking distance in daily life); c) HRQoL-level (Q-TFA global score); d) satisfaction-level regarding prosthesis comfort (Prosthetic Comfort Score (PCS)). Changes over time were analyzed using generalized estimating equations (GEE).

## RESULTS

All 28 potentially eligible patients (17 men) were included in the study (median age: 56 year, range: 28-70 year). In these patients 29 BAPs were implanted of which 25 on a transfemoral (one bilateral) and 4 on a transtibial level. The six- and twelve-month follow-up visits were completed for 27 and 28 patients, respectively. At baseline 25% and at follow-ups 0% of the patients were wheelchair-bounded. Relative to baseline, hip abductor strength in both limbs increased significantly (six-month: 0.13-0.15 Nm ($p<0.05$); twelve-month: 0.19 Nm ($p<0.001$)) and prosthesis wearing time increased significantly (six-month: 33 points ($p<0.001$); twelve-month: 36 points ($p<0.001$)). The TUG scores improved significantly at the twelve-month follow-up (six-month: -0.7 seconds; twelve-month: -2.0 seconds ($p<0.05$)), the 6MWT scores did not change significantly and the patient-reported walking distance increased significantly (six-month: 1217 meter ($p<0.05$); twelve-month: 2073 meter ($p<0.05$)) relative to baseline. HRQoL-level increased significantly (six-month: 24 points ($p<0.001$); twelve-month: 22 points ($p<0.001$)) and the PCS increased significantly (six-month: 2.7 points ($p<0.001$); twelve-month: 3.0 points ($p<0.001$)) relative to baseline.

## DISCUSSION & CONCLUSION

The influence of BAP surgery in combination with rehabilitation was in particular positive on function-, HRQoL- and satisfaction-level in patients with socket-related problems, both for patients with a transtibial as transfemoral amputation. The outcomes on activity level were inconclusive. Patient-reported outcomes changed positively, in particular, and to a lesser extent, the results of objective tests. One obvious health benefit of the described intervention, which has a large impact on patients' lives, is reduction of wheelchair-boundedness to 0% at both follow-ups.

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# FINANCING HEALTH REHABILITATION CENTERS FOR PROVISION OF QUALITY SERVICES TO DIS ABLED POPULATION IN TANZANIA

AUTHORS: Saria J.S, Shangali G.H, Mtalo B.L, Shirima G.D.

**BACKGROUND:**

15% of the world's population has some form of disability. The choices for financing health care are general revenues; social insurance, private insurance, and outof-pocket payments to those who are able to pay and this are few. Where private health insurance dominates health care financing ensure that people with disabilities are covered. The Governments can improve health outcomes for people with disabilities by improving access to affordable rehabilitation services.

**AIM:**

Improved health outcomes for people with disabilities through financing rehabilitation services, ensure disabled people are covered and consider measures to make the premiums affordable, and the accessible rehabilitation services.

**METHOD:**

Descriptive Cross sectional study, both Quantitative and Qualitative were used. 23 Facilities in ten regions visited. 12/19 Centers (63.2%) were purposively sampled in the seven (7) Zones in Tanzania.
Quantitative and Qualitative (Triangulation) applied. Ministry of Health & Social Welfare, Regional Medical Officers, Drs In charges, Directors of Consultant hospitals, District Medical Officers, Heads of the Orthopedics /Physiotherapy units as stakeholders.
Clients utilizing the rehabilitation services were among the respondents. Ethical Clearance obtained, including informed written consent to study participants. Structured, and Semistructured questionnaire including checklists were tools for data collection. Data analysis by use of SPSS 20.5 version.

**RESULTS:**

Of 85 respondents out of total 203 respondents, 35/85 (41.2%) indicated budget available, while 48/85 (56.5%) indicated no corresponding budget. 8/23 facilities (34.8%) received external support that included consumable materials for operations of fistula; funds for renovations, staff training, and for support to Albinism issues. The organizations providing external support included ICRC-SFD at CCBRT, MOI and Mwananyamala Municipal Hospital; Medical Missionary Relief at Mbalizi DDH; DANIDA and Zanzibar Outreach Infant Club Foot Appeal at Mnazi Mmoja Hospital; CARITAS-VERBAND Dusseldorf, Germany; Lillian Foundation at Monduli; TB and Leprosy Relief at Ruvuma Regional Hospital; and African Medical and Research Foundation (AMREF) at St. Joseph (Peramiho) Hospital. 2/85 (2.4%) indicated not aware at all of such budget. For the facilities with no budget, the provision of rehabilitation services to disabled population difficult

**DISCUSSION & CONCLUSION:**

Governments can improve health outcomes for people with disabilities improving access to quality, and affordable services, by the best use of available financial sources. The evidences on the need of services and all what is around welfare of people with physical disabilities are the pre-requisites for establishing sound programmes, practices and policies. Therefore, improved financing care systems are crucial, to the provision of rehabilitation services disabled population.

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# IMPROVED REVENUE COLLECTION TO SUSTAIN FINANCING HEALTH SERVICES AT REGIONAL REFFERAL HOSPITALS IN TANZANIA

AUTHORS: Saria J.S, ET. All

**BACKGROUND:**

Health financing is fundamental to the ability of health systems to maintain and improve human welfare. If sustainable financing mechanisms are not put in place, the health systems will not yield results (WHO 2000, 2005). Contributions collected through the social insurance system should finance the full insured cost of the health or pre-specified proportion of that cost. The contribution level/rate is tied to the cost of providing health insurance

**AIM**

To ensure that funding is made available for operational services, as well as the right financial incentives to providers, and all individuals' access to effective and personal health care

**METHOD**

Descriptive Retrospective/Prospective
Longitudinal study was applied. Retrospectively the National Health Insurance revenue Funds collected was identified, prospectively the gaps was narrated and solutions for proper revenue collection implemented, thereafter the results of before and after proper implementation was compared, the effectiveness through use of action plan. Prospectively the activities effectively implemented and showed effectiveness was standardized. 10 Regional Referral Hospitals Sampled and are continuous followed after every six months for a period of five (5) years. Key persons from regional referral hospitals are the respondents. Ethical clearance obtained, analysis by use of identified and adopted quality improvement monitoring tools.

**RESULTS:**

10/27 referral hospitals sampled and implementing proper revenue collection. The four kinds of revenue namely NHIF, OC, Basket fund and Others was monitored after six months from initial take off as follows; National Health Insurance Fund revenue collection(NHIF); before intervention of proper revenue collection ranged from ranged from Ths 259468629 /2,615,618,990 (9.92%) to 647342638/2615618990 ( 24.7% ) with increase rate of 14.78%. To operational Cost (OC) from 11340250 /2615618990 (0.43%) to 90373189 (3.46%) an increase of 3.025 %). On Basket Fund (BF) ranged from 4383000-2615618990 (0.168%) to 400029932 (15.29%) with an increase rate of 15.1%. On others type of revenue before ranged from 6310000/2615618990 (0.24%) to 94185000/2615618990 (3.6%) an increase of 3.12%. Comparing the total range of 10.8% before intervention to 47.05 after, there's increased rate of revenue collection by 36.3%.

**DISCUSSION & CONCLUSION:**

Financing systems are critical for reaching universal health coverage. Health financing levers to move closer to universal health coverage lie in three interrelated areas: raising funds for health; reducing financial barriers to access through prepayment and subsequent pooling of funds in preference to direct out-ofpocket payments; and allocating funds in a way that promotes efficiency and equity. Improved revenue collection has a great impact in financing.

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# ADOLESCENT IDIOPATHIC SCOLIOSIS – CORRECTION IN BOSTON NIGHT BRACE

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## BACKGROUND

Surgical correction and fusion is the method of choice for large spine deformities. However, brace treatment is an efficacious treatment alternative for smaller, but progressive curves, in children and adolescents. Bracing has been disputed, but proved to be efficacious with strict indications for moderate curves (Weinstein 2013, 2008). A primary curve correction in brace was an important prognostic outcome factor (Olafsson 1995). Most studies deal with full time bracing, which might be a cumbersome task for a child.

## AIM

When changing our brace policy from full time to night bracing, we registered the primary correction of the first 92 patients aiming to compare this information at after treatment follow up. The aim was to analyse the corrective ability of Boston night brace and to screen possible problems at its introduction.

## METHOD

The treatment indication was the same as for Boston full time brace: adolescent idiopathic scoliosis 25 – 40(45) degrees Cobb on a standing x-ray, verified progress, and at least one year remaining growth according to obvious clinical signs and/or radiographic age according to hand x-ray. A consecutive series of 92 children, 75 girls and 17 boys, mean age 13,3 (8,2 – 17,4 or 10–15 without outliers) years, were included. Mean Cobb was 32,2 (25-45) degrees.

## RESULTS

There were 42 thoracic, 26 thoracolumbar, 17 lumbar, and 7 primary double curves. The distribution of thoracic apex was 3 of T7, 24 of T8, and 15 of T9.
The mean Cobb in brace was 3,3 (0-34) degrees. Excluding one patient with 34 degrees, the mean was 2,9 (0-25) degrees. 89 % presented a curve of less than 10 degrees in brace. Overcorrections were registered as 0 degrees. The mean correction in brace was 90 %. The brace acceptance was high. There were no skin problems

## DISCUSSION & CONCLUSION

A good treatment outcome is shown to be correlated to the daily time in brace in full time bracing (Weinstein 2013). Good outcomes increased from 40 to 90 % when bracing time increased from 6 hours or less to 12,9-17,6 hours pro day. A further increase in bracing time did not give any additional improvement of outcome. The present study is a base for a later follow up study to see if bracing only in night time will be enough to keep good long term results.

### Conclusion

Boston night brace gave an excellent primary correction and patient acceptance. Future studies are needed for long term outcome.

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# VIBROTACTILE WEARABLE BIOFEEDBACK SYSTEM INTEGRATED WITH FORCE SENSORS AT PLANTAR FOOT COULD RELIEVE FOOT VARUS DEFORMITY IN PATIENTS WITH STROKE

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## BACKGROUND

Plantar sensory input is a crucial component of proprioceptive system, which is important for maintaining balance and gait control. Foot orthoses are traditionally prescribed to correct/compensate foot deformity and relieve foot pain in patients. Adding some electronic components at insoles to capture the plantar force information and providing corresponding feedback information could compensate sensory loss in patients and amputees [1-3], this may further be applied to help improve lower limb motor control.

## AIM

To investigate the effect of instant biofeedback of plantar pressure distribution at medial and lateral forefoot on alteration of foot inversion and push-off forces during stance phrase in patients with hemiplegic stroke.

## METHOD

This study was conducted in a university locomotion laboratory. Convenience sampling approach was adopted to recruit 8 patients with hemiplegic stroke (7M+1F, age 54±10 years, height 175±6 cm, weight 72±11 kg) in this study. All participants walked with visible foot inversion and seven of them walked with visible foot plantarflexion in swing phrase. The foot inversion and plantarflexion deformities were flexible and can be corrected by external forces. A vibrotactile biofeedback system was developed and evaluated, which integrated two force sensors at plantar surface of foot in a pair of flat insoles measuring the plantar forces at medial and lateral forefoot, and wirelessly sent instant control signals to one vibrator at wrist when the magnitude of detected plantar force at medial-side forefoot was lower than 50% of the lateral-side's.

A three-dimensional motion capture system (3D) motion capture system (Vicon Nexus 1.8.1, Vicon NexusTM, Vicon Motion Systems Ltd., UK) and an in-shoe plantar pressure measurement system (novel pedar-x system, PedarTM, novel GmbH, Munich, DE) were used to measure each subject's spatial-temporal gait parameters and plantar pressure distribution during walking in each of the two experimental conditions with randomized sequences: 1) with biofeedback system turned-off, and 2) with biofeedback system turned-on.

## RESULTS

Upon turning on the biofeedback system, the medial-side plantar pressure at both forefoot and midfoot of the affected limb increased significantly and became close to that of the sound limb, while the plantar pressure at rearfoot and-side midfoot of the affected limb decreased significantly in subjects (Figure 1, $p<0.05$). The subjects adjusted their gait pattern by significantly decreasing the foot external rotation and hip flexion, and increasing the pelvic backward rotation of both limbs during stance phrase ($p<0.05$). Although no significant difference was found, subject's affected limb also revealed notable reduction of foot inversion in stance phrase and increase of plantar-flexion in terminal stance phrase during walking upon using the device.

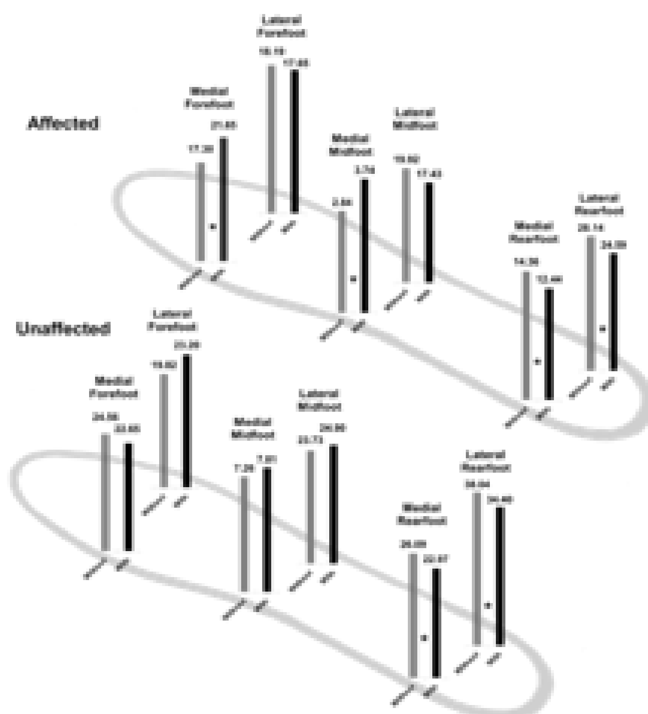


Figure 1. Mean plantar pressure values (kPa) at different foot regions with and without biofeedback system turned-on

## DISCUSSION & CONCLUSION

Instant vibrotactile biofeedback of plantar pressure distribution at medial and lateral forefoot helps relieve the foot inversion, facilitate initiation of swing phrase, and additionally increase weight-bearing symmetry in stance phrase during walking in patients with stroke. The positive results of this study shed new lights on future research of wearable plantar force-based biofeedback system for improving gait in people with impaired lower-limb motor control. It further allows the targeted gait training and improvement of motor control to be conducted in both indoor and outdoor environments.

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# A CASE-CONTROL STUDY OF BODY COMPOSITION, PREVALENCE AND CURVE SEVERITY OF THE PATIENTS WITH ADOLESCENT IDIOPATHIC SCOLIOSIS

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## BACKGROUND

It is important to elucidate the etiopathogenesis of adolescent idiopathic scoliosis (AIS) in order to devise an effective preventive and therapeutic management. The meta-analysis study conducted by Zhang et al. (2015) reported a pooled prevalence of scoliosis (with different causes) was 1.02% in mainland China. Despite body composition alterations in the patients with AIS are increasingly clarified (Barrios et al., 2011; Ramirez et al., 2013), there are few studies investigating the difference in the body composition between the patients with AIS and healthy controls in Asian countries.

## AIM

The purpose of the study is to investigate the body composition alterations between the patients with AIS and healthy controls, and the corresponding prevalence and curve severity in the patients with AIS.

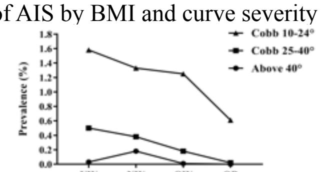
## METHOD

The information of the study sample was obtained from a screening programme conducted in 2014-2016. The AIS cohort was paired with an age-and-gender matched healthy cohort. The stratification of BMI and curve severity was according to the criteria developed by the U.S. Center for Disease Control and the Scoliosis Research Society. The prevalence and curve severity of the patients with AIS were investigated. Multi-group comparison of body composition parameters were done according to BMI between the patients with AIS and healthy controls.

## RESULTS

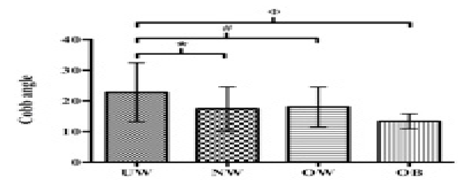
A total of 79,122 primary and secondary school students were screened. A number of 1,202 patients with AIS and an age-and-gender matched cohort were recruited from local schools. The underweights had the highest prevalence of AIS (Figure 1) and significantly higher Cobb angle as compared to other three BMI subgroups (Figure 2); despite the patients with AIS had lower body weight, body fat mass, percentage of body fat and fat free mass as compared with healthy controls, controversial results were observed in the underweights after the study samples were stratified according to BMI (Figure 3).

Figure 1 Prevalence of AIS by BMI and curve severity



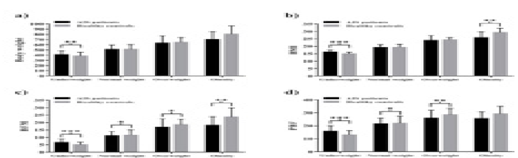

UW: Underweight; NW: Normal weight; OW: Overweight; OB: Obesity; BMI: Body Mass Index.

Figure 2 Comparison of curve severity of patients with AIS according to BMI subgroups




UW: Underweight; NW: Normal Weight; OW: Overweight; OB: Obesity. *p<0.05 for UW vs. NW; #p<0.05 for UW vs. OW; □p<0.05 for UW vs. OB

Figure 3 Comparison of body composition parameters between AIS patients and healthy controls



AIS: Adolescent Idiopathic Scoliosis; BMI: Body Mass Index; BFM: Body Fat Mass; PBF: Percentage of Body Fat. *p<0.05; **p<0.01; ***p<0.001.

## DISCUSSION & CONCLUSION

Based on the sporadic body composition of patients with AIS observed in the current study, the pathophysiological alternations may be different before and after the onset of scoliosis. Well-designed human or animal studies on underweights would be helpful to understand the mechanisms of the pathophysiological alternations and better predict the development of the disease. Integration of the data from different research sites would also help to detail the characteristics of BMI and curve severity in the patients with AIS.

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# THE MEASUREMENT METHODS OF COMPLIANCE OF SPINAL BRACES IN ADOLESCENT IDIOPATHIC SCOLIOSIS: A SYSTEMATIC REVIEW

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## BACKGROUND:

Efficacy of brace treatment for adolescent idiopathic scoliosis (AIS) is related to the time that the brace is used, witch is called "brace compliance". Subjective and objective means have been utilized for measurement of compliance with spinal braces.

## AIM:

The aim of this study is to systematically review the methods for monitoring the compliance in spinal braces that are used in AIS management.

## METHOD:

The search was conducted in PubMed, Science direct, Medline and Scopus with the keywords: compliance, temperature sensor, pressure sensor, brace wear time, adolescent idiopathic scoliosis and brace treatment. Inclusion criteria were English language, and compliance, or wearing time in title and keywords.

## RESULT:

Based on the inclusion criteria, 13 of 20 identified articles were included that were published between 1988 and 2016. It can be said that the proper way for reliable compliance measurement can be achieved via different means. Previous studies used subjective approaches such as questionnaires or interviews by patients and/or parents. In such studies, researchers can not specify non-compliance patients to exclude from the study. Overestimation of wear time is reported in subjective measurements that reduces reliability of the research. Objective approach is more valid and accurate and includes using of temperature sensor, pressure monitor, strap tension or smart orthosis to measure the compliance.

## DISCUSSION & CONCLUSION:

Different methods of compliance monitoring have potentials and limitations. Temperature sensor is more reliable, but it cannot display the tightness of brace. Tightness can be shown using pressure sensors, but it is limited by factors such as strap tension, weight fluctuations and body positions. A combination of both temperature and force sensors can be used in compliance monitors, or within "smart orthosis" to effectively monitor the brace wearing time.

# SAGITTAL MISALIGNMENT PATTERNS AND PATHOGENESIS OF ADOLESCENT IDIOPATHIC SCOLIOSIS

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## BACKGROUND

Adolescent Idiopathic Scoliosis (AIS), the most common type of idiopathic scoliosis, is a three-dimensional deformity of the spinal column, which includes the vertebrae and rib cage, that occurs during the adolescent period 1. The spinal column of a patient with AIS has abnormal curvature and displays misalignments in all planes 2. However, the misalignment patterns and deformities of the sagittal aspect is relatively ignored in AIS compared to the coronal plane. In addition, there is still a lack of understanding regarding detailed deformities, patho-mechanism, and sagittal misalignment patterns. Several coronal curve pattern classifications already exist3-5. However, these classifications fail to clearly categorize the misalignment patterns of other planes, such as the sagittal plane.

## AIM

The purpose is to identify the mechanism of sagittal deformities and the misalignments of the AIS scoliotic spinal column, and to classify sagittal misalignment patterns in relation to already established coronal curve patterns by quantifying spinal deformities and misalignments through spinal radiographic analysis.

## METHOD

This is a retrospective study using 200 PA spinal and lateral view spinal radiographs of 100 patients randomly selected from a pool of patients seen at a scoliosis clinic, between 2005 and 2012 with diagnosed AIS. These200 spinal radiographs satisfied the conditions: patient must be 10 years or older when the radiograph was taken, with a Risser value of 0–2, primary curve angles of 20°–50°, and with no prior orthotic treatments for scoliosis.

Any radiographs, even if they meet the conditions, were excluded when: patients had leg-length discrepancies of more than 2cm, patients had any deformities of the lower extremity, and patients had any surgical procedures on the lower extremity or spine. Five sagittal alignment angles were measured on each sagittal spinal column segment using the lateral view radiographs.

## RESULTS

Seven major sagittal misalignment patterns were identified based on the measurements of the five-sagittal spinal segment alignment angles. The means and standard deviations for each sagittal alignment angle measure were calculated for each sagittal misalignment pattern type. Non-parametric two-sample tests were performed in order to verify whether each sagittal misalignment type is distinct. The 7 major sagittal misalignment patterns were also classified with coronal curve types depending on the apex locations, and the means and standard deviations of each sagittal alignment angles were calculated by coronal curve type. There is significant evidence that sagittal misalignments exist in the spines and trunks of patients with AIS. In addition, there are certain sagittal misalignment patterns that correspond to coronal curve patterns.

## DISCUSSION & CONCLUSION

On spinal segments in which there are coronal apical vertebral bodies and lateral displacement ranges of coronal curvature, corresponding sagittal misalignment patterns were identified. The anteriorly directed force theory 6,7 spinal functional anatomy, and spinal sagittal compensatory mechanisms can explain the rationale for the sagittal misalignment patterns and the relationship between the coronal and sagittal planes. This study will help improve treatment for AIS by addressing the full complexity of AIS's deformities, including the previously ignored sagittal plane.

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# PRESSURE CASTING (PCAST) ASSESSMENT FOR TRANSTIBIAL AMPUTEE IN VIETNAM

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[1] University of Melbourne, [2] RMIT University, [3] Caulfield Hospital, [4] Vietnamese Training Centre for Orthopaedic Technologists

## BACKGROUND

Many challenges are faced by large numbers of people with lower limb amputation in developing countries. Foremost are cost and access to skilled prosthetic services. Attempts have been made to develop socket fabrication techniques that require little or no prosthetic skill. This study investigated a water pressure casting technique (PCAST) [1] to fabricate and fit transtibial prosthesis using the International Committee of the Red Cross (ICRC) polypropylene socket components.

## AIM

The aim is to determine whether the PCAST can produce a comfortable socket, determined by measures of satisfaction, physical function, gait and period of usage, in a developing country setting using low-cost ICRC components.

## METHOD

Fifty-three volunteers with unilateral transtibial amputation that were classified as active prosthesis users were recruited from the Vietnamese Training Centre for Orthopaedic Technologies. Ethics approval and informed consent were obtained. The participants were fitted with a PCAST socket and ICRC components. The following tasks were completed: timed up-and-go (TUG), six-minute walk (6MWT), gait trials and satisfaction questionnaire. These tasks were also completed after the extended usage period (146 ± 28 days). A GAITRite instrumented walkway (457 cm long, 80 Hz) was used to record gait parameters. The participants also completed the "Satisfaction with Prosthesis Questionnaire" (SATPRO). Descriptive statistics were calculated. Data sets were assessed for normality. Repeated measures multivariate analyses of variance with contrast testing (two-tailed) were used to compare data.

## RESULTS

Thirty-one of the fifty-three participants were successfully fitted with a PCAST socket. Fourteen fits failed, and eight failed to return, withdrew or became deceased. SATPRO results (n = 31) showed high levels of satisfaction (81%) on both initial PCAST fit (Pre) and after the extended usage-period (Post) (Table 1). The 6MWT increased by 28m (p = 0.01) after the extended usage period. The TUG, SATPRO and majority of gait measures remained unchanged. Single and double support (%GC) measures exhibited some significant differences but these differences were not considered to be clinically relevant.

## DISCUSSION & CONCLUSION

The PCAST socket was successfully fitted and used by thirty one of the fifty three participants over a period of 146 days. High satisfaction scores were found after the initial fit and extended usage-period. The 6MWT showed significant improvement whereas spatial and normalized temporal gait measures remained unchanged over the usage period. This shows the PCAST can produce a comfortable and functional socket for people with unilateral transtibial amputation using ICRC prosthetic components.

| | Pre | Post | p-value |
|---|---|---|---|
| Step Count | 41.1±9.6 | 37.1±8.5 | 0.11 |
| Speed (cm/s) | 93.6±19.5 | 94.9 | 0.48 |
| Cadence(steps/m | 95.6±10.7 | 97.4±10.8 | 0.07 |
| 6MWT (m) | 307.0±68 | 327.8±65 | **0.01** |
| TUG (s) | 10.2±2.6 | 9.7±2.1 | 0.28 |
| SATPRO (%) | 79.0±16 | 82.7±13 | 0.30 |
| **Intact Limb** | | | |
| Step Length (cm) | 56.7±6.9 | 56.8±7.3 | 0.91 |
| Stride Length | 117.0±14 | 116.6±13 | 0.80 |
| Support Base | 11.4±2.7 | 10.8±3.0 | 0.24 |
| Swing Time (%) | 35.2±2.7 | 35.8±2.6 | **0.01** |
| Stance Time (%) | 64.8±2.7 | 64.2±2.7 | 0.01 |
| Single Sup (%) | 39.7±2.8 | 39.9±2.6 | 0.54 |
| Double Sup (%) | 25.5±3.3 | 24.7±3.3 | **0.03** |
| Step Time (ms) | 630±72 | 618±79 | 0.15 |
| Stride Time (ms) | 1272±145 | 1250±141 | 0.12 |
| Swing Time (ms) | 446±40 | 445±43 | 0.88 |
| Stance Time (ms) | 827±120 | 805±113 | 0.05 |
| Single Sup (ms) | 506±69 | 499±66 | 0.31 |
| Double Sup (ms) | 326±69 | 311±69 | 0.16 |
| **Residual Limb** | | | |
| Step Length (cm) | 59.9±7.7 | 59.5±6.6 | 0.61 |
| Stride Length | 116.8±14 | 116.6±13 | 0.87 |
| Support Base | 11.3±2.8 | 10.8±2.9 | 0.29 |
| Swing Time (%) | 39.8±2.7 | 40.0±2.7 | 0.38 |
| Stance Time (%) | 60.2±2.7 | 59.9±2.7 | 0.36 |
| Single Sup (%) | 35.3±2.7 | 35.9±27 | **0.01** |
| Double Sup (%) | 25.4±3.4 | 25.0±38 | 0.47 |
| Step Time (ms) | 642±83 | 629±75 | 0.06 |
| Stride Time (ms) | 1270±145 | 1246±143 | 0.10 |
| Swing Time (ms) | 506±69 | 499±66 | 0.31 |
| Stance Time (ms) | 765±92 | 747±94 | 0.07 |
| Single Sup (ms) | 446±40 | 445±43 | 0.87 |
| Double Sup (ms) | 325±69 | 313±69 | 0.11 |

Table 1. Descriptive statistics (mean ± SD) for physical function and basic gait parameters for the PCAST pre and post the extended usage-period

## REFERENCES

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ACKNOWLEDGEMENTS: This project was supported by grants from Promobilia Foundation.

# SMART SHOES FOR DIABETIC PATIENTS

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## BACKGROUND

Every 30 seconds a lower limb is lost due to diabetes somewhere in the world. Foot ulcer precedes and is responsible for 85% of all lower limb amputations (LEA) in the diabetic population. Moreover, 94% of diabetic ulcers occur under the area of increased plantar pressure. Current off-loading devices do not permit to reduce the incidence of LEA.
To address these issues, additional preventive and alternative approaches to the existing methods are needed.

## AIM

To develop for diabetic patients an intelligent footwear wearable in everyday life and able to automatically off-load the foot zone with high plantar pressure. The goal is to accelerate wound healing and/or prevent from new ulcer formation.

## METHOD

The proposed intelligent shoe is composed of an insole having a number of miniature dampers filled-in with magneto-rheological fluids (Fig. 1). The damper unit is composed of an electromagnetic valve which interacts with the magneto-rheological fluid. Under each foot area, a single actuator is able to control its vertical deformation in response to variable external stresses. Areas with high peak plantar pressure are softened, whereas surrounding modules are kept stiff. Thus, it is possible to create a local depression of the insole allowing the off-loading of particular part of the foot (Fig. 2).

## RESULTS

The developed actuators were tested and support a pressure up to 600 kPa with a vertical difference of 2.1 mm between on and off-state module. The power consumption is about 63 mW.
A system of 7 dampers was assembled in order to validate the off-loading strategy. To simulate the particular profile of the foot zone with a high plantar pressure, an irregular surface was designed. A sensor was placed in the corresponding area of each module to measure the pressure between the tested surface and the modules during the loading. When the plantar pressure of a zone exceeds a certain threshold (set at 300 kPa) the corresponding module is flexible, while the neighboring modules remain stiff to support the load.

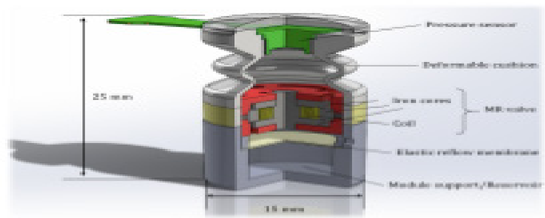


Figure 1. Magneto-rheological Soft Miniature Damper

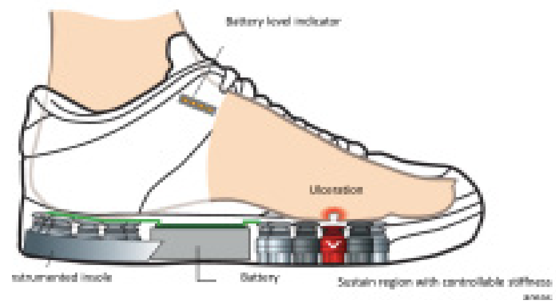


Figure 2. Concept of the Intelligent Shoe

## DISCUSSION & CONCLUSION

The main advantages of the proposed solution offers, with respect to the state of the art off-loading techniques, the possibility to constantly adapt the shoe sole to the changing loading conditions at each step and during the daily living activities. The prototype of the smart shoe requires further research on the electronics and will be validated in clinical trials.
In conclusion, we developed a smart shoe able to adapt the softness according to the actual loading while walking. The shoe should be wearable in everyday life conditions.

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# STATUS OF NEED VERSUS PROVISION OF PROSTHETICS AND ORTHOTICS SERVICES

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Tumaini University Makumira, Kilimanjaro Christian Medical University College.

## BACKGROUND

The need for prosthetic and orthotic (P/O) devices is growing immensely. World Health Organization estimates persons with physical disabilities in need of prosthetic and orthotic devices and related rehabilitation services in developing countries represent 0.5% of the population and only 5-15% actually has access to them.

## AIM

To know what extent the demand for P/O services among hospital patients was met by the current supply in Lusaka from 2010 – 2014.

## METHOD

Descriptive cross sectional study design was used in Lusaka at 3 orthopeadic hospitals. Study population consisted of physically disabled individuals who visited the hospitals requiring P/O services and P/O practioners. Questionnaires, document reviews and observation were means of collecting information.

## RESULTS

The research showed that 3,720 prosthetic/orthotic devices were supplied and 12,608 people required P/O services. The challenges affecting P/O services were; insufficient materials and equipment, insufficient personnel financial constraints, transport and patient compliance.

| | Amputations performed | Prostheses supplied |
|---|---|---|
| **Foot** | 1,057 | 91 |
| **Trans tibial** | 1,761 | 617 |
| **Knee Disarticulation** | 847 | 142 |
| **Trans femoral** | 1,117 | 500 |
| **Hip Disarticulation** | 795 | 6 |
| **Transhumeral & Transradial** | 739 | 25 |
| **Total** | **6,316** | **1,381** |

Table 1: Figures of amputations and prostheses supplied (2010-2014)

| | Cases seen | Patient supplied with orthoses at each level |
|---|---|---|
| | **Number** | **Number** |
| **Involvement of lower limbs** | 2,905 | 2,087 |
| **Involvement of the spine** | 1,949 | 79 |
| **Involvement of upper limbs** | 1,438 | 173 |
| **Total** | **6,292** | **2,339** |

Table 2 : Figures of cases of locomotor/spinal involvement and orthotic supply (20v10- 2014)

## DISCUSSION & CONCLUSION

The results from the study show that the provision of P/O services is meeting 30% of the identified demand available in the area. The gap in demand and access was also seen in a previous study done in Zambia by Leob and Eide (2006) in which the need and access was 301/ 1,642 (18.3 %). There is need to expand the service provision of P/O devices to cater for the high demand. The challenges identified confirmed with other previous studies done in different places (WHO and USAID, 2011; Magnusson, 2014; Wyss et al., 2013). This study was primarily limited by the poor record keeping in information on the supply and demand.

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# EFFECT OF INTERFACE COMPONENTS ON RESIDUAL LIMB WEIGHT-BEARING TOLERANCE IN THE NORTHWESTERN UNIVERSITY FLEXIBLE SUB-ISCHIAL VACUUM (NU-FLEXSIV) SOCKET

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**BACKGROUND**

Lower limb prosthetic sockets interface with soft tissues that are ill-suited to the loading that occurs during activities. Additionally, the transected bone at the distal end is unable to tolerate loading at full body weight (BW) (1). Hence, sockets must be designed to support the body and enable effective load transfer during activities by distributing weight bearing forces comfortably over the residual limb. Transfemoral sockets typically distribute weight bearing forces through a proximal brim that provides some pelvic support, however in the newly proposed Northwestern University Flexible Sub-Ischial Vacuum (NU-FlexSIV) Socket, all weight bearing loads must be borne by the thigh.

**AIM**

The aim of this study was to assess the relative contribution of interface components (liner and socket) on the ability of persons with transfemoral amputation (TFA) to bear weight comfortably on the residual limb.

**METHOD**

Subjects with unilateral TFA who wore a NU-FlexSIV Socket participated in a single visit. During a static assessment of socket fit, with a digital scale attached to a hard support surface, the subject applied weight onto the residual limb for three trials each of three randomly presented residuum conditions: bare limb, liner clad limb, and wearing the same liner and socket. Subjects were instructed to transfer as much weight onto the residual limb as tolerable while holding onto a walking frame for balance. For each trial, weight and pain were recorded on an 11-point ordinal scale (where 0 = no pain and 10 = the most intense pain imaginable). The magnitude of BW and pain level for each condition was compared with a repeated-measures one-way ANOVA and Friedman's test, respectively ($\alpha$=0.05), with a Bonferroni correction used to account for multiple post-hoc pairwise comparisons.

**RESULTS**

Thirteen subjects participated in the study (3 females; mean age 50±13 years; height 179±9 cm; weight 80±17 kg; residual limb length 24±3 cm). Subjects wore a variety of liners, including medi Relax 3C (n=1), Össur Seal-In X (n=8), and Össur Synergy (n=4). Soft tissues were classified as firm (n=4), medium (n=6) and soft (n=3). There was a statistically significant ($p<0.001$) difference in both pain and percentage BW between residuum conditions (Figure 1). While BW difference was significant between each condition, pain difference was only significant between the liner+socket and other two conditions. With a bare limb subjects placed a mean of 22±16% BW on their residual limb with a median pain score of 4 (interquartile range, IQR, 3-5); with the liner only subjects placed a mean of 30±18% BW on their residual limb with a median pain score of 5 (IQR 3-5); and with the liner and socket subjects placed a mean of 84±9% BW on their residual limb with a median pain score of 0 (IQR 0-1).

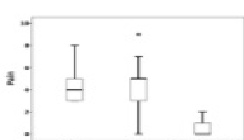

Figure 1. Box plots of % body weight (BW) (left) and pain for each condition (right). Center bars denote median values, box boundaries denote quartile range, and whisker extremes denote maximum and minimum values for each variable. The circle symbol in the pain box plot represents an outlier of these data.

Pain changes for the liner and socket condition compared to the other two conditions exceeded the minimally clinically important difference (MCID) reported for chronic musculoskeletal pain of 1 point (2).

**DISCUSSION & CONCLUSION**

Using the same technique of weight bearing on a scale, Persson and Liedberg (1) reported that persons with transtibial amputations tolerated between 3-79% BW on the bare residual limb and persons with transfemoral amputations tolerated 10-39% BW. Our transfemoral data are comparable at between 4-52% BW on the bare residual limb.

The ability to bear full BW on the residual limb is important given that it occurs with every step. The developers of the NU-FlexSIV Socket propose that this is accomplished by a total surface bearing socket that globally compresses the soft tissues, thereby preloading residuum tissue and pressurizing internal fluid (3). This idea is not new (4), however, the degree to which limbs can be compressed and the socket successfully donned has increased with availability of more compliant socket materials. Most recently, this idea has been proposed as the underlying principle for the compression and release socket, which applies three or more localized, longitudinal areas of high compression to the residual limb (5). By contrast, the NU-FlexSIV Socket provides high global compression via an undersized liner and socket (3). While this study provides some indirect support for this proposed theoretical role of tissue compression in creating a hydrostatic weight bearing interface between the amputee and the prosthesis, it suggests that the socket was the major contributor. The relative increase in system stiffness of the socket compared to the liner alone likely further restricts displacement of the residuum soft tissue during loading to facilitate hydrostatic conditions that may increase ability to bear weight with reduced pain.

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# EVALUATION OF A PASSIVE TRUNK SUPPORT CONCEPT ON ACTIVATION OF TRUNK MUSCLES

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## BACKGROUND

Some patients with paresis (both hypotonic and hypertonic) require extra stability and support for movement at the trunk region in order allow for trunk flexion and to effectively use their arm and head during regular daily activities. However, to date, only static support systems are available. In this study a new concept for a trunk support device for patients with paresis is presented and its effectiveness is evaluated. The device supports the trunk while allowing motion of the trunk.

## AIM

The goal of the current study is to observe the effect of the trunk support device on the activation of trunk muscles.

## METHOD

Measurements were done on 10 healthy participants in three different experimental conditions (a control condition and two different configurations of the orthosis) and in four different flexion angles (10°, 20°, 30°, 40°) for each condition. The activation level of the trunk muscles (iliocostalis, longissimus, external oblique and rectus abdominis) was measured using surface EMG electrodes. Accelerometers were used to provide feedback to the participants to ensure that they reached the same trunk angles across the experimental conditions and a metronome was used to ensure similar speed of movement to reach these angles. As this preliminary study is only aimed to observe the effectiveness of the device in unloading trunk muscles, no patients were included in the experiment.

## RESULTS

The measurement showed a reduction of loading of back muscles while using the orthosis compared to not using the orthosis. Specifically, muscle activation was reduced with over 25% for the iliocostalis and longissimus muscles and was 25% in 10° flexion to almost 35% in 40° flexion. The effect on the abdominal muscles, which do not need to generate moments during trunk flexion, was not significant.

## DISCUSSION & CONCLUSION

The preliminary measurements of the trunk support device show that it reduces the back-muscle activity to needed maintain a flexed trunk posture. Although the presented results were observed on healthy human participants, with little modifications and finer tuning the device can be made suitable to be used by patients with paresis. In conclusion, the present device reduces the muscle force needed to maintain a stable trunk. Therefore, it may appear to be suitable for application with paretic patients with insufficient trunk muscle force.

# A LIMITS OF STABILITY PROTOCOL UTILIZING MEASURES OF THE CENTER OF MASS AND CENTER OF PRESSURE IN TRANSTIBIAL PROSTHESIS USERS: LEARNING EFFECTS AND RELIABILITY

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## BACKGROUND

Completion of activities of daily living require a person to be able to volitionally control movements of their body. Individuals who use a prosthesis have decreased measures of this control when assessed using the Limits of Stability (LoS) protocol [1-4]. However, the reliability of the LoS protocol has not yet been established in users of lower limb prostheses. It is important to develop a widely available method and to establish the reliability of this protocol for use in prosthesis users in order provide guidelines for its continued employment in this population.

## AIM

The aim of this investigation was to quantify the reliability and learning effects of the LoS outcome variables in unilateral transtibial amputees when assessed using measures of both the center of pressure (CoP) and center of mass (CoM).

## METHOD

Trantibial prosthesis users (n=7) and matched controls (n=7) executed five test trials of the LoS protocol (Figure 1) twice a day, on two successive days. A custom real-time data visualization was developed (Visual3D v5.2, C-Motion, GermanTown, MD) allowing subjects to execute the LoS protocol while receiving real-time feedback regarding center of pressure position (Figure 1). Angular goal positions were determined individually based on participant anthropometrics (Figure 2). Analysis assessed inter-trial learning effects and reliability of variables derived via the center of mass and center of pressure (directional control, maximum excursion, reaction time, end-point excursion, and mean velocity).

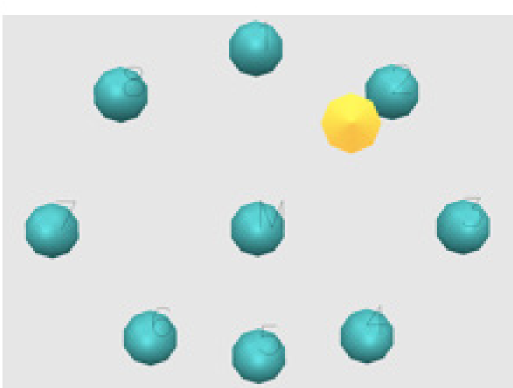

Figure 1. Visual representation of real-time CoP feedback given to participants.

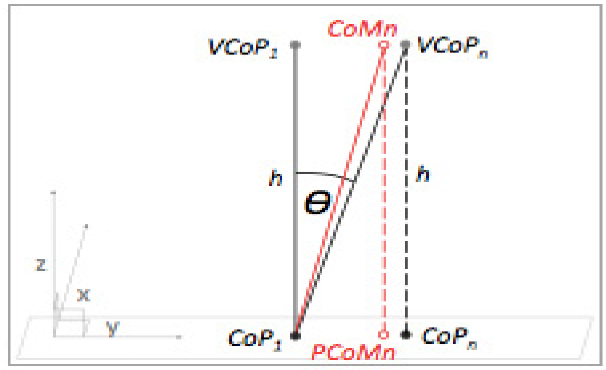


Figure 2. CoP and CoM during the LoS protocol. PCoM=projection of center of mass on floor, VCoP=vertical projection of CoP at height (h) of participant CoM. As CoM shifts during LoS, so does the CoP, but not exactly in phase or amplitude with each other. Thus, PCoMn and CoPn are not the same position.

## RESULTS

Reliability of the outcome measures was good to excellent for all measures except the reaction time variable (Pooled 95%CI of ICC=0.248-0.484). An inter-trial learning effect existed in directional control for prosthesis users when the first trial was included (center of mass: 95%CI of r=0.065-0.239; center of pressure: 95%CI of r=0.076-0.249).

## DISCUSSION & CONCLUSION

Reliable results for the LoS protocol can be produced using the real-time data visualisation process described which was executed using standard biomechanics lab equipment, and center of pressure and center of mass for derivation of outcome variables in prosthesis users. There was a low reliability for the reaction time variable in the protocol assessed. Results show that researchers should execute at least one practice trial prior to that which is used in subsequent analysis and interpretation.

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# THE COMPARISON OF THE MILWAUKEE AND LYON BRACES IN BRACE CORRECTION AND QUALITY OF LIFE IN ADOLESCENT THORACIC HYPERKYPHOSIS

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**BACKGROUND**:

Hyperkyphosis is a spinal deformity that affects approximately 1-8% of adolescent. Spinal braces are most common non-surgical treatment. However, bracing may be a stressful experience and affect quality of life (QOL); Therefore, quality of life for profile spine deformity (QLPSD) questionnaire is used. It is reliable and valid instrument, which determines mental/psychosocial functions.

**AIM**:

The comparison of the Milwaukee and Lyon braces in brace correction and quality of life in adolescent thoracic hyperkyphosis through using QLPSD Questionnaire.

**METHODS**:

The study population were adolescents 10 to 17 years old who attended to orthotics center, that hyperkyphosis angle was between 55 and 75. About 23 adolescents wore Milwaukee brace (n=15) and Lyon brace (n=8). Milwaukee group (mean age: 14 years old, mean cobb angle: 67.9 degree) was matched to Lyon group (mean age: 13.75 years old, mean cobb angle: 61.7 degree). In-brace correction was reported through comparison of the cobb angle before wearing brace and after two months intervention. QLPSD questionnaire could measure QOL. Kolmogorov – Smirnov test, T-test and Pearson's correlation coefficient were used in this study.

**RESULTS**:

Comparison of in-brace correction showed that there was no significant difference between two groups (p= 0.073). Also there was no significant difference between QOL scores (p= 0.018). In Lyon group there was a negative correlation between in-brace correction and quality of life (QOL) (r=-0.317, p=0.222) but there was a positive correlation in Milwaukee group (r=0.373, p=0.075). Moreover, there was a negative correlation between compliance and QOL in Milwaukee group (r=-130, p= 0.323) and Lyon group (r=-0.226, p=0.295).

DISCUSSION & CONCLUSION:

The Milwaukee and Lyon braces had the same effects in brace correction and decrease quality of life; also, it among patients who wore Lyon brace was improved. This factor might be due to lack of neck ring in Lyon brace. Regarding to same effectiveness of braces, individuals usually prefer to use Lyon brace because of minimizing deleterious effects on quality of life.

# EFFECT OF TUNED SOLID ANKLE-FOOT ORTHOSES ON STANDING BALANCE IN CEREBRAL PALSY CHILDREN WITH SPASTIC DIPLEGIA AND CONTRATURE OF THE GASTROCNEMIUS MUSCLE

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## BACKGROUND

Ankle-foot orthoses (AFOs) are often prescribed to children with spastic diplegic cerebral palsy (CP) and contracture of the gastrocnemius to improve walking. Mobility improvements in these children may have a substantial effect on quality of life. Tuned AFOs or solid AFOs with footwear combination (SAFOFC) which enhance walking may also have effects on standing balance. This aspect is often overlooked.

## AIM

This study aims to examine the effect of tuned SAFOFCs on standing balance in children with spastic diplegic CP and contracture of gastrocnemius muscle by measuring sway parameters of centre of mass (COM) and centre of pressure (COPC)1.

## METHOD

An optoelectronic system and dual force plates were used to assess COM and COPC parameters in nine children with spastic diplegic CP and contracture of gastrocnemius muscle (a minimum 5° plantar flexion) in three conditions: barefoot; solid AFOs which set the ankle at 90 degrees (90SAFO)-standard prescription in Thailand – and SAFOFC cast at gastrocnemius length and tuned2. A wearing time of six hours a day was required over a two week period.

$$\mathrm{COPCx} = \frac{(COP_L x R_{yL})}{(R_{yL} + R_{yR})} + \frac{(COP_R x R_{yR})}{(R_{yL} + R_{yR})}$$

$$\mathrm{COPCy} = \frac{(COP_L y R_{yL})}{(R_{yL} + R_{yR})} + \frac{(COP_R y R_{yR})}{(R_{yL} + R_{yR})}$$

Where: COPCx is the x combination of left and right COP (COPLx and COPRx). COPCy is the y combination of left and right COP (COPLy and COPRy). (COPLx, COPLy) is the coordination of COPL. (COPRx, COPRy) is the coordination of COPR. RvL, RvR are the left and right vertical ground reaction.

Sway parameters (range of anterposterior and mediolateral displacements, mean velocity and 95% confidence ellipse) were calculated and tested for significant difference using one-factor repeated measured General Linear Model (GLM) ANOVA.

## RESULTS

Nine participants were recruited as a convenience sample. Seven participants completed testing with both orthoses. The other two participants used one of the orthosis before drop out because of the difficulty in transportation due to severe flooding at the time of testing.

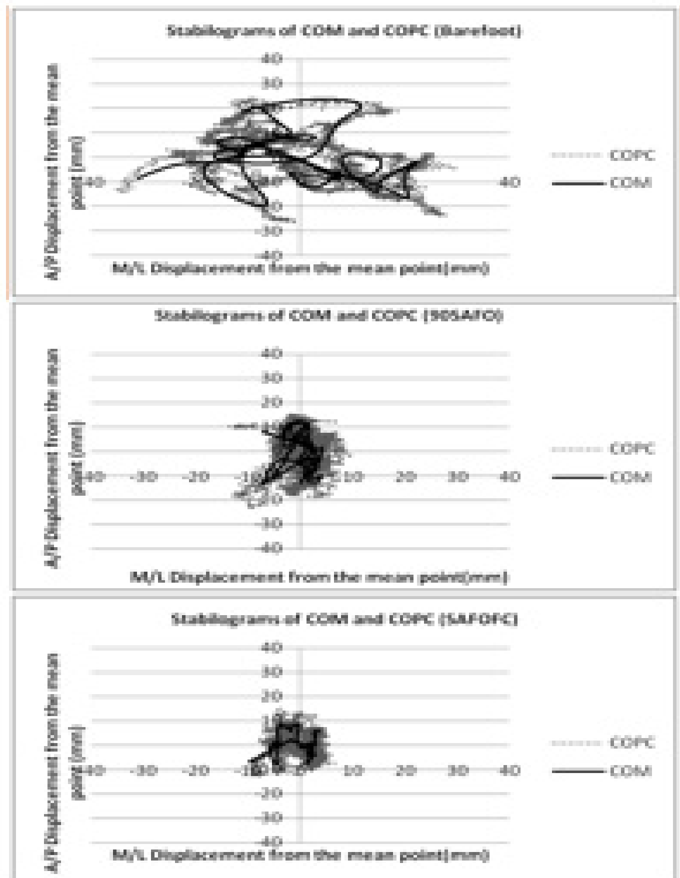


Figure 1. Stabilograms for 30s from three conditions: Barefoot, 90SAFO, and SAFOFC from a representative subject.

## DISCUSSION & CONCLUSION

SAFOFC resulted in minimal value of sway parameters compared with 90SAFO and barefoot conditions. This may be because the gastrocnemius contracture was properly accommodated, hence facilitating a greater range of knee extension and standing balance. Therefore, tuned SAFOFC can improve both gait3 and standing balance in CP children with spastic diplegic and contracture of gastrocnemius.

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# EFFECTS OF KNEE ORTHOSIS DESIGN ON PROPRIOCEPTION AND BALANCE

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## BACKGROUND

Several authors have demonstrated that knee orthoses improve proprioception in healthy subjects and those with a pathology (1-5). The specific design of orthoses has also been shown to influence proprioception (1).
The functional benefits of improved proprioception resulting from orthosis use are unclear. While some have demonstrated that improved proprioception is linked to subsequent improvements in postural control (1), others report no such association (3).

## AIM

The aim of this research was to determine if knee orthosis design significantly affects proprioception and balance in a group of able bodied adults.

## METHOD

Healthy subjects (n=20, range=22-55 years) executed tests of knee joint proprioception and balance under three randomized conditions; no orthosis, neoprene orthosis, and orthosis with rigid joints. Pressure under the orthosis was measured using pedar pliance sensors, (novel GmbH, Munich, Germany).

Proprioception was tested in an isokinetic dynamometer (ISOmed2000 D&R Ferstl GmbH, Hemau, Germany) utilizing two standardised tests: Detection of Passive Motion and Reproduction of Joint Angles.
Balance was evaluated using the Modified Sensory Organisation Test (Pro Balance Master, Neurocom International Inc., Clackamas, USA).
Proprioception and balance data were analyzed using a Friedman's ANOVA and their correlation was analyzed using Spearman's rank correlation coefficient.

## RESULTS

The orthosis with rigid joints applied the greatest amount of pressure to the knee joint. When wearing the orthosis with rigid joints, detection of passive motion was significantly poorer for the totaled results and for the condition in which the knee was initially positioned in 70 degrees of knee flexion. No significant differences were observed in relation to joint position sense or balance and the correlation between proprioception and balance was found to be poor.

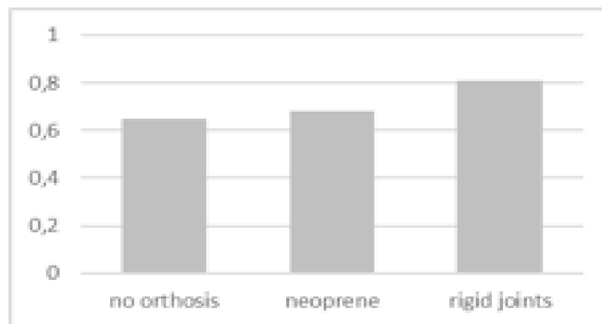


Figure 1. Median error on detection of passive motion test (totaled results).

## DISCUSSION & CONCLUSION

Results suggest that there is a limit in the amount of pressure that should be applied to the knee joint by an orthosis and that pressure exceeding this limit is likely to compromise proprioceptive feedback. No improvements in balance were associated with the application of an orthosis in this healthy sample of subjects.

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# BENEFITS OF A MICROPROCESSOR-ENHANCED HYDRAULIC KNEE TO UNLIMITED COMMUNITY AMBULATORS WITH A UNILATLERAL TRANSFEMORAL AMPUTATION

Andreas Kannenberg

## BACKGROUND

Prosthetic knees with microprocessor stance and/or swing control (MPK) have been demonstrated to reduce falls and the risk of falling and to improve walking capabilities and overall function and mobility compared to non-microprocessor controlled prosthetic knees (NMPK) (1-3). However, MPKs are often cost-prohibitive for health care systems in emerging countries. Therefore, a more affordable, MP-enhanced, default stance hydraulic knee with an MP-gait phase switch mechanism but otherwise conventional stance and swing control was developed to make benefits of advanced prosthetic technology also available to patients in emerging countries.

## AIM

The aim of this study was to evaluate the functional benefits of the new, MP-enhanced 3E80 prosthetic knee joint compared to standard NMPKs usually fitted in individuals with transfemoral amputations in Latin America.

## METHOD

This study enrolled community ambulators with a unilateral transfemoral amputation. Patients underwent a baseline assessment with their existing prosthetic knee as well as a follow-up assessment after 8 weeks of accommodation to the 3E80 MP-enhanced knee. Outcome measures assessed were the number of self-reported falls in the past 4 weeks prior to the assessment, Timed-up-and-go test (TUG), Four-Square-Step test (FSST), 2-minute walk test (2MWT) on level and uneven terrains with Borg rating of perceived exertion, timed ramp and stair tests, Activity-specific balance confidence scale (ABC scale), Falls Efficacy Scale (FES-I), question #1 (overall satisfaction) of the Prosthesis Evaluation Questionnaire (PEQ) and the Satisfaction with the Prosthesis (SAT-PRO) questionnaire.

Normally distributed data were analyzed using the t-Test for paired samples, not-normally distributed data were analzed with the Wilcoxon test with thresholds for statistical significance set a priori to $p<.05$.

## RESULTS

Thirteen participants (11 male, 2 female) with a mean age of 33.1 ± 8.8 years, who had used their existing prostheses for 5.8 ± 2.6 years, completed the study protocol. Eleven of the subjects (86%) were using a 3R80 rotary hydraulic knee that only differs from the intervention knee in its non-MP vs. an MP-controlled gait phase switch mechanism. One subject each used a 3R92 friction brake knee and a 3R21 4-bar knee with pneumatic swing control.

The number of reported falls in the past 4 weeks prior to the assessment decreased significantly by 77% from 2.2±2.5 to 0.5±1.1 ($p=.04$) when using the MP-enhanced knee. Similarly, the rating of perceived balance confidence on the ABC scale improved significantly by 17% from 75.3±15.3 to 87.2±8.7 ($p=.005$). The FSST, TUG, and FES-I did not reveal any significant differences between the knee conditions.

The 2MWTs on level and uneven terrains demonstrated significant improvements in the distance walked in the MP-enhanced knee as compared to the NMPK condition that exceeded one of the minimal detectable change reported in the literature [4] and whose corresponding increase in walking speed of 0.18 m/s was well above the widely accepted minimally clinically important difference of 0.1 m/s. [5-7] On the individual level, 8 subjects each (62%) improved their average walking speed by more than 0.1 m/s on either terrain, and 5 participants (38%) improved this much on both terrains. The Borg RPE for the 2MWTs did not show a difference between the knee conditions, and neither did the completion times in the timed ramp and stair tests. Subjects´ satisfaction with the intervention knee was significantly higher than with their previous NMPKs.

## DISCUSSION & CONCLUSION

The improvements in self-report falls and the risk of falling when using the MP-enhanced hydraulic knee had the same magnitude as those reported for prosthetic knees with full MP stance and swing control (1-3). In addition, participants were able to increase their walking speeds in the 2MWT from 1.03 to 1.21 m/s on level and from 1.07 to 1.25 m/s on uneven terrain with the MP-enhanced knee. Together with the significantly improved ABC score, this clinically meaningful improvement may reflect increased confidence in the prosthesis that is likely the result of the safer and more reliable MP-controlled gait phase switch mechanism. In this study, the MP-enhanced knee did not improve slope and stair mobility. This is not surprising as negotiating slopes and stairs depends on the control of the entire stance phase, which is basically the same non-MP controlled one as in 86% of the NMPKs (3R80), rather than on the gait phase switch mechanism. Improvement in participant satisfaction with the intervention knee was significant and similar in magnitude to that reported for other MPKs (1-3). We assume that, based on our findings and subjects´ comments, this increase in satisfaction and unequivocal preference is mainly due to improved safety and balance confidence. The 3E80 MP-enhanced hydraulic knee may therefore be a more affordable option for health care systems of emerging countries to further improve the level of prosthetic care of community ambulators who desire or need more safety but are satisfied with the functional support of a regular hydraulic prosthetic knee.

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# THE BIOMECHANICAL NEED OF THE PROXIMAL BRIM IN TRANSFERMORAL PROSTHETIC SOCKETS FOR OPTIMIZED FORCE TRANSMISSION IN DIFFERENT GAIT SITUATIONS

Malte Bellmann

## BACKGROUND

There are different prosthetic socket technologies for the treatment of transfemoral amputees. Within this context, ischium containment socket technologies have established in the past. They differ from other technologies in shape and functionality (1,2,3). The main difference is to be found in the proximal functional area that is responsible in different proportions for the force transmission between the residual limb and the bony pelvis structures. Socket technologies without force transmission in the pelvic region are available as well (subischial sockets).

## AIM

Within the scope of this biomechanical study is the investigation of force transmission principles by main functional elements of a transfemoral prosthetic socket. The study aims at further increasing the understanding of force transmission between residual limb and prosthetic socket in different gait situations.

## METHOD

To record the forces in the four main socket areas (area of ischium containment, lateral support, frontal support, volume and control area), the sockets are segmented according to these areas and implemented in a CFK frame. Load sensors between frame and socket segments are able to record the forces acting on the corresponding segments. The measuring data are transferred via a mobile wireless LAN system to a central PC and triggered synchronically to a stationary gait analysis system (Kistler, Vicon). Loading between the residual limb and three different sockets (CAT-CAM, MAS, subischial socket) was measured each with 6 transfemoral amputees in the following situations: level walking at three different walking velocities, descending stairs and ramps (sockets installed on a prosthetic knee joint and foot).

## RESULTS

The results suggest that the principles of force transmission within the four main socket areas do not differ significantly from each other between a CAT-CAM and MAS socket during different gait situations. With both socket types, a high degree of axial force is transferred by the medially located containment area. With the subischial socket that does not contact the pelvis, significant differences can be identified compared to both ischial or ramal containment sockets, however. They are to be found in the position of the total force running through the socket and the potential of stabilizing the stump within the socket both in the sagittal and transversal plane. This leads to the conclusion that the force transmission principles are different.

## DISCUSSION & CONCLUSION

In the past, theoretical models have been used to describe principles of load transfer between residual limb and socket. They assume that - also with ischial containment total contact sockets - an axial force can only be transferred by the soft tissue cover of the residual limb. However, clinical observations have not always confirmed this approach. Overloading is often caused in residual limb areas that according to the socket technology used should not transfer any forces. The method described in this study allows for the first time to objectify by comparison which socket areas are involved in force transmission and to what extent.

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# ORTHOSES WITHIN THE TREATMENT OF OSTEOARTHRITIS OF THE KNEE: BIOMECHANICAL COMPARISON OF KO AND AFO PRINCIPLES REGARDING FUNCTION AND EFFECT

Thomas Schmalz

## BACKGROUND

Knee orthoses (KO) to offload the medial compartment are one of the conservative treatment options in osteoarthritis of the knee. They use a 3-point pressure principle to generate a counteracting moment that reduces the natural external knee adduction moment. A novel ankle foot orthosis (AFO) shifts the center of pressure of the ground reaction force laterally, resulting in offloading the knee joint by a direct reduction of the external adduction moment.

## AIM

Based on biomechanical measurements, KO and AFO - both successfully used in the treatment of patients - are compared with respect to their total effect on knee offloading.

## METHOD

Two patient groups were tested during level walking. The first group (n=16, age 56±12y, BMI 27.9±4.5kg/m2, KELLGREN grade 2-3) was fitted with a KO (GenuArthro, Ottobock), the second group (n=12, age 64±12y, BMI 29.3±5.0kg/m2, KELLGREN grade 2-3) with an AFO (Agilium Freestep, Ottobock). For the KO group, the orthotic counteracting moment was defined by a specific calibration [1]. The gait analysis data were determined in the situations without (WOB) and with orthosis (WB). For the measurements, an optoelectronic camera system (27 passive markers, 12 Bonita cameras, VICONPEAK, Oxford, GB), coupled to two force plates (9287A, KISTLER, Winterthur, CH), was used. The 3D kinematics of the upper ankle joint and the knee joint and the external joint moments were used as specific assessment parameters.

## RESULTS

For the KO group, the mean maximum knee adduction moment was 0.62 Nm/kg for WOB and WB. At the time of the first maximum of the knee adduction moment,

the orthosis produced a compensatory abduction moment of 0.06 Nm/kg (10%). The pain as assessed on a 10-point VAS was reduced from 6.4 without to 3.3 ($p \leq 0.01$) with the orthosis. For the AFO group, the mean maximum of the knee adduction moment was reduced from 0.72 Nm/kg to 0.63 Nm/kg ($p \leq 0.01$) in WB. With the orthosis, pain was reduced from 7.7 to 3.8 ($p \leq 0.01$) on the VAS. In the AFO group, the 3D kinematics of the knee showed a reduction of the internal rotation of the tibia with the orthosis, reflected by 6° (p□0.01) difference in the transversal knee angle.

## DISCUSSION & CONCLUSION

The results confirm that both orthotic mechanisms are effective. The rigid bridging of the subtalar joint by the AFO limits eversion resulting in a lateral shift of the COP and thus in a reduction of the knee adduction moment. Based on the results of this and previous studies with KO [e.g. 2] and AFO [e.g. 3], the knee offloading can be estimated at about 10-15% for both mechanisms. Therefore, both principles may be considered biomechanically equivalent.

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# FUNCTIONAL COMPARISON OF CONVENTIONAL KNEE ANKLE FOOT ORTHOSES AND A MICROPROCESSORCONTROLLED ORTHOTIC LEG SYSTEM BASED ON BIOMECHANICAL, METABOLIC AND SAFETY PARAMETERS

Thomas Schmalz

## BACKGROUND

Patients with severe lower limb muscle weakness have often to be treated with a knee-ankle-foot orthosis (KAFO). Conventional KAFO principles are locked orthoses (LKAFO) and stance control orthoses (SCO). They allow for level walking, offer different safety levels and do not permit knee flexion in the weight-bearing condition. The microprocessor-controlled KAFO system C-Brace reduces these fundamental limitations of conventional KAFOs (cKAFO) significantly as it allows for damped knee flexion during weight-bearing and increased safety.

## AIM

This study investigates potential patient benefits of the microprocessor-controlled system compared to cKAFOs using biomechanical, metabolic and safety-relevant parameters.

## METHOD

Six patients participated (56±13y, 70±12kg, 164±11cm) who had been using cKAFOs for at least 2 years (4xSCO, 2x-LKAFO). After the biomechanical tests with the cKAFO (level walking, descending ramps and stairs), the subjects were fitted with the C-Brace followed by an adaptation period of 12 weeks on average. After this period, the biomechanical tests were repeated with the C-Brace. For the measurements, 2 force plates (KISTLER, Wintherthur, CH), coupled with a kinematic measuring system (12 BONITA cams, VICON, Oxford, GB), were used (assessment parameters: ground reaction forces, joint angles and joint moments). The metabolic parameters were measured during a 6-minute treadmill test at self-selected velocity (METAMAX3B, CORTEX, Leipzig, Germany). The safety of the KAFO systems was evaluated based on a study design from prosthetics [1].

## RESULTS

With the C-Brace, stance flexion was used by 5 patients. The mean swing flexion angle was 66.6° with the C-Brace, and 74° ($p \leq 0.05$, $n=4$) with the SCO. With the previous device, 4 of 6 patients were able to descend ramps step over step, none of the patients could perform this motion pattern when descending stairs. With the C-Brace, all patients could descend ramps as well as stairs step over step. With the C-Brace, the kinematic parameters and the joint moments of the sound side were similar to those in healthy subjects [2]. Oxygen cost with the C-Brace was reduced on average by 8% in 3 out of the 4 SCO patients (0.198 vs. 0.216 ml/kg*m) and by 4 and 10%, respectively, in the 2 LKAFO patients. During testing of safety (SCO vs. C-Brace), patients were at risk of falling in 61% of all trials with the SCO, but only 7% of all trials with the C-Brace.

## DISCUSSION & CONCLUSION

Due to the possibility of safe damped knee flexion during weight-bearing, the C-Brace allows the patients to descend ramps and stairs nearly naturally. The significantly higher safety level of the C-Brace encourages the patient to use these functions with a high degree of confidence without requiring any specific motor control of the orthosis. Despite a higher mass this effect results in a reduction of the metabolic energy consumption.

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# LONG-TERM DAMAGES AFTER LOWER EXTREMITY AMPUTATION? – SYSTEMATIC REVIEW

Eva Proebsting

**BACKGROUND**

It is often assumed that leg amputations result in a greater risk of degenerative changes to the locomotor system1, 2. Long-term damages after lower extremity amputation are already analysed in three systematic reviews5–7. All three studies show, that amputees have a higher risk for knee and hip osteoarthritis on the sound side. The altered gait with increased load on the sound side seems to be the reason5–7.

**AIM**

This paper analysed the extent to which the above described assumption is supported by the scientific literature. In particular, the study analysed the level of risk of various degenerative diseases in amputees.

**METHOD**

A systematic literature search was conducted for publications that had investigated changes caused by amputations in the EMBASE scientific database, Medline, and the database of the Journal of Prosthetics and Orthotics. Furthermore, the lists of references of identified publications were also analyzed for pertinent publications. All suitable articles were qualitatively analyzed and the available quantitative results of the studies were summarized.

**RESULTS**

The search came up with 43 publications. 17 studies3,4,8-22 report back pain. 5 papers8, 13, 15, 22, 23 analyze changes to the spine. A total of 14 studies1, 4, 8-10, 13, 15, 22, 24, 26, 28, 38-40 examined osteoarthritis. 15 articles8, 24-37 dealt with bone density. 9 studies16, 25-27, 36, 41-44 report muscular changes relative to a muscle atrophy on the sound side.
A quantitative summary of the studies for back pain and arthritis is shown in Fig. 1.

87% of patients exhibited reduced bone density in the hip on the prosthetic side and all amputees exhibited muscular atrophy in the residual limb

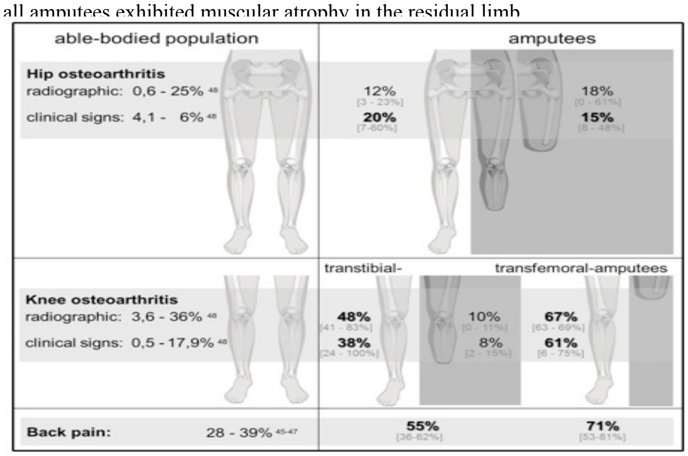


Figure 1. Quantitative summary of the prevalence of back pain and arthritis.

**DISCUSSION & CONCLUSION**

It may be possible to reduce the risks of back pain, knee osteoarthritis in the stound side, reduced bone density on the prosthetic side hip and muscular atrophy with novel prosthetic components and by optimising prosthetic fitting. On the one hand, an optimised prosthesis will be used more often. On the other hand, it will be exposed to greater loads and therefore the load to the locomotor system could be distributed more evenly between the two legs. Both aspects would result in a more physiological loading of the locomotor system.

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# CLINICAL EFFECTS OF AN INNOVATIVE SPINAL ORTHOSIS ON LOW BACK PAIN AND PAIN-FREE WALKING DISTANCE

Ingo Volker Rembitzki

BACKGROUND

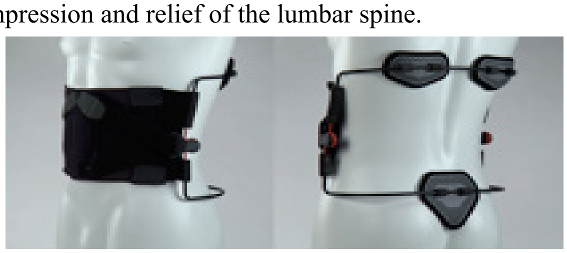
Lower back pain (LBP) is a common problem with a mean prevalence of 31% in general population [1]. In many cases LBP, especially in patients with radiculopathy, deteriorates with increasing walking distance, forcing people to stop after a certain distance limiting their mobility in a severe way. Treatment options include physical therapy, orthoses, surgery and/or pain medication. Physical therapy should always be a key element to strengthen back muscles in their basic function to support the bony spine structure. An innovative spinal orthosis was developed to reduce LBP and to increase pain-free walking distance (PFWD) by using a dynamic spring construction that straightens the lumbar spine. An observational study was conducted to collect data from the first clinical experience.

AIM

The aim of this observational study is to evaluate the effect of a new dynamic orthosis in patients with low back pain, spinal stenosis and a reduced walking distance.

METHOD

The 'Dyneva' spinal orthosis consists of an open metal frame construction where the upper and lower parts of the back frame are connected with a dynamic realignment spring (Figure 1). The torque of this spring is exposed to the lumbar spine during dynamic locomotion, resulting in a straightening with consequential decompression and relief of the lumbar spine.



31 subjects (age 65.0±11.5) with LBP were treated over a period of 4 weeks with a baseline assessment prior to the fitting of the 'Dyneva' and after 4 weeks of use. The assessment included changes in pain level and the change in PFWD.

**RESULTS**

The trial period with the Dyneva over 4 weeks showed an increase in the reported PFWD in 61% of all patients. 39% reported no change, and none of the patients reported a reduction. Average waking distance was increased by 602 meters (50%) (Figure 2). 26 patients rated their pain levels at baseline and after 4 weeks of Dyneva treatment. 14 of them stated a reduction of their pain level at the end of the intervention period; in 1 patient the pain level was increased.


Figure 2: average change of PFWD

Overall there was a mean decrease of pain on the VAS scale of 1.27 points; the difference was highly statistical significant ($p<0.001$). 85% of the patients reported that they wanted to continue wearing the 'Dyneva' orthosis, since they benefitted either from reduced pain level and/or increased PFWD.

**DISCUSSION & CONCLUSION**

The 4-week intervention with the 'Dyneva' spinal orthosis showed clinically and statistically significant effects regarding the reduction in LBP and the improvement of PFWD. Over 60% of the patients improved their walking distance during the intervention period, enabling them to achieve a higher grade of mobility in their daily life.

The orthosis may significantly contribute to patients' remobilization; significant clinical improvements are present for all tested indications. The subjects' high preference (85%) is a compelling first result showing the immediate effects of the 'Dyneva' orthosis.

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# A FEASIBILITY STUDY OF USING CLINICAL ULTRASOUND FOR ASSESSMENT OF SPINAL FLEXIBILITY IN THE PATIENTS WITH ADOLESCENT IDIOPATHIC SCOLIOSIS (AIS)

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## BACKGROUND

Spinal flexibility is one of the essential parameters to assist orthosis design for the patients with AIS, but it might not be feasible to assess comprehensive spinal flexibility of a patient in the past because extra radiation exposure is needed. Clinical ultrasound is a promising technique for spinal assessment because it is radiation-free and was reported to be reliable and valid to assess lateral curvature and vertebral rotation in the patients with AIS.

## AIM

To investigate the feasibility of using clinical ultrasound for assessment of spinal flexibility in the patients with AIS.

## METHOD

This study recruited the subjects with AIS and their spinal fexiblity was assessed by a clinical ultrasound system (Scolioscan) in six positions, including standing, supine, sitting, sitting with lateral bending (left and right side), prone and prone with lateral bending (left and right side). Routine radiographic assessment were conducted in standing and supine position. Spinal flexibility is calculated as: Spinal flexibility = (Curve Angle standing – Curve Angle assessment position)/ Curve Angle standing ×100%. The Spinal flexibility assessed in different positions will be compared by repeated measures ANOVA. The correlation between ultrasound and radiograph measurement will be analyzed by Pearson correlation coefficient and regression equation.

## RESULTS

A total of fourteen subjects (mean Cobb angle = 27.8°+6.1°) were recruited. This pilot study indicated a feasibility of using clinical ultrasound to assess spinal deformity in the proposed body postures (Figure 1). Ultrasound assessments showed that the spinal flexibility in six positions are significantly different from each other, with the spinal flexibility in supine, prone, sitting position were 56.3%, 44.1% and 11% respectively; spinal flexibility of convex side bending in sitting and prone positon were 113.4% and 117.0% respectively (Figure 2). Radiographic assessments demonstrated that the supine flexibility was 33.8%.

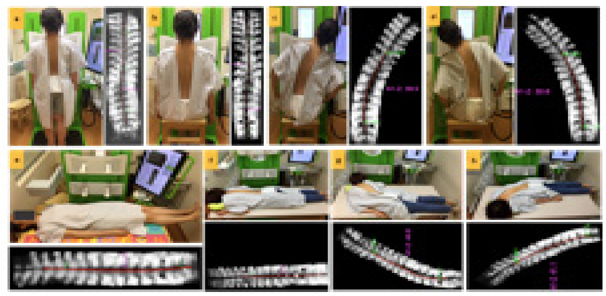

Figure 1 Assessment Positions and Corresponding Ultrasound Images (a)Standing (b) Sitting (c, d) Sitting with lateral bending (e) Supine (f) Prone (g, h) Prone with lateral bending.

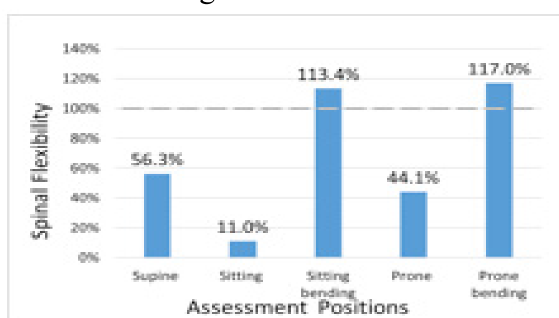


Figure 2 Spinal Flexibility in Different Positions

## DISCUSSION & CONCLUSION

The preliminary results verified the feasibility of clinical ultrasound to assess spinal flexibility in the patients with AIS. Supine and prone position tend to correct scoliotic deformity and convex side bending position may overcorrect the spinal deformity. Nonetheless, further study is required to verify the preliminary findings and investigate the reliability of clinical ultrasound assessments via comparing with radiographic assessments.

# LOWER LIMB AMPUTEES GAIT CAPACITY AND FUNCTIONAL ABILITY AFTER FIVE YEARS OR MORE.

Lena Gudmundson reg. physiotherapist, Linda Englund reg. physiotherapist

## BACKGROUND

Few studies that focus on person with lower limb amputation (LLA), have reported function of using a prosthesis after more than a year. The reason is partly because many suffer from comorbidity and do not survive five years after amputation. In this general Nordic population we have studied gait capacity, functional ability and prosthetic use, including lower limb amputees who have used prostheses for 5 years or more.

## AIM

The aim of this study was to compare gait capacity and functional ability with prosthetic users who have used prosthesis for five years or more.

## METHOD

A total of 60 participants who have used prosthesis five years or more, (range 5-77 years), were included in this retrospective cross-sectional study. The participants were between 25-94 years old (median 62yr), 41 men. Gait capacity was evaluated with the" 2-Minute Walk Test" (2MWT), functional ability was evaluated with the "Timed Up and Go"
(TUG) test and the "Locomotor Capabilities Index -5" (LCI5) Participants also answered questions about prosthetic use in time of hours and days. In order to compare differences of outcomes in the various tests with the amount of prosthetic use, participants were divided into three groups according to how much they used their prosthesis in number of hours., Group1, (Gr1), had used prosthesis most and Group 3 (Gr3), had used prosthesis least.

## RESULTS

For the entire group, the mean of 2MWT was 132 meters, (SD 48), TUG 12 seconds (SD 5). The median of LCI-5 was 51 points (range 8-56).

The participants who used their prosthesis most, (Gr 1), had improved gait capacity and functional ability

Table 1 Result between groups; age, TUG, 2MWT and LCI-5

| | Prosthetic use | N | Non-response | Average | SD | Min | Max |
|---|---|---|---|---|---|---|---|
| Age | Gr 1 (91-100) | 30 | 0 | 61 | 15 | 33 | 87 |
| | Gr 2 (71-90) | 17 | 0 | 63 | 16 | 36 | 94 |
| | Gr 3 (10-70) | 12 | 0 | 60 | 21 | 25 | 90 |
| TUG | Gr 1 (91-100) | 26 | 4 | 9 | 3 | 5 | 16 |
| | Gr 2 (71-90) | 15 | 2 | 13 | 5 | 6 | 23 |
| | Gr 3 (10-70) | 10 | 2 | 16 | 6 | 7 | 25 |
| 2MWT | Gr 1 (91-100) | 26 | 4 | 155 | 43 | 60 | 232 |
| | Gr 2 (71-90) | 15 | 2 | 115 | 41 | 42 | 200 |
| | Gr 3 (10-70) | 8 | 4 | 91 | 37 | 40 | 148 |

| | Prosthetic use | N | Non-response | Min | Max | percentiles | | |
|---|---|---|---|---|---|---|---|---|
| LCI-5 | Gr 1 (91-100) | 30 | 0 | 8 | 56 | 49 | 56 | 56 |
| | Gr 2 (71-90) | 17 | 0 | 13 | 56 | 34 | 45 | 56 |
| | Gr 3 (10-70) | 12 | 0 | 16 | 56 | 27 | 38 | 49 |

*SD: standard deviation; TUG: Timed Up and Go; 2MWT: The 2- Minute Walk test; LCI-5: Locomotor Capabilities Index-5*

## DISCUSSION & CONCLUSION

Amputees who use their prosthesis daily for more than 14 hours a day and have had the prosthesis more than 5 years have better gait capacity and functional ability compared to those who use their prosthesis less. In our study we did not find any differences between peoples age, gender, nor between TTA and TFA in terms of performance in gait capacity and functional ability.

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# BONE-ANCHORED PROSTHESES IN BILATERAL TRANSFEMORAL AMPUTATION - DESCRIPTION AND OUTCOME IN 12 CASES TREATED WITH THE OPRA IMPLANT SYSTEM

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## BACKGROUND

Treatment for bone-anchored prostheses in selected individuals with amputations has been performed in Sweden since 1990 using the OPRA implant system. The majority of treated patients has unilateral transfemoral amputation (TFA). The very first patient treated had bilateral TFAs. To date 12 patients with bilateral traumatic TFAs have been treated in Sweden.

## AIM

The aim was to describe our experience of the OPRA treatment in individuals with traumatic bilateral transfemoral amputation over the last 25 years.

## METHOD

Hospital records were reviewed for all patients with traumatic bilateral TFA that had been treated with OPRA at the Sahlgrenska University Hospital until year 2015. General demographics and medical records details of mobility in terms of use of prostheses and wheelchair were noted at baseline (before treatment) and at the latest follow-up. The material includes 12 patients (9 men, 3 women) with a mean age of 30 years (15-50) at amputation and 35 years (19-62) at treatment start. Ten patients were treated on both limbs and two on one limb. The 22 treated residual limbs were classified as short (n=10), medium (n=10) and long (n=2).

## RESULTS

Seven patients were treated bilaterally at the same surgical sessions. In 3 cases one limb at the time was treated with 1-3 years between treatments. The follow-up time was Md 7 years (1-20). The rehabilitation was individualised.

At baseline 3 patients did not use any prostheses, 5 used prostheses 2-4 days/week (at most 3 hours/day) and 4 used prostheses daily (4-9 hours/day). All patients using prostheses also used walking-aids while walking. The everyday mobility-aid was wheelchair without wearing prostheses in 8 patients and in 4 cases wheelchair and prostheses were combined. At follow-up 1 patient did not use any prostheses, 3 used prostheses 4-6 days/week (4-9 hours/day) and 8 used prostheses every day (5-15 hours/day). Three patients walked un-aided and 8 patients used walking-aids. The everyday mobility-aid was wheelchair without wearing prostheses in 1 patient, combination of prostheses and wheelchair in 8 and only prostheses in 3 patients.

## DISCUSSION & CONCLUSION

This report shows that treatment with bone-anchored prostheses in patients with traumatic bilateral TFA improves the prosthetic use and can lead to un-aided walking. We hypothesize this is due to improved prosthetic anchoring and comfort in sitting as well as in standing and walking. Even if mobility-aids such as wheelchair and walking-aids are still commonly used, more prosthetic use and un-aided walking can be achieved by patients treated with bilateral bone-anchored TFA prostheses.

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# EXPLORING THE EFFECTS OF A NON-MECHANICAL KNEE BRACE ON KNEE KINEMATICS & KINETICS DURING STEP DESCENT IN HEALTHY INDIVIDUALS & THE IMPLICATIONS FOR PATIENTS WITH KNEE OSTEOARTHRITIS

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## BACKGROUND

The use of knee bracing in osteoarthritis is not universally applied but represents a possible treatment options for patients not ready or suited for surgery. Current data focuses on mechanical bracing which uses three-point fixation to physically alter the mechanics of the knee [1]. Although these have been found to be biomechanically effective, such braces can be unattractive to patients. Controlling symptomology by altering neuromuscular control mechanisms with the use of non-mechanical (proprioceptive) knee braces has been previously shown in patellofemoral pain [2]. This could greatly improve patient acceptance of such devices in patients with knee OA, however little research has examined their efficacy and symptom relief.

## AIM

To identify the efficacy of a proprioceptive knee orthoses on lower limb kinematics during step decent in age matched healthy participants and to determine symptom relief in participants with mild knee OA.

## METHOD

Fourteen healthy participants and four OA cases aged between 30 and 60 years of age volunteered for the study. Participants were asked to perform a 10 cm stepdown tasks with and without the OA Reaction Brace. The dominant or osteoarthritic knee was examined along with the ipsilateral ankle and hip joints. Kinetic and kinematic data was collected using a 10 camera Qualisys system and analysed using the calibrated anatomical system technique (CAST). OA cases with mild/moderate knee OA were also scored using the Knee Osteoarthritis Outcome Score (KOOS) prior to testing and after 4 weeks of brace use.

## RESULTS

Significant changes in biomechanics during step descent were seen in both groups with the use of the brace. Knee kinematics demonstrated reductions in maximum internal rotation at the knee ($p=0.005$), transverse range of movement ($p=0.001$) and the range of transverse angular velocity ($p=0.001$) when wearing the brace in the healthy participants. In the knee OA cases the maximum internal rotation angular velocity ($p=0.006$) was reduced. At the hip, healthy participants showed a reduction in maximum internal rotation angular velocity ($p=0.025$). However, ankle inversion angle in healthy participants increased ($p=0.049$) with the brace, as did the maximum supination angular velocity ($p=0.010$), while the maximum inversion angular velocity was reduced ($p=0.024$) when wearing the brace. However, in the OA cases only the maximum angular velocity during pronation was reduced ($p=0.042$). The OA cases demonstrated significant improvements in KOOS score with the use of the brace over the four weeks**.**

## DISCUSSION & CONCLUSION

Proprioceptive knee bracing can alter patient reported outcome measures and lower limb biomechanics. Lower limb biomechanics not only significantly altered at the braced joint but also in unbraced or adjacent articulations during the step down task. Further research is needed to examine the longer term effects of such devices on a larger number of patients with mild knee OA.

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# ON THE (IM-)POSSIBILITY TO PREDICT WHO MAY BENEFIT FROM A MICROPROCESSOR CONTROLLED PROSTHETIC KNEE COMPONENT

Andreas Hahn

## BACKGROUND

With the availability of microprocessor controlled prosthetic knee components in the mid 1990`s advanced function based on controlled knee flexion under load and swing control became available. Those components were presumed to preferentially suit more mobile amputees despite early evidence suggesting at least equal benefit to lower mobility grades [1]. Recent research confirms the latter[2,3,4]. Often, however, access to such technology is denied on clinical rationales with sometimes uninvestigated presumptions.

## AIM

We investigate an extended set of clinical variables on their potential to predict an individual's capability to utilize functional benefit provided by an advanced hydraulic microprocessor controlled exo-prosthetic knee component.

## METHOD

Based on data from trial fittings with Genium (Ottobock Healthcare Products GmbH, Austria) gathered in Germany a retrospective cohort analysis is performed. Performance assessment categories included functional benefits [1], subjects perception and advanced maneuvers. Prosthetists and subjects assessments are noted in 5 point-Likert or dichotomized scales. An extensive set of clinical variables including age, mobility grade, etiology, body mass index (BMI), comorbidities, residual limb condition, socket type, previous fitting etc. is investigated via linear and logistic (uni- and multivariable) regression models. Effect size estimates and quality of the regression models allow an estimate of predictive power.

## RESULTS

A cohort of 899 individuals, age 49.0±12.9ys; BMI 26.6±4.6; mobility grade classification MG2: 12.5%, MG3: 64.1%, MG4: 22.8%; etiology: 68.9% trauma, 15.4% tumor, 6.0% vascular disease; and predominantly male (83%) was investigated. Amputation level was transfemoral in 80.1% and knee-disarticulation in 18.9% of the subjects. Subjects were experienced prosthetic walkers having their first prosthesis since 21.2±15.6yrs. 78% had at least one comorbidity. Most sensitive performance indicators per category were [# hits with $p<0.05$): variably gait speed (22), toileting (18) and stairs ascend (29). Effect estimates span up to 0.37 (mobility grade, $p < 1E-26$ (!) ) but regression models fail to reveal predictive power in any of the investigated variables nor their combination (univariable $r2 <0.05$, multivariable $r2<=0.263$). BMI failed to reach statistical significance.

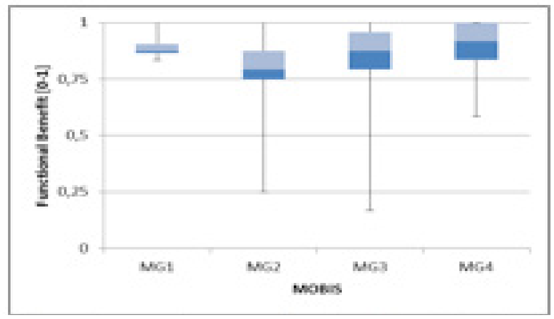


Figure 1. Compound measure of functional benefit depending on mobility grade rating. The effect of mobility grade is insufficient to predict individual response.

## DISCUSSION & CONCLUSION

The statistical significance of the findings is remarkably high. While all clinical effects are plausible, none of the investigated variables (nor their combination) exhibit predicitive power. This corresponds to other findings [3, 5, 6].

Based on the size of this sample we conclude that the investigated variables themselves may not be suitable to judge on an individual's potential to benefit from an advanced MPK and hence must be dismissed as both: predictors as well as indicators for denial.

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# BENEFITS OF GENIUM MICROPROCESSOR CONTROLLED KNEE: A LITERATURE REVIEW

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## BACKGROUND

In 2011 a new microprocessor controlled knee Genium was introduced in the market. New sensors, algorithms and technical solutions enable the knee to offer a range of new functions to lower limb amputees. They include, for example, climbing the stairs reciprocally, overcoming obstacles, walking backwards, standing on slopes, optimized physiological gait, etc. Several clinical studies have been conducted evaluating the effect of the knee in active transfemoral amputees.

## AIM

The objective of this work was to review and summarize the published clinical evidence on Genium to this date.

## METHOD

Pubmed search was performed to identify the publications with Genium. The reference lists from those publications were reviewed for additional potentially relevant peer-reviewed articles. The published articles that were additionally known to the authors were reviewed and if relevant included. Technical, review articles as well as case report and an article having physical therapy focus were excluded. Thirteen articles were identified and nine of them included in the review. Quality assessment of the studies was not conducted.

## RESULTS

Outcomes reported in nine included articles were grouped into following categories (Figure 1): level walking 1,4,6,7,9, stairs2,5-9, ramps1,5-7,9, uneven ground and obstacles4-6, safety4,6,7,9, activities6, quality of life, preference and satisfaction 3. All the articles report of transfemoral amputees (MFCL-3 and 4) when transitioning from C-Leg to Genium. Gait analysis revealed improved toe clearance due to better swing phase control and reduced speed-dependency of maximum knee flexion angle during level walking with Genium7,9.
During stance phase, larger knee flexion angle was measured resulting in a more physiological gait pattern1. A more reliable release of swing phase during small steps was reported7, 9, as well as safer loading when waking backwards6, 9. 70-80 percent of the subjects were able to ascend stairs reciprocally due to new functionality2,5,8,resulting in more physiological hip and knee flexion and improved toe clearance on the prosthetic side2 and reduced loading and hip and knee movement on the sound side8,9. Increased maximum knee flexion angle and foot clearance were reported on ramps1,5,7,9. Safety improvements are reported during walking and standing4,6,7,9. Perceived safety and difficulty when performing forty-five meaningful activities of daily living showed clinical relevant results for Genium6. Finally, the knee was associated with a significant advance on Prosthetic Evaluation Questionnaire evaluating prosthesis-related quality of life3.

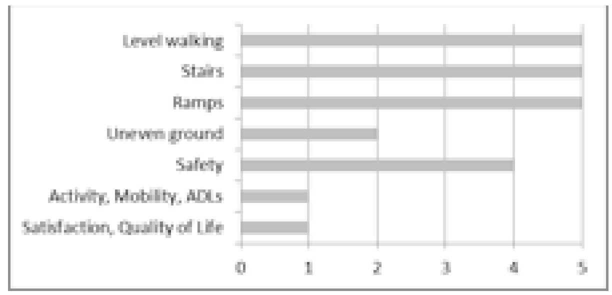


Figure 1. Number of publications per outcome category.

## DISCUSSION & CONCLUSION

Wide spectrum of the outcome measures used in the reviewed studies span main ICF domains including body function and structure, activity and participation. The results suggest increased efficacy of Genium in comparison to C-Leg in the areas of safety, functional mobility, activities of daily living and quality life. A qualitative assessment is needed to weigh the validity, reliability and objectivity of the studies and to increase the confidence in the current conclusions.

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# EFFECTS OF MICROPROCESSOR CONTROLLED KNEE JOINT FITTINGS IN ADOLESCENT SUBJECTS ON FUNCTIONALITY, MOBILITY AND SAFETY

Nadine Wismer

## BACKGROUND

Still today, the literature discussing the benefit(s) of a Microprocessor Controlled Knee (MPK) component for adolescents with transfemoral limb loss is sparse. A case study with a 13 year old subject reported improvements with C-Leg compared to a non-microprocessor controlled knee (NMPK) regarding level walking, cognitive demand, mobility and quality of life1 and in three further studies comparing C-Leg to NMPKs few subjects of 20 years or younger were included2,3,4. The results are promising and therefore further evidence on adolescent MPK users is needed.

## AIM

The aim of this research was to investigate the effects regarding functionality, mobility and safety due to transition from NMPK to MPK joints in adolescent subjects.
METHOD

A retrospective, cross sectional analysis of adolescent transfemoral amputees (20 years and younger) that underwent a C-Leg or C-Leg compact fitting was conducted. Data are a subgroup of a larger sample retrieved and published earlier5. Effects on function and safety as assessed by both subjects and practitioners were assessed on either 5-point Likert scales or corresponding measures. Results were then compared to previously reported findings for adult subjects of 21 years and older.

## RESULTS

19 data sets of subjects aged 20 years or younger were used for analysis. 17 were trial fittings, one was a final fitting and from one there is no information available. In 88% of the cases the trial fitting were conducted in a single day. As previous fittings C-Leg was used in 16 subjects, C-Leg Compact in one subject. No information on the test device is available for two subjects. Subjects mean age was 17.1±2.0 years and time since amputation 4.2±7.0 years. Amputation etiology included trauma (36.8%), tumor (31.6%) and malformation (26.3%). Furthermore, subjects were characterized regarding their mobility grade (MOBIS: MG1: 6.25%, MG2: 43.75%, MG3: 18.75%, MG4: 31.25%). Subjects showed a potential to change mobility grade after been fitted with a MPCK (MG1□MG2: 6.25%, MG2□MG3: 25%, MG3□MG4: 12.5%). The potential of functional benefit was even more prominent in terms of relief of sound limb (92%), capability to perform divided attention tasks (94%), harmonization of gait pattern (100%), capability to vary gait speed (94%) and reduction in walking effort (87%). Perceived safety was improved in 87% of subjects. Since 87% of subjects reported at least one fall during the last 12 months and 80% reported multiple falls during the same period, the high potential of benefits in safety seems to be highly relevant.

## DISCUSSION & CONCLUSION

Population characteristics differ between adolescent and adult transfemoral amputees. Amputation time is shorter (4.2 vs 17.5 years) while tumor (32% vs 13%) and congenital malformation (26% vs 2%) were more prominent amputation causes in subjects of age 20 years and younger. Moreover, less subjects were identified as MG3 (16% vs 39%) and more subjects were identified as MG4 (31% vs 6.5%) in adolescents compared to adults. Even though the characteristics differ, functional benefits resulting from the change from NMPKs to C-Leg are of similar height for both adolescent subjects and adults. Since the frequency of falling is higher in adolescent subjects with 80% of subjects reporting multiple falls during the last 12 months, the requirement for safety in younger subjects is as least as high as in adults. The potential of functional benefits by MPKs was shown to be high in adolescent group: fear of falling was reduced in 94% and perceived safety was increased in 87% of adolescent subjects. Overall, the present study showed that adolescent subjects are equally suitable for MPK fittings as adults.

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# A MODEL TO EXPLAIN THE EFFECT OF SHOCK ABSORBING PYLONS ON GAIT

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## BACKGROUND

Shock absorption is provided during the loading response phase of able-bodied gait as body weight is rapidly transferred from the trailing to the leading leg. Shock forces are normally attenuated through the combined influence of the heel pad, stance-knee flexion, hip flexion, pelvic obliquity and ankle plantarflexion. Shock absorbing pylons (SAPs) are commonly prescribed for use in lower-limb prostheses to provide shock absorption and reduce forces transmitted to the residual limb during gait. However, contrary to expectations, studies have determined that SAPs do not generally increase shock absorption [1-4].

## AIM

The purpose of this study was to determine the effect of a shock absorbing pylon on the magnitude of an impact force in the in vitro testing of a physical model of the residual limb and prosthesis.

## METHOD

A characterization of the residual limb/prosthesis model was performed during a controlled impact using an impact testing apparatus [5]. Two tapered, cylindrical models of a transtibial residual limb were fabricated out of plaster and a synthetic ballistics gel, which is a soft tissue analogue calibrated to the density of human tissue. Two copolymer polypropylene sockets were fabricated to fit the residual limb models: one was fit directly over the plaster model to create a rigid interface, and the other was fabricated to accommodate the ballistics gel model and a 9mm silicone gel liner. An Endolite TT Pro SAP was placed in series with each socket, mounted in the impact testing apparatus, and dropped under free fall onto a force platform to measure the force impulse. The SAP was tested using 4 different spring stiffness conditions: rigid, 130 N/mm, 100 N/mm and 75 N/mm. Ten trials of force data were collected for each residual limb model/SAP stiffness condition.

## RESULTS

For the rigid residual limb model, the peak forces measured during the impact testing were clearly distinguishable between the rigid SAP condition and the less stiff springs (Figure 1). However, for the compliant residual limb model, impact testing demonstrated that the peak impact forces were approximately the same magnitude for all SAP stiffness conditions (Figure 2).

## DISCUSSION & CONCLUSION

The SAP has a substantial effect on peak impact forces when the interface between the prosthesis and the residual limb is rigid (Figure 1). This is because the SAP with springs has the lowest stiffness among the series of elements in the residual limb/prosthesis system, so its mechanical characteristics will dominate system response. Thus, the SAP clearly provides shock absorption under these conditions. However, in the more realistic model in which the residual limb has compliance (Figure 2), the SAP has no observable effect on the magnitude of the peak impact forces.

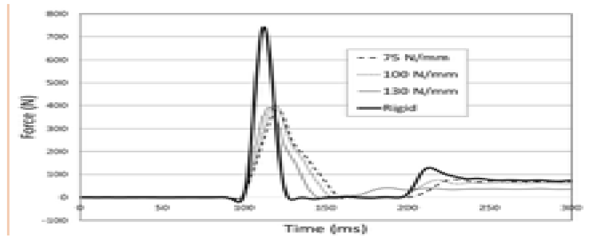


**Figure 1. Averaged impact forces for the rigid residual limb model.**

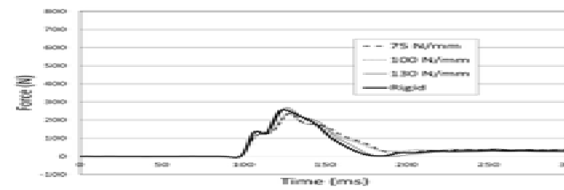


**Figure 2. Averaged impact forces for the compliant residual limb model**.

This is because the stiffness of the residual limb is considerably lower than that of the softest SAP spring, so the characteristics of the residual limb dominate system response. Therefore, the SAP does not provide substantial shock absorption under these conditions, which better approximates an individual with transtibial amputation wearing a prosthetic limb.

Prosthetists should carefully assess their client's residual limb soft tissue coverage before fitting them with a SAP. If the limb has adequate soft tissue contained within the socket, and particularly if a thicker gel liner is utilized, then a SAP may not be necessary for shock absorption during gait. However, SAPs may still be desirable for individuals with lean or bony residual limbs or for individuals who have had osseointegration.

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# EXTERNAL SOCKET REACTION MOMENTS, A WAY TO QUANTIFY UNILATERAL TRANSTIBIAL PROSTHETIC ALIGNMENT?

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## BACKGROUND

Current prosthetic dynamic alignment procedures have considerable limitations. Generally, alterations of the alignment are based on a subjective observation of the gait pattern and these alterations will direct the prosthetic foot position towards a non-standardized optimum. Additionally, prosthetic alignment is usually focused on maximizing gait symmetry in kinematic and spatio-temporal gait parameters. However, this objective ignores the compensatory forces that are needed to maintain a symmetrical pattern [1,2]. Moreover, a recent study showed that asymmetry could be a prerequisite for a stable and smooth gait [3]. To address these issues, the measurement of moments working at the base of the prosthetic socket, external socket reaction moments (ESRM), has been introduced in an attempt to objectively quantify prosthetic alignment [4].

## AIM

To investigate if a predetermined kinetic alignment criterion can be optimized by using real-time feedback during the dynamic alignment process in unilateral transtibial amputees.

## METHOD

10 transtibial amputees with a pin-system and without stump tissue damage were included. Subjects wore their own socket during testing. The shank, prosthetic foot and shoes were replaced using the same material in all subjects. First, the prostheses were aligned using conventional alignment procedures. Kinetic parameters were measured in this initial alignment (IA) condition. Subsequently, the frontal plane ESRM during gait was measured and presented to the prosthetist in real time using a Gait Real-time Analysis Interactive Lab (GRAIL) system.

The prosthetist adapted the prosthetic alignment towards a predetermined mean ESRM during the stance phase of 0 Nm/kg. A Socket Comfort Score (SCS) was reported after IA and the Final Alignment (FA). A paired sample t-test was performed on the weight-normalized ESRMs and the SCSs.

## RESULTS

A significant ($p<0.001$) change was found in the absolute frontal plane ESRM (mean ± SD) from IA (|0.104| ± 0.058 Nm/kg) to FA (|0.012| ± 0.015 Nm/kg) (Figure 1). In addition a significant ($p<0.001$) change of the adduction orientated frontal knee moments was observed from IA (-0,127± 0.079 Nm/kg) to FA (-0.055 ± 0.089 Nm/kg), however this change was more variable among participants.

Four patients showed no difference in SCS, three a reduction and three an increase. On average, no significant ($p=0.37$) change in the SCS was observed.

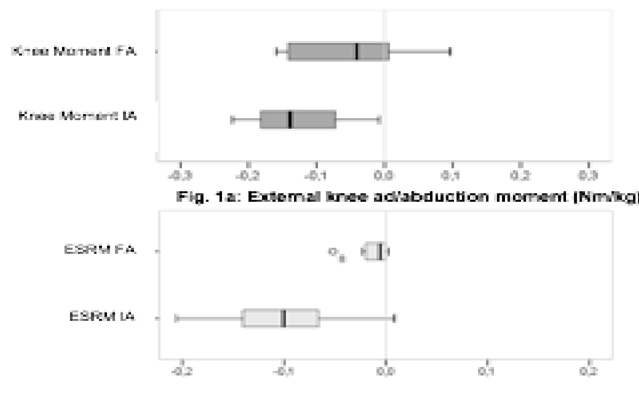


Figure 1: Boxplots of the mean ESRM and Knee Moment in the frontal plane during the stance phase of gait after IA and FA. Negative is defined as an adduction moment, positive an abduction moment.

## DISCUSSION & CONCLUSION

It is possible to align prostheses towards a kinetic optimization criterion using real-time feedback. However, optimization towards an average zero ESRM did not result in optimal SCS, possibly due to the fact that there was no predictable change in the kinetics in the adjacent knee joint. Therefore, future studies that investigate objective optimization criteria, should investigate the influence of alignment changes in multiple joints.

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Abbreviations: ESRM = External Socket Reaction Moment, FA = Final Alignment, GRAIL = Gait Real-Time Analysis Interactive Lab, IA = Initial Alignment, Nm/kg = Newton meter per kilogram, SCS = Socket Comfort Score

# ENGAGING STUDENTS IN PROSTHETIC AND ORTHOTIC RESEARCH

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## BACKGROUND

Research based education is often related to the discussion about quality development in higher education. Researchers in the field argues that students in all types of higher education institutions should experience learning through and about research and inquiry (1). There are different ways of engaging undergraduates in research (1-3).

The research group "Clinical interventions and Biomedical Technology "at Oslo and Akershus University College, have engaged P&O and Physiotherapy students as participants in major research projects organized by researchers. The institutions interest in motivating students for research has its basis in the need for more evidence-based practice, and more research and M.Sc and Phd candidates in the P&O and Rehabilitation field.

## AIM

The objective of this project was to find ways to involve students in major research projects and find out if and how a "research based" method contributes to the students' way of thinking about research and inquiry after graduating, and after starting their professional practice.

## METHOD

When the students had performed their bachelor research project and graduated, they were asked to answer a short questionnaire (n= 21). Period since finalized project: ≤ 5 yrs. The question asked comprised the following issues: 1) If the topic of the research project had shown to have clinical significance 2) The possible influence of the project concerning interest to involve in further research. 3) The possible significance of the project concerning the interest towards working evidence based in clinical practice.4) The projects possible influence on the aspiration to join an M.Sc or Phd program. 5) If the prospect of the research project resulting in a scientific paper gave further motivation. The answers were classified into three major categories for each question, (see table 1).

**RESULTS: N=21**

| RESEARCH PROJECTS INFLUENCE AFTER GRADUATION | CAT 1<br>GREAT EFFECT | CAT 2<br>SOME EFFECT | CAT 3<br>NO EFFECT |
|---|---|---|---|
| Clinical significance as a professional | 16 | 5 | 0 |
| Interest for further research involvement? | 17 | 2 | 2 |
| Working evidence based in clinical practice. | 11 | 6 | 4 |
| Aspiration to join an M.Sc. or Phd program | 13 | 5 | 3 |
| Scientific paper as a motivation factor | 9 | 11 | 1 |

## DISCUSSION & CONCLUSION

The results show that the subjects found their research participation to have a high degree of clinical significance. The majority reported that their interest for research involvement had been strengthen, and some of them had become involved in clinical research in their work place after graduation. Evidence based practice is for some reasoned to be a matter of course in clinical work and necessarily not a motivating factor. The prospect of becoming co-author on a scientific paper had been a motivating factor for the majority. The majority also answered that joining a M.Sc or Phd programme was encouraged by their research experience at BSc level. For some informants this was also a question of economy and support from their work place.

The results indicates that involving students in major research projects contributes to how the students relate to research in their professional life and motivate them for further education in research.

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# THE BIOMECHANICAL EFFECTS ON GAIT OF ELEVATED VACUUM SUSPENSION COMPARED TO SUCTION SUSPENSION

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## BACKGROUND

Literature suggests that elevated vacuum (EV) suspension can provide substantial benefits compared to alternative methods. While suction suspension uses a one-way valve to push air out, EV actively draws the air out to improve consistency. This has been shown to improve locomotor capability [1], be conducive to wound healing [2], reduce pistoning [3] and improve user satisfaction [4]. However, there is a lack of detailed gait analysis data to compare suction and EV suspensions.

## AIM

To measure the change in negative vacuum developed over time and identify the resulting differences in kinematic and kinetic gait parameters, between EV and suction suspension methods.

## METHOD

Four K3 transtibial amputees volunteered as participants. Each amputee wore an EchelonVAC prosthetic ankle (Endolite, Basingstoke, UK), which combines EV suspension with a hydraulic ankle mechanism. Each participant was asked to walk at a self-selected speed, while the negative pressure developed in the socket and 3D gait analysis were simultaneously performed. Initially, a one-way valve was attached to the socket, so that it behaved as suction suspension. Subsequently, the gait analysis was repeated with vacuum mechanism restored, with negative pressure build up being measured throughout. Adapting the device in this way eliminated the requirement to doff the socket between tests, minimising reproducibility error. Furthermore, this experimental setup ensured that when EV capability was reactivated, no extra bulk or mass was added to the prosthesis.

## RESULTS

During suction suspension testing, the peak negative vacuum generated reached ~8inHg, with a peak-to-peak amplitude, over a gait cycle of 8inHg. These values were consistent across all gait cycles measured. During EV testing, initially the peak vacuum was ~8inHg, with an amplitude of ~6inHg, but this changed over time to a peak of ~13.5inHg and an amplitude of ~2.5inHg (Figure 1). Once the vacuum had built up, EV suspension showed a trend towards increased prosthetic stride length. In terms of kinetics, the first vertical ground reaction force (GRF) peak and the braking impulse were both increased under the prosthesis, indicating increased use of prosthetic limb. The degree of asymmetry (DOA) between the two limbs in terms of work done by each of the joints was reduced with EV suspension.

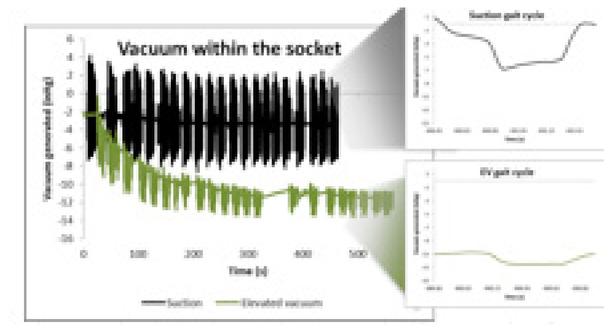


Figure 1. The change in negative vacuum build up over time for suction (black) and elevated vacuum (green) suspensions. The insets show individual gait cycles towards the end of each test.

## DISCUSSION & CONCLUSION

Once the vacuum had built up, the EV suspension displayed a much higher peak vacuum magnitude, achieving a more secure gait and improved control of the prosthesis. The lower peak-to-peak amplitude of the negative pressure implies less variation over a gait cycle and thus a more consistent connection. The reduced load on the intact side during early stance may suggest better control of foot placement and thus improved stability, potentially leading to reduced risk of falling. Furthermore, the increased loading symmetry reduces the risk of developing secondary health conditions such as osteoarthritis.

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# THE EFFECTS OF MICROPROCESSOR-CONTROL OF HYDRAULIC ANKLES ON INTER-LIMB SYMMETRY AND THE RISK OF FALLS DURING RAMP AMBULATION

Dr Michael McGrath [1], Dr Piotr Laszczak [1], Mr. Joe McCarthy [1], Dr David Moser [1], Prof. Saeed Zahedi [1]

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## BACKGROUND

Scientific studies have shown the biomechanical benefits of hydraulic prosthetics ankles compared with traditional energy storage and return (ESR) designs [1]. More recently, the advent of incorporating microprocessor-control (MPC) into hydraulic ankles has led to further potential advantages, particularly when descending slopes [2]. Slopes can increase an amputee's reliance on their intact limb for support and present an increased likelihood of insufficient toe clearance during swing phase, particularly during ascent, increasing the risk of tripping.

## AIM

To highlight the effects MPC has on hydraulic ankles during ramp walking, with regards to inter-limb symmetry and minimum toe clearance (MTC).

## METHOD

A mixed cohort of K3 lower limb amputees (TT/TF, n=6) volunteered for this study. The above knee amputees used their habitual, mechanical knee devices. For this test, they were all fitted with an MPC hydraulic ankle (Elan, Endolite). Firstly, with the MPC deactivated, 3D gait analysis was performed as they descended and ascended a 5° inclined ramp. The ramp had an integrated force plate (Kistler Group, Winterhur, Switzerland) so both kinematic and kinetic data could be obtained. Subsequently, the MPC was activated and the protocol was repeated.

## RESULTS

During ramp descent, the MPC increased the resistance to dorsiflexion, providing a braking effect. This was visible in the 5% increase in the ground reaction force (GRF) braking impulse. This reduced the walking speed. The work done by the prosthetic ankle increased by 13%, to reduce the DOA of work done by the prosthetic and intact limbs by 5%.

During ramp ascent, the MPC increased walking speed by 5%. The work done by the intact side hip reduced by 8%. These effects combined to see the total work done by the joints of the intact limb reduced by 7%. Additionally, the MTC on the prosthetic side increased from a mean of approximately 14mm to approximately 19mm (Figure 1).

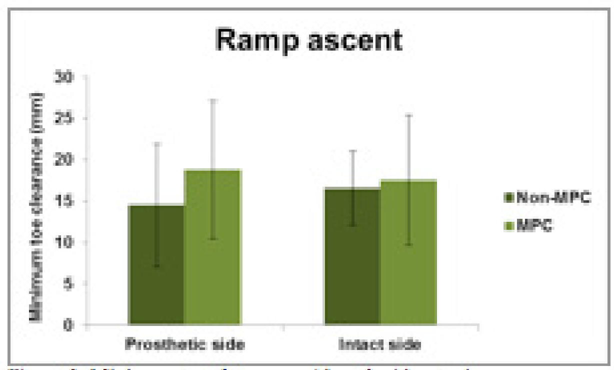


**Figure 1. Minimum toe clearance with and without microprocessor control.**

## DISCUSSION & CONCLUSION

MPC furthers the biomechanical benefits of hydraulic ankles during ramp ambulation. Walking speed reduction in ramp descent implies a more stable, safe gait, while in ramp ascent, the increase in walking speed displays improved performance. The reductions in DOA have long-term benefits by reducing the risk of back pain and degenerative joint diseases. Decreasing the work done by the intact limb also implies reduced energy expenditure. Finally, increased prosthetic toe clearance during ascent helps mitigate the risk of tripping.

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# HANDSMART GROUP: PROGRESS OF AN INTERNATIONAL NETWORK OF CLINICIANS FOCUSED ON THE REHABILITATION OF INDIVIDUALS

## WITH UPPER LIMB ABSENCE

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## BACKGROUND

The exciting and constantly changing environment in the field of upper limb prosthetics challenges clinical teams on a daily basis. With this in mind, the handsmart group was formed in February 2016 to create an international network of peers and to provide open resources for those engaged in rehabilitation of individuals with upper limb loss or difference. Having created an online platform in September 2016, the handsmart group was able to follow its vision: provide the most holistic rehabilitation approach for every person with upper limb loss or difference, now and in the future.

## AIM

The initial aims of this project were to enhance public awareness for the upper limb prosthetics community, to establish a network among peers worldwide, to support clinical practice with evidence based rehabilitation resources and to acquire sources of consistent funding.

## METHOD

Sixteen international clinicians started the “handsmart group” with this vision in mind. Each of these individuals specializes in upper limb loss/difference rehabilitation while working either in clinical or research settings. Discussions at the first meeting in February 2016 were facilitated by an independent moderator. Decisions were made based on voting and consensus agreement. The larger group divided into four working groups based on the aims listed above. Each work group discusses and votes on relevant issues to achieve the goals of the handsmart group. The larger group will meet in person once a year to evaluate and discuss the results, methods and organization.

## RESULTS

The group has identified six fundamental strategic keys based on the group’s shared core values (figure 1). The group developed fundamental work plans for the first enterprise year. The handsmart website (http://handsmartgroup.org) was launched in autumn 2016. This is a platform for networking, sharing information, communication, accessing resources and supporting comprehensive clinical practice for international clinicians in upper limb prosthetics. The website is promoted in person at conferences and virtually through a network of peers and interested individuals. The handsmart group is currently in the process of incorporating as a non-profit (plus 501c3) in the US. The group has recognized that the future of this project is dependent on the ability to acquire consistent sources of funding.

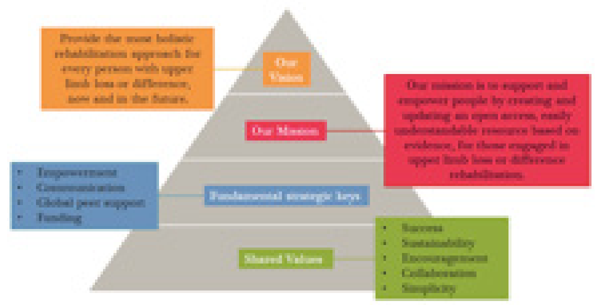


**Figure 1. handsmart group strategy pyramid**

## DISCUSSION & CONCLUSION

The members work on a voluntary basis and invite external parties involved in upper limb loss/difference rehabilitation to collaborate and support the group: patient organizations, commercial companies, professional organizations and other team members. Additionally the group will continue to support evidence based rehabilitation practices and expand the worldwide network of upper limb prosthetic rehabilitation peers.

All of these initiatives will enable successful work in the promotion of its mission and vision and will improve the lives of those with upper limb loss or difference everywhere.

The handsmart group thanks ProsthetiKa for funding the handsmart website. The handsmart group also thanks the Ottobock Company and especially Martin Schöppl for initiating this project. Though Ottobock initiated and organized the first meeting, the handsmart group is independent and follows the international needs and interests of all people. There is no financial interest in this group.

## REFERENCES

The results just described are the work of all 16 members of the handsmart group: Diane Atkins, Birgit Bischof, Liselotte Hermansson, Wendy Hill, Julie Klarich, Debra Latour, Ayala Nota, Sandra Ramdial, Eitan Raveh, Agnes Sturma, Shawn Swanson Johnson, Kristi Turner, Claudia Winkler, Paula Wijdenes and Daniela Wüstefeld.

# EFFECT OF BRACING ON BODY-IMAGE, SLEEP QUALITY AND BACK FLEXIBILITY IN ADOLESCENTS WITH IDIOPATHIC SCOLIOSIS AND SCHEUERMANN'S KYPHOSIS

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## BACKGROUND

Spinal deformities and their management approaches have negative effects on personal and social quality of life (QoL). Evaluation of these effects has an important role on treatment process. Bracing is one of the most common non-operative treatment in adolescents idiopathic scoliosis (AIS) and Scheuermann's kyphosis (SK). So, the effects of these deformities and their treatment on all aspects of life should be taken into consideration during the bracing.

## AIM

To investigate the effect of bracing on body-image, quality of sleep and back flexibility in adolescents with IS and SK.

## METHOD

This cross-sectional multicenter study focused on body-image, sleep quality and back flexibility in 97 adolescents with AIS (69) and SK type I (28) with age of 10-20 years, who have been Milwaukee braced treatment. Quality of life data were collected using Persian version of "Quality of Life Profile for Spine Deformities (QLPSD) Questionnaire". In QLPSD the higher the score, the poorer is the patient's quality of life. Parametric and nonparametric independent analyses of covariance were used to determine differences between demographics and QoL indicators.

## RESULTS

The patients with AIS had higher body-image mean score of 11.16 in comparison with SK patients with the mean score of 9.18 (p=0.025). AIS patients, who had been braced 3 and 6 months or less had poorer body-image and back flexibility.

In SK patients, "back flexibility" and "sleep disturbances" were significantly better in patients who had been braced more than 3 and 6 months, respectively. Also males with SK had poorer body-image in comparison with females (p=0.001). (Table 1)

| | Quality of Life Dimensions | | |
|---|---|---|---|
| | Sleep Disturbances | Body-image | Back Flexibility |
| Bracing Duration | Mean (SD) | Mean (SD) | Mean (SD) |
| Idiopathic Scoliosis | | | |
| >3months | 8.82 (3.86) | 10.59 (4.33) | 10.37 (3.81) |
| ≤3 months | 10.55 (3.54) | 12.55 (2.72) | 12.75 (2.77) |
| p value | 0.088 | 0.028 | 0.008 |
| >6 months | 9.09 (4.00) | 9.88 (4.21) | 9.74 (3.72) |
| ≤6 months | 9.54 (3.69) | 12.40 (3.44) | 12.34 (3.19) |
| p value | 0.583 | 0.008 | 0.002 |
| Scheuermann's Kyphosis | | | |
| >3months | 9.58 (4.03) | 8.88 (3.15) | 9.50 (3.38) |
| ≤3 months | 11.75 (4.99) | 11.00 (5.22) | 13.25 (1.50) |
| p value | 0.306 | 0.482 | 0.014 |
| >6 months | 8.47 (3.98) | 8.20 (3.25) | 8.93 (3.49) |
| ≤6 months | 11.54 (3.84) | 10.31 (3.49) | 11.31 (3.01) |
| p value | 0.044 | 0.111 | 0.051 |

Table 1. Results of Analysis of Variance

## DISCUSSION & CONCLUSION

It seems that clothing of Iranian girls with SK causes the better body-image. Unlike the Lonner's study, our results showed that AIS patients had poorer body-image than SK. Body-image in AIS has been improved after 3 months of bracing and increased over the time. Sleep disturbances decreased after 6 months in SK. After 3 months of bracing, back flexibility of both groups improved and increased over the time in AIS.

# THE EFFECT OF PERFORATED SILICONE LINERS ON TEMPERATURE AT THE LOWER LIMB RESIDUUM SURFACE

Dr Piotr Laszczak [1], Dr Michael McGrath [1], Mr. Joe McCarthy [1], Dr David Moser [1], Prof. Saeed Zahedi [1]

[1] Chas. A. Blatchford and Sons Ltd

## BACKGROUND

Silicone liners provide comfort and protection for amputees but they can also lead to excessive sweating [1]. Sweating at the residuum/liner interface has been shown to be detrimental to residuum skin health [2], reducing the ability to perform activities of daily living (ADLs) [3]. Some liners have begun to be designed with perforations, to allow better air ventilation. It is hypothesised that this could reduce residuum surface temperature, thus decrease the likelihood of sweating.

## AIM

To determine whether the perforated silicone liners influence the surface temperature of lower limb residua, compared to traditional, non-perforated silicone liners.

## METHOD

Four transtibial amputees, of K3 activity level, were recruited to participate in the study. Temperature at the residuum surface was measured with six thermistors, previously reported appropriate for use at the lower-limb residuum [4], and calibrated with laboratory bench tests prior to amputee testing. These were placed at different anatomical locations on the residuum. Each amputee had their residuum temperature monitored throughout the entirety of the testing protocol. The liner was donned and the amputee was asked to walk at a self-selected speed on a treadmill for 12 minutes. Subsequently, the temperature was measured for a further 18 minutes of resting, indicating the rate of recovery. The protocol was repeated for a non-perforated liner and for Silcare Breathe (Endolite, Basingstoke, UK) perforated liners, multiple times. The order in which the liners were tested was randomised.

## RESULTS

For both liners, the greatest temperature changes were observed at the posterior proximal region of the residua. Depending on the sensor location and liner used, the residuum temperature increase after 12 minutes walking ranged between 0.5-2°C, which aligns with to-date literature [4]. For most residuum locations, the temperatures after walking and after resting were lower for the perforated liner. At the end of each 'stage' of the protocol, the mean temperature change across all of the residuum locations was lower for the perforated liner, while the changes in residuum surface temperatures were more uniform across all locations.

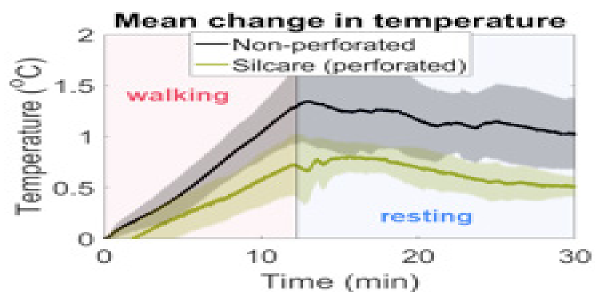


Figure 1. Mean changes in temperature over walking and resting time across all residuum locations of a single amputee, with the perforated (green line) and non-perforated (black line) liners. Shaded bands correspond to ±SD.

## DISCUSSION & CONCLUSION

Both the absolute values of the residuum temperatures, as well as their increase rates during walking, agree with the existing literature. The spatial temperature profile is as expected, with the posterior proximal location exhibiting the highest temperatures, arguably due to the density of blood vessels in the soft tissue.

Reductions in temperature and a more uniform temperature distribution at the residuum surface were achieved with the perforated liner, implying a more even distribution and consistency of temperature and heat transfer. This could improve comfort and help alleviate health problems caused by excessive sweating.

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# EMERGENCY P&O TRAINING AND EDUCATION EXPERIENCE OF THE NATIONAL SYRIAN PROJECT FOR PROSTHETIC LIMBS NSPPL INSIDE SYRIA

Raad Alholani Almasre

## BACKGROUND

We believe that the situation of P&O services in the war zone inside Syria is an exceptional one. The combination of high numbers of amputations, closed border, changing authorities, and disintegration of health facilities created the need to train local P&O technicians to meet the increasing demands. These same factors also meant that we have to create a new ways of delivering education and training.

## AIM

The aim is to describe our unique experience of P&O training and education inside war zone in Syria.

## METHOD

Retrospective descriptive historical review of the last four years of the steps undertaken by NSPPL to provide the P&O training and education. We also summaries the theoretical and practical short and long courses secured by NSPPL to train and educate a number of local young Syrian to be the next generation of P&O technicians. A unique mixture of distance learning, expert visits, practical workshops, collaboration with organization and universities formed the skeleton used to accumulate the needed skills and knowledge. The article also explains the modified basis educational program used by NSPPL inside Syria.

## RESULTS

NSPPL followed strict recruitment criteria following consultation with expert in the field. Advertisement, short-listing, interviewing, and trial period helped choose the best candidates. Short courses were provided by experts from NAYA QADAM (UK), SALFORD University (UK), Ankara University, PROTED ®, Handicap International. NSPPL student are currently enrolled in a three-year course by human study towards obtaining Cat II ISPO certification. By December 2017, NSPPL would have completed its one-year basic P&O training to a second group of Syrian students.

| | Trainees | Technicians | Technicians assistant | ISPO Students |
|---|---|---|---|---|
| 2013 | 5 | 1 | 1 | |
| 2014 | 7 | 1 | 1 | |
| 2015 | 10 | 5 | 3 | |
| 2016 | 18 | 15 | 1 | 12 |
| 2017 | 0 | 15 | 14 | 12 |

Figure 1. Staff Members

## DISCUSSION & CONCLUSION

P&O field is rich of successful examples of training; however, closed borders and changing dangerous situation prevented maintained P&O aid. NSPPL was created as an emergency response in a neighbouring country and quickly expanded to a thoroughly thought off places inside Syria implementing safety procedures to protect its personnel and patients. We believe that NSPPL used a verity of educational resources that led to successfully caring for over 3000 patients.

# RANDOMIZED, CROSS-OVER MULTICENTER STUDY EVALUATING A NOVEL ELECTRONIC PROSTHETIC KNEE JOINT FOR MODERATELY ACTIVE AMPUTEES

Stephan Domayer MD/PhD

## BACKGROUND

Moderately active amputees (MFCL K2) tend to have limited control over mechanical knee joints (NMPK), and have a significantly increased risk of falling. This can limit both mobility and participation, leading to a progression of vascular disease. Microprocessor controlled knees (MPK) have been shown to decrease the rate of falling and to favor a progression of patients to higher mobility levels, however, this technology has been mainly used for highly active amputees at this time [1,2].

## AIM

The aim of this multicenter, comparative, randomized, cross-over trial was to evaluate if patients with MFCL K1 or K2 could benefit from a new MPK that has been designed for the eldery (Kenevo), particularly in terms of a reduced risk of falling.

## METHODS

Between March and November 2015, 27 participants (age: 65.6 ± 10.1 years, weight: 76.6 ± 16.0 kg, interval since amputation 61.4 ± 85.5 months, 22 male, 5 female, 26 transfemoral, 1 knee disarticulation, MFCL K2: 24, K1:3), who had used mechanical knee joints before, could be enrolled. After randomization, patients were fitted alternately with Kenevo and NMPK knees over a period of minimum 4 months, and underwent dedicated training sessions (Figure 1).

The primary assessment parameter for falling was the timed up and go test (TUG) [3]. Additionally, we carried out the SF-36, LCI-5, QUEST 2.0, and documented the number of falls. The statistical analyses were carried out with SPSS using student´s t-tests and Mann-Whitney U tests.

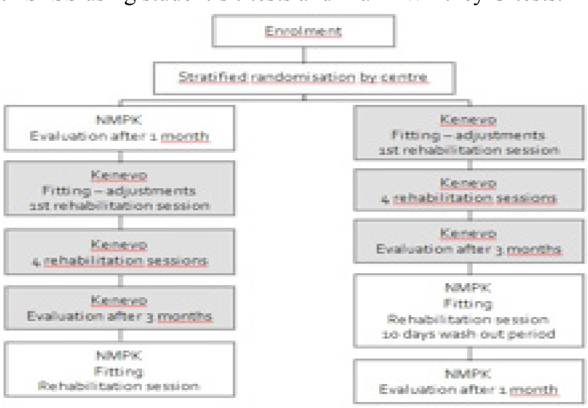


Figure 1. Study design

## RESULTS

We found a significant reduction of the TUG test after Kenevo in comparison to NMPK (19.4 ± 5.1s vs. 23.1 ± 5.4s, p = 0.001). Furthermore, the global LCI-5 improved significantly with Kenevo (p=0.02). QUEST 2.0 results showed the level of satisfaction was significantly improved with Kenevo globally (p=0.002), regarding services (p=0.009), and technology (p=0.002).
The SF-36 scale for quality of life was improved with Kenevo with regard to the mental score MH (p=0•009), the limitations related to mental health RE (p=0•04), the physical function PF (p=0•04), limitations related to the physical function RP (p=0•005), and vitality VT (p=0•02). See Figure 2.
tOver the last month of use, 3 falls occured with NMPK, and one with Kenevo. This difference was not significant in terms of the statistical analysis due to the small number of cases, however, this corresponds well to the results in the TUG test.

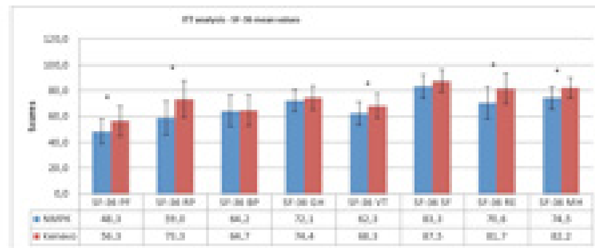

Figure 2. Results of the SF36

## DISCUSSION&CONCLUSION

This study demonstrates that moderately active amputees do profit significantly from Kenevo in terms of improved security, increased mobility, improved quality of life and a reduced number of falls. These data add substantial evidence to prior studies indicating increased security for MFCL K2 amputees [4], and further substantiate the notion that MPK technology should be used for these patients.

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# BUILDING P&O SERVICES THROUGH INTERNATIONAL PARTNERSHIPS – A CASE STUDY INVESTIGATING THE STRENGTHS OF COLLABORATION IN PROSTHETICS AND ORTHOTICS EDUCATION AND SERVICES

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## BACKGROUND

The study is based on a strategic alliance between four partner organizations in Norway, Africa and Asia; SMO (Norway), KCH (Malawi), TATCOT (Tanzania) and CSPO (Cambodia). The objective for their collaboration has been to learn from each other to improve their P&O services. This has been done through several mutual one year exchanges of staff, mainly P&Os. We wanted to find out if and how the partnership has benefited the four involved organizations. The study investigates how individual learning in a development aid partnership translates into organizational effectiveness through the concept of dynamic capabilities, defined as a learned and stable pattern of collective activity through which the organization systematically generates and modifies its operating routines in pursuit of improved effectiveness (Zollo & Winter, 2002, p.340)

## AIM

Research question: In what way does learning and knowledge sharing in a development aid partnership contribute to build dynamic capabilities? Sub-questions: 1) What and how do the P&Os learn during their exchange? 2) How has the individual knowledge and skills been shared with the home organization?

## METHOD

Qualitative case study, with an embedded multiple-case design. The four entities in the partnership, serve as case studies. The specific case's led to a thorough literature review on the concept "dynamic capabilities", resulting in the above research question. We interviewed 49 participants from the staff-exchange programme. Based on specific selection criteria's, 17 participants were excluded, and we remained with 32 informants. All of the interviews were recorded, and transcribed verbatim. When it comes to analysis of case study evidence, there are few fixed formulas. However, the transcribed interviews were categorized and coded by hand, according to the themes from the theory, our interview guide and research question. The interpretations, which are done in the study, can be documented in the data and through the presentation of the data. The study is reported to and approved by The Norwegian center for research data (NSD).

## RESULTS

Related to Sub question 1, the informants gained a lot of knowledge and skills relevant to the different areas of the P&O profession, I.e. technical & clinical, collaboration & communication, Problem-solving & creativity, Teaching & Supervision skills. The participants, especially from Africa and Asia, gained new knowledge about modern components, technology and health, safety and environment (HSE). Their understanding about system, processes and management increased as well as their professional confidence. They learned all of this through "learning by doing", working side by side with the local staff, applying their knowledge in a new and different setting. In short, the P&Os gained professional experience that they would not get in their home organization. In regards to sub question number 2, the participants reported that their new acquired competence has been transferred to the home organization through practical-clinical seminars/workshops and through "learning by doing", where what has been transferred is determined by the challenges, or the needs for learning that arises on a day-to-day basis, through performing operating routines. The organizations, especially in Africa and Asia, have implemented several smaller and bigger changes in their organizations due to their new competence acquired through the partnership. I.e revised and updated curriculum, new manuals, better work environment, better tools and equipment.

## DISCUSSION & CONCLUSION

Our findings suggest that the differences between the partners are the partnerships greatest strength. These differences seem to foster a certain form of behavior and attitude; the P&O exchanged to another organization for one year gain new perspectives, knowledge and competence, which in turn help them to see their own organization in a different light and provide them with ideas how to improve their own organization. We conclude that the partnership contributes to the organizations effectiveness, and build dynamic capabilities, by increasing the P&Os awareness in their daily work, helping make implicit knowledge explicit. Which in turn increases the P&Os effectiveness, defined as "doing the right things" not "doing things right". Meaning that they learn to work smarter and how to provide better rehabilitation services. What the participants learned has helped the partner organizations renew their internal resources, increased the knowledge among the staff, making their human resources better equipped to meet the criteria's from the patients.

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# FALLS IN PERSONS WITH UPPER-LIMB LOSS

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## BACKGROUND

Natural arm dynamics play a critical role in locomotor stability, for steady-state walking by minimizing body angular momentum [1] and recovery from a perturbation through ballistic movements to redirect the whole-body center-of-mass [2]. These contributions have important implications for fall risk in persons with upper-limb loss. Fall prevalence has been documented for persons with lower-limb loss [3], but this concern has not been explored for those with upper-limb loss.

## AIM

The purpose of this study was to investigate fall prevalence, balance confidence, and predictors of falls in persons with upper-limb loss at or proximal to the wrist.

## METHOD

Data were collected (4/2016 – 1/2017) on persons at least 18 years of age with limb loss at or proximal to the wrist. A 35 multiple-choice, English-language online survey, anonymously collected information on: prosthesis use, fall history and circumstances, limb loss, body and health characteristics, and balance confidence (Activities-specific Balance Confidence (ABC) Scale [4]). The survey was advertised through limb loss-related listservs and prosthetic services.

Respondents provided informed consent and were permitted to skip questions. Summary statistics were prepared for all data. A binary logistic regression analysis was performed to assess the impact of relevant variables including age, sex, body-mass index (BMI), physical activity, perceived physical capabilities, upper-limb loss characteristics (most proximal level, time since loss, cause), prosthesis use inside or outside of the home, balance confidence, and presence of lower-limb loss on fall classification: frequent fallers (≥2 in the past 12 months), and non-fallers (≤1).

Only variables that were significant contributors at $p \leq 0.02$ in a univariate regression analysis were included in the final multivariate analysis and the critical $\alpha$ was set at 0.05. Incomplete records were removed for the regression analysis.

## RESULTS

Data were collected on 109 subjects. Some variables were analyzed on a reduced sample as respondents did not answer every question. Summary statistics are displayed in Table 1. Overall, 46% of respondents (n=105) reported a fall in the past year, 63% of which fell more than once. Causes of most recent falls were reported as loss of balance (45%), dizziness (2%), push/pull (10%), fatigue (10%), slipping (33%), and tripping (45%). Fourteen subjects experienced lower-limb loss, including partial foot and hip disarticulation. The final model (n=84, 23 fallers, $\chi 2(7)=$ 33.256, p<0.001, 61% sensitivity, 93% specificity) correctly classified 85% of cases (12% increase from the constant-only model) and explained 47% of outcome variance. The assumptions on independent variable multicollinearity and linearity with the outcome were satisfied. Factors that contributed to increased likelihood of being classified as a faller were: reduced physical capability (p=0.03), upper-limb prosthesis use (p=0.027), reduced balance confidence (p=0.021), presence of lower-limb loss (p=0.228), reduced physical activity (p=0.803), and increased BMI (p=0.341). Although included in the final model, time since limb-loss had little effect on classification (p=0.671).

| Item | Category | n |
|---|---|---|
| Sex | *Male* | 50 |
| | *Female* | 48 |
| Age (years) | 43±17 [18-82] | 98 |
| BMI (kg/m²) | 27±8 [12-55] | 93 |
| **Upper-limb loss** | | |
| Time since loss (years) | 29±20 [<1-79] | 97 |
| Cause | *Congenital* | 46 |
| | *Other* | 51 |
| Number | *Unilateral* | 82 |
| | *Bilateral* | 16 |
| Level | *Through-elbow and proximal* | 66 |
| | *Below-elbow* | 32 |
| **Prosthesis use** | | |
| Type used (inside and/or outside the home) | *Cosmetic* | 17 |
| | *Body-powered* | 19 |
| | *External/electric-powered* | 22 |
| | *Hybrid (body+ external)* | 1 |
| | *Passive w/ terminal device* | 6 |
| | *Sport/Recreation* | 10 |
| | *None* | 42 |
| ABC Score (%) | 86±19 [26-100] | 92 |

**Table 1. Summary statistics; mean ± 1 standard deviation [range].**

## DISCUSSION & CONCLUSION

Results suggest that although persons with upper-limb loss do not generally suffer from low balance confidence, they report a high prevalence of falls that is only 6% less than that for persons with lower-limb loss [3]. These findings suggest an undocumented health hazard in this patient group. Falls appear to result from common risks such as slips and trips, but risk of repeated falls for these individuals may be elevated due to relatively low perceived balance confidence and physical capabilities, as well use of an upper-limb prosthesis. Study limitations include the small sample size and fall classification based on retrospective data that may suffer from recall bias. Overall, falls may be an important health concern for persons with upper-limb loss and research should further explore underlying factors related to this risk. Importantly, although balance confidence in this patient group is relatively high, these individuals may benefit from closer monitoring to estimate their risk of falling. Such monitoring could create awareness of this risk and identify patients in need of targeted intervention to address this potential health concern.

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# PILOT STUDY ON THE EFFECTS OF UPPER-LIMB LOSS AND PROSTHESIS USE ON LOCOMOTOR STABILITY

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## BACKGROUND

During steady-state walking, natural arm dynamics facilitate locomotor stability by minimizing body angular momentum through counterbalancing leg motion [1] and reducing trunk sway to constrain body center-of-mass (BCoM) excursion within the base of support [2]. Consequently, persons with upper-limb loss may experience reduced locomotor stability that may be dependent on prosthesis use.

## AIM

The purpose of this pilot study was to investigate the effects of upper-limb prosthesis use and matching inertial properties of the prosthetic limb to the sound limb on walking stability.

## METHOD

Kinematics were measured using an optical motion capture system (Motion Analysis Corp. (MAC), CA, USA) and a modified Helen Hayes marker set [3] with additional trunk and arm markers. BCoM was estimated from an individual body segment model. A custom 'mock prosthesis' was designed to match the mass and inertial properties of the prosthetic limb to the sound limb (Figure 1).

The mock prosthesis length, mass, and location of the center-of-mass were estimated using an algorithm based on established able-bodied anthropometric regression equations [4]. Subjects walked over-ground on a level walkway at three self-selected speeds (slow, normal, and fast) under three prosthesis conditions: 1) without wearing a prosthesis, 2) wearing their customary prosthesis, and 3) wearing the mock prosthesis. At least five walking trials were collected and analyzed for each speed by prosthesis condition iteration.Three-dimensional trunk rotations (relative to the global axes) were estimated using Orthotrak software (MAC).
Margin of stability (MoS) was estimated as the minimum distance between the lateral foot border (5th metatarsal to define the base of support) and extrapolated BCoM (a velocity-weighted BCoM) positions [5]. Step width and variability of step width, length, and time were also calculated.

## RESULTS

Two subjects with unilateral transradial (TR; 61yrs, 186cm, 90kg) and transhumeral (TH; 62yrs, 179cm, 111kg) limb loss participated in the study. Trunk rotations at a single walking speed are displayed in Figure 2 (speed-matched at 1.3 m/s to data of 13 non-disabled control subjects (51±6yrs, 172±9cm, 74±15 kg)).

MoS was greater on the prosthetic and sound side for the TR and TH subjects, respectively, but displayed little difference between prosthesis conditions. Minimal changes were seen in step width across conditions, but variability in step width, length, and time generally increased with use of a prosthesis (both customary and mock but with less clear individual trends).

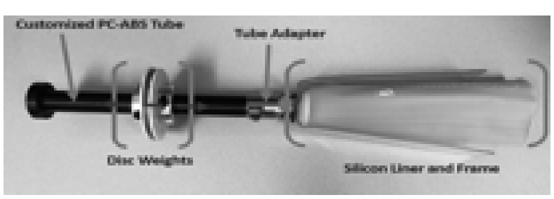


**Figure 1**. Mock prosthesis. Length is modified by replacing the tube. Mass is modified through adding disc weights, which are secured in location by cuffs that allow translation of the center-of-mass.

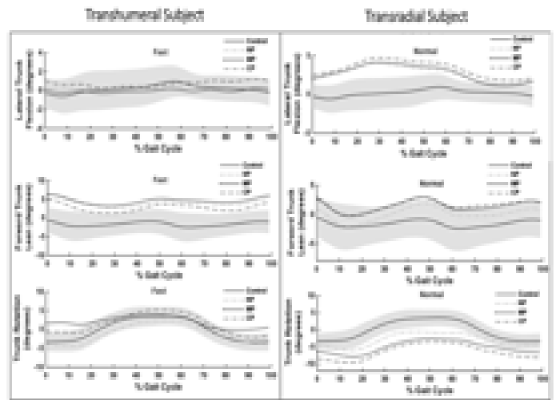


**Figure 2.** Frontal (top), sagittal (middle), and transverse (bottom) plane trunk rotations for both subjects and controls (solid band represents control standard deviation) during a gait cycle. NP=no prosthesis; MP=mock prosthesis; CP=customary prosthesis.

## DISCUSSION & CONCLUSION

These subjects with unilateral TR and TH limb loss displayed asymmetric trunk rotations with temporal profiles similar to controls. Trunk motion was minimally affected by prosthesis use and trends were not clear. Subjects displayed asymmetric MoS which aligned with the direction of asymmetry in lateral trunk lean, but was also not affected by the prosthesis.

The side with greater MoS would suggest decreased opportunity for the BCoM to exceed the base of support and generate a risk to balance. Surprisingly, use of a prosthesis increased gait variability, suggesting reduced locomotor stability. Persons with unilateral upper-limb loss walk with asymmetric trunk motion that is not impacted by prosthesis use. However, prosthesis use may result in reduced stability during walking and this should be further explored as it could affect the risk of falls. Future work involves analysing data from an additional 8 subjects for inclusion in these results.

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# A STUDY ON HEMODYNAMIC STATE OF RESIDUAL LIMB AFTER TRANS-FEMORAL AMPUTATION

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## BACKGROUND

The peripheral vascular disease, represented by diabetes, is one of the main causes of lower limb amputation. These cases may face continuous damage of the residual limb even after amputation because of those predisposing factors such as the disordered flow field, high blood pressure and low wall shear stress that could lead to atherosclerosis and thrombosis.

On the other hand, the hemodynamic state is related to the occurrence and development of pressure ulcers, deep tissue injury, muscle atrophy and other residual limb problems. In addition, the external pressure from prosthetic socket and the changes in internal tissue stress would in turn affect the distribution of hemodynamic parameters. Therefore, to investigate the hemodynamic state of residual limb could be conducive to the promotion of amputees' comprehensive rehabilitation.

## AIM

The aims of this project are to study and compare the hemodynamic parameters distribution of the main arteries of the residual and sound limbs, and to investigate the risk area of concern.

## METHOD

A unilateral trans-femoral amputee was recruited as the subject of this study to carry out detailed ultrasound examination and computer tomography (CT) angiography of her both thighs at the 12th month after her surgery. CT images were imported into the software MIMICS (v10.0) to perform 3D reconstruction of five main arteries (common femoral artery, superficial femoral artery, deep femoral artery, the descending branch of lateral femoral circumflex artery, medial femoral circumflex artery) of the residual limb and sound limb separately.

Using the measured ultrasonic flow velocity curve as the inlet boundary condition, and the three-element Windkessel (lumped parameter) models to set up four outlet boundary conditions, the numerical calculation of blood flow in a cardiac cycle based on the 3D-lumped parameter coupling model of bilateral limbs was achieved.

## RESULTS

Four feature moments namely from rapid ejection period (t1), slow ejection period (t2), isovolumic relaxation period (t3), and slow filling period (t4) were selected for the residual / sound limb comparative analysis about the states of wall pressure (WP), wall shear stress(WSS), low shear stress area (LSSA, <0.4Pa), and the velocity field in bifurcation site. As shown in Figure 1, WP values of both sides were the highest at t1. The relatively high WP area of the residual limb was larger than that of the sound limb. Figure 2 shows that, from t2, both sides appeared obvious LSSA, especially at t4. The LSSA number was more in the residual limb.

The relatively high WP and low WSS areas of both sides concentrated in the bifurcation site and the upper half of deep femoral artery. Figure 3 illustrates that, at t3 and t4, low velocity disturbance can be observed in both sides. Moreover, by analyzing the velocity distribution on the cross sections near the bifurcation site, it was found in the residual limb that the velocity field disorder was more serious and the secondary flow direction was more complex.

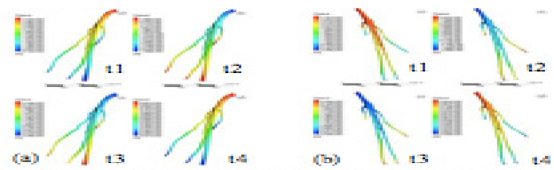


**Figure 1.** The distribution contour of arterial WP at the four moments. (a) the sound limb; (b) the residual limb.

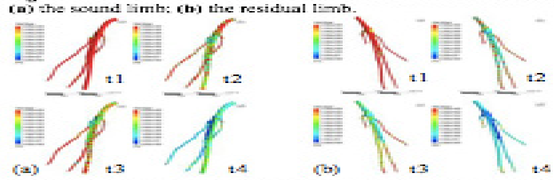


**Figure 2.** The distribution contour of arterial low WSS at the four moments. (a) the sound limb; (b) the residual limb.

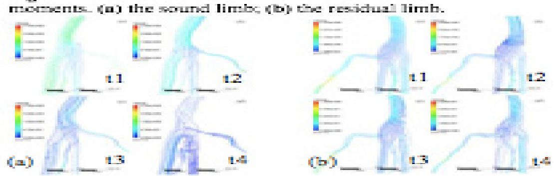


**Figure 3**. The velocity streamline in the bifurcation site at the four moments. (a) the sound limb; (b) the residual limb.

## DISCUSSION & CONCLUSION

The hemodynamic state of the main arteries of the residual limb was found different from that of the sound limb. The possibility of occurrence of various vascular lesions was greater in the residual limb than in the sound limb. The high risk areas located at the arterial tree bifurcation site and the upper half of deep femoral artery due to high WP, low WSS, and velocity field disorder. These findings could contribute to the prevention of the vascular diseases in residual limb, and provide blood flow information for the pathological exploration and the remission methods of residual limb problems, as well as for prosthetic design.

# MINOR CHANGES OF GAIT CHARACTERISTICS IN PATIENTS TREATED WITH BONE-ANCHORED TRANS-FEMORAL PROSTHESIS AS COMPARED TO BEFORE TREATMENT

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## BACKGROUND

A transfemoral amputation (TFA) generally results in gait deviations most significantly present at stance phase. Patients with TFA are traditionally provided with socket-suspended prostheses although today a direct bone-anchored prosthesis is an option in selective cases. Previous studies have reported that patients walked faster and further using bone-anchored prosthetic solutions (1, 2). There is a lack of prospective studies reporting differences in gait characteristics in terms of kinematic and kinetic data in this group of patients.

## AIM

The aim was to report gait characteristics in stance phase for patients with unilateral TFA before and 2-year after treatment with bone-anchored prostheses and as compared to normal gait.

## METHOD

Patients treated with bone-anchored TFA prostheses in Sweden (3) and were using socket prostheses before treatment were included. Gait analysis was performed before treatment and at 2-years follow-up. The study population consisted of 24 patients (12 males 12 females), aged 44.5 years and amputation since in mean 13.5 years at treatment. Cause of amputation was mostly due to trauma and the majority had a medium to short residual limb. An age-and-gender matched healthy control group (n=72) were included and performed the gait analysis once. Kinematic and kinetic data were collected with an 8 camera QualisysTM motion capture system. Data from the affected side stance phase were then used for further analysis.

## RESULTS

The result showed a decreased flexion-extension movement of the trunk (2.2°, p=0.017); a decreased pelvic tilt (3.2°, p=0.08); and an increased hip extension on the affected side (5.4°, p=0.003) at 2-year follow-up. No other temporospatial, kinematic or none of the kinetic data showed any statistical significant differences between the two assessments. The observed differences in patients were still significantly different when compared to the controls.

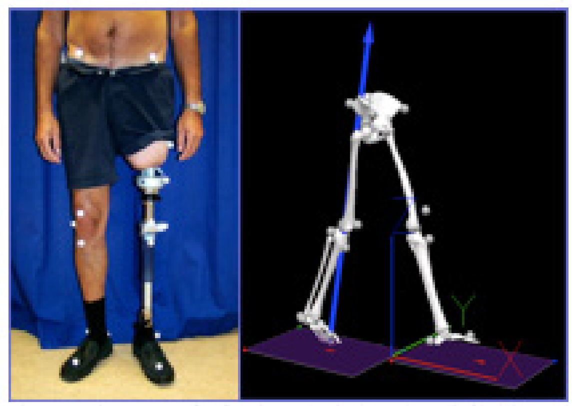

**Figure 1** Placement of reflective spherical markers (left), illustration from gait analysis software (right).

## DISCUSSION & CONCLUSION

Minor improvements in gait characteristics were observed 2-years after treatment with bone-anchored TFA prostheses. Improvements were primarily seen in pelvic tilt and hip extension with values closer to the controls. Gait characteristics in patients with TFA treated with bone-anchored prostheses may be considered as more or less manifest even though the prosthetic suspension has been fundamentally changed. The focus of improvement is thus not less gait deviations but other improvements in everyday living.

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# CONTROL OF PROSTHETICS THROUGH EMG PATTERNS ASSOCIATED TO PHANTOM LIMB VOLUNTARY GESTURES IS POSSIBLE IN TRANSHUMERAL AMPUTEES WITHOUT SURGICAL REINNERVATION

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## BACKGROUND

There is a need to extend the control possibilities of upper limb amputees over their prosthetics, especially with newly available polydigital hands. While decoding phantom hand and wrist movements from EMG electrodes placed on the forearm of transradial amputees has been commonly studied [l], little extension of this approach to transhumeral amputees has been done.

Nonetheless recent studies showed correlations between distal phantom hand voluntary movements and muscle activity in the residual upper arm in transhumeral amputees [2], i.e., of muscles that initially had no physical effect on the concerned hand joints.

## AIM

The purpose is to evaluate the extension of this concept to transhumeral patients (who did not undergo reinnervation surgery [31) by classifying the muscle activities in their residual upper limb naturally generated when mobilizing their phantom limb.

## METHOD

We asked three transhumeral patients (24 to 62 years old) to perform a control task during which they had to mobilize their phantom limb to activate associated buttons on a graphical user interface. To this aim, twelve EMG electrodes were placed over their residual limb and a state-of-the art classifier (LDA with a classical set of features) was trained over two demonstrations of each of their possible phantom movements including at least the elbow flexion and extension, the wrist pronosupination and the hand closing and opening. The patients were then asked to randomly control some buttons on a GUI which were associated to a movement class and control by the raw classifier output. Tests were performed over 5 randomized repetitions of each possible movement.

## RESULTS

Patients, without being trained neither to this task nor to mobilize their phantom limb, were able to control the interface through classification of their phantom limb related myoelectric patterns with a rather important success rate (over 80% when considering basic sets of 6 hand, wrist and elbow movements) as shown in Fig. l.
In addition to the six listed movements, two patients were also able to control some finger movements (thumb, major and little finger, for which the classifier was also trained) which were successfully recognized by the controller with, however, a slightly reduced efficiency (see Fig. l).

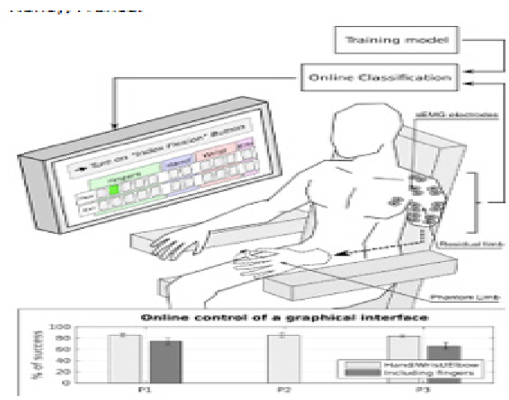


**Figure l.** Control task and success rates obtained during online control of a graphical interface for each participant, averaged among the six elbow/wrist/hand phantom movements (light grey) and including 6 extra phantom fingers movements (thumb, major and little finger, in dark grey).

## DISCUSSION & CONCLUSION

While remaining preliminary (with a need to perform experiments with larger populations and study the possible effects of training and long-term phantom mobilization), these results will have several impacts. Beyond changing the way the phantom limb is apprehended by both patients and clinicians, such results could pave the road towards a new control approach for the 85 % of transhumeral amputated patients with a voluntary controllable phantom limb. This could ease and extend their control abilities of functional upper limb prosthetics with multiple active joints without undergoing muscular reinnervation surgery.

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# DEVELOPMENT OF A PROSTHETIC HAND OUTCOME MEASURE: FRAGILE GRASPING WITH A COGNITIVE DISTRACTION

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## BACKGROUND

Able-bodied individuals perform dexterous and bimanual tasks with ease, even while distracted, due to their ability to “feel”. Myoelectric prosthetic users lacking this sensory feedback tend to have limited performance that is further inhibited while distracted. In this study, we explore a new cognitive and visual distraction measure that significantly hinders the performance of able-bodied individuals while grasping fragile objects. The result forms a comparison baseline to determine the effectiveness of future technologies in upper extremity prosthetics.

## AIM

The aim of this study is to analyze the effect of a cognitive distraction on able-bodied individuals performing a timed fragile grasping task. The purpose is to develop an upper extremity outcome measure that can be applied to amputees.

## METHOD

In this IRB approved trial, 21 individuals have performed a fragile grasping task with and without cognitive and visual distraction. In a timed test, each subject was instructed to grasp a saltine cracker (Nabisco), transfer it to their other hand, and place the cracker in a pre-determined location. This was to be done as fast as possible without breaking or dropping crackers. The total number of crackers transferred in 30 seconds is recorded. To achieve cognitive distraction, the subject was directed to continuously summarize a known media source such as a book, television show, or movie for the duration of the task. This was repeated 5 times while alternating between no distraction and distraction. To achieve visual distraction, a visual barrier was placed between the subject and the hand during the transfer of the cracker.

## RESULTS

A two-way ANOVA test with repeated measures was implemented and it was found that both the testing condition (method of distraction) and trial-to-trial performance of individuals demonstrated significant differences ($P<0.01$). A post-hoc multiple comparisons test was performed via Tukey’s multiple comparisons test to determine what conditions differed significantly. It was found that both the blindfold and cognitive distractions caused significant ($P<0.01$) reductions in performance compared to the non-distracted control states: dominant or non-dominant hands. Significant decline in function with cognitive or visual distraction, indicates the efficacy of the distraction technique.

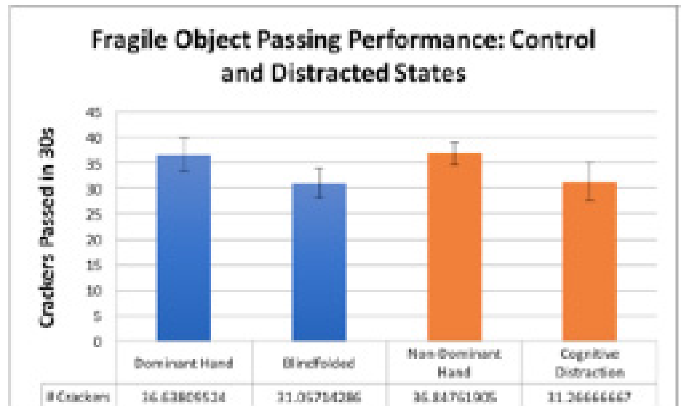


Figure 1. Able-body Fragile grasping performance data.

## DISCUSSION & CONCLUSION

To date, there has not been a means to demonstrate the effect of distraction on function in the upper extremity. The methods of distraction used in this study resulted in a significant decrease in the speed of fragile item grasping for able-bodied individuals. This is a promising result for the future of prosthetic research in determining the ease of use of different prosthetic hands and the role of vision and focus as it relates to day to day function.

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# SIMPLE AND FUNCTIONAL LOW-COST PROSTHETIC HAND DECOUPLES GRASP FORCE FROM GRASP POSTURE

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[1] University of New Brunswick

## BACKGROUND

The fingers and thumb of the human hand provide two distinct functions: they (1) apply force to objects in (2) a variety of grasp patterns. Body-powered and myolectric prostheses typically mimic human anatomy in combining these functions. However, due to design constraints this design decision results in either a limited number of grasp patterns, low efficiency, increased weight, increased complexity, and/or increased cost. However, there is no reason that the same components need to both apply force and be responsible for grasp patterns.

## AIM

The aim of this prosthetic hand design is to decouple grasp force from grasp posture, in an effort to reduce complexity weight and cost, and improve ruggedness, functionality, efficiency, and cosmesis.

## METHOD

Our design provides grasp force through thumb flexion. The thumb is either actuated by a motor housed in the thumb for our myoelectric version (Figure 1), or by a Bowden cable attached to the thumb for our body-powered version. The design provides a variety of grasp postures by incorporating bistable spring mechanisms in each of the fingers (Figure 2), as well as positionable thumb abduction (Figure 1).

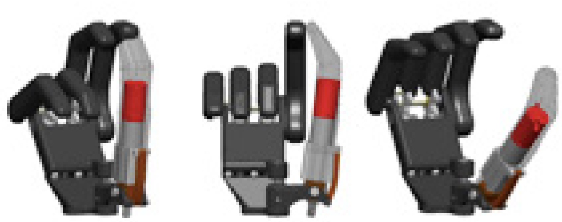

**Figure 1**. Myoelectric hand in various grasp patterns

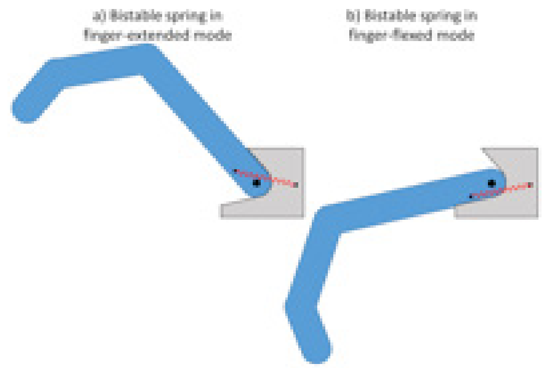


**Figure 2**. Bistable spring provides grasp posture for individual fingers using only a simple spring.

## RESULTS

Because actuation is only provided by the thumb, the fingers can be fully covered by a cosmetic covering without affecting grasp efficiency. The bistable spring mechanism is simple, rugged, and reliable. Users can manually position each of the fingers either fully flexed or fully extended, and they can position the thumb in one of two positions. This enables the hand to achieve lateral key-pinch, fine pinch, 3-jaw chuck, each with the lateral fingers fully flexed or fully extended, for a total of 6 grasp patterns.

## DISCUSSION & CONCLUSION

By decoupling grasp force from grasp posture, we have produced a simple, low-cost, rugged, reliable design that achieves improved efficiency and cosmesis.

## ACKNOWLEDGEMENT

This work was supported by the New Brunswick Innovation Foundation.

# THE EFFECT OF KNEE BRACING ON PAIN, SYMPTOMS AND PATELLOFEMORAL LOADING IN RECREATIONAL ATHLETES WITH PATELLOFEMORAL PAIN

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## BACKGROUND

In athletic populations patellofemoral pain symptoms force many to limit or even end their participation in sports activities. It has been shown that between 71-91 % of those who present with patellofemoral pain have ongoing symptoms up to 20 years following diagnosis [1]. Overloading of the patellofemoral joint is considered to be a key risk factor for the initiation of pain symptoms in athletes [2]. Treatment options for patellofemoral pain typically include; exercise, patella taping, knee bracing, foot orthoses and manual therapy.

## AIM

The study aimed to investigate the effects of an intervention using knee bracing on pain, symptoms and patellofemoral loading during sporting tasks in recreational athletes.

## METHOD

Twenty participants (11 males & 9 females) with patellofemoral pain were provided with a Trizone knee brace which they wore for a period of 2 weeks. Lower extremity kinematics and patellofemoral loading were obtained during three sports specific tasks, jog, cut and single leg hop. In addition their self-reported knee pain scores were examined using the Knee injury and Osteoarthritis Outcome Score (KOOS). Data were collected before and after wearing the knee brace for 2 weeks. Differences in biomechanics and KOOS scores were examined using 2 factor (gender, brace) mixed methods ANOVA's for each task. In addition the effect size was calculated using partial Eta squared ($\eta p2$).

## RESULTS

Significant reductions were found when wearing the brace in the run and cut movements for peak patellofemoral forces ($p<0.05$, $\eta p2>0.27$), patellofemoral pressure ($p<0.05$, $\eta p2>0.24$), patellofemoral loading rate ($p<0.05$, $\eta p2>0.39$) and in all movements for the peak knee abduction moment ($p<0.05$, $\eta p2>0.39$). Significant improvements were also shown for KOOS subscales symptoms ($p<0.05$, $\eta p2=0.71$), pain ($P<0.05$, $\eta p2=0.71$), sport ($p<0.05$, $\eta p2=0.66$), function and daily living ($p<0.05$, $\eta p2=0.65$), and quality of life ($p<0.05$, $\eta p2=0.28$). No differences in effect where seen between males and females although females generally showed a larger reduction in patellofemoral forces and pressure.

## DISCUSSION & CONCLUSION

Previous papers have investigated the effects of knee bracing, however the effects of bracing in a subgroup of recreational athletes with patellofemoral pain is limited. This study provides a comparison of knee pain symptoms when using knee bracing and explored changes in the biomechanical loading during different sports movements that could be responsible for these symptoms.

Male and female recreational athletes who suffer from patellofemoral pain can be advised that knee bracing can reduce pain symptoms by reducing the patellofemoral forces and pressures.

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# SELF-EFFICACY AND PROSTHETIC USE FOR PERSONS WITH A LOWER LIMB AMPUTATION

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## BACKGROUND

Perceived self-efficacy is an individual´s belief of what he/she is capable of in a given situation (1). According to social cognitive theory it has an influence on motivational levels and coping strategies (2). While self-efficacy has not been previously investigated in an amputee population, in other groups it has been shown to be correlated with outcomes such as activity, participation, balance, walking capacity and physical performance (3-5).

## AIM

The aim of this study was to describe levels of general selfefficacy in individuals with a Lower Limb Amputation (LLA) and to determine if there were any differences in prosthetic specific outcomes and general self-efficacy based on the type of prosthetic knee used.

## METHOD

Forty-two persons with above or through the knee amputations, fitted with a non-microprocessor controlled knee (non-MPK) or a microprocessor controlled knee (MPK) were included in the study. Participants were aged between 18-66 years and amputated for non-vascular causes. The Questionnaire for Persons with a Transfemoral Amputation (Q-TFA) and the Swedish version of the General SelfEfficacy Scale (GSE) were used. Differences between the two prosthetic knee groups and Q-TFA scores for individuals with low versus high GSE scores were analysed using The MannWhitney U-test. To determine the strength of correlation between the GSE scale and Q-TFA scores a Spearman's correlation coefficient was used.

## RESULTS

Mean age was 49 years +-13, Thirty-three percent of participants (n=14) were classified as having low GSE scores (< 30) while 67% (n=28) were classified as having high GSE scores. Twenty-three participants (55%) were using a non-tMPK, while 19 (45%) were using a MPK knee joint. The nonMPK group was significantly older than the MPK group (mean age = 55 years and 41 years respectively) ($p < .001$) and had been amputated for a longer time (29 years versus 16 years) ($p = .003$). Those with higher GSE scores demonstrated significantly higher prosthetic use ($p=0.011$). No difference was observed between groups with non-MPK versus MPK in either the GSE or any of Q-TFA scores. There was a weak to moderate correlation between GSE and Q-TFA scores ($r = .20 - .52$).

## DISCUSSION

Individuals included in this study had generally high GSE scores. This study showed that those with a high GSE score used their prosthesis more hours per day compared to those with low GSE scores. High GSE scores were also shown to be positively correlated with mobility and negatively correlated to problem scores. The GSE scale was not able to discriminate between non-MPK vs MPK groups.

## CONCLUSION

Psychological variable seems to influences function and mobility with a prosthesis. These variables require more attention during rehabilitation.

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# BRACE TREATMENT INFLUENCED BY LUMBO-SACRAL TRANSITIONAL VERTEBRA IN ADOLESCENT SCOLIOSIS

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## BACKGROUND

An oblique lumbosacral transition is suspicious of a lumbosacral transitional vertebra (LSTV) - Bertolotti Syndrome. The diagnosis of LSTV depends on extent and quality of malformation and the MRI examination technique.

## AIM

The aim of the study is to find causes for poor brace-correction of lumbal curves and the lumbosacral transition in adolescent scoliosis.

## METHOD

20 adolescent patients with scoliosis and oblique lumbosacral transition were examined. All of them demonstrated a poor in brace correction and were radiological suspicious to LSTV. In this cases an MRI investigation was initiated. The images were examined by its quality (Tesla), representation (axial, coronal, sagittal) and by the Castellvi classification (Figure 1).

## RESULTS

Only in 3 cases LSTV could be detected (Castellvi Type Ia, Ib and IIa). In 2 cases LSTV could be excluded.
In 15 delivered recordings the quality of the MRI was unable to answer the question LSTV. The MRI images were inappropriate in 3 cases (1,5 Tesla). MRI-standards for disc surgery, with only a sagittal and axial plane were delivered in 12 cases.

The adjustment of the MRI was focused on the lumbar spine and not to the segment L5/S1. Also in 5 cases the lateral part of L5/S1 was not portrayed and the iliolumbar ligament could not be dedected (Figure 2).

## DISCUSSION & CONCLUSION

In cases of oblique lumbosacral transition an MRI, in a high quality, should be organized. For the representation of a fibrous transition like an iliolumbar ligament disorder or Castellvi Type I and II an MRI device with> 3.5 Tesla is necessary. The lack of the coronal plane prevents the diagnosis of LSTV and cannot be accepted.

The adjustment of the MRI has to be focused on the L5/S1 segment. In conclusion all cases with a limited brace correction of a lumbosacral curve an MRI should be initiated. The examination has to include all 3 body planes and has to be focused on the segment L5/S1 in a high quality.

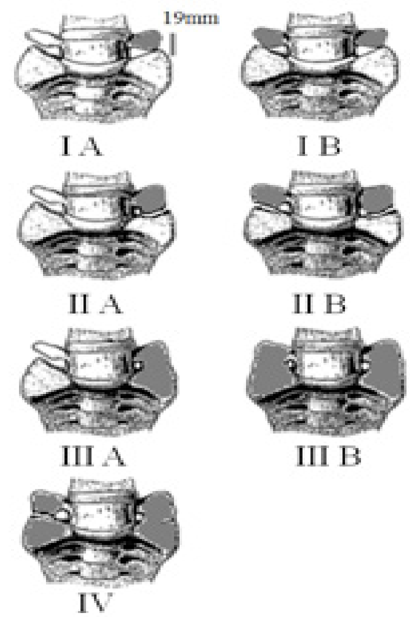


**Figure 1**. Castellvi-Classification

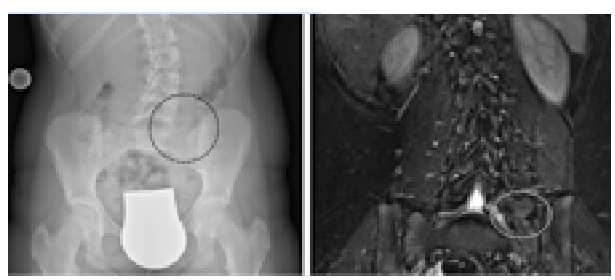

**Figure 2.** Castellvi-Classification Type II A

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# AT-HOME USE AND PERFORMANCE OF CONVENTIONAL BODY-POWERED PROSTHESES AND A NOVEL VOVC TERMINAL DEVICE

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## BACKGROUND

Many people use body-powered prostheses, but little is known about how many movements they make per day with their prosthesis. In addition, some people choose voluntary-opening (VO) prostheses, whereas others choose voluntary-closing (VC) prostheses. It is unclear if a device that could operate in both modes (VOVC) would be more useful.

## AIM

The first goal of this study was to quantify how many movements per day persons make with a body-powered device. The second goal was to quantify if a VOVC device that we recently developed [1] would be useful in their daily lives.

## METHOD

We designed an instrumented harness that could monitor how many movements users made each day, as well as the force they exerted on the TD. We recruited 3 subjects with a transradial amputation to participate in this study, with informed consent of a protocol that was approved by our local ethics board. We also tested them with our novel VOVC device. Following this we performed outcome measures on their conventional and VOVC device in randomized order, including Box and Blocks, Jebson, SHAP, and a qualitative survey.

## RESULTS

Results of the study are shown in Table 1. All three subjects chose to use both modes of the VOVC device, both at home in daily use, and during their outcome measures. One of the subjects did better on the Box and block using the VOVC device than their conventional device, and two did better on the Jebson using the VOVC device than their conventional device.

All of the subjects did better on the SHAP using their conventional device than using the VOVC device.

| | | | |
|---|---|---|---|
| Subject # | 1 | 2 | 3 |
| Conventional device | VC | VO | VO |
| **Average daily movements** | | | |
| Conventional device | 727 | 334 | 105 |
| VOVC device, VO mode | 18 | 235 | 128 |
| VOVC device, VC mode | 8 | 13 | 41 |
| **Box and Block** | | | |
| Conventional device | 27 | 30 | 29 |
| VOVC device | 23 | 41 | 26 |
| VOVC device mode chosen | VC | VO | VC |
| **Jebson** | | | |
| Conventional device (sec) | 321 | 190 | 166 |
| VOVC device (sec) | 255 | 204 | 163 |
| % of tasks selected VO mode | 43% | 71% | 57% |
| **SHAP** | | | |
| Conventional device (index of functionality) | 44 | 65 | 68 |
| VOVC device (index of functionality) | 35 | 62 | 65 |
| % of tasks selected VO mode | 38% | 96% | 4% |

## DISCUSSION & CONCLUSION

The fact that all three subjects chose to use both modes, both at home, and during outcome measures, suggests that devices that can switch modes are useful. The experimental device used in this study [1] had a number of limitations that were identified in the qualitative questionnaire, including limited pinch force, which may have limited the performance of that specific device. However, VOVC devices as a category, appear to be useful in daily life and should receive more research attention.

## REFERENCES

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## ACKNOWLEDGEMENT

The authors thank James Lipsey and José Ochoa for their contributions to the design of the device and electronics. This work was supported by the U.S. Department of Education, National Institute for Disability and Rehabilitation Research (grant H133E130020). However, those contents do not necessarily represent the policy of the U.S. Department of Education, and you should not assume endorsement by the U.S. Federal Government.

# UPPER LIMB ABSENCE: DEVELOPMENT OF AN INSTRUMENT TO ASSESS FUNCTIONAL CAPACITY OF THE NON-AFFECTED BODY STRUCTURES AND FUNCTIONS

Sietke Postema[1], Raoul Bongers[2], Andrea Cutti[3], Corry van der Sluis[1], Michiel Reneman[1]

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## BACKGROUND

As current prostheses are no full replacement of an amputated limb, the nonaffected body structures and functions are burdened with increased physical loads after the loss of an upper limb. As a consequence, the individual's functional capacity may be altered. As a mismatch between demands and capacity may increase the risk on development of musculoskeletal complaints, an instrument to assess functional capacity of individuals with upper limb absence (ULA) is warranted.

## AIM

Two studies were conducted, which aimed to 1) develop and pilot test an instrument to assess functional capacity of the nonaffected body structures of individuals with ULA, and 2) assess test-retest reliability and safety of this instrument.

## METHOD

Study 1: An existing set of functional capacity evaluation tests for individuals with work-related upper limb disorders was adapted for use by one-handed individuals; necessary changes were discussed by the research team. Twenty individuals with ULA pilot tested the tests, as well as twenty controls matched for age, gender, weight, and height. Study 2: A different group of 23 individuals with ULA were invited to perform these tests twice, in order to assess test-retest reliability and safety.  Inclusion criteria for both studies were: having an upper limb amputation or reduction deficiency at or proximal to the carpal level, good self-reported function of the non-affected hand, age ≥18 years, and healthy enough to perform physically demanding tests (assessed with the physical activity readiness questionnaire).

## RESULTS

Study 1: the instrument consists of six tests: overhead lifting, repetitive overhead lifting, overhead working, repetitive reaching (two items), fingertip dexterity (two items), and hand grip strength. Ten individuals with transhumeral ULA (all male, median age 49 years) performed the tests without prosthesis, and showed lower lifting capacity compared to their matched controls, who were allowed to use both hands. One-handed lifting capacity was equal between groups. Overhead working capacity was lower in the ULA-group. Another ten individuals with transradial ULA (seven males, median age 49 years) used their prosthesis during testing, and showed a trend for lower lifting capacity compared to their matched controls. Other tests showed no significant differences between groups.
Study 2: five out of eight test items showed acceptable test-retest reliability (ICC-values ≥.75), while three items had ICC-values <.75. One participant developed a bruise after testing, no other adverse reactions occurred. A pain response was present in 30% of the individuals.

## DISCUSSION & CONCLUSION

Overhead working capacity of individuals with transhumeral ULA was lower than in matched controls. One-handed lifting capacity was, not surprisingly, lower than two-handed lifting capacity. Other tests showed equal capacity between individuals with ULA and matched controls. However, due to asymmetric usage of the body, individuals with ULA may experience increased physical load on non-affected structures and functions. Therefore, we hypothesize that equal capacity may actually denote a relative deficit of capacity for individuals with ULA. Good or excellent test-retest reliability was observed in five items, while the remaining three items showed poor or moderate reliability. The instrument was considered safe in use, when the right precautions are applied.

# HEEL WEDGE VARIATION SYSTEMATICALLY AFFECTS GAIT WITH AN ORTHOSIS

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Extremity Trauma and Amputation Center of Excellence, Ft Sam Houston, TX, USA

## BACKGROUND

Severe lower limb injuries can negatively affect many aspects of an individual's life1. One option for patients with these injuries is the Intrepid Dynamic Exoskeletal Orthosis (IDEO). The IDEO is a custom-made dynamic response carbon fiber ankle-foot orthosis (AFO), designed to restore function, including very high levels of activity2,3. The heel wedge is an integral part of the IDEO-heel wedge-shoe system (Figure 1).

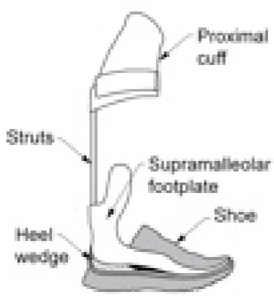


Figure 1. The IDEO-heel wedge-shoe system, showing a standard heel wedge.

## AIM

The purpose of this study was to determine the effects of heel wedge properties on center of pressure (COP) velocity during gait for individuals using an IDEO. COP velocity was selected as an indicator of the smoothness of forward progression.

## METHOD

Twelve unilateral IDEO users with impaired limb function due to fracture, tendon rupture, arthritis, fusion, or volumetric muscle loss participated. Biomechanical gait data were collected as participants walked at a controlled speed using their IDEO with 6 different standard heel wedges: 2 durometers (soft, firm) X 3 heights (1cm, 2cm, 3cm).

COP velocity during stance was calculated. Self-reported pain, IDEO comfort, and smoothness of gait scores were combined to determine wedge preference. Repeated measures ANOVA and Friedman tests were utilized with $\alpha=0.05$. After study results were analyzed, several patients were fit with a new heel wedge which extended further distally under the IDEO footplate. COP velocity and wedge preference were evaluated for four patients during clinical assessments with these extended wedges.

## RESULTS

Time to peak COP velocity (% stance) was significantly earlier when walking with 1cm (19.8±5.3%) compared to 2cm wedges (25.8±9.7%), 1cm compared to 3cm wedges (32.4±12.1%), 2cm compared to 3cm wedges, and soft (23.2±7.9%) compared to firm wedges (28.9±12.3%) (all $p<0.01$). Peak COP velocity (m/sec) was significantly greater when walking with 1cm (1.74±0.96) than 3cm wedges (1.26±0.42) ($p=0.008$).

The least preferred wedge (1cm soft) produced the highest peak COP velocity. Clinical evaluations after the study showed a substantial decrease in peak COP velocity when changing from a standard to an extended wedge (Figure 2), which most patients preferred.

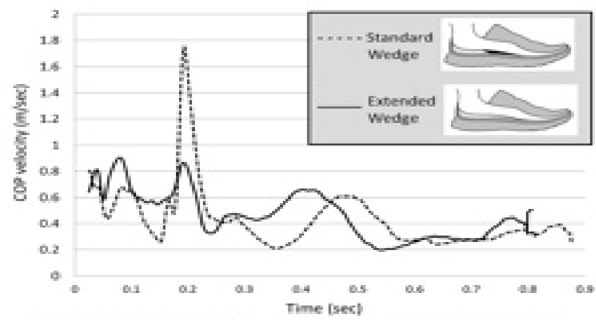


Figure 2. COP velocity from representative trials collected during clinical assessments of heel wedges of different lengths, but same durometer and height.

## DISCUSSION & CONCLUSION

Generally, shorter and softer wedges stopped compressing earlier, leading to significantly earlier and greater peak COP velocity, as the foot pivoted on the heel and abruptly transitioned to the forefoot. Use of extended wedges allowed a smoother transition to the forefoot and decreased peak COP velocity.

Use of heel wedges with other types of AFOs may improve smoothness of roll-over for those devices as well. In conclusion, adjusting the heel wedge is a simple way to systematically alter the function of the IDEO-heel wedge-shoe system and has great potential to improve an individual's gait with an AFO.

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The views expressed herein are those of the authors and do not reflect the official policy or position of Brooke Army Medical Center, the U.S. Army Medical Department, the U.S. Army Office of the Surgeon General, the Department of the Army or the Department of Defense or the U.S. Government.

# SURVEY OF HIGHER MOBILITY GRADE PATIENTS WITH KNEE DISARTICULATION IN LIMB CENTRE'S IN THE SOUTH EAST OF ENGLAND

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## BACKGROUND

The knee disarticulation (KD) level is a controversial level of amputation in the UK and is often ignored in favour of a trans femoral level. There are many documented opinions concerning the advantages and disadvantages of this level and of the merits of various surgical techniques. A recent systematic review 1 highlighted the lack of quality of life outcomes in this group.

## AIM

To survey the higher functioning KD patients within prosthetic limb fitting centres concerning the frequency of intervention required by the prosthetic service and also the patient's assessment of their quality of life and satisfaction with their prosthesis.

## METHOD

All KD patients were identified throughout 8 prosthetic centres of the Inter Regional Prosthetic Audit Group (IRPAG) and data collected concerning their reason for amputation, surgical technique, age at amputation, whether they were prosthetic users and SIGAM mobility grade. Higher functioning SIGAM E and F patient's prosthetic notes were then analyzed further to study frequency of new sockets and attendance for adjustments to the limb. Patients were also asked to complete the Trinity Amputation and Prosthesis Experience Scales 2 (TAPES) survey. Results were then matched with the patient's data set, anonymized and collated.

## RESULTS

352 different KD patients were identified with 368 amputations, 16 were bilateral KD amputees.
47% (n=167) of the KD patients had SIGAM mobility grade E or F. At the time of abstract submission 72 sets of prosthetic data had been received and 29 TAPES returned.
Congenital patients (CPs) had twice as many sockets manufactured than the non congenital patients (NCPs). Both groups had been prosthetic users for similar length of time (average 14 years CPs compared with 12 years NCPs). Both the CPs and NCPs were equally adjusted to prosthetic use although the NCPs felt more restricted functionally. There were fewer instances of residual limb pain in the CPs (20% compared with 50%) and no instances for phantom limb pain in the CPs compared with 65% in NCPs. The pain experienced by CPs was less frequent, of shorter duration and of lower level than that of the NCPs,CPs and NCPs suffered with similar incidence (60%) of other medical problems but were different in nature.

## DISCUSSION & CONCLUSION

Understandable differences are noted between the CPs and NCPs in prosthetic input due to growth.
General and social adjustment was good in both groups. Functional limitations experienced by the NCPs may be due to older age at amputation, associated pathology / trauma and higher incidence of residual and phantom limb pain.

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# THE IMMEDIATE EFFECT OF A SOFT BRACE ON PAIN, ACTIVITY LIMITATIONS, SELF-REPORTED KNEE INSTABILITY, AND SELF-REPORTED KNEE CONFIDENCE IN PATIENTS WITH KNEE OSTEOARTHRITIS.

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## BACKGROUND

Soft braces (knee sleeves) are recommended in the non-surgical management of patients with knee osteoarthritis (OA). Because of their ease of use, lack of complications and low cost, soft braces are commonly used with the aim to reduce pain and activity limitations. The evidence for clinical efficacy of soft braces is however limited and of low-quality. Moreover, the level of tightness, at which soft braces elicit their effects has not been studied well, however, could be highly relevant for therapeutic outcomes.

## AIM

To (i) evaluate the effect of a soft brace on pain, activity limitations, self-reported knee instability, and self-reported knee confidence, and (ii) to assess the difference in effect between a non-tight and a tight soft brace in patients with knee OA.

## METHOD

Forty-four patients with knee OA and self-reported knee instability participated in the study. A within-subject design was performed, comparing no soft brace versus soft brace, and comparing tight versus non-tight soft brace. A non-tight brace was one size larger than a tight brace. Participants of the study attended a single testing session during which they were subjected to walking, with and without a soft brace, on an instrumented treadmill in two testing conditions: level walk and perturbed walk.
The outcome measures were: pain, activity limitations assessed outside the treadmill with the Get Up and Go (GUG) test and 10-meter walk test, self-reported knee instability and self-reported knee confidence. Linear mixed-effect model analysis was used for continuous outcomes. Logistic Generalized Estimating Equations analysis (GEE) was used for dichotomous outcomes.

## RESULTS

The participants had a mean ± SD age of 65.7 ± 9.3 years, a mean ± SD BMI of 29.8 ± 5.5 kg/m², and 29 (65.9%) were women. Wearing a soft brace significantly reduced activity limitations and pain, and improved self-reported knee stability and knee confidence, compared to not wearing a soft brace (all Ps<0.05). There was no difference in the observed effects between a non-tight and a tight soft brace (all Ps>0.05), except for the 10-meter walk test (P=0.03).

## DISCUSSION & CONCLUSION

Within the limitations of the study, which mainly included lack of true blinding, the results of the study indicate that a soft brace is an effective intervention, targeting pain, activity limitations, and self-reported knee instability and knee confidence in the immediate-term in patients with knee OA. Further studies evaluating mode of action based on exerted pressure are needed, as well as studies on the generalization to functioning in daily life.

# AN AUGMENTED REALITY METHOD OF VISUALISING TRANSTIBIAL SOCKET PRESSURES AND LIMB ORIENTATION

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## BACKGROUND

The measurement of in-socket pressure distribution has been a research concern for decades. Inappropriate application of pressure to the residuum has been implicated in discomfort, pressure injury, development of skin conditions and subsequent reduction in function [1]. Despite this interest, measurement systems have not moved from research tools into routine practice. One reason suggested for this is difficulty in interpretation: they lack the context of position relative to the measured socket and in associating the results with the orientation of the socket during movement [2]. These aspects may be improved by using an augmented reality system to visualise results by providing a scaled model, displaying measured pressure values and oriented to provide positional context.

## AIM

To investigate the potential for using an augmented reality system on a recording of transtibial socket pressure distribution obtained using an inverse-problem measurement system.

## METHOD

A representative 3D model of a transtibial socket was created in Solidworks and imported to an augmented reality application (eDrawings iOS) in order to be associated with a positioning barcode. A set of dynamic measurements of in-socket pressures in eight locations during walking was obtained using a neural network-based system (reported in detail elsewhere [3]). The changes in pressure distribution were represented on the socket model by altering the colour of patches on the socket surface, and socket orientation modified to represent different phases of the gait cycle. The finished model was viewed using a smartphone.

## RESULTS

Researchers were able to successfully observe changes in 3D position and relative load of different measurement locations on a scaled model of the participant's socket. An example of this is shown in figure 1.

**Figure 1.** Virtual socket with coloured patches to indicate relative load distribution, and orientated to display early and late stance

## DISCUSSION & CONCLUSION

Although it proved possible to visualise relative pressure distribution using this commercial system, it was time-consuming and complex to achieve using this implementation with commercially available software. Validation of the utility of such a presentation system in a clinical setting is also required as part of the development process. A future implementation using a custom program may be a more effective and flexible solution in this particular application.

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# SENSITIVITY OF AN INVERSE-PROBLEM SOCKET PRESSURE MEASUREMENT SYSTEM TO CHANGES IN APPLIED FORCES FROM STANDING

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## BACKGROUND

Measurement of relative pressure distribution in prosthetic sockets using an inverse problem solution has seen promising results in preliminary testing [1, 2]. Such a system has the potential for significant advantages over existing methods, including avoiding interference at the interface, providing complete coverage of the socket and not requiring detailed knowledge of the limb/socket properties [3]. However, a system that is intended for clinical use must be sensitive to measured changes in applied force, and this is the subject of this report.

## AIM

The aim of this study was to assess the ability of an inverse-problem solver in measuring the magnitude of differences in total applied pressure through a transtibial amputee's socket during the application of different proportions of body weight.

## METHOD

The TSB socket of a traumatic transtibial amputee (M, age 53, amputee for 24 years) was instrumented with 11 strain gauges on the external surface. These strains were recorded using 3 LXRS devices (Lord Microstrain) and transmitted wirelessly to the host PC. The relationship between these the changes in these strain values and the sum of internal pressures in 8 positions was estimated using an ensemble of 100 neural networks. Data collection was performed using custom LabView (National Instruments) software, and neural networks of a feedforward-backpropagation design were implemented with the MATLAB (Mathworks) neural network toolbox. The participant was asked to stand with their prosthesis side on a force platform, and to stand while applying ~25%/50%/75% of bodyweight through the prosthesis side.

The proportional change in applied load was compared to that recorded by the force platform, taken as an average over two seconds of stable standing. Ethical approval study was granted by the University Ethics Committee.

## RESULTS

The participant's comfortable standing placed 49% of total bodyweight through the prosthetic side. Heavy standing increased this to 81%, and light standing reduced this to 20%. Estimates from the artificial neural network mirrored this pattern: the sum of estimates from the 8 sites measured increased for heavy weight-bearing and reduced for light weight-bearing (Table 1).

| Condition | Force Plate | Pressure Measurement |
|---|---|---|
| Heavy Standing | 167% | 138% |
| Balanced Standing | 100% | 100% |
| Light Standing | 42% | 60% |

**Table 1** - Changes in measured and estimated total applied force in response to different measurement conditions, expressed as a percentage of the 'balanced' standing condition.

## DISCUSSION & CONCLUSION

The system correctly evaluated the change in overall applied pressure magnitude. The exact changes in pressure magnitude did not reflect the changes in total applied force – this may be because the measurements did not completely cover the socket interface, that there was a significant component of force applied as shear rather than as normal stress or it may reflect a residual systemic inaccuracy in the neural network estimation.

The fact that light standing was overestimated and heavy load underestimated may point to a previously reported bias in the ANN method which can be substantially corrected using a polynomial correction factor [4]. Through developing and refining the parameters used in the construction and validation of the neural networks, the reliability may be improved further, as will increased understanding of the changes in pressure measurement in different circumstances.

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# CLINICAL INTEGRATION OF 3D PRINTED SOCKETS AND LINERS

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## BACKGROUND

Traditional fabrication of prosthetic sockets and liners has many steps and is very time consuming showing a need integrating 3D printing into the prosthetic industry. Initial trials conducted in the early1990s (1-4). These lacked structural strength and were still very time consuming to fabricate. Material sciences along with 3D printing techniques have improved since these trials making 3D printing more appealing to incorporate within a prosthetic clinic.

## AIM

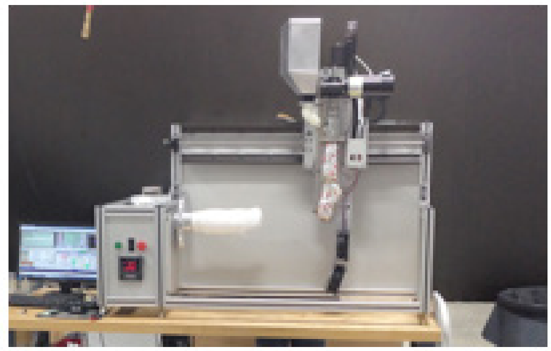
The purpose is to review one clinic's complete integration of fitting 3D printed sockets and liners.

## METHOD

300 amputees were fit with 3D printed sockets and liners over a 5 year period. Amputees were at transfemoral and transtibial levels. Sockets and liner molds were fabricated from a Squirt Shape printer using extruded copolymer plastic. Final sockets did not involve post carbon fiber lamination or additional fiberglass wrap. Various internal textures to test impact on socket fit.

## RESULTS

All amputees were successfully fit with 3D printed sockets and liners. Fabrications time ranged from 1.5 - 3 hours. Observations of improved fit were noted compared to previously fit socket. Majority of patients indicating less movement and increase control within socket. Three failure were recorded. Same day fittings occurred with 50% of patients.



**Picture 1**. Squirt Shape printer

## DISCUSSION & CONCLUSION

3D printed sockets and liners showed to be successfully integrated into a prosthetic clinic. Fabrication time was significantly reduced allowing clinic to fit amputee same day and requiring less clinical visits. Unexpected improvement to socket fit was concluded to be from inherent rough inner socket wall. Durability was successful with the exception of 3 failures determined to be from inadequate socket wall thickness at distal end. This was corrected with improved software programming. Definitive use with converting to copolymer plastic provided properties conducive to prosthetic sockets. Further research is warranted to explore internal socket texture on improving socket fit.

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# WORKPLACE INJURIES IN PROSTHETISTS AND ORTHOTISTS.

v

## BACKGROUND

There has been little research looking at occupational health and safety in the Prosthetics and Orthotics(P/O) profession; and none regarding work related musculoskeletal disorders. This is despite evidence from clinicians and claims data that suggests P/Os physical work demands are hazardous. Particularly in terms of manual handling, environmental exposures (chemicals and noise) and work-related stress1. Previous research examining other Allied Health professions suggests that work-related illnesses and disorders are likely to arise from a broad range of physical and psychosocial hazards2-4.

## AIM

The aim of the study was to: 1. determine the prevalence of musculoskeletal disorders (MSD) in Prosthetists/Orthotists working in Australia and 2. identify work-related predictors to these MSDs.

## METHOD

An observational, retrospective, cross sectional, research design was utilised to gain an understanding of the MSD injury prevalence rate in the Prosthetic and Orthotic field in Australia. A previously validated survey5 that was modified for use within the Prosthetics/Orthotics work context was circulated to P/O working in Australia, via the Australian Orthotic and Prosthetic Association (AOPA). The AOPA is the peak representative professional body in Australia. Participants were invited to complete the survey, either online via (qualitricsTM) or via a paper copy. Surveys were distributed and accepted over a four-month period. Data were imported into SPSS and statistical analysis was undertaken. T-tests and Chi squared tests were used to determine difference between groups as appropriate. A value of $p<0.05$ was deemed statistically significant.

Prevalence was calculated by the number of positive responses from the cohort of responses received. Correlations between MSD and factors based on the research framework were tested. These included age, gender, exposure (hours of work), experience, physical demands, psychosocial demands, type of work, work/life balance, work organisation, psychosocial working conditions and workability. Reliability testing was conducted and interaction effects were checked and not significant. All factors that had a correlation greater than 0.2 were included in a regression model.

Using a binomial logistic regression model, the effect of several workplace and demographic factors, were examined: gender, age, hours of work (per week), length of time working, work organisation and physical demands. Linearity of the continuous variables with respect to the logit of the dependent variable was assessed via the Box-Tidwell34 procedure. A Bonferroni correction was applied using all twelve terms in the model resulting in statistical significance being accepted when $p <0.004$.

## RESULTS

139 (53% response rate) surveys were returned and included in the statistical analysis. Females represented 56% of respondents of 35.8 (±8.1) years, respondents average years of experiences was 8.6(±5.8) year for females and 12.3(±10.4) years for males. Respondents worked as Orthotists, Prosthetists and a combination of both (table 1). Males were older than females (p=0.03) Prosthetists statistically worked longer hours than orthotists and clinicians working as both P&O (p=0.02). Nearly eighty percent of participants reported experiencing pain in the previous six months. 79.7% (102, n=128). Reporting of pain was significantly higher in females compared to males $\chi2(1, n=128) =4.734$ p=0.03.

| Measure | | number | % | |
|---|---|---|---|---|
| Gender | Female | 71 | 56 | |
| | Male | 57 | 44 | |
| Type of work | >75% | 54 | 42 | |
| | >75% | 39 | 30 | |
| | P&O | 36 | 28 | |
| | | Mean | SD | Range |
| Age | Female | 35.8 | ±8.1 | 26-59 |
| | Male | 33 | ±7.5 | 24-56 |
| Years of experience | Female | 8.6 | ±5.8 | 1-33 |
| | Male | 12.3 | ±10.4 | 1-38 |
| Length of time in | Women | 3.9 | ±3.3 | 0-15 |
| | Men | 4.5 | ±5.5 | 0-30 |
| Hours of work/week | Women | 38.9 | ±9.6 | 8-80 |
| | Men | 40.6 | ±10.4 | 16-80 |

A MSD prevalence of 80% for Prosthetists/Orthotists in Australia was identified. The regression model was statistically significant, $\chi2(6) = 32.35$, p= 0.00. The model explained 37% (Nagelkerke R2) of the variance in MSD and correctly classified 85.6% of cases. Of the six predictor variables four were statistically significant: Gender, hours of work, Work organisation and Physical demands. A lack of understanding of the P&O job role by other health professions and managerial staff negatively affected P&Os along with issues around funding and provision of devices.

## DISCUSSION & CONCLUSION

Work related musculoskeletal disorders are a major problem in the Australian Prosthetics and Orthotics population. A high prevalence (80%) of MSDs supports the assertion that P/Os are at high risk of injury. Factors that have been shown to predict this include being female, working longer hours along with work organisation and the physical demands of the job. Further research should look at the effect of both psychosocial factors, in combination with the physical factors as have been examined in this study, for a more comprehensive understanding.

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# THE SAFETY OF OSSEOINTEGRATED IMPLANTS FOR TRANS FEMORAL AMPUTEES

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## BACKGROUND

Osseointegrated implants are an alternative prosthetic attachment for individuals with amputation who are unable to wear a socket. However, the concept of a metal implant anchored to the bone and communicating with the external environment raises substantial concern about the risk of ascending infection, as well as related local and systemic consequences. Although infections associated with bone-anchored prostheses are well described in the field of dentistry, little data on safety have been published for their application in trans-femoral amputees.

## AIM

The main purpose of this paper is to report on the safety of the press-fit type osseointegrated implants currently used.

## METHOD

This is a prospective study of 86 patients aged 25-81 years, with median follow-up of 34 months (range: 24-71 months). All patients had trans-femoral amputation and were managed with osseointegration in 2009-2013. The procedure was performed in two stages involving placement of a customized implant and creation of a stoma. All adverse events were prospectively recorded and categorized by type (infection or other) and severity. Infections were classified into four grades of severity based on clinical and radiological findings: 1. Low-grade superficial infection; 2. High-grade superficial infection; 3. deep infection; and 4. septic implant failure.

## RESULTS

31 patients had an uneventful course without any complication. 25 patients had minor complications but no infections. 24 patients had infections, all of whom were grade 1/2 and did not necessitate surgery. No patients suffered with grade 3/4 infections. 26 patients had other adverse events requiring intervention including: inadequate osseointegration with replacement of implant (1); stoma hyper-granulation (17); implant breakage (2); breakage of dual cone component safety pins (3); and proximal femur fractures (3).

## DISCUSSION & CONCLUSION

Mild infection and irritation of the soft tissue in the skin penetration area are common for trans-femoral amputees treated using osseointegrated implants, but can be successfully managed with simple measures. Severe infections resulting in septic implant loosening are rare. These findings suggest that careful surgical handling of the soft tissue is essential for limiting the potential risk of deep infection.

# OSSEOINTEGRATED IMPLANTS FOR TRANS FEMORAL AMPUTEES: RADIOGRAPHIC EVALUATION OF BONE REMODELING

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## BACKGROUND

Peripheral vascular disease (PVD) is a slow and progressive circulation disorder characterised by the narrowing and blockage of blood vessels, leading to severe pain, infected gangrene and often amputation as the final outcome. PVD is the primary cause of lower extremity amputations in developed countries. Over the past three decades, advancements in peripheral vascular surgery have helped salvage many limbs otherwise destined for amputation. Nevertheless, intervention through vascular surgery alone is not sufficient in many cases and additional structural reconstruction through orthopedic surgery is often required. A number of studies exist in the literature showing the beneficial effects of osseointegration in lower limb amputees. However, no study to date has been published regarding the use of osseointegrated implants in vascular amputees.

## AIM

This study is a case series of 5 patients who suffered from PVD and received an osseointegrated implant as part of the treatment regime. The purpose of this paper is to describe our experiences of performing osseointegration surgery in patients with PVD and present the clinical outcomes.

## METHOD

Between 2014 and 2015, 6 osseointegration surgeries were performed in amputees who had lost their limb due to PVD, of which 5 patients were available for follow-up for a minimum of 2 years. All 5 patients included were trans-tibial amputees (TTA) who received osseointegrated implants that were press-fit into the amputated limb. Selection criteria included age over 18 years, limb loss due to PVD, and unilateral TTA with socket-related problems. These patients represented approximately 5% of all osseointegration procedures during the time period of this study.

In addition to an observational description, additional outcome measures included the Questionnaire for persons with a Trans-Femoral Amputation (QTFA), Short Form Health Survey 36 (SF-36), K Levels, Six Minute Walk Test (6MWT), and Timed Up and Go (TUG). Preand post-operative values for each outcome measure were acquired and compared. Adverse events were recorded including infection, revision surgery, fractures, implant failures and death.

## RESULTS

At the 2-year follow-up time point, all patients were still using the osseointegrated prosthesis. There were no reports of implant failure and no revision surgeries were required. The values of quality of life and functional outcome measures were consistent with the average values obtained from regular osseointegration patients, and showed significant improvements compared to pre-operative levels. A mild superficial infection event was recorded in one case, which was treated successfully with oral antibiotics.

## DISCUSSION & CONCLUSION

Although this case series represents a minor fraction of the osseointegration patient cohort, the implications of using osseointegration to retain a functional knee joint is significant for patients in terms of mobility, quality of life and even survival. These preliminary results suggest that osseointegration may be considered as an alternative method to help PVD patients maintain a higher activity level after amputation, which in turn improves their chances of survival as well as quality of life.

# OSSEOINTEGRATED IMPLANTS IN PATIENTS WITH PERIPHERAL VASCULAR DISEASE: A CASE SERIES OF 4 PATIENTS

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## BACKGROUND

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# SWEDEAMP –THE SWEDISH NATIONAL REGISTRY INCLUDING DATA FROM AMPUTATION TO PROSTHETIC SUPPLY AND FOLLOW-UP

Ilka Kamrad

## BACKGROUND

The medical process around amputation of the lower extremity is complex. With the intention to improve the medical care linked to amputation, the Swedish amputation and prosthetics registry for the lower extremity (SwedeAmp) was started in 2011.

## AIM

To describe the data registered in SwedeAmp during the first 5 years.

## METHOD

The registry includes data regarding amputation, prosthetic supply, and patient-reported outcome measures at baseline (pre amputation) and at follow-up 6, 12, and 24 months after amputation. All data are entered to the registry on-line with a personal log-in.

## RESULTS

From 2011 through 2015, 4214 amputation procedures in 3102 patients (mean age at amputation 72 (SD 17) years; 40% women), 1399 prosthetic supplies and 968 registrations of baseline data with 941 follow-ups were recorded. In 80% of the patients, the underlying condition was diabetes and/or vascular disease, and 42% were 80 years or older at the time of amputation. The mortality rate after major amputation was 23% within 6 months and 30% within 1 year. Transtibial amputation (TTA) was the most common level of the registered procedures. For this level, the most frequently used surgical technique was sagittal flaps, followed by liner compression in over 80% of the cases, and median time from surgery to fitting of first individual prosthesis was 70 (range 11-500) days. The most common TTA prosthetic type was a silicone liner with vacuum suspension combined with an energy storing foot.

The Prosthetic Use Score (score range from 0 to best possible 100) for patients with TTA due to diabetes/ vascular disease ranged from 40 to 50 at all three follow-ups, and a lower prosthetic use score was noted for patients with transfemoral amputation (TFA). Preoperative (baseline) Locomotor Capability Index-5 (score range from 0 to best possible 56) was 42 in patients with diabetes/vascular disease. Twelve months after amputation LCI-5 was 27 for TTA patients and 17 for TFA patients. More than 40% of all patients registered at follow-up experienced stump pain and around 60% experienced phantom pain, without improvement between 6 and 24 months.

## DISCUSSION & CONCLUSION

SwedeAmp records the complete process for patients with lower limb amputations in Sweden and includes baseline, amputation, prosthetic supply, and follow-up data. The registry is still young and has not yet gained complete coverage over the whole country. Hence, only descriptive data are presented. We consider SwedeAmp to have a high future potential to identify factors leading to national guidelines for optimal indications, choice of amputation level, surgical technique, rehabilitation, and prosthetic devices.

# EFFECTS OF FLEXIBLE AND RIGID ROCKER PROFILES ON IN-SHOE PLANTAR PRESSURE

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## BACKGROUND

Up to 25% of all patients with Diabetes Mellitus will develop foot ulcers. [1,2]. Rocker profiles are commonly used in the prevention of diabetic foot ulcers. These rocker profiles are mostly stiffened to restrict plantar- and dorsiflexion of the toes. Especially restriction of the latter is believed to ensure reduction of plantar pressures at the forefoot and first toe[3,4]. However, the difference in effect on plantar pressure between rigid rockers and flexible rockers that allow toe dorsiflexion is unknown.

## AIM

The aim of the current study was to evaluate the differences in plantar pressure between completely rigid and flexible rocker profiles that allow dorsiflexion of the toes.

## METHOD

Thirty healthy female adults participated in this study. Inclusion criteria were female sex, age ≥18 years, and shoe sizes EU38/39/40. Each participant walked with four rocker configurations and one control. The rocker configurations were; 1) flexible, apex positioned at 50% (Flex 50), 2) rigid, apex positioned at 50% (Rigid 50), 3) flexible, apex positioned at 60% (Flex 60), and 4) rigid, apex positioned at 60% (Rigid 60). In shoe pressure was measured using the Pedar® system (Novel, Germany). Data from twelve mid-gait steps were obtained in our Motion Lab for each participant. Peak plantar pressure (PP) was determined for seven masks and analysed using generalized estimate equation (GEE).

## RESULTS

Figure 1 shows the proportional differences in PP (relative to the control). Overall GEE showed a significant difference between shoe conditions in PP (p=0.032). Pairwise comparison for the first toe showed a 12% smaller increase in PP ($p<0.001$) for flexible configurations compared to rigid. PP for the central and lateral forefoot was significantly more reduced for rigid configurations compared to flexible with differences between 5% and 9% ($p<0.001$). For the heel, rigid configurations showed larger increase in PP of around 5% when compared to flexible ($p<0.001$).

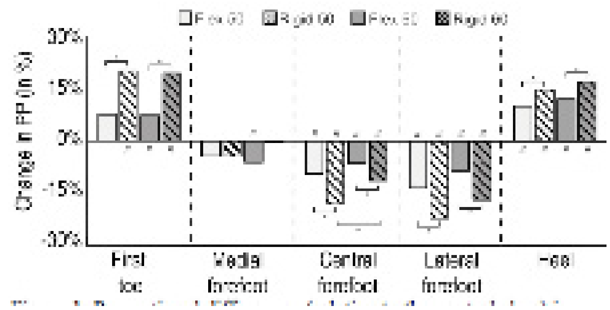


**Figure 1**. Proportional differences (relative to the control shoe) in peak plantar pressure (PP) for all four experimental conditions. *: significant difference between conditions ($p<0.001$). #: significant difference between control and experimental condition ($p<0.001$).

## DISCUSSION & CONCLUSION

This is the first study evaluating the differences in plantar pressure between rigid rockers and rockers that allow toe dorsiflexion. The results suggest that flexible rockers are preferred for the first toe, while for offloading of the central and lateral forefoot rigid rockers are favoured. For offloading of the medial forefoot the flexible rocker with the apex positioned at 60% is preferred over the other conditions. These findings indicate that a hybrid between rigid and flexible rockers may result in optimal offloading in individual cases, depending on the areas that are at risk of ulceration for each individual. To conclude, stiffened rockers are suitable for forefoot offloading, especially for the central and lateral forefoot. Rockers in general, but rigid rockers in particular, result in elevated pressures at the first toe.

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# CAN TREATMENT RESPONSE TO A SHOE DESIGNED FOR KNEE OSTEOARTHRITIS BE PREDICTED FROM BIOMECHANICAL AND CLINICAL MEASUREMENTS?

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## BACKGROUND

Increases in the forces at the knee have been associated with increased load at the knee and progression of knee osteoarthritis [1]. Recent advances in footwear design have led to the development of a new shoe which has been shown to reduce knee loading without realigning the ankle or knee joints [2]. However, no study has explored if this effect is universal or whether there are different groups of responders and non-responders.

## AIM

To explore differences in knee moments when wearing a standard shoe and the FlexOA shoe and determine whether individuals' responses could be predicted from Biomechanical and Clinical assessments.

## METHOD

Changes in joint angles and moments of 32 subjects (64 healthy knees) were measured during walking when wearing the FlexOA shoe and when wearing a standardised shoe using the Calibrated Anatomical System Technique (CAST). The magnitude of individuals' responses where explored in relation to the clinical assessment of the Foot Posture Index, Hip Range of Motion, Strength of Hip Rotation, Assessment of the Femur Neck Anteversion and ankle motion which have all be described as possible compensation mechanisms in knee osteoarthritis.

## RESULTS

Significant reductions in the Knee Adduction Moments during stance phase (9.3%) were recorded ($p<0.0001$), however despite this difference 19 of the 64 showed a response of either an increased knee adduction moment, indicating a negative-response, or no clinically important change to the FlexOA shoe, figure 1. A further exploration showed a correlation between change in knee adduction and the initial knee adduction moment in the control shoe. This indicated that those with a knee adduction moment larger than 0.4 Nm/kg are more likely to respond than those below this threshold. No significant differences were seen between the responder and non-responder subgroups in the any of the clinical scores used.

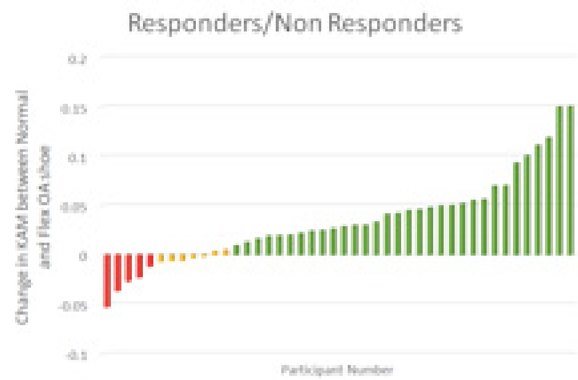


**Figure 1**. Biomechanical responders/non-responders to the FlexOA shoe measure by change in knee adduction moment (KAM)

## DISCUSSION & CONCLUSION

In some patients with knee OA conservative interventions can produce biomechanical and clinically important improvements2. However, these results suggest that responder/non-responder subgroups exist when considering the FlexOA shoe. In this data the magnitude of the initial knee adduction moment can be used to predict responders and non-responders with a threshold of 0.4 Nm/kg, interestingly however none of the clinical assessments used were able to predict these groups. Further exploration of different clinical assessment scores that may be suitable as predictors for this response is needed. More research exploring if subgroups exist and which interventions are useful for these subgroups would help our ability to optimise conservative intervention for the benefit of patients with knee osteoarthritis.

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# CAPACITY BUILDING FOR CAT II PROSTHETISTS & ORTHOTISTS IN NEPAL

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## BACKGROUND:

Handicap International has implemented physical rehabilitation services in Nepal since 2005. Nepalese O&P professionals have completed training in lower limb prosthetics/orthotics and are employed as Lower limb Prosthetic & Orthotic technologists. ISPO CAT II training covers aspects of direct clinical services, but de-emphasizes areas like evidence based practice. In some less-resourced countries like Nepal, CAT II professionals lead and manage P&O services. There is a need to build capacity of these professionals to bridge the gap in skills needed to fulfill the responsibilities expected from them. Choosing locally-driven approaches for capacity building is key to develop and maintain those capacities over time (1).

## AIM:

To promote a model of capacity building for CAT II professionals to enhance their skills to manage the services in a low resource setting independently.
METHOD: ISPO Category II lower limb orthotists and lower limb prosthetists (3 males: 2 females) with 4.8 mean years of experience since graduating, agreed to participate in mentoring. Using a structured participatory approach, training needs were documented, and individualized training program implemented. Training included mentoring, access to formal workshops, remote follow up, and other methods. Performance was tracked using a simple scoring tool that includes areas such as skills, knowledge, values and managerial capacities for a total of 18 indicators; scores range from 0(requires immediate review) to 3 (strong). Assessments of five P&Os were conducted in 2013, 2014, 2015 & 2016.

## RESULTS:

A comparative analysis of mean scores of skill assessments of five CAT II P&Os from 2013-2016 showed an increasing trend in the semiannual skill assessment from 1.2 to 1.61, which demonstrates the enhancement of their skills with regular implementation of the CDPs.

| Date | 1 | 2 | 3 | 4 | 5 | Mean | SD |
|---|---|---|---|---|---|---|---|
| baseline | 1 | 1,4 | 1,6 | 0,8 | 1,2 | 1,2 | 0,316 |
| 6m | 1,1 | 1,5 | 1,1 | 1,3 | 1,2 | 1,2 | 0,167 |
| 12m | 1,1 | 1,5 | 1,1 | 1,3 | 1,2 | 1,2 | 0,167 |
| 18m | 1,1 | 1,4 | 1,4 | 1,4 | 1,56 | 1,37 | 0,167 |
| 24m | 1,41 | 1,52 | 1,41 | 1,41 | 1,58 | 1,466 | 0,080 |
| 30m | 1,54 | 1,64 | 1,48 | 1,62 | 1,6 | 1,58 | 0,065 |
| 36m | 1,41 | 1,81 | 1,62 | 1,81 | 1,41 | 1,61 | 0,200 |

## DISCUSSION & CONCLUSION:

We present a systematic process to assess the need for training, plan and deliver capacity development, and measure performance over time. We show iterative improvement over time in this group of professionals. In low resource settings, not only clinical work but also managing the service and promoting evidence based practice is vital and can be an area of concern. Formal training opportunities are expensive and difficult to obtain. The presented model of capacity development may be one solution to develop, where resources for higher level and formalized training are unrealistic or not available.

## REFERENCES:

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# MEASURING REAL TIME PRESSURE AND SHEAR AT THE FINGERTIP-OBJECT INTERFACE

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## BACKGROUND

Our hands frequently handle objects and the proprioceptive sense relies on a range of mechanoreceptors, e.g. at the fingertips. Hand grasping control is dependent on the simultaneous measurement of both pressure and shear forces at the fingertip-object interface to prevent slipping and enable dextrous object manipulation. This is particularly important for prosthetic hand control, neuroprosthetic systems and potentially assisting in a range of rehabilitation techniques e.g. for upper limb amputees, stroke survivors etc. We have developed a novel pressure and shear sensor system which is capable of simultaneously and also independently measuring pressure and shear at the fingertip-object interface [1]. The functionality of the system was preliminary validated by real time feedback during simple hand-grasping activities.

## AIM

To develop a pressure and shear sensor system capable of measuring pressure (grasping) and shear (slipping) stresses at the finger/object interface, validated by pilot tests using a healthy subject.

## METHOD

A healthy subject was recruited who had no hand function deficiencies. Two test protocols were designed and conducted. First, a single sensor was mounted on the face of the index fingertip (inset of Fig. 1(a)). The subject was then asked to perform a simple press-push-lift action on a solid surface repeatedly at the subject's natural speed. Subsequently, five sensors were attached to the faces of all five fingertips. The subject was asked to repeatedly perform a simple hand function activity: grab-lift-hold-putting down a square block (0.7kg) at a comfortable speed. Synchronised pressure and shear signals were obtained from all 5 sensors.

## RESULTS

Fig. 1(a) shows pressure (P), x-direction shear (Sx) and y-direction shear (Sy) measurement vs time from the single finger press-push-lift test. Repeatable P, Sx and Sy were observed; while Sy is greater than Sx as the finger push action was predominantly aimed for the y-direction. Peak values of P, Sx and Sy are 30kPa, 10kPa and 24kPa, respectively. Fig. 1(b) shows a typical P and Sx profile from 5 finger locations during the grip-lift-hold-putting down test. During the gripping-lifting phase, up to 45kPa and 50kPa of P were detected from the thumb and index finger, respectively. The thumb and index finger contacted first, with the other fingers following. This was followed by a holding phase where P and Sx stabilised at approximately 10kPa of P and 5kPa of Sx for 5s. During the final putting down phase, there was an increase of Sx to 11kPa, as the subject began to release the object.

## DISCUSSION & CONCLUSION

The P, Sx and Sy peak values from the press-push-lift tests (Fig. 1(a)) align with the reported loading range [2].

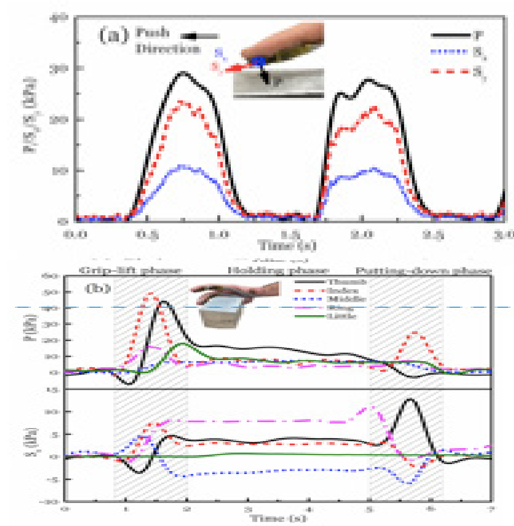


**Figure 1**. P and S as a function of time obtained from (a) the single finger press-push-lift test, (b) the the hand grip-lift-hold-putting down test (negligible Sy is not presented here).

Sy values are comparable with P values, further indicating the importance for shear detection during pushing and other similar finger actions. The synchronised P and S results from the grip-lift-hold-putting down tests (Fig. 1(b)) provide enriched biomechanical information of active finger functions in a hand task. During the grip-lift phase, a rapid increase of P and Sx was observed which may be associated with initial contact with the object. In the holding phase, P fluctuates due to minute changes of grasping force. Within the putting down phase, S increases as P decreases indicating the subject was reducing the grasping force in preparation for releasing the object. P and Sx signals from the thumb and index finger present higher values compared with signals from the other fingers, suggesting they were dominant during the grasping action. The sensor technology could be potentially exploited to benefit several areas e.g. prosthetic hand control, provide in-situ biomechanical pressure and shear data and assist hand/upper limb function analysis.

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## ACKNOWLEDGEMENTS

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# CHOOSING A MULTI- FUNCTIONAL HAND THAT SUITS THE UNILATERAL TRANS-RADIAL PATIENT'S REQUIREMENTS

Judy Davidson, Occupational Therapist

## AIM OF THE STUDY:

Enabling the trans-radial amputee to choose his own multi-functional hand has been a project for the last 4 years.

## TECHNIQUES USED:

In NSW, the insurers need justification of the functional benefits of the multifunctional hand prior to its approval. This is difficult to be specific without the individual amputee having the use of a trial prosthesis. Since 2013 the following 7 unilateral trans-radial amputees have had trials of a mixture of Ilimb, Michelangelo and Bebionic and Pro digit hands hands prior to prescription: The funding bodies for all these prosthetic requests insist of information about why that prosthesis is the appropriate one and why that client requires that specific prosthetic option. The also request information of other prosthetic options considered or trialled.

## RESULTS:

Each trial costs about $5,000 if an interim socket has to be fabricated but $1,000 if they already have a suitable socket. Every insurer has approved the interim socket and trial of the hand. They can see their way to approve $5,000 without high levels of justification but the cost of $100,000 requires oversite by the NSW governing body and is much more stringent) As a result the patients are able to determine their preference based on a variety of factors including cosmesis and function. Appropriate functional justifications dealing with specific tasks are able to be submitted for funding to easily answer the questions. To date all but AS have had the multifunctional hand approved. The conlusion after training was that AS had a single site and was having difficulty controlling a rigid grip hand and sufficient justification could be achieved at that time. It might be achieved in the future after use of the rigid grip hand.:

The method of prosthetic control was identified accurately, the postures that were identified, the outcome from other trials if another hand has been used. The amputee also takes responsibility for their own decisions Manufacturers know that they have to be able to loan hand to make future sales. To date all of the requests have been approved. Specific tasks are identified. Not all results have been successful.

# A THREE-DIMENSIONAL METHOD FOR ESTIMATING LIMB STIFFNESS IN UNILATERAL TRANSTIBIAL AMPUTEE RUNNERS

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## BACKGROUND

The estimation of limb stiffness plays an important role in understanding how an individual's centre of mass is dynamically supported during running gait [1]. Estimates of limb stiffness are typically two-dimensional and can vary widely depending upon model assumptions and data requirements [2]. Estimating limb stiffness is of particular relevance to lower limb amputee running gait, where the stiffness of prosthetic componentry is selected on the basis of optimising performance. Models for estimating limb stiffness in this population must account for the functioning of the variety of prosthetic components used by lower limb amputees.

## AIM

The aim of the current study was to compare modelled estimates of limb stiffness derived from a 3D model utilising direct measurements of kinematics and kinetics to a variety of existing 2D spring-mass models with varying assumptions, in the context of straight line running in both unilateral transtibial and able-bodied participants.

## METHOD

Three recreationally active able-bodied control (CON) (age 24 ± 2.6 years, height 1.8 ± 0.4 m, mass 76.9 ± 3.4 kg) and one recreationally active unilateral transtibial amputee (TTA) (age 38, height 1.82, mass 92.8) participants performed straight line running trials along a 15m runway. The TTA participant used a Blade XT prosthesis (Chas A Blatchford and Sons Ltd.) for all trials. Three-dimensional kinematic (200Hz) and kinetic (1000Hz) data were collected. Estimates of limb stiffness from four previously published spring-mass models were compared to the three-dimensional method (3DM) developed in the current study.

The 3DM utilised directly measured 3D locations of the hip joint centre and centre of pressure in the global lab co-ordinate system to determine the 3D change in limb length (ΔLlimb) during the braking phase. Limb (spring) loading was defined as the peak measured 3D GRF in the direction of the limb vector (Flimb).

**Table 1.** Estimates of limb stiffness (kN/m) (mean ± SD) from straight-line running trials using the three-dimensional method (3DM) proposed in the current study and existing models reported in literature (A-D).

| | Limb Stiffness Model | | | | |
|---|---|---|---|---|---|
| Group | 3DM | Model A | Model B | Model C | Model D |
| CON | 38.1 ± 7.53 | 34.63 ± 6.74 | 8.34 ± 2.33 | 10.53 ± 3.37 | 16.61 ± 20.43 |
| TTA | 45.54 | 41.59 | 9.13 | 11.89 | 20.43 |

Model A [2]; Model B [3]; Model C [4]; Model D [5].

## RESULTS

Estimates of limb stiffness from previously published spring-mass models were lower than those from the 3DM in both straight-line running in both CON and TTA (table 1). The model producing the closest estimates to the 3DM also used direct 2D measures but, estimates were still lower by between 8.4-9.1%. Estimates of limb stiffness were higher (all models) for the TTA participant than for control participants (table 1).

## DISCUSSION & CONCLUSION

The 3DM presented in the current study may provide a more realistic estimate of limb stiffness in lower limb amputee running gait by providing a more accurate estimation of the change in effective limb length. Estimates of limb stiffness were greater in the TTA vs. CON which suggests that changes in effective limb lengths were smaller (limb less compliant) for the prosthetic limb vs. the CON limb, although further investigation is required to confirm this. This new approach can aid the understanding of how limb stiffness is modulated during human running, and may be particularly helpful in understanding how changes in prosthetic components can affect limb stiffness in lower limb amputee runners.

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# BONE SYNOSTOSIS AND PERMANENT OUTCOME IN PEDIATRIC BILATERAL AMPUTEES.

Burhan Dhar

Bony overgrowth is one of the major complications in skeletally immature amputee after below knee amputation. Overgrowth stemming from terminal appositional, endosteal proliferation (rather than physeal growth), this overgrowth results from a combined process of periosteal and endosteal new bone formation and from terminal remodeling. It is characterized clinically by swelling, erythema, warmth, tenderness, formation of a bursa, and extreme cases perforation of the soft tissues by bone. Clinical management includes frequent prosthetic adjustments and operative revision of the limb, which are done at great financial cost to the health-care system and psychosocial cost to the child and family.

**PATIENT REPORT:**

• First case: 6 year old, female, product of normal spontaneous vertical delivery, history of maternal drug abuse, with congenital lower limb deformities diagnosed to have bilateral tibia hemimelia with non functional feet and ankles.

• Second case: 5 year old, male, product of normal spontaneous vertical delivery, diagnosed to have vasculitis affecting his vascular supply of lower limbs ending up with gangrenous limbs with demarcated line just above the ankle.

**STEPS OF SYNOSTOSIS AMPUTATION PROCEDURE:**

The known basic principles of transtibial amputation in skin incision and soft tissue dissection was followed. After exposing the tibia and fibula, care was taken to avoid excessive fibular soft tissue stripping. The fibula was exposed two centimeters below the level of proposed tibial osteotomy. Anterior and lateral compartment musculature transected at that level. Similarly, tibia was osteotomized at the preplanned more proximal level.. Patient was fitted with the prosthesis in two months .The design of the prosthesis included a total contact socket with equal weight bearing including the bottom of the residual limb. Patient was provided with the gait training with the prosthesis immediately after fitting of Prosthesis.

**RESULTS:**

Bone synostosis procedure benefits the amputees in the following ways:

1-Prevention of excessive fibular motion Reconstruction of the medullary canal.
2-Improved venous return to the heart by myoplasty, Prevention of nerve adhesion.
3-Improve prosthesis fitting .
4-Decreasing osteoporosis due to disuse .

**CONCLUSION**

Bone Synostosis surgery is technically challenging with more operative time needed than conventional techniques, but it has a high success potential and high patient satisfaction by preventing bony overgrowth and its complication regarding pain, instability & prosthetic problems. Such amputations can lead to improved quality of life in children and thereby expand their horizon..

# GROUND REACTION FORCES INVOLVED IN COMPLETING A RAPID CHANGE OF DIRECTION MOVEMENT

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## BACKGROUND

An ability to change direction quickly is important in sport. This movement requires relatively high and rapid three-dimensional forces and impulses to brake the forward motion and to enable the sideways movement. Prostheses are generally designed to enable forward progression with a spring element deforming to store and return energy in the sagittal plane. It is not known how an amputee generates the forces and impulses to overcome the mechanical tendency for forward progression.

## AIM

The two aims of this research are (i) establish how amputees generate the forces and impulses required to enable a change of direction (CoD) movement when wearing an energy storing foot (ESF) and (ii) to determine if the stiffness of the spring influences the results.

## METHOD

Ten unilateral male transtibial (TT) amputees (age=34.6±8 years, height=1.81±0.08metres, mass=84.2±21.48kg) participated. Data were captured using 12 Vicon cameras and 2 Kistler force plates (FP) sampling at 120Hz and 960Hz respectively (filtered 4th order Butterworth filter, cut off frequency of 6Hz and 300Hz resp). Data was collected over two sessions with prescribed stiffness first and increased stiffness second. Participants jumped forward onto FP1, landing on the intact leg, then immediately side jumped to land on the prosthetic leg on the adjacent FP2. The movement was repeated with the prosthetic leg leading. Ten good trials (clean landing on FPs and a controlled landing on FP2) were collected and the middle five analysed. Paired samples t-test was used to analyse the effect of stiffness on both the prosthetic to intact limbs.

## RESULTS

Peak forces, loading and decay rates and impulses were determined on FP1 for both the intact and prosthetic sides in each stiffness. Significant differences were evident between the intact and prosthetic sides.

| GRF | P | I |
|---|---|---|
| Peak Braking Force ($N.kg^{-1}$) | -5.18± 1.93 | -6.79 ± 2.01 * |
| Peak Medial Force ($N.kg^{-1}$) | 3.29 ±0.9 | 4.49 ±0.77 * |
| Peak Vertical Force ($N.kg^{-1}$) | 20.95 ± 4.99 | 21.02 ± 4.07 |
| Braking Impulse ($N.kg.s^{-1}$) | -0.86 ± 0.29 | -1.06 ± 0.21 * |
| Medial Impulse ($N.kg.s^{-1}$) | 0.63 ± 0.11 | 0.82 ± 0.19 * |
| Vertical Impulse ($N.kg.s^{-1}$) | 4.11 ± 1.38 | 4.50 ± 1.44 |

*$p<0.05$

**Table 1**: Three-dimensional Ground Reaction Force features during the braking phase for the intact and prosthetic limbs

| GRF | P | I |
|---|---|---|
| Peak Propulsive Force ($N.kg^{-1}$) | -2.09 ± 0.47 | -2.99 ± 0.68 * |
| Peak Medial Force ($N.kg^{-1}$) | 5.17 ± 0.92 | 6.34 ± 1.17 * |
| Peak Vertical Force ($N.kg^{-1}$) | 15.62 ± 2.12 | 17.53 ± 1.76 * |
| Propelling Impulse ($N.kg.s^{-1}$) | -0.32 ± 0.10 | -0.36 ± 0.11 |
| Medial Impulse ($N.kg.s^{-1}$) | 0.86 ± 0.19 | 0.82 ± 0.10 |
| Vertical Impulse ($N.kg.s^{-1}$) | 2.80 ± 0.66 | 2.27 ± 0.22 * |

*$p<0.05$

**Table 2:** Three-dimensional Ground Reaction Force features during the propulsion phase for the intact and prosthetic limbs

## DISCUSSION & CONCLUSION

It was anticipated that the amputees would generate different forces and impulses on the prosthetic side in performing the movement reflecting that they would not be able to alter the forward and medial momentum effectively on the prosthetic side. In the braking phase of the movement, the peak shear forces and the impulses were greater on the intact limb, suggesting a greater change in forward and sideways velocity. In the propulsion phase the peak forces in all 3 dimensions were significantly greater on the intact side, but only the vertical impulse was significantly different and it was smaller on the intact side. This suggests a similar velocity in the direction of the movement during propulsion. It would appear that the amputees can propel in the direction of the movement by generating a similar impulse, but a smaller peak force.

# VALIDITY AND FEASIBILITY OF A TEMPERATURE SENSOR FOR LONG-TERM ADHERENCE MONITORING IN FOOTWEAR

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## BACKGROUND

Orthopedic footwear is frequently prescribed to a wide variety of patients. Adherence of use of orthopedic footwear is a prerequisite of their effectiveness, but has mostly been assessed using methods, like questionnaires, interviews or diaries, with poor accuracy and reliability. A recent study has shown that temperature can be used to assess orthopedic footwear use and nonuse, however, the sensor used could only collect data over a short period of time and had relatively large dimensions. A new technology is now available, comprising a temperature sensor that is small and capable of long-term data collection (>100 days).

## AIM

To assess the validity and feasibility of a new temperature sensor for measuring footwear use and nonuse in healthy participants.

## METHOD

In ten healthy participants, the validity of a small temperature sensor (Orthotimer, Balingen, Germany) was assessed to discriminate between time periods of use and nonuse of orthopedic footwear over a period of 48 hours. The sensor, imbedded in the insole of their preferred footwear, was compared to a 1-min time-lapse sports camera (GoPro Hero Sessions, San Mateo, California, United States of America) secured to the shoelace and focused on the lower leg. Based on the photos use and nonuse of the footwear could be assessed. The data from both sensor and camera where analyzed using custom-written Matlab scripts. The correlation coefficient between footwear use based on the sensor and camera was calculated. The ease of the installation of the sensor in the insole and the data collection and analysis will be assessed as feasibility criteria.

## RESULTS

Mean footwear use measured with the camera was 8.10 (±2.46) hours per day, and measured with the sensor 8.16 (±2.37) hours per day. There was a strong correlation between footwear use assessed by camera and by sensor, r = 0.995. Figure 1 shows a subjects' use and nonuse of footwear over a period of 48 hours. The peaks of the temperature slope curve are used to indicate the donning and doffing of the footwear.

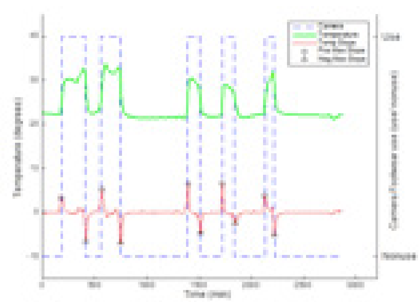

Figure 1. Camera and sensor data of a single participant over a period of 48 hours of footwear use and nonuse. Circles (O) and triangles (Δ) indicate max temperature slopes that are used to determine footwear use.

## DISCUSSION & CONCLUSION

The temperature sensor is valid and feasible for the assessment of use and nonuse in (orthopedic) footwear. The installation of the sensor, in the insole of the participants' preferred footwear, and the data collection were performed easily.

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# VALIDATION OF INERTIAL MEASUREMENT UNITS WITH OPTICAL TRACKING SYSTEM IN PATIENTS OPERATED WITH TOTAL HIP ARTHROPLASTY

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## BACKGROUND

Patient reported outcome measurement (PROMs) will not in detail capture the functional joint motion before and after total hip arthroplasty (THA). Therefore methods, more specifically aimed to analyse joint movements may be of interest. If so, such a method should be readily accessible and easy to use if applied to larger groups of patients studied before and after a surgical intervention such as THA.

## AIM

We aimed to evaluate the accuracy of inertial measurement units (IMU) by comparison with an optical tracking system (OTS) simultaneously used to record pelvic tilt, hip and knee flexion in THA subjects.

## METHOD

49 subjects, 25 males 24 females, mean age of 73 years (range 51-80) operated with THA at the Sahlgrenska University Hospital, Sweden during 2011-2013, participated. All patients were studied with a portable IMU system including sensors attached lateral to the pelvis, the thigh and the lower leg. For validation, a 12-camera motion capture system was used to determine the positions of 15 skin markers (Oqus 4, Qualisys AB, Göteborg, Sweden). Comparison for the two systems was made in sagittal plane of pelvis, hip- and knee flexion range. The mean values of the IMU´s on left and right pelvis were compared with OTS data.

| | Mean | 95% C.I. | Mean | 95% C.I. | p-value |
|---|---|---|---|---|---|
| Pelvic ROM (degrees) | *5.4* | *4.5-6.3* | *4.9** | *4.4-5.3* | *0.91* |
| Hip ext-flex ROM right side (degrees) | *36.8* | *35.2-38.5* | *34.0* | *32.2-35.9* | ***0.019*** |
| Hip ext-flex ROM left side (degrees) | *37.7* | *36.0-39.4* | *34.4* | *32.7-36.2* | ***0.008*** |
| Knee ext-flex ROM right side (degrees) | *55.1* | *53.5-56.7* | *54.9* | *53.1-56.6* | *0.74* |
| Knee ext-flex ROM left side (degrees) | *54.4* | *52.8-55.9* | *54.4* | *52.8-56.0* | *0.98* |

**Table 1** Gait parameters for optical tracking system (OTS) and inertial measurement units (IMU) presented as mean values and 95% confidence intervals of mean. P-values refer to Mann Witney U-test between OTS and IMU.

## RESULTS

Comparison between the two gait analysis methods showed no significant difference for pelvic tilt or knee flexion range on either side. The IMU system did however record less hip flexion on both sides (Table 1).

## DISCUSSION & CONCLUSION

We found that IMUs can produce reliable data of the range of motion of pelvis tilt and knee flexion. There was however a notable difference regarding recordings of hip flexion ranges. This may be due to soft tissue artefacts, misplacements of IMU's or malalignment between the two methods. In conclusion, a validation of IMU´s by using OTS during gait in 49 total hip arthroplasty subjects resulted in reliable data for pelvic and knee flexion range in sagittal plane but notable differences for hip flexion range.

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# USE OF COMMERCIAL GAMES IN LOWER LIMB PROSTHETIC REHABILITATION

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## BACKGROUND

In the recent years, commercial games have received attention from clinicians as potential rehabilitation tools. Most frequently, Wii/Wii Fit has been adopted and used informally in lower limb prosthetic rehabilitation facilities. Despite this, empirical data about the prevalence of use as well as therapists' perspectives about the use of these games in practice are still lacking.

## AIM

The overall aim was to gain an understanding about the use of commercial games, particularly Wii/Wii Fit, in lower limb prosthetic rehabilitation as well as therapists' perspectives about the use of these games in practice.

## METHOD

A cross-sectional online survey was sent to physical and occupational therapists across prosthetic rehabilitation facilities in Canada. The survey was developed based on the literature and our clinical experience. It was later refined through five iterations based on feedback received from thirteen Canadian researchers/therapists with backgrounds in rehabilitation. The survey had ten close-ended questions related to the use of commercial games in practice (e.g. types of the games, the frequency of use) and the therapists' perceived benefits and challenges/barriers associated with the use of Wii/Wii Fit in lower limb prosthetic rehabilitation.

## RESULTS

Data were collected from 82 therapists. The majority of the sample were physical therapists (61/82, 74.4%), whereas the rest were occupational therapists. The mean (SD) years of professional practice was 18.2 (9.8). Overall, 46.3% (38/82) reported that they use commercial games in prosthetic rehabilitation; of those, 94.7% (36/38) used the Wii/Wii Fit.

Most respondents (47/82, 57.5%) indicated that they would recommend the Wii/Wii Fit as a home program to their clients. The most common perceived benefits were the Wii/Wii Fit games being motivating (n=75/82, 91.5%), complementing traditional therapy (n=75/82, 91.5%), and increasing clients' level of engagement (n=69/82, 84.2%). The most reported perceived barriers/challenges were lack of time (n=58/82, 70.7%), lack of familiarity with the games (n=58/82, 70.7%), and time/effort requirement to set up the games (n=49/82, 59.8%).

## DISCUSSION & CONCLUSION

Commercial games, particularly Wii/Wii Fit games are commonly used in lower prosthetic rehabilitation in Canada. Most of the physical therapists and occupational therapists in Canada view the Wii/Wii Fit positively. Knowledge translation activities and developing standard treatment protocols would be helpful in minimizing the barriers identified in this study. The main study limitations are that we did not include recreational therapists and therapists from smaller and private prosthetic facilities. Additionally, the wording of the questions may have been confusing and affected the responses. Given the prevalence of Wii Fit use and the positive attitude of therapists towards these games, the next important step is to conduct a randomized controlled trial to generate evidence about the efficacy and effectiveness of these games in practice.

# A STRUCTURED EXERCISE PROGRAMME IMPROVES POSTURAL CONTROL IN COMMUNITY-DWELLING LOWER LIMB AMPUTEES

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## BACKGROUND

Lower limb amputees are more prone to falling than age- matched able-bodied individuals [1]. Falls can have debilitating consequences such as fear of falling, activity avoidance, injury or even hospitalisation. Exercise has the potential for improving balance in lower limb amputees, through enhanced somatosensory and proprioceptive training and increased strength. No study, to date, has quantified the effects of a structured exercise programme on postural control in lower limb amputees, as measured with computerised dynamic posturography.

## AIM

The aim of this study was to determine whether a 12-week exercise programme would improve postural control on the NeuroCom EquiTest (Natus Medical Inc., Pleasanton, USA) in a group of lower limb amputees. It was hypothesised that the exercise group would demonstrate improved Equilibrium and Strategy scores on the Sensory Organization Test (SOT) and better weight symmetry on the Motor Control Test (MCT) compared to the control group.

## METHOD

Fifteen transtibial and transfemoral amputees (Exercise: n=7; Control n=8) were recruited via the local NHS Artificial Limb Centre. They were stratified into the exercise vs. control groups based on their level of amputation, age and gender. Participants completed the six SOT balance conditions and weight symmetry was measured with the MCT [2] at baseline (PRE) and 12 weeks later (POST). The exercise group undertook a structured exercise programme, including 1-hour supervised exercise twice weekly and individualised home- based exercise once weekly then progressing to twice weekly. The circuit-based exercise programme consisted of strength, flexibility, dynamic balance and aerobic exercises. The control group did not engage in any structured exercise. The postural control data were analysed using a general linear methods analysis to determine whether significant differences existed between, and within, groups over time ($p<0.05$).

## RESULTS

All participants except for one control completed the SOT and MCT on the NeuroCom; they were subsequently excluded from this analysis. The exercise group demonstrated significantly higher Equilibrium scores in Condition 5 compared to the control group (p=0.023; 95% CI [2.224, 24.384]) and demonstrated significant improvements in postural control with a large effect size (p=0.012; d=1.53; 95% CI [7.335, 48.604]) over time (Table 1). Strategy analysis revealed that the exercise group also increased their reliance on the ankle strategy in Condition 5 following the exercise intervention (p=0.028; d=0.98; 95% CI [2.376, 35.766]). Over time, the control group displayed a trend towards more negative scores (greater reliance on the strengthof the intact limb) during the medium and large forwards translations in the MCT (p=0.055 and p=0.087, respectively), whereas the exercise group did not demonstrate any change.

Table 1. Group mean (SD) Equilibrium scores (out of 100) and Strategy scores (100= 100% ankle strategy) for dynamic Conditions 4-6 of the SOT. Weight symmetry on the MCT, with more negative values indicating greater intact limb response strength, and thus more weight asymmetry, at the onset of (medium, large, backwards, forwards) perturbations. Weight symmetry score of 0=perfect symmetry.

| EQUILIBRIUM SCORE | PRE | POST | PRE | POST | PRE | POST | PRE | POST |
|---|---|---|---|---|---|---|---|---|
| | EO, Sw-Ref Sup SOT Condition 4 | | EC, Sw-Ref Sup SOT Condition5 | | EO, Sw-Ref Sup & Sur SOT Condition 6 | | SOT Composite score | |
| Exercise | 74.8 (33.4) | 89.8 (5.7) | 39.4 (32.3) | 69.3 (6.8) | 44.5 (35.0) | 61.5 (18.9) | 75.6 (5.5) | 79.2 (5.9) |
| Control | 86.0 (7.0) | 86.2 (6.6) | 41.9 (24.3) | 53.1 (12.6) | 52.9 (31.6) | 61.7 (17.7) | 71.1 (7.8) | 74.2 (7.6) |

| STRATEGY SCORE | PRE | POST | PRE | POST | PRE | POST |
|---|---|---|---|---|---|---|
| | EO, Sw-Ref Sup SOT Condition 4 | | EC, Sw-Ref Sup SOT Condition5 | | EO, Sw-Ref Sup & Sur SOT Condition 6 | |
| Exercise | 74.2 (32.8) | 88.3 (2.7) | 44.2 (32.0) | 66.4 (13.3) | 48.0 (33.5) | 65.7 (14.2) |
| Control | 83.1 (7.4) | 80.7 (11.3) | 48.6 (14.5) | 46.9 (19.3) | 58.7 (17.6) | 60.2 (29.9) |

| WEIGHT SYMMETRY | PRE M-Back | POST M-Back | PRE L-Back | POST L-Back | PRE M-Fwd | POST M-Fwd | PRE L-Fwd | POST L-Fwd |
|---|---|---|---|---|---|---|---|---|
| Exercise | -27 (18) | -16 (12) | -25 (19) | -19 (8) | -25 (19) | -16 (9) | -25 (21) | -16 (10) |
| Control | -32 (25) | -35 (30) | -27 (26) | -35 (32) | -23 (21)** | -34 (29)** | -26 (23)** | -35 (29)** |

Shaded areas indicate significant improvements over time.
** Indicate a trend (0.05<p<0.10) towards change
EO=Eyes open; EC= Eyes closed; Sw-Ref Sup= Sway-referenced support surface; Sw-Ref Sup & Sur= Sway-referenced support and surround

## DISCUSSION & CONCLUSION

Lower limb amputees compensate for losses in somatosensory and proprioceptive inputs by relying more heavily on visual input [2]. Conditions 4-6 in the SOT represent the most challenging dynamic conditions, with Condition 5 inducing inaccurate somatosensory cues and absent visual input. Thus, improvements in Equilibrium and Strategy scores for the exercise group indicated this group likely benefitted from balance exercises performed on compliant surfaces that emphasised training of the somatosensory system and challenged dynamic balance. The findings also indicated that appropriate balance exercises could reduce reliance on visual input. This would be beneficial under everyday conditions, such as when ambient light is reduced. The control group demonstrated a trend towards increased reliance on the intact limb to generate a strength response following a forwards postural perturbation in the MCT. Consistent with our hypothesis, this reflected more weight asymmetry in the control group. This finding in itself was consistent with previous research that amputees bear more weight through their intact limb [2]. Targeted balance training has the potential for increasing strength on the affected (prosthetic) limb and improving weight symmetry. Our findings suggest a 12-week exercise programme can lead to positive neuromuscular adaptations in a group of lower limb amputees

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# THE IMPORTANCE OF SHOE WEAR ON PROSTHETIC FEET IN TROPICAL ENVIRONMENTS

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## BACKGROUND

Previous studies have shown that low cost prosthetic feet have had a short lifespan in tropical nations (Jensen, 2006). This is known to be linked to the lack of practitioners in these nations, and the low funds available to continue to replace damaged feet (Jensen, 2006). Clinicians have observed that shoes tend to protect the prosthetic foot from wear, but it is unclear the magnitude of internal protection (Pye, 2015). This study investigated the effect of shoes on the preservation of prosthetic feet when exposed to harsh UV light and humid conditions. It is hypothesized that the mechanical properties of the feet would be maintained in both the forefoot and heel regions if shoes were worn over the prosthetic feet, and significantly deviate if no shoes were worn.

## AIM

The aim of this study is to provide insight into finding a low-cost simple solution to extending the lifetime of prosthetic feet in tropical countries.

## METHOD

ISO 10328 static testing was performed on six samples of the ICRC feet. Three samples were tested with shoes (S group), while the other three were tested without (NS group). Following this testing, the samples were put in an environmental chamber where they were exposed to UV light at 38°C and 98% humidity for 400 hours. After this exposure, the samples were put through ISO 10328 static testing again along with the cyclic test. Lastly, after the cyclic test, the ISO 10328 standard prescribes a final static proof test identical to the initial static proof test unless failure is observed during the cyclic test. Additionally, the feet were checked for visible damage before and after testing. Creep, stiffness and maximum deformation data was collected during the static proof test.

**TABLE 1**: Differences in mechanical factors in forefoot (FF) and heel (H) before and after testing. tests.

| | *FF* | | *H* | |
|---|---|---|---|---|
| | NS Group | S Group | NS Group | S Group |
| *Δ Stiffness (N/mm)* | 125.7± 28.1* | 79.9± 44.7* | 70.1 ± 9.56* | 30.9 ± 15.1 |
| *Δ Creep (mm)* | 2.46 ± 0.17* | 2.52 ± 0.19* | 2.15 ± 0.06** | 0.37 ± 0.08* |
| *Δ Displacement (mm)* | 4.6 ± 2.94** | -9.96 ± 7.76* | 10.19 ± 2.39* | -5.73 ± 3.14 |

**indicates a significant difference (p value <0.05)*
***indicates a very significant difference (p value <0.01*

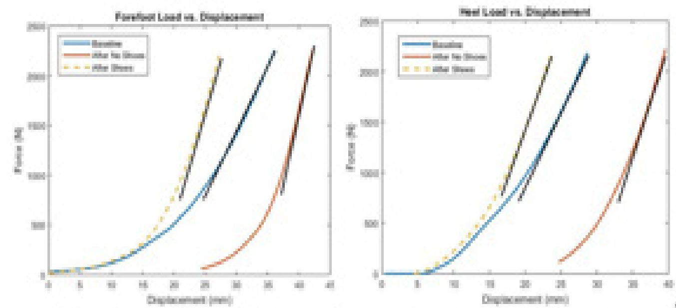


**Figure 1**. These graphs display the results of the static tests of both the shoe and the no shoe groups in a force vs. displacement relationship for the FF and H region of the feet.

## DISCUSSION & CONCLUSION

The hypothesis stated that the shoe group would show no significant differences after testing. When analyzing the FF region, it was found that the shoe group and the no shoe group both saw significant changes in maximum stiffness, creep, and maximum deformation from the baseline tests (TABLE 1) disproving this prediction. In the S group, the max displacement decreased significantly, while the NS group saw a significant increase. Creep in this region may also be affected by the flexibility of the forefoot during loading, not just the deformation of the foot upon compression. In the H region, it was found that the shoe played a significant role in protecting the foot from changes in increases in maximum stiffness and maximum displacement. While the creep was still found to increase significantly with the application of a shoe, it was also significantly less than the change seen in the NS group. This could mean that the sole of the shoe works to adequately protect the H from changes in stiffness while ambulating in harsh environments

Changes in mechanical properties of the heel region of the ICRC foot were significantly reduced by the application of a shoe in harsh environmental conditions. Further testing is needed with a larger sample size to confirm the preliminary results of this study.

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# THE RELATION BETWEEN BALANCE SUPPORT AND METABOLIC ENERGY COST OF WALKING IN PEOPLE WITH A LOWER LIMB AMPUTATION

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## BACKGROUND

Walking with a lower limb prosthesis involves a higher metabolic cost compared to normal walking. Reducing this metabolic demand requires knowledge of its underlying sources. While biomechanical studies focusing on the role of constrained push off [1] and leg swing [2] have failed to fully account for the increase in energy cost of walking, Hoffman et al [3] proposed that impaired balance control might be an additional contributing factor.

## AIM

To investigate the role of impaired balance control in the metabolic demand of prosthetic walking, by assessing the effect of handrail support on metabolic energy cost and gait parameters in people walking with a lower limb prosthesis.

## METHOD

Fifteen participants with a unilateral lower limb prosthesis (9 transtibial (TT), 6 transfemoral (TF), age 32-84, cause trauma/vascular/other 7/5/3 ) walked for four minutes on a motorized treadmill at fixed self-selected walking speed with and without handrail support. Metabolic energy cost was obtained through indirect calorimetry (Oxycon Mobile, Care Fusion, NL) and spatiotemporal gait parameters (step length, -time, -width, symmetry) were derived from the treadmill embedded forceplate (C-Mill, ForceLink, NL). The effect of handrail support in TT and TF amputees on energy cost and gait parameters was analyzed using a 2-way ANOVA. Additionally an explorative analysis was performed to assess the correlation between the effect of handrail support and indicators of walking ability during unsupported walking (walking speed, energy cost, step parameters and ABC-scale)

## RESULTS

Although on average, energy cost while walking with support was 7.2% (TT) and 5% (TF) lower than unsupported walking , this effect did not reach statistical significance (p=.118). No interaction of support and level of amputation was found. Handrail support significantly increased step length, step time and symmetry, while it reduced step width in both groups. Walking speed (r=-.076) and energy cost during unsupported walking (r=.85) showed a significant correlation with the reduction in energy cost with handrail support. No correlation was found with gait parameters or ABC score.

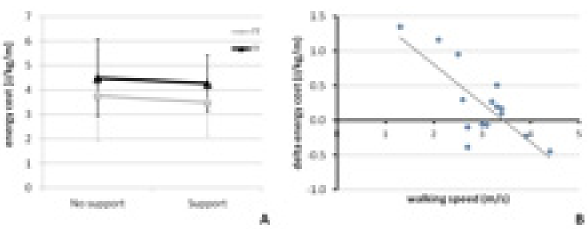

**Figure 1**. a) The effect of handrail support on the energy cost of walking in TT and TF, b) the relation between this effect and self-selected walking speed.

## DISCUSSION & CONCLUSION

The results of this study show that in our study population of lower limb amputees, on average, balance support had a small non significant effect on the energy cost of walking. However, this effect appears to depend on walking ability. People with a low self-selected walking speed and high energy cost had a benefit up to 16% in energy cost in this study. The reduction in energy cost with handrail support coincided with changes in the gait pattern indicative of increased gait stability [4]. Therefore, we conclude that restoring balance control might be an effective intervention to reduce the energy cost of lower limb amputees with limited walking ability.

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# THE EFFECT OF ENERGY STORING AND RETURN PROSTHETIC FEET ON STEP LENGTH ASYMMETRY AND MARGINS OF STABILITY DURING WALKING

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## BACKGROUND

Energy storing and return (ESAR) prosthetic feet have long been prescribed to reduce the energy cost of walking. Increasing evidence, however, exists that energy cost is only marginally effected by ESAR feet. Nevertheless ESAR feet remain popular among people with a lower limb amputation. Likely other benefits exist. A potential advantage might be found in a positive effect of ESAR feet on gait stability. Previously Hak et al (2014) demonstrated that a reduced push of with the prosthetic foot could result in reduced back margins of stability and hence a larger risk of disturbed progression during walking. Amputees seem to reduce this risk by shortening step length of the intact leg. An ESAR foot might enhance push off and enhance the backward margin of stability allowing a more stable and symmetric gait pattern.

## AIM

To investigate the effect of energy storing and return feet on push off power, step length asymmetry and backward margins of stability during walking in people with a lower limb amputation.

## METHOD

15 participants with a unilateral lower limb amputation were included in this study. All subjects had undergone amputation because of trauma and were experienced with walking with an ESAR foot. Participants walked in a gait laboratory on both their ESAR foot and a SACH foot at 1.2 m/s. An optoelectronic motion analysis system (Vicon, Oxford United Kingdom) and a set of two force plates (Kistler; Winterthur, Switzerland) were used to record gait kinematics and kinetics from which ankle push off work, step length and center of mass velocity (vcom) could be derived (Wezenberg et al 2014). Backward margin of stability (MoSBW) was calculated according to Hak et al (2014).

## RESULTS

With the ESAR foot participants generated more push off work at the ankle (0.11 ± 0.03 J kg−1) than with the SACH foot (0.05 ± 0.02 J kg−1, $p < 0.001$). This coincided with an increase in center of mass velocity and a reduction in step length asymmetry. Intact step length was 0.05 ± 0.04 smaller than prosthetic step length with SACH and only 0.01 ± 0.04 m smaller with ESAR foot ($p<0.05$). The reduction of step length asymmetry was reached while backward margin of stability was preserved (Fig 1).

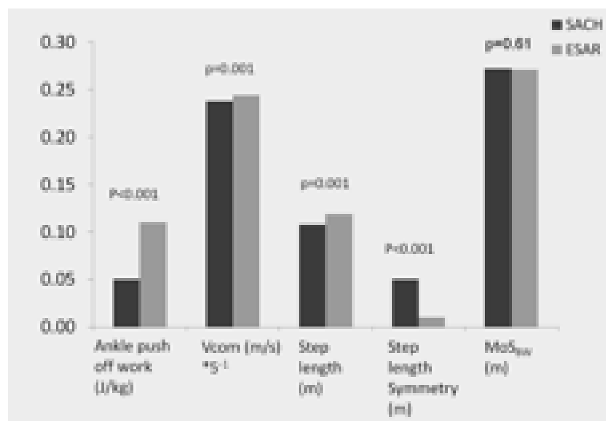


**Figure 1**. differences in gait parameters between walking with a SACH (dark bars) and an ESAR (light bars) foot .

## DISCUSSION & CONCLUSION

The ESAR foot enhances ankle push off power, thereby increasing center of mass velocity in double support. This allows to walk with a more symmetric step length without reducing backward margin of stability. This effect of the ESAR foot on gait stability and asymmetry might explain the preference of lower limb amputees to use ESAR feet despite their limited benefits on gait economy.

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# DEVELOPMENT OF A SOCKETMASTER SYSTEM FOR OPTIMISING THE DESIGN OF PROSTHETIC SOCKET FOR ABOVE KNEE AMPUTEES

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## BACKGROUND

The functional outcome of lower-limb prosthesis is highly dependent upon the characteristics and anatomical profile of the residual limb and the fit of the prosthetic socket. A poorly fitted prosthetic socket can cause discomfort, pain and in many cases prosthetic rejection. The techniques available to design a comfortable socket have not progressed significantly over the last century. The current approach to produce a comfortable prosthetic socket is time-consuming and highly dependent on the expertise of the prosthetist. Sockets are often made without access to comprehensive information related to the comfort of an amputee.

## AIM

To develop a new technique for rapid design of prosthetic sockets for above knee amputees with enhanced comfort.

## METHOD

To integrate various micro sensors into a mechanical Master Socket. A gait loading apparatus will also be developed. They combined will form a SocketMaster medical tool which can help prosthetists achieve fast and customised design of prosthetic sockets for lower-limb amputees. The Master Socket can be adjusted mechanically and electronically by the prosthetist at different gait positions while the residual limb is positioned inside it. Comprehensive pressure and friction between the Master Socket and the residual limb will be collected. These data will be used to optimise the socket design to maximise the user's comfort. The final 3D solid model will be fed into a rapid prototyping machine for fast fabrication.

## RESULTS

The prototype micro sensors and their electronic readouts have been designed, fabricated and evaluated. The mechanical structure of a Master Socket and its integration with the sensors has been designed and its fabrication and assembly is near completion. A gait loading apparatus has also been produced.
Figure 1 shows a preliminary stability test scenario where a mock-up residual limb was placed within the Master Socket frame of the whole system. The hardware of the SocketMaster system is currently being integrated with control system and data processing software. Clinical trials have started at the London Prosthetic Centre. A total of 50 patients are expected to be involved in our clinical trials.

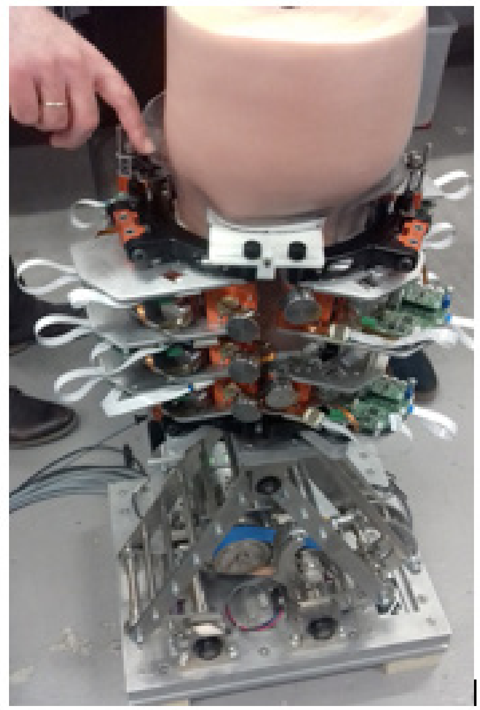

**Figure 1.** The SocketMaster system. This design is a property of Innora (IknowHow Informatics S.A.)

## DISCUSSION & CONCLUSION

With this novel concept of a SocketMaster system, pressure, friction and other parameters on the interface between the residual limb and the socket at three key postures in a gait cycle will be measured. These data will be processed by dedicated software which, together with soft tissue evaluation by an indentation device and a biomechanical model, will yield an optimised socket design within 2-3 hours. The resultant digital 3D solid model will allow manufacturing of a socket by a rapid prototyping machine or a 3D printer. It is expected that the SocketMaster system will enable same-day socket design and fabrication with enhanced comfort for the patients.

**Acknowledgement:**

The SocketMaster project has received funding from the European Union's Horizon 2020 for research and innovation programme under grant agreement no. 645239.

# EVALUATION OF PRESSURE DISTRIBUTION OF KYBOOT SHOES IN COMPARISON TO OTHER FOOT WEAR IN DIABETIC PATIENTS AND IN HEALTHY SUBJECTS

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## BACKGROUND

Every 30 seconds a limb is lost somewhere in the world as a consequence of diabetes. These amputations are preceded by a foot ulcer in 84% of cases. Therefore, to reduce risk of ulceration, relief of mechanical pressure is indicated. Currently therapeutic footwear, custom made, is provided by the Ministry of Health to diabetic patients that are at risk of developing foot ulcers. The Kybun shoe could offer a cheaper yet effective solution to prevent foot ulcers and concomitantly achieve better compliance as it looks like ordinary shoes.

## AIM

Comparison and evaluation of pressure distribution, gait pattern, changes in the movement of the center of pressure, and comfort of wear using KyBoot shoes versus normal foot wear in diabetic and healthy subjects.

## METHOD

10 healthy subjects and 11 individuals with diabetes participated in our study. Neuropathy was defined as the inability to sense the pressure of a 10g monofilament in 5 out of 9 pre-determined points on the plantar side of the patients' feet. We measured the pressure distribution and movement of the Center of Pressure with insole pressure sensors (Tactilus®) which is able to record pressure up to 30 psi (206 kpa) in real-time. Gaitrite® is a gait analysis walkway system that provided data on gait characteristics. The participants were asked to complete a questionnaire on comfort of wear and satisfaction on both the normal and Kyboot shoes.

## RESULTS

We did not find significant difference between the diabetic and non-diabetic participants. The maximal heel to forefoot pressure ratio was significantly lower in gait with KyBoot shoes 9.7±5.6 compared to 23.7±14.0 in normal shoes ($p<.001$), (See Fig. 1)

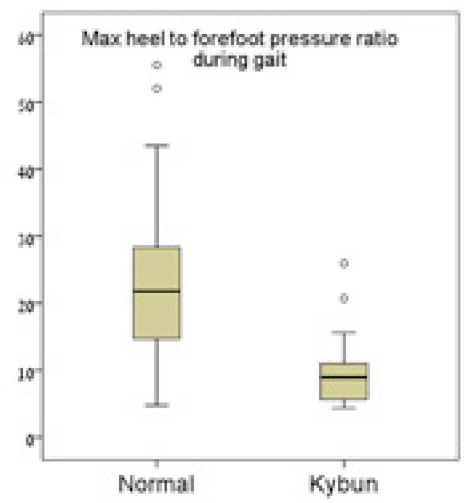


**Figure 1.**

During gait, the average pressure was significantly lower with the Kybun shoes compared to the regular shoes (42.9±10.7kPa and 49.1±11.4kPa, respectively; $p<.001$). The kybun shoes increased the maximal contact area from 121.8±13.9cm2 to 126.8±14.5cm2 ($p=.011$).The subjects ambulated with reduced medio-lateral (2.0±0.4mm and 2.5±0.5mm,; $p<.001$) and anterior-posterior (12.3±2.4mm and 14.6±2.0mm,; $p<.001$ movement of the Center of Pressure, for Kybun and normal shoes respectively.

## DISCUSSION & CONCLUSION

In both groups, the measured objective parameters as well as the subjective questionnaire information support the potential of reduction of the risk for foot ulcers and thus the risk for amputations in diabetic patients. The study limitations: we examined the Kyboot against the regular shoe which the patient is using daily. The sample size is relatively small.

# METHOD TO ASSESS BIOMECHANICAL COUPLING AT TRANS-FEMORAL RESIDUUM/SOKET INTERFACE

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## BACKGROUND

Assessment of dynamic biomechanical coupling at the lower limb residuum/socket interface is important, for example in gaining full understanding of the interface biomechanics, aiding the socket design and fit, as well as improving rehabilitation outcomes [1]. However, the interface biomechanics remains poorly understood, mainly due to the lack of assessment techniques which could be suitably applied at the socket interface. A novel interface coupling model [2], based on 3D motion capture, has been developed to evaluate the kinematic coupling motion at this critical interface. An interface pressure and shear sensor system [3] is employed to measure the corresponding loading kinetics. These technologies have been combined to provide in-situ interface biomechanical parameters during amputee walking tests.

## AIM

To assess the combined kinematics and kinetics at the residuum/socket interface on a trans-femoral amputee.

## METHOD

Three separate stress sensors [3] were placed at anterior-proximal (AP), posterior-proximal (PP) and anterior-distal (AD) locations of the residuum of a trans-femoral amputee. The participant was then required to walk on a level surface at a self-selected speed in a gait laboratory, equipped with CODA motion capture system and Kistler force plate. Synchronised sensor and 3D marker data were collected simultaneously during all walking trials. The angular couplings in all anatomical planes (such as, α in sagittal plane – Fig. 1a inset) and axial coupling (L in Fig. 1b inset) were calculated based on 3D marker data [2].

Interface kinetics, incorporating pressure (P), longitudinal shear stress (SL) and circumferential shear stress (SC), as shown in Fig. 1c and Fig. 1d inset, were also collected.

## RESULTS

Fig. 1a shows an increase of up to 10° in the angular coupling, α, during stance phase. L (Fig. 1b) appears to decrease (residuum is "pushed" into socket) from approx. 480mm (at initial contact) to approx. 456mm at 50% of gait cycle (GC). The residuum was 'pulled out' of socket after terminal stance, reflecting the recovery of L to the initial contact value.

**Fig. 1**c shows a 'double-hump' pressure profile with peak values of approx. 57kPa and 30kPa at PP and AP locations, respectively. Corresponding values for SL peak of 13kPa and 2kPa were measured at PP and AP locations, respectively (Fig. 1d). By contrast, SC at all locations were low compared to SL.

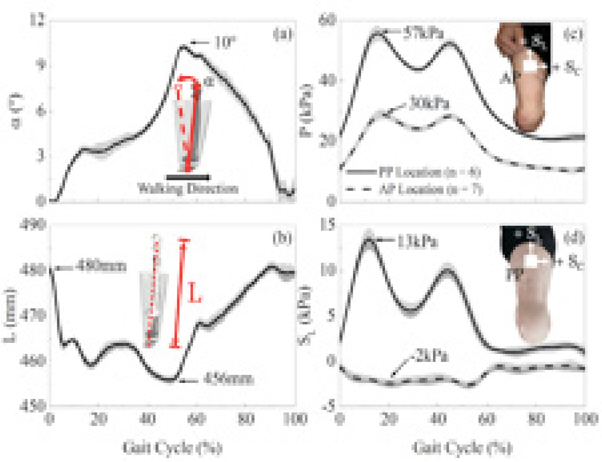


**Figure 1**: (a) Angular coupling α and (b) axial coupling

## DISCUSSION & CONCLUSION

Angular coupling of up to 10° (Fig. 1a) suggests that the residuum engages with the PP location of the socket wall during stance phase. The peak P and SL obtained in this study align well with previously reported values [3]. Higher pressure values at PP (57kPa) compared to AP (30kPa) also indicates the residuum engaging with the PP location of the socket, during the initial phase. Indeed it is established that the PP location of the socket provides a seating interface for trans-femoral amputees during stance phase, providing stability to the prosthetic knee and trunk. By comparing results from Fig. 1b, and Fig. 1d, it is observed that the decrease of L during the first half of the stance phase, coincides with an increase in SL. This corresponds with a mechanism involving 'push-in' of the residuum, resulting in the longitudinal shear towards the proximal direction. The presented approach involving both 3D motion capture and interface pressure and shear measurement offers the potential to aid the biomechanical understanding at the residuum/socket interface.

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## ACKNOWLEDGEMENTS

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# CARBOHYDRATE AND FAT OXIDATION DURING WALKING WITH DIFFERENT SPEEDS. A COMPARATIVE STUDY OF PERSONS WITH UNILATERAL TRANSFEMORAL AMPUTATION AND HEALTHY CONTROLS

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## BACKGROUND

Fat is the preferred fuel when healthy persons walk with their preferred walking speed (1). The quantity of energy from carbohydrate (CHO) stores of the body is only 1 % of that available in fat (2), thus it is plausible that conservation of CHO energy reserves governs the selection of the PWS (1). Research on fuel selection during prosthetic ambulation could provide important insights that may be valuable for rehabilitation and exercise programs following lower limb loss.

## AIM

The present study investigates carbohydrate and fat oxidation and total energy expenditure (TEE) of persons with a transfemoral amputation (TFA) and healthy controls (CON) during walking with five different speeds.

## METHOD

Eight TFA (37±11 yrs) and eight age matched CON (39±12 yrs) participated in this study. All participants performed five consecutive trials walking on the floor with their preferred walking speed (PWS) and with speeds that were 25 % and 12.5 % lower and higher than their respective PWS.. Each walking trial (speed) was interspaced by rest intervals of two minutes with quiet sitting. The sequence of walking speeds was randomized. During all trials, the VO2 consumption and VCO2 production was measured breath-by-breath with a portable metabolic analyzer (Metamax 3B, Cortex Biophysik, Germany). Carbohydrate (CHO) and fat oxidation was calculated by indirect calorimetry using stoichiometric equations (3).

## RESULTS

For the TFA, fat utilization accounted for about 45 % of the TEE when walking with the PWS (Fig 1). At faster speeds, CHO oxidation increased steeply and at the fastest walking speed for the TFA (~90 m min-1), fat utilization was only 22 % of the TEE. A walking speed of 90 m min-1 is close to the CON PWS, and at this speed, fat utilization was 45 % of the TEE for the CON and significantly different from the TFA walking with 90 m min-1 ($p < 0.01$).

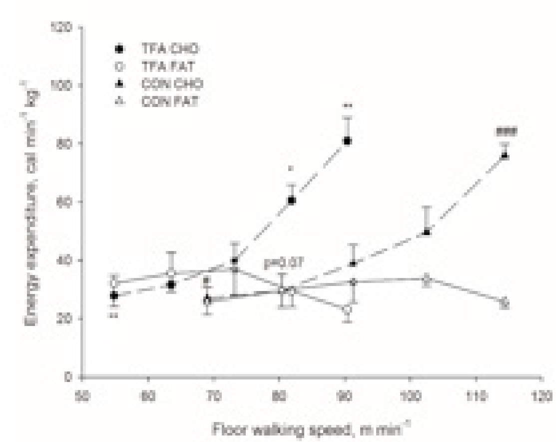


**Figure 1**. Carbohydrate and fat oxidation rates of the TFA and CON during floor walking

Values are means ± SD. CHO = carbohydrate. The PWS of the TFA and CON are marked as open (□) and closed (□) symbols, respectively. Compared to TFA PWS: * $p < 0.05$, ** $p < 0.01$. Compared to CON PWS: # $p < 0.05$, ## $p < 0.01$, ### $p < 0.001$. There were no significant differences for fat utilization across different walking speeds, for neither the CON nor the TFA.

## DISCUSSION & CONCLUSION

Carbohydrate and not fat oxidation dominates energy expenditure for both the CON and the TFA when they walk with their respective PWS. When the CON walk with their PWS, the TEE is 32% lower compared to the TFA when they walk at the same absolute speed (90 m min-1).Faster walking speeds than the PWS may not be sustainable for longer periods for the TFA, due to high rates of CHO oxidation and risk of depletion of CHO stores in the body.

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# EVALUATION OF THE EFFECTS OF DIFFERENT SUSPENSION SYSTEMS FOR PEOPLE WITH TRANSTIBIAL AMPUTATION

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## BACKGROUND

Since human existence, cosmetic and functional losses that occur after amputation tried to be resolved by different prosthetic designs. Suspension systems are essential for lower limb prothesis as they provide good prosthetic fit. Secure suspension decreases residual limb movement within the prosthetic socket by firmly attaching the prosthesis to the residual limb (1). A good suspensıon system and socket fitting in prosthetic devices significantly effect the amputee's comfort, mobility, and satisfaction (1-4).

## AIM

This study was performed to determine the presence of any difference between Pin Suspension (PS) and Active Vacuum Suspension (AVS) on walking capacity, functional mobility, weight bearing in the prosthetic side, prosthetic satisfaction and body image.

## METHOD

Nine patients whithout any obstacle to both socket applications in terms of stump height, type and edema were evaluated in this study. Both suspension systems were administered to the patients included in the study. First, amputees have used PS for 3 months following alignment of the prosthesis and training period. Then again they used AVS for 3 months following alignment of the prosthesis and training period. For each system, after adapting prosthesis 'LASAR Posture' was used to evaluate weight bearing on the prosthetic side, '6 Minute Walk Test' (6MWT) for walking capacity, 'Time Up and Go' (TUG) test for functional mobility, 'Prosthetic Satisfaction Index' (PSI) for prosthetic satisfaction and 'Amputee Body Image Scale' (ABIS) for body image perception.

## RESULTS

There were significant difference between PS and AVS in terms of prosthetic side weight bearing percentage, walking capacity, functional mobility and prosthetic satisfaction ($p<0.05$), in favor of AVS. There was not any significant difference between the body image scores ($p>0.05$).

| | PS | AVS | Wilcoxon signed-rank test |
|---|---|---|---|
| | X±SD | X±SD | p |
| Weight Bearing (%) | 41,75±6,43 | 48,2±2,37 | **,015*** |
| 6MWT (m) | 299,89±49,73 | 330,78±53,7 | **,007*** |
| TUG (sec) | 9,88±1,98 | 9,19±2,09 | **,038*** |
| PSI | 63,46±20,07 | 81,23±13,93 | **,012*** |
| ABIS | 55±19,91 | 55±20,56 | ,631 |

**Table 1**. Clinical Features of the Patients

## DISCUSSION & CONCLUSION

There are very few studies that compare PS and AVS. In our study, from the view of function and prosthetic satisfaction, AVS was found to be more effective in transtibial amputees. It is believed that our study will be a guide to the future studies including higher number of amputees, different amputation levels and different suspension systems.

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# A UNIFORM DEFORMABALE MODEL OFFERS AN IMPROVED METHOD TO QUANTIFY PROSTHETIC FOOT PERFORMANCE

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## BACKGROUND

The Össur Proflex foot has been shown to produce similar push-off power to an intact foot/ankle using traditional inverse dynamics (ID).1 This data has been met with some skepticism because such an achievement in performance seems improbable with a traditionally designed passive prosthetic system. However, the traditional ID method relies on two critical assumptions; 1) fixed joint centers between segments, and 2) each segment is a rigid body. Whereas, modern energy storage / energy return (ESER) prosthetic feet are made of carbon fiber laminate that relies on the deformation of the foot to provide movements. The instant center of rotation of the deformable foot and shank sections are moving which violates assumptions in traditional inverse dynamics techniques. 2 The unified deformable (UD) segment model overcomes the shortcomings of inverse dynamics by calculating total power generated below the knee joint and is not dependent on ankle joint center movement.3

## AIM

The aim of this study was to 1) define if the fixed ankle joint center assumption inherit with traditional calculation of ankle joint power was acceptable when evaluating energy storage and return prosthetic feet and 2) apply the UD method to determine if the Össur Proflex foot (a new ESER design) was able to generate more push-off power than an Össur Variflex foot (a classic ESER design) and comparable power to an intact foot/ankle.

## METHOD

Five people with a uni-lateral transtibial amputation not associated with vascular disease (80.5 ± 13.9 kg, 1.73 ± 0.08 m, 44 ± 13.9 y/o) provided informed consent for this IRB approved study. The participants walked at on an instrumented dual belt treadmill (GRAIL system, Motek Forcelink) for five different conditions (0.8, 1.1, and 1.1 m/s) while wearing an Össur Proflex foot or an Össur Variflex foot.
The order of conditions was randomized. The Human Body Model markerset was modified to include three additional markers on the both shanks to allow simultaneous calculation of lower limb power using a uniform deformable (UD) model that does not assume fixed ankle joint center or the foot as a rigid body.1 Kinematic data (100 Hz) and ground reaction force data (1000 Hz) was collected in Vicon Nexus 2.2. Data Analysis: Data was first processed in Visual3D to calculate lower limb power via ID and UD analyses. Data from ten strides per subject/foot/treadmill condition were then used for statistical analysis. The primary outcome measure was energy delivered during push-off which was integral of power during push-off with respect to time. A mixed ANOVA (treadmill condition, within factor of foot) with Tukey post-hoc evaluated statistical differences ($p < 0.05$) between feet. A two-factor RM ANOVA (method x treadmill conditions) evaluated differences between methods.

## RESULTS

There was a significant effect of prosthetic foot with the ID method ($p < 0.001$) and the UD method ($p < 0.001$). Post hoc test revealed there was no differences between the Proflex and sound limbs using the ID method (Figure 1) but there was a difference using the UD method (Figure 2) at 1.1 and 1.4 m/s. The Proflex foot (PF) generated more energy at push-off than the Variflex foot (VF) but less than the sound limbs (SND) using UD. The ID method resulted in greater push-off values than the UD meth o d ($p = 0.001$).

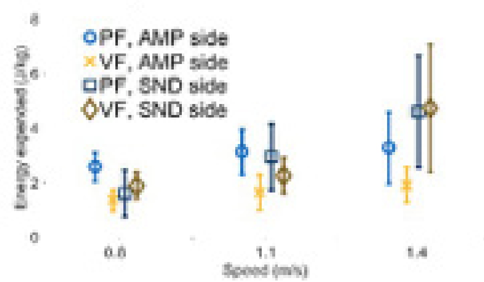


**Figure 1**. Push-off calculated with inverse dynamics.

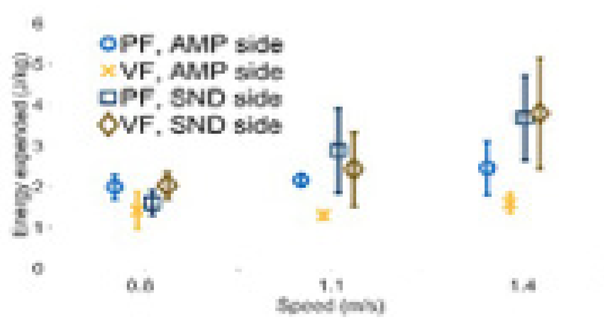


**Figure 2.** Push-off calculated with the uniform deformable model

## DISCUSSION & CONCLUSION

The Össur Proflex foot does deliver more energy during pushoff than the Variflex foot but not as much as an intact foot/ankle system when using the UD method. The differences between ID and UD methods are likely due to the inappropriate assumptions inherit in ID methods when applied to prosthetic feet. Future work may focus on the sources of energy in the human/prosthesis system that enable additional push-off seen in the Proflex foot.

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# QUALITY OF LIFE AND FUNCTIONALITY IN PATIENTS WITH LOWER EXTREMITY AMPUTATION IN A REHABILITATION HOSPITAL, BRAZIL.

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## INTRODUCTION

Patients highlight the importance of quality of life in the definition of a result of successful treatment. The functionality and quality of life remain core issues cited by patients with amputation (Suckow et al., 2015). A specialized rehabilitation, pain management and psychological support are needed for achieving better results in the evaluation of quality of life, which is often observed as a result of rehabilitation medicine (Schaffalitzky, Gallagher, MacLachlan, & Wegener, 2012).

## AIM

The study aims to evaluate the quality of life and functionality of the lower limbs amputee after rehabilitation program.

## METHOD

This is a cross-sectional study with 49 patients with lower limb amputation. The instruments used in the research were the SF-36 to assess the quality of life, and the FMA (Functional Measure for Amputees) to assess functionality. Data on the socio-demographic characterization and about amputation were collected from electronic medical records. Inclusion criteria consisted in patients with amputation higher than six months and in use of prosthetic. The research took place in the orthopedic workshop of a rehabilitation hospital during the scheduled review or preparation and adjustments to the prosthesis. We conducted a comparative assessment by gender, type of amputation with the instruments used.

## RESULTS

The sample is composed mostly by people under 30 years (35%), male (59.2%), single (51%), with higher education (40%), employees (71%) and 69.4% have amputation above the knee. 67% have no restriction for the gait, but 16.3% walk about 100 steps and 45% returned to the activities as before. Patients with difficulty to walk, have locomotor capacity index of 35.8, with the patients with TF amputations have higher scores than TT. The average daily time use of prosthetic is 13.1 hours (SD = 4.3). Amputees by accidents and congenital use it for a longer time than the causes tumors ($p < 0.001$). In the SF-36, women had lower scores in all areas. In addition, the functional capacity and vitality presented lower scores. The social aspect had the highest average.

## DISCUSSION AND CONCLUSION

There is an impairment in the quality of life of these patients, women with the worst evaluation and amputee's tumors need better rehabilitation approach. According to several authors (Akarsu, Tekin, Safaz, Göktepe, & Yazicioğlu, 2013; Asano, Rushton, Miller, & Deathe, 2008; Fortington, Dijkstra, Bosmans, Post, & Geertzen, 2013; Knezevic et al., 2015; Pezzin, Dillingham, & MacKenzie, 2000), in all domains in SF-36, had lower scores than those observed in this study. The quality of life is related to inherent to patient factors and amputation requiring a multidisciplinary approach to improve the quality of life and function of these patients.

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# PHANTOM MOTOR EXECUTION IN THE LOWER LIMB AIDED BY MYOELECTRIC PATTERN RECOGNITION AND VIRTUAL REALITY: A CASE STUDY ON A CHRONIC PHANTOM LIMB PAIN SUFFERER.

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## BACKGROUND

Phantom Motor Execution (PME) facilitated by Myoelectric Pattern Recognition (MPR) and Virtual Reality (VR)1 poses itself as an effective treatment for Phantom Limb Pain (PLP). Notably, a recent clinical trial using the methodology on a population of 14 upper limb amputees with intractable chronic PLP showed statistically significant improvements (approx. 50% reduction) in all the metrics used to measure PLP2.

## AIM

This study aimed to assess, for the first time, the efficacy of PME facilitated by MPR and VR in reducing PLP in the lower limb.

## METHOD

A 70-years-old male with traumatic trans-femoral amputation since 35 years on the right side was treated twice a week, for a total of 23 sessions. Each session consisted of pre-treatment pain assessment, electrode placement, PME treatment (2.0 h) and post-treatment pain evaluation. Pain was assessed in terms of Weighted Pain Distribution (WPD), Numeric Rating Scale (NRS), Pain Perception Frequency (PPF) and Short Form of McGill Pain Questionnaire (SF-MPQ)3.

Moreover, effects on quality of life, disability and participation levels as well as intrusion of PLP in activities of the daily living and sleep were monitored. The PME treatment consisted in using myoelectric signals produced in stump muscles during phantom motions in order to control a VR limb. This was made possible thanks to the MPR system BioPatRec.

## RESULTS

Figure 1 shows the visual representation of WDP as it is registered at the beginning of each session: a general, however not complete, reduction of pain can be noticed. The highest levels of PLP (4 and 5), usually present in the evening and at night disappeared over time. As a consequence, length and quality of sleep increase from 2h/night with interruptions to 7h/night undisturbed.

SF-MPQ showed a significant reduction (>50%) in the number of chosen pain descriptors as well as in the Pain Rating Index. Quality of life improved drastically: the patient reported less tiredness, improved mood and regained ability to drive for long distance (> 200 km at a time, not possible before). Moderate levels of PLP (1-3 in Figure 1) are still present, accounting for unchanged score in NRS and PPF.

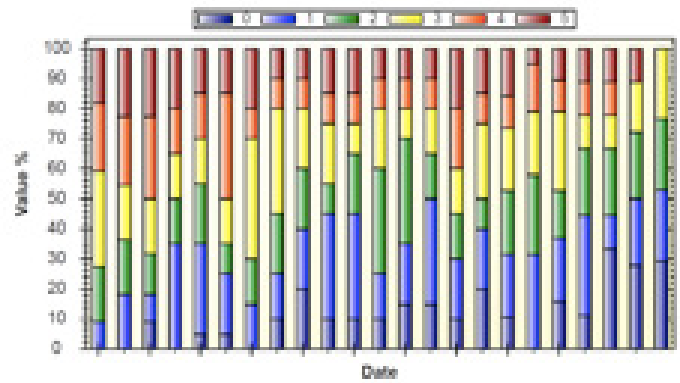


**Figure 1**. Weighted Pain Distribution (WPD). Each bar represents a treatment session. The pain rating is from 0 to 5 where 5 (red) is the worst possible pain

## DISCUSSION & CONCLUSION

In accordance with previous studies on upper limbs1, 2 a clear trend in pain reduction is outlined. However, pain is not eliminated completely probably due to the limited length of the treatment. In comparison with previous work on the upper limbs2, it appears that longer time might be required to appreciate significant pain reduction in the lower limb. On the other hand, the results here reported are limited to one subject and it is necessary to investigate a wider population before generalizing. To conclude, PME facilitated by MPR and VR can potentially be used to reduce PLP in the lower limb.

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# A DESCRIPTION OF PHYSICAL REHABILITATION CENTERS AND THEIR SERVICE QUALITY IN ETHIOPIA

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## BACKGROUND

There are nine physical rehabilitation centers (PRCs) in different regions of Ethiopia. All are providing prosthetic, orthotic, wheelchair and physiotherapy services. These services and their quality have no well documented evidence that helps to compare the past with today's practices. This review of existing information helps PRCs in Ethiopia to gain information about the service quality. It emphasizes the causes and factors that impact the service and its quality in the PRCs.

## AIM

To describe PRC services in Ethiopia, clarify the causes of any low quality service, share experiences between PRCs and clarify the role of the multi-disciplinary team (MDT) and its function in Ethiopia.

## METHOD

This study is done using a descriptive method and data were collected from each center by using proportional allocation based on the number of the study subjects in each center. The subjects were selected from each center by lottery and each interviewed based on a structured questionnaire that was designed by the investigator based on other studies, guidelines, manuals and reports. Following the interviews, documentation in each center was reviewed and included in the analysis. Finally, collected interview data were reported in the text form and analyzed as to provide a more complete overview.

## RESULTS

There are 23 prosthetist/orthotists (P&O), 11 physiotherapists (PT) and 28 bench technicians (BT) who work the nine PRCs in the country that serve approximately 12,500 prosthetics & orthotics users per year. On average, one P&O produces 15 orthosis or orthoses prosthesis each week. In most PRCs (95%), the MDT consists of a PT, P&O and BT.
Though this team exists; 85% of its tasks are not completed. For instance, 60% of clients' files have no full assessment and are not correctly documented. Setting treatment goals for the admitted patients is not regularly undertaken within the agreed timeframe. Little evidence of the PTs checking the production quality of devices exists and 50% of users have no pre and post fitting exercise regimen. Six (70%) of the centers follow the steps from admission to discharge but 80% of the centers don't practice each step properly.

## DISCUSSION & CONCLUSION

Generally, the practice of MDT in PRCs of Ethiopia is not fully functional. The PT and P&Os appear to be working apart which impacts negatively on service provision.

Potential improvements could include:
• A nationally based guide line for PRCs
• Regular refreshment and skills training
• Team training for PTs and P&Os
• Expanded university level training to include P&O
• Local team management to work hard to achieve their mission
• MDT performance management to ensure quality.

# KINEMATIC EFFECTS OF PROVIDING ANKLE-FOOT ORTHOSES IN THE EARLY REHABILITATION POST-STROKE: A RANDOMIZED CONTROLLED TRIAL

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## BACKGROUND

Regaining walking ability is an important goal in rehabilitation after stroke. Ankle-foot orthoses (AFOs) are often prescribed after stroke and are found to improve ankle kinematics [1]. Most research studying AFO-use after stroke included chronic stroke patients, of which many were already using an AFO in everyday life. One may argue that in these subjects the effect of removing an AFO is tested. However, studying the actual AFO-provision early after stroke is more in line with daily clinical practice, which warrants for research studying the effect of actual AFO-provision. Furthermore, studies focusing on the optimal timing of AFO-provision after stroke are missing. This is important as one may speculate that for example the development of compensatory strategies in proximal lower limb segments may decrease when foot-drop in the distal segment is limited in an early stage because of early AFO-provision. Therefore, we conducted a randomized controlled trial to study the effects of providing AFOs on two different moments in the rehabilitation post-stroke.

## AIM

To study the short-term effects of the actual provision of AFOs on lower limb kinematics in subjects in the early rehabilitation post-stroke; and to study whether timing of AFO-provision influenced these effects.

## METHOD

Unilateral hemiparetic stroke patients admitted to the rehabilitation center were included. Subjects were maximal six weeks post-stroke and had an indication for AFO-use. Subjects were randomly assigned to AFO-use: early (at inclusion; week 1) or delayed (eight weeks later; week 9).
Three-dimensional gait analysis (Vicon) with and without AFO was performed in randomized order while walking at self-selected walking speed on a level walkway. Measurements were performed after AFO-provision, in week 1 (early) or 9 (late). The primary outcome measure was ankle dorsiflexion. Secondary outcomes measures included hip and knee flexion, hip abduction and pelvic tilt and obliquity. All angles were calculated at initial contact, at foot-off and during swing. Furthermore, walking speed was measured.

## RESULTS

Twenty subjects (8 early, 12 delayed) were included in the analysis. On average, gait analysis was performed 39.8 (9.1) and 90.2 (6.4) days after stroke in the early and delayed group, respectively. Ankle dorsiflexion at initial contact, foot off and during swing increased significantly after AFO-provision, see table 1. Knee and hip flexion increased at initial contact after AFO-provision, no effects at foot-off or during swing were found. Hip abduction, pelvic tilt and obliquity (results not shown) and walking speed were not affected by AFO-use. No significant effects of timing were found on kinematic parameters when effects of AFO-provision were compared between the early and delayed group (results not shown).

| | Effect (°) | | | |
|---|---|---|---|---|
| | Without AFO | With AFO | Difference | $p^*$ |
| **Ankle dorsiflexion** | | | | |
| IC | -3.6 (7.3) | 3.0 (3.9) | 6.6 (4.0;9.1) | <0.001 |
| FO | 0.0 (7.4) | 5.2 (3.7) | 5.2 (2.9;7.6) | <0.001 |
| SW (min) | -6.1 (7.8) | 2.6 (3.5) | 8.7 (5.9;11.5) | <0.001 |
| SW (max) | 3.1 (6.2) | 6.7 (3.9) | 3.7 (2.0;5.3) | <0.001 |
| **Knee flexion** | | | | |
| IC | 18.1 (5.7) | 20.4 (6.4) | 2.3 (1.6;3.0) | <0.001 |
| **Hip flexion** | | | | |
| IC | 25.9 (10.7) | 27.4 (10.5) | 1.6 (0.7;2.4) | 0.001 |
| Walking speed (m/s) | 0.44 (0.22) | 0.46 (0.22) | 0.02 (-0.01; 0.05) | 0.112 |

**Table 1**: Effect of providing AFOs (N=20)
Abbreviations: AFO: ankle-foot orthosis; IC: initial contact; FO: foot-off; SW: swing. Mean (SD) or median (interquartile range) is presented.
*Paired samples t-test (mean, 95% confidence interval) is presented.

## DISCUSSION & CONCLUSION

This study found kinematic changes after providing AFOs to subjects after recent stroke. Ankle angles changed from plantarflexion to dorsiflexion at initial contact and during swing. Minor effects were found for knee and hip flexion and no effects were found on hip abduction and pelvis movement. This means that in our study AFO-provision did not affect possible compensatory strategies around hip and pelvis like pelvic hiking or circumduction. The point in time at which an AFO was provided post-stroke, early (week 1) or delayed (week 9 of the study), did not influenced the effects of AFO-provision on the short-term.
Whether or not long-term effects are present is subject for future studies.

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# LIMB USE ONE YEAR AFTER PROSTHETIC FITTING IN A CONSECUTIVE SAMPLE OF PATIENTS WITH A TRANS-FEMORAL AMPUTATION: A 2 CENTRE PILOT STUDY

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## BACKGROUND

Patients referred for limb fitting post transfemoral amputation (TFA) are not all suitable for limb fitting or the physical and cognitive demands of rehabilitation (1). Successful limb fitting in this group may be as low as 24% with subsequent high rates of abandonment (2). The Transfemoral Fitting Predictor (TFP) is an observed assessment tool that was developed to assist in assessing the potential of patients to use a prosthesis prior to referral for prosthetic fitting (3). Two Prosthetic Services in Scotland use the TFP as a screening tool. Prosthetic Service 1 (PS1) is referred patients who undergo intensive inpatient prosthetic rehabilitation and Prosthetic Service 2 (PS2) is referred patients who are predominantly discharged home prior to limb fitting and rehabilitation as an out-patient. Little is known whether the use of the TFP tool is helping standardise referral rates and reduce abandonment rates at 1 year after fitting at both these centres and whether the two different models of care impact on these same factors.

## AIM

To determine if use of the TFP standardises prosthetic referral rates and whether intensive inpatient prosthetic rehabilitation improves limb use one year after fitting of patients with a primary unilateral TFA.

## METHOD

63 patients who had a TFA and were consecutively referred to 2 prosthetic services were included: 21 at Prosthetic Service 1 and 43 at Prosthetic Service 2. Demographic data and cause of amputation were assessed using clinical records. Those patients who were limb fitted were routinely followed up at one year using the Functional Measure for Amputees (FMA) (4).

## RESULTS

The cause of amputation in the majority of cases at both centres was related to peripherap arterial disease (PAD) and over 80% were male (PS1 85%; PS2 81%). The cohort from Prosthetic Service 1 were slightly younger (PS1 60.9; PS2 66.7) with a lower incidence of PAD +/- Diabetes (PS1 75%; PS2 84%). 18% (n=21) of a consecutive sample of 117 people undergoing a primary unilateral TFA were referred from the local Vascular Surgery Unit to Prosthetic Service 1. All 21 were cast and fitted with a prosthesis. Of those fitted, 76% reported continued prosthetic use one year on. One patient had died, 2 had abandoned use and 1, although fitted, had only had his prosthesis x 3 months so was not eligible to complete the FMA (see table 1). 2 patients were excluded as had become bilateral transfemoral. On average prosthesis was worn 5.5 days per week (range 2-7) and for an average of 8.9 hours per day (range 2-17). 26% (n=43) of a consecutive sample of 163 people undergoing a primary unilateral TFA were referred from the local Vascular and Orthopaedic Surgery Units to Prosthetic service 2. 42 were cast and fitted with a prosthesis, 1 having died prior to fitting. Of the 42 patients fitted, 58% (n=25) reported continued prosthetic use one year on, four patients had died, 11 had abandoned use, 1 was lost to follow-up and 1 had become bilateral so was excluded. The patients still wearing their prosthesis one year after fitting reported doing so on average 5.7 days per week (range 2-7) and for an average of 5.7 hours per day (range 1-12).

| | Number referred for LF (referral rate) | Number limb fitted (LF) at Clinic | Outcome at 1 year | | | | |
|---|---|---|---|---|---|---|---|
| | | | LF | Abd | Died | Excl | Lost to follow up |
| PS1 | 21 /117<br>(18%) | 21 | 16<br>76% | 2<br>10% | 1<br>5% | 2<br>10% | 0<br>0% |
| PS2 | 43 /168<br>(26%) | 42<br>(n=1 deceased) | 25<br>58% | 11<br>26% | 4<br>10% | 1<br>2% | 1<br>2% |

Table 1: Referral rate, outcome at clinic and at 1 year follow up.

## DISCUSSION & CONCLUSION

It would appear that fewer primary TFA amputees are referred to Prosthetic Service 1 for limb fitting. This is despite both services using the TFP as a screening tool prior to patients being appointed. However, more of those who are limb fitted by Prosthetic Service 1, continue to use their prosthesis 1 year after fitting. There was a similar self-reported level of limb use (days per week) in both cohorts at one year, however patients in Prosthetic Service 1 used their prosthesis for an average of 3 hours more per day. Reasons for the lower rate of referral to Prosthetic Service 1 warrants further investigation. Intensive inpatient rehabilitation may be linked to increased daily use of prosthesis and lower rates of limb abandonment at 1 year.

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# AN OSSEOINTEGRATED PERCUTANEOUS PROSTHETIC SYSTEM FOR TREATMENT OF TRANSFEMORAL AMPUTEES: a prospective 5-year follow up

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## BACKGROUND

In 2014 we published the first prospective study (Ref 1) on the results of bone-anchored amputation prostheses in transfemoral amputees (TFA). The OPRA study (Osseo-integrated Prosthesis for the Rehabilitation of Amputees) includes 51 patients with 55 implants recruited from 1999 to 2007. At the 2-years follow-up (FU) in May 2010, 3 patients were excluded (1 dead, 1 lost to FU, 1 withdrawn due to contralateral extremity problems).

## AIM

We now report the observed 5-year follow-up.

## METHOD

A titanium-screw (fixture - F) is inserted into the remaining skeleton (S1 operation). Six months later a transdermal implant (abutment - A) is inserted into the fixture (S2 operation). An abutment screw (AS) secures the F and A. Pre- and postoperative data containing adverse events together with SF-36, and Q-TFA questionnaires results has been collected.

## RESULTS

At 2-years FU four implants had been removed due to loosening (3) or infection (1), leaving 44 remaining patients (48 implants) in the study. The cumulative implant survival was 92 %. The patients had an average of one superficial infection every two years, successfully treated conservatively with peroral or local antibiotics in all cases. There were 6 deep infections in 4 patients. All but one were successfully treated by conservative means. Four patients had 9 mechanical complications (bent or fractured As or ASs) and 3 skeletal fractures occurred. Prosthetic use, prosthetic functions and global quality of life were all significantly improved ($p<0.001$).

At 5-years FU no additional fixture losses were reported, but another patient had passed away unrelated to the procedure (43 patients/47 implants). No additional F has been removed, hence the cumulative implant survival rate remains stable at 92%. Between the 2- and 5-year FU superficial and deep infections occurred in 22 and 7 patients, respectively. Another 8 patients had bent or fractured A, and 15 patients had mechanical problems due to wear leading to exchange of the A or AS.

## DISCUSSION & CONCLUSION

The OPRA-technique continues to be promising with an observed cumulative survival rate of 92 % at 5-years FU. The mechanical issues and deep infections are of concern and are continuously monitored. So far these issues have been successfully solved.

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# IMPACT OF DIFFERENT BRAKE SCENARIOS FOR RAMP DESCENT ON JOINT WORK USING AN INTEGRATED TRANSFEMORAL PROSTHESIS

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## BACKGROUND

Ramp ambulation is a highly challenging task for transfemoral amputees. From research we know that especially the dynamics of ramp descent are very different compared to level ground ambulation with negative net energy [1, 2]. By changing the braking strategy of the integrated limb it might be possible to change the gait dynamics.

## AIM

In order to gain a deeper biomechanical understanding, different braking scenarios for ramp descent were investigated. Of specific interest were the biomechanical effects of different control strategies.

## METHOD

Four transfemoral K3 amputees participated in the study with two data collection sessions. Signed consent was given. The integrated prosthesis consisted of a microprocessor controlled hybrid knee joint and a microprocessor controlled hydraulic foot-ankle under a single master controller. Changes in the braking strategy were done wirelessly and the same alignment was used during the whole data collection session. Four braking strategies were measured: a) no brake (NB), b) foot brake (FB), c) knee brake (KB), d) limb brake (LB). The participant and the prosthetist were blinded as to which braking strategy was applied.

Kinetic and kinematic data were collected using a Codamotion Gait Analysis System and a Kistler force plate on a 5° ramp at self-selected normal speed.

Additionally, subjective feedback from the participant and the prosthetist was collected.

## RESULTS

When investigating the impact of joint work the following aspects could be found:

The work of the hip joint for LB was lower for both sides compared to NB, FB and KB (statistically significant compared to FB and KB for the residual side ($p=0.016$ and $p=0.001$)). FB and KB showed slight increases compared to NB.

The lowest knee work could be found in LB for both sides, with the intact side reaching statistical significance compared to NB ($p=0.048$). Knee work was slightly increased on the residual side and slightly decreased on the intact side for FB and KB compared to NB. Summing the total work of all joints, LB had the lowest joint work (residual side FB $p=0.049$ and KB $p=0.044$, intact side KB $p=0.046$). A slight decrease of speed could be seen from NB to LB, however without reaching statistical significance.

## DISCUSSION & CONCLUSION

Based on the findings there seems to be an indication that by changing the braking strategy, the overall ambulation dynamics can be influenced, showing impact on both the residual and intact sides. These changes improved gait symmetry – something which has been linked to reducing osteoarthritis and back pain. LB showed a reduction of hip and knee work compared to the other conditions, implying less energy expenditure during use. We conclude that different braking strategies can influence the overall gait dynamics by changing the braking/propulsive bias of both the knee and foot.

A larger follow-up study could provide further insights into the effects of braking control of an integrated prosthesis.

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# IMPROVEMENT IN FUNCTIONAL CAPACITY ON TRANS FEMORAL AMPUTEES AFTER IMPLANTATION OF A KEEP WALKING ENDO-IMPLANT DESIGNED TO PROVIDE DISTAL SUPPORT

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## BACKGROUND

Preservation of the femoral condyles in patients with KDA facilitates distal support within the socket in contrast to what happens in TFA. This allows direct transfer of the weight bearing loads toward the distal end of the residual limb what leads to a lower energy consumption and, consequently, an increase in independence for walking compared with TFA. The advantages of KDA compared with TFA have led to the design of an endomedular implant with a distal spacer, that performs the same function as the femoral condyles, and allows a direct load on the residuum over the distal surface of the socket.

## AIM

The aim of the present study was to evaluate the differences in walking abilities in the parameters of distance and speed, in TFA patients, without and with the femoral implant that allows distal load of the residuum.

## METHOD

Prospective before-after multicentre study in a group of 29 TFA patients. For inclusion, the patients had to have, at least, 12 months prior experience as a unilateral TF amputee wearing a prosthesis. Except for the adapted distal load socket, the hardware didn't change. The subjects were their own control. Objective measurements of the principal parameters such as speed and distance were obtained by a standard 2-MWT, as well as oxygen consumption, heart rate, bone density and pain. The rehabilitation protocol used was our standard protocol and the follow-up period was 14 months.

## RESULTS

6 subjects abandoned the study, returning to their previous state without secondary con-sequences, due to causes not related with the implant (3 for secondary infection after neuroma or bone spike surgery and 3 for other medical causes). This first group of 23 patients who finished the follow up was a mix of 11 trauma, 3 tumoral and 9 vascular patients with comorbidities such as diabetes, muscular skeletal and cardiovascular respiratory diseases. All of them were classified as K2 and K3 subjects. This group obtained the following mean statistical improvements; 2MWT distance covered from 103.61 to 128.04 meters (p=0.000), VAS pain scale from 2.74 to 0.35 (p=0.001), daily hours of prosthesis use from 10.70 to 12.87 hours (p=0.001), oxygen consumption from 18.377 to 20.077 (p=0.043). Other improvements, although without statistical significance, were PCI from 0.549 to 0.473 (p=0.297), and bone mineral density of the femoral neck from 0.61274 to 0.67479 (p=0.171). Technical aids were less necessary for walking.

**Figure 1**. Keep Walking Implant

## DISCUSSION & CONCLUSION

The results of the study show improvements in functional capacity and gait speed in TFA, 14 months after receiving a distal weight bearing femoral implant, independent of the etiology (Figure 1).
This increase of the distance in the 2MWT reflects an increase in gait speed that may be translated into greater capacity of the individual to carry out community tasks, such as crossing the street.

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# FOOT SHAPE AND ASYMMETRY IN CHARCOT FOOT – ASSESSMENT USING THE FOOT POSTURE INDEX (FPI-6)

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## BACKGROUND

Charcot neuroarthropathy (CN) or 'Charcot foot' frequently results in changes in foot shape and structure (see figure 1) which have an impact on function and risk of ulceration [1]. While clinical tools to assess foot shape are available [2], there is no reported data for feet with CN of which the author is aware.

## AIM

This study aims to quantify clinically observed changes in foot posture resulting from CN, using the Foot Posture Index (FPI-6) [2].

## METHOD

Case notes of patients seen in a specialist diabetic orthotic clinic between April 2014 and April 2016 were reviewed. Comparison was made between affected and unaffected feet in patients with CN. An equally sized control group of diabetic patients without CN was also identified for comparison. Data was tested using Fisher's exact test, with significance set at <0.05.

## RESULTS

Twenty-seven patients with CN with 28 affected feet were included in the study. Of the 27 patients with CN, 4 were unilateral amputees. Among patients with CN, incidence of ulceration was four times greater in affected feet than unaffected feet during the period (53.57% vs 13.64%). There was a large variance in FPI-6 in both affected (+1 to +12) and unaffected (-1 to +10) feet. Mean score for affected feet was +6.82 (n=22), mean for unaffected feet was +5.05 (n=19). Mean differential in FPI-6 (n=19) indicated that affected feet were 2.16 points more pronated overall than unaffected feet. Considering all FPI-6 scores as positive numbers to indicate mean overall asymmetry between affected and unaffected feet, considering complete pairs of feet, CN feet differed by a mean of 3.00 points from unaffected feet. 26.32% of patients with a CN affected foot were classified as having severe asymmetry, compared with 0% in the control group (see figure 2). Patients in the Charcot group were less likely to have normal asymmetry than the control group (p=<0.0001) and more likely to have severe asymmetry (p=0.0121). There was a significant difference between left and right feet in the control group (p=0.0394) with an average asymmetry of 0.93. CN affected feet were significantly (p=0.0294) more likely to have a FPI-6 score outside the normal range (+1 to +7) compared to unaffected feet. The CN affected feet were more frequently pathologically pronated (>+10) compared to unaffected feet but this was not statistically significant (p=0.0507).

**Figure 1.** Foot asymmetry in Charcot foot

## DISCUSSION & CONCLUSION

While some CN affected feet were slightly supinated, they were more frequently pronated when compared to unaffected feet. There was a statistically significant difference between the left and right foot in both patients with and without CN, seen in an orthotic clinic. The mean asymmetry of 0.93 in patients without CN just exceeds a published standard error of measurement value of 0.7, and is within the normal range of asymmetry [3]. The mean asymmetry between feet in patients with CN was much larger (3.00) and is classed as asymmetrical [3]. Patients in the CN group were significantly less likely to have normal asymmetry than the control group and more likely to have severe asymmetry. This study provides new data on foot shape following CN. The FPI-6 may be a suitable tool for outcome measurement in this patient group. Further work could look at individual FPI-6 items, or the influence of time or treatment on foot shape following CN.

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# USE OF OUTCOME MEASURES AMONG PROSTHETISTS AND ORTHOTISTS IN THE UNITED KINGDOM

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## BACKGROUND

Outcome measures (OMs) are an important aspect of providing healthcare, and have various potential uses within prosthetics and orthotics [1]. Little is known about current practice concerning use of outcome measures among prosthetists and orthotists.

## AIM

This study aims to identify current use and barriers to use of OMs among prosthetists and orthotists in the United Kingdom (UK).

## METHOD

A 34 item online questionnaire was devised and administered via the website of the British Association of Prosthetists and Orthotists (BAPO). Data was analysed using SPSS 22 software. Chi-square tests were performed, with a confidence interval of 95%. The Chi-square tests compared demographic factors and reported barriers to OM use between two groups – those classed as routine users and non-routine users. Routine users were defined as those reporting use 'most of the time' or 'for every episode of care'. Non-routine users were defined as those reporting use 'never', 'rarely', or 'sometimes'. This aimed to identify factors which may positively or negatively influence frequency of use and to determine whether reported barriers varied between the groups and was based on the categories used in a similar study [2].

## RESULTS

109 complete responses were received. Results indicate that the majority of prosthetists and orthotists in the UK use OMs with only 6.4% reporting use as 'never', however only 28% are routine users. Use of OMs was significantly affected by factors including education, work environment, and clinical specialty. Lack of training, availability of clinical time for review appointments and motivation were cited as barriers to routine use. While 72 individual OMs were reported, only 14 were reported with a frequency of 5 or more (see figure 1). This may reflect a disjointed approach to OMs, with different centres and clinicians selecting different measures.

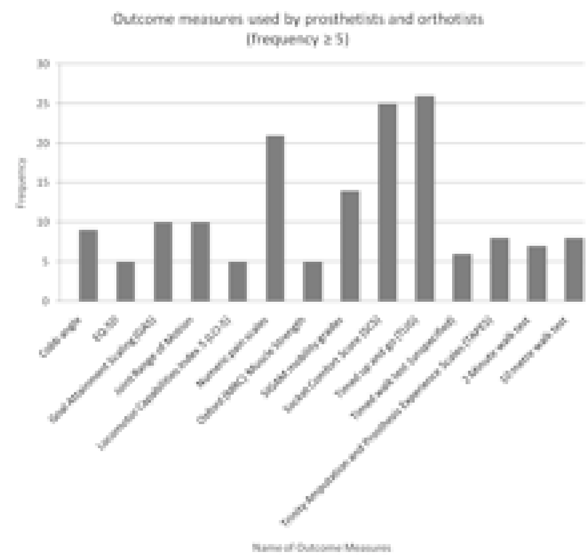


**Figure 1**. Outcome measures used by prosthetists and orthotists

## DISCUSSION & CONCLUSION

A picture of current practice concerning OMs among UK prosthetists and orthotists is presented. Overcoming the cited barriers to use is likely to require both education, including post graduate training courses and revision to undergraduate degree programs, and changes to the commissioning and management of services. Introductory guidelines on the use of OMs by prosthetists and orthotists have since been developed, informed by this study [3].

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# USER TRAINING FOR PATTERN-RECOGNITION BASED MYOELECTRIC PROSTHESES USING A SERIOUS GAME

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## BACKGROUND

Individuals with upper-limb deficiency who are fitted with a prosthesis are normally trained in the use of such device. During training pattern-recognition based control, the way training improves control skills and what kind of feedback facilitates skill acquisition is still poorly understood. Moreover no training protocols for pattern-recognition control have been described in the literature that do not require an expert trainer which limits the clinical applicability of pattern-recognition controlled prosthetics.

## AIM

The aim of this study is to investigate how different kinds of feedback improve the control skills of pattern-recognition control.

## METHOD

Nine able-bodied volunteers participated in an initial experiment in which they either performed conventional system training or gamified system training with no prior user training. Based on the results of the initial experiment, a follow-up experiment will be conducted where four different kinds of training regimes are investigated namely; conventional training with knowledge of results but without coaching, conventional training with knowledge of results and knowledge of performance, serious game training or training with no feedback (control). Each group will include 15 participants, who train one hour per day for five consecutive days. Offline and online accuracy as well as the repeatability index, separability index and mean semi-principal axis [1] will be reported for each group.

## RESULTS

In the initial experiment control performance was measured using the motion test [2] and a questionnaire was used to measure the participants experience of the system training and evaluation. No significant differences were found between the groups.
Preliminary results of the follow-up experiment will also be reported.

## DISCUSSION & CONCLUSION

The finding that no differences were found between the groups in the initial experiment could be ascribed to the way the game targets were set in the gamified system training and to an unintuitive mapping between movement and game control. In the follow-up experiment that will be performed a fixed mapping inspired by Radhakrishnan et. al [3] is used where the electromyogram measured at each electrode located on the forearm is mapped to a direction.

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# USING PVC/POLYPROPYLENE TUBE FOR ASSEMBLING PASSIVE TRANS-RADIUS PROSTHESIS

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## BACKGROUND

Many prosthetics centers utilize an aluminum tube, and tube adaptor to assemble a passive trans radial prosthesis with a socket, hook/hand or a proper length extension and prosthetic hand/hook.
Most low income countries cannot afford to buy the aluminum tubes and its adapter for the fabrication so virtually all sockets are extended with polypropylene forearm. This fabrication technique adds more weight to prosthesis as well being considerably more time consuming to fabricate compared to using the tube and its adapter to fabricate.
Even passive trans radial prostheses are often too heavy to wear by the patient due to double layer of socket, as well as the bolt and wrist unit which all contribute weight

## AIM

Trial a new technique of using polypropylene tube instead of the aluminum tube. This will , reduce cost of fabrication, reduce the weight of prosthetic compared to the double layer draping forename, reduce time of fabrication process by its polypropylene property fasten alignment adjustment during fitting.

## METHOD

It was invented through FK home seminar on new technique of making upper limb prosthesis in August 2013. It was decided to utilise the 21 millimeter dimension PVC tube, 2 stoppers and 8 millimeter T-nut and bolt to extend the length of trans-radial prosthesis. The experiment produced a significantly improved outcome compared with the old technique that was being taught and practiced in different prosthetic and orthotic centers. After the seminar, this new technique has continued to be utilised on a dozen of patients by different prosthetists to test the reliability of the material, strength, durability and its consistency.

## RESULTS

Using polypropylene tube for assembling passive trans-radius prosthesis provides more cost effective fabrication compared with using other component and material. It is also easier to fabricate compared to using aluminum tube or double layer of polypropylene forearm socket. It is easy and faster to adjust alignment during fitting, using heat gun to change ulna or radius deviation. Finally, it provides lighter weight prosthesis compared with double layer polypropylene forearm.
In 2014, this new component and fabrication technique was shared with other prosthetists and orthotists during the Cambodia Prosthetics and Orthotics annual congress. In 2015, the factory started to produce polypropylene tube and it adapters. Since that time it has been introduced to three Physical Rehabilitation Centers in Cambodia as well as being taught to students instead of using conventional method.

## DISCUSSION & CONCLUSION

A PVC/polypropylene tube can be used to make the forearm of passive trans radius prosthesis. The component material and technique contribute to lowering the cost of the prosthesis and shortening the fabrication time and fitting process. This finding should be recommended to use in other P&O centers, especially in low income countries.

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# A MULTI-DIMENSIONAL EXERCISE PROGRAMME IMPROVES GAIT ENDURANCE AND PREVENTS FALLS IN COMMUNITY-DWELLING LOWER LIMB AMPUTEES

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## BACKGROUND

Lower-limb amputees (LLAs) commonly present with muscle strength asymmetries, often relating to preferred use of the intact limb. Increased muscular strength and symmetry have been shown to improve gait function. However, previous strength training programmes for LLAs have not investigated the effect on functional tasks [1]. Taking longer to complete the Timed Up-and-Go (TUG) test [2] as well as the inability to safely turn while walking [3] have been associated with an increased risk of falls, in transtibial amputees (TTAs) and elderly persons, respectively.

## AIM

This study assessed the impact of a 12-week, multidimensional, individualised exercise programme on measures of strength, the TUG test, the distance covered in the 6-minute walk test (6MWT), and on falls prevention.

## METHOD

Fifteen participants [exercise: n=7 (mean(SD) age: 59.7(12.7) years; female: n=3, male: n=4; TTA: n=2; Transfemoral (TFA): n=5), and control: n=8 (mean(SD) age: 64.9(16.4) years; female: n=1, male: n=7; TTA: n=3; TFA: n=5)], with a range of amputation aetiologies were recruited into the study. Groups were matched by age, gender and level of amputation. Measures of maximal, resisted strength for seven lower-limb muscle groups (bilateral hip flexors, extensors and abductors; intact and affected (TTAs only) knee flexors and extensors, intact plantarflexors and dorsiflexors) were collected through hand-held dynamometry (M550, Biometrics, Newport, Wales), at baseline (PRE) and after the 12-week intervention (POST). Participants also completed the TUG test and the 6MWT at both time points. Self-reported falls history was collected for the two years prior to baseline testing (BASE) and at one year follow-up (FOLLOW-UP).

Exercise group participants took part in a twice-weekly, 1 hour supervised group exercise session, and completed home-based exercises once weekly, progressing to twice weekly. The exercise programme incorporated strength, flexibility, balance and aerobic exercises. A repeated measures general linear model was used to indicated whether significant differences existed between, and within, groups over time ($P<0.05$).

## RESULTS

Intact limb knee extensor maximal strength decreased significantly for participants in the control group, but not the exercise group (Table 1). There were no other significant muscle strength changes for participants in either group. Within-subject results for the TUG, the 6MWT and falls incidence are also shown in Table 1. Between group analysis showed that there were no significant differences at either PRE or POST for muscle strength, the TUG, the 6MWT and falls incidence, although some large effect sizes were found.

| Intact Maximal Knee Extensor Strength (kg) | | | | | |
|---|---|---|---|---|---|
| | PRE | POST | Mean Change [CI] | Effect Size (*d*) | *P* |
| Exercise | 23.9 (6.8) | 20.3 (3.2) | -3.6 [-75.7 to 4.6] | 0.72 | 0.078 |
| Control | 23.7 (6.7) | 18.2 (2.8) | -5.5 [-91.8 to -16.8] | 1.16 | 0.009* |
| | | | | | |
| TUG (s) | | | | | |
| | PRE | POST | Mean Change [CI] | Effect Size (*d*) | *P* |
| Exercise | 13.9 (4.5) | 11.7 (3.1) | -2.2 [-4.3 to 0.0] | 0.58 | 0.048* |
| Control | 14.1 (6.1) | 13.7 (5.9) | -0.4 [-2.3 to 1.6] | 0.07 | 0.716 |
| | | | | | |
| 6MWT (m) | | | | | |
| | PRE | POST | Mean Change [CI] | Effect Size (*d*) | *P* |
| Exercise | 139.6 (186.6) | 297.1 (136.4) | +157.5 [46.3 to 268.7] | 0.98 | 0.009* |
| Control | 202.2 (230.5) | 239.5 (189.2) | +37.3 [-66.8 to 141.3] | 0.18 | 0.453 |
| | | | | | |
| Falls (n=) | | | | | |
| | BASE | FOLLOW-UP | Mean Change [CI] | Effect Size (*d*) | *P* |
| Exercise | 12.1 (14.8) | 0.3 (0.5) | -11.8 [-7.8 to 31.4] | 1.56 | 0.011* |
| Control | 2.8 (2.3) | 6.8 (5.1) | +4.0 [-0.9 to 6.9] | 1.08 | 0.308 |

**Table 1.** Group mean (SD) strength and clinical measures following a 12-week individualised exercise programme (CI – confidence interval [95%]).

## DISCUSSION & CONCLUSION

This is the first study to document the functional improvements of a multidimensional exercise programme on clinical outcome measures. Knee extensor muscle strength is important for many daily tasks, such as rising from a chair and returning to a seated position. Maximal muscle strength did not increase for the exercise group; this is likely due to emphasis on improving muscle endurance rather than power during the exercise class.
This was further evidenced by the large effect size (d=0.98) and significant improvement in 6MWT in the exercise group. There was also a clinically meaningful and statistically significant reduction in falls in the exercise group which has implications for patient welfare and healthcare provision. We believe that exercise is essential for maintaining functional performance in LLAs. Completing the TUG quicker, and walking further in the 6MWT are indicative of increased gait speed, turning ability, and physical mobility. In conclusion, a multi-dimensional exercise programme has demonstrated positive results for improved gait endurance and falls prevention in community-dwelling LLAs.

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# PIONEERING INNOVATION IN PROFESSIONAL EDUCATION: AN HOLISTIC APPROACH TO POSTGRADUATE TEACHING IN AMPUTATION AND PROSTHETIC REHABILITATION

Mary Jane Cole

## BACKGROUND

There is a paucity of interdisciplinary postgraduate qualifications within the field of amputation and prosthetic rehabilitation for professions currently working in this area or would like to move into the field. The University of Southampton (UK) has engaged in an extensive process to develop a postgraduate pathway to target this professional development requirement. This paper presents the novel process of development and delivery, describing a holistic approach to postgraduate teaching in amputation and prosthetic rehabilitation.

## AIM

The aim was to develop quality education at postgraduate level that would be accessible to multiple disciplines, explore key practice and contemporary issues and engage key national stakeholders in its development.

## METHOD

The British Association of Chartered Physiotherapists in Amputee Rehabilitation (BACPAR) identified a need in their membership for a postgraduate level education course in this area. This national professional network advertised a call inviting all Higher Education Institutions (HEIs) in the UK to submit proposals for delivering postgraduate education. Eleven HEIs expressed interest, five of which subsequently submitted more detailed outlines of potential content and delivery. The BACPAR Education working group [1] evaluated each of the final proposals and the University of Southampton was selected to deliver a range of new and exciting learning opportunities in 'Amputee Rehabilitation and Prosthetic Use' [2].

## RESULTS

The team engaged national stakeholders and Patient, Public Involvement (PPI) representation in the development and validation of flexible and innovative multidisciplinary learning opportunities.

In collaboration with BACPAR and other external stakeholders, two new modules ('Amputation & Prosthetic Rehabilitation' and 'Contemporary Issues in Limb Loss') were designed with content relevant to all disciplines in this field. Provision was made to offer flexible learning opportunities (i.e. block week-end teaching), ranging from a single module to an MSc pathway in Amputation & Prosthetic Rehabilitation including exit awards at PGCert and PGDip levels. Students registered on the MSc pathway can also select options from across the University in areas such as diabetes and bio-engineering [3,4]. Since its launch in 2016, the course has delivered education to a multidisciplinary cohort including physiotherapists, occupational therapists, prosthetists and bioengineers from the UK and EU.

## DISCUSSION & CONCLUSION

The delivery of healthcare in a demanding and evolving specialist area, such as amputation and prosthetic rehabilitation, requires professionals to be highly knowledgeable and skilled. In addition they must be reflective and critical of their practice and the evidence base, and be able to communicate effectively in a multidisciplinary team. This stakeholder-led approach to design and deliver a professional postgraduate education has provided an integrated holistic learning platform for both National and International students.

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# SELF REPORTED ACTIVITY AND PARTICIPATION REHABILITATION IN PEOPLE WITH LOWER LIMB AMPUTATION

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Curtin University , Royal Perth Hospital

## BACKGROUND

Limited knowledge exists on long term outcomes of people with lower limb amputation for the domains of activity and participation1-3. Function is potentially limited by comorbidities and sequelae of amputation1,2. It is important to know whether outcomes achieved during rehabilitation are sustained after discharge for resource utilisation, service planning and funding.

## AIMS

1. To determine self reported activity and participation levels in people with lower limb amputation after rehabilitation discharge. 2. To investigate if return to driving and work were associated with variables including prosthetic use, age, diabetes, amputation cause, metropolitan residence, number of limbs and level of amputation.

## METHOD

Medical records were abstracted for 201 consecutive tertiary rehabilitation participants from Royal Perth Hospital, the state amputee rehabilitation centre. Charlson Comorbidity Index (CCI) scores were calculated for participants4. Participants were interviewed using the Locomotor Capabilities Index 5 (LCI5)5 and a questionnaire. Descriptive statistics were generated. Chi squared analysis was used to determine if the presence of dichotomous variables were associated (Confidence Intervals 95%) with return to driving or work.

## RESULTS

At median, 1.5 years (Interquartile range (IQR), 1.2 to 2.2) after discharge, 74% (149) of participants were prosthetic users. CCI score for the total cohort was median, 2 (IQR, 1 to 4). Table 1 summarises outcomes after amputation. A total of 45% (91) participants worked prior to amputation and 28% (56) of the total cohort had returned to paid work after amputation. Return to work was significantly associated with being a prosthetic user and transtibial amputation level (Positive likelihood ratio (+LR) < 2.36, p < .006). A total of 55% (111) returned to driving following amputation. Unilateral amputation, traumatic cause, not having diabetes and being a prosthetic user were significantly associated (+LR < 2.56, p < .0001) with return to driving.

**Table 1:** Outcomes after amputation.

| **Mobility** | **% (n)** |
|---|---|
| Wheelchair use | 71 (143) |
| **Total Locomotor Capabilities Index 5 (LCI5) Score** | **Median (IQR)** |
| Prosthetic users (n = 149) | 51 (41 to 56) |
| Return to work (n = 52) | 56 (54 to 56) |
| Return to driving (n = 96) | 54 (47 to 56) |
| **Sequelae of amputation** | **% (n)** |
| Residual limb pathology | 72 (144) |
| Remaining limb | |
| Pain | 49 (83) |
| Pathology | 44 (75) |
| Falls | 69 (139) |

## DISCUSSION & CONCLUSION

Return to work and driving were low but more likely in prosthetic users with good locomotor function. Wheelchair use and residual limb pathology were high. These findings will assist future model of care development.

## AKNOWLEDGEMENTS:
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# DIRECT NEURAL SENSORY FEEDBACK AND CONTROL VIA OSSEOINTEGRATION

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## BACKGROUND

Prosthetic technology has the potential to restore the functional lost after limb amputations. Osseointegration has been used over decades for the direct skeletal attachment of limb prosthesis resulting in proven improvements in prosthetic functionality and quality of life1. Control technologies on the other hand, had been limited to use surface electrodes and provide limited to no sensory feedback.

## AIM

We investigated the feasibility of creating a clinically viable, self-contained prosthetic system that allowed for direct skeletal attachment, neural control, and direct neural sensory feedback via neurostimulation.

## METHOD

The OPRA Implant System (Integrum AB, Mölndal, Sweden) was enhanced to provide bidirectional communication between implanted neuromuscular interfaces and external devices (osseointegrated human-machine gateway – OHMG), while preserving the original features that allow for osseointegration and stable percutaneous interfacing2. We designed an embedded system, named as Artificial Limb Controller (ALC), to read from the implanted muscular electrodes and translate myoelectric signal into prosthetic movements via direct control or pattern recognition. Artificial sensors in the prosthetic terminal device deliver signals related to grip force to the ALC, which in turns produce charge-balanced biphasic electric pulses to stimulate the afferent nerve fibers, thus producing the perception of tactile sensations. Grip force was encoded using frequency modulation.

## RESULTS

The OHMG was implanted in the first patient in January 2013 and continue functional until today. A first analogue version of the ALC for direct prosthetic control, and without neural sensory feedback, has been used by the patient since 3 weeks after implantation in activities of the daily living. The new digital version of the ALC in use since January 2017, which include direct neural feedback, has shown to improve controllability by allowing the patient to grab delicate objects, such as grapes or eggs, without damaging them while blindfolded.

**Figure 1.** Osseointegrated human-machine gateway (OHMG) providing bidirectional communication between the self-contained artificial limb controller (ALC) and implanted neuromuscular interfaces. The patient is capable to grab a grape blindly by receiving direct neural information from sensory embedded in the thumb of the hand.

## DISCUSSION & CONCLUSION

Here we present a clinical solution based on osseointegration and implanted neuromuscular interfaces (OHMG), along with the self-contained embedded system for both control and direct neural sensory feedback. This is the first neuroprosthetic system that allows both control and sensory feedback via implanted electrodes that can be safely used in activities of the daily living. This close-loop controlled neuroprosthesis is now used by patients and its efficacy will be monitored for at least two years in up to 18 patients to be implanted in 2017.

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# GAIT CHARACTERISTICS IN TRANSTIBIAL AMPUTEES AMBULATING WITH AND WITHOUT A MICROPROCESSOR-CONTROLLED HYDRAULIC PROSTHETIC ANKLE

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## BACKGROUND

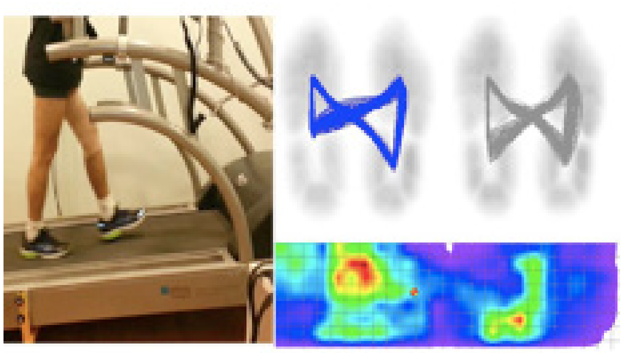
A prosthetic foot with a hydraulic ankle provides significant advantages for high level functioning amputees: improvement in symmetry and generally gait pattern that is closer to natural [1]. The hydraulic prosthetic ankle has recently been upgraded to include computerized control over the ankle movement. To date, hydraulic feet with and without computerized control have not been thoroughly compared. Specifically, the effects of a computerized ankle on various important factors have not been investigated yet, e.g. movement of the Center of Pressure (COP) and the patient's satisfaction.

## AIM

The aim of this study was to compare the aforementioned parameters while walking on flat or inclined surfaces.

## METHOD

Twelve traumatic transtibial (K3) amputees walked on a computerized treadmill (FDM-T, Zebris, Germany) set to 0° and ±5°. The 0° test was performed at normal velocity and 20% faster. The subjects were tested using their own non-computerized hydraulic ankle (Echelon, Endolite, UK) and retested after ambulating for 2-4 weeks with a computerized hydraulic ankle (Elan, Endolite, UK). The test included gait analysis and recording of surface pressure, and COP movement. The comparison included also patient's satisfaction and movement ability, evaluated by the PEQ-MS (Prosthesis Evaluation Questionnaire-Mobility Subscale).



In this figure, a subject walking on a treadmill [left frame] and the resulting movement of the Center Of Pressure [upper right frame] with the Echelon [blue] and Elan [gray], as well as the surface pressures [lower right frame]

## RESULTS

The symmetry of the COP path was evaluated using the Degree of Asymmetry (DoA) [2]. The DoA improved by 0.07 ($p=.021$) when using the computerized prosthetic ankle while ascending a slope.
The vertical forces measured by the computerized treadmill increased by 9.5% at the heel when using the computerized ankle while ascending a slope ($p=.007$) and increased by 9.2% while walking on a plane at faster velocity ($p=.034$). No differences in vertical forces were found while descending a slope or walking on a plane at a normal gait velocity.
The average score of the PEQ-MS questionnaire increased significantly when using the computerized ankle from 75.5 to 88.5 ($p=.001$). Specifically, the score improved by 20.6 and 28.1 points when the subjects rated their ability to walk up and down a steep hill, respectively.

## DISCUSSION & CONCLUSION

The improved symmetry in the COP path while ascending a slope reflects a more efficient transfer of weight over the ankle, resulting in agait pattern closer to normal. The increased force over the prosthetic heel while ascending slopes or walking fast, may be contributed to greater propulsive reaction forces and contribute to improvement in gait parameters.
To conclude, advantages of a computerized ankle were demonstrated, helping to better understand this new technology that active amputees may benefit from.

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# USING A C-MILL TO ENHANCE GAIT TRAINING AND EVALUATION OF TRANSFEMORAL AMPUTEE WALKING WITH MICROPROCESSOR KNEES

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## BACKGROUND

Learning to make fast avoidance reactions is important for amputees in order to reduce their fall risk [1] .The C-Mill (ForceLink, Netherlands) is a treadmill that uses visual and acoustic cues for training and evaluation of impaired gait and balance. Gait parameters (step width, Center of Pressure (COP) symmetry, etc) are automatically recorded. The system allows amputees to practice in daily challenging scenarios within a safe and controlled environment.

## AIM

Suggest the use of C-Mill for improving gait symmetry and balance in K2-3 Transfemoral Amputees walking with micro processor knees. Both as a training method as well as diagnostic tool.

## METHOD

1 Bilateral Transfemoral (TF), K2 mobility level amputee and 2 Unilateral TF, K3 mobility level were included. They were evaluated at the beginning and at the end of their initial gait training and after 3 months from their discharge. We used a test mode which lasts 8 minutes and consist of 5 different sections in which the amputee is training his gait patterns and learning avoidance strategies in a safe and controlled environment. We adjusted the treatment session variability in order to enhance the microprocessor knee's ability to change step length and walking speed as well as obstacle avoidance.

## RESULTS

Analysing the Bilateral TF amputee results, within the rehabilitation period, we observed better symmetry in the COP movement (see, Fig 1.) and also decrease in the step width from 0.3 to 0.265m. Spatio - temporal measurements were recorded as well.

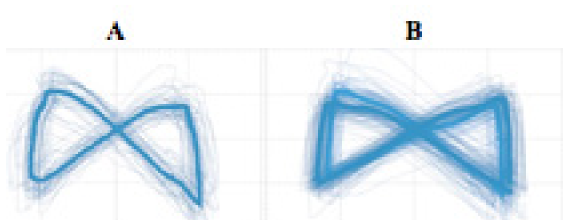


**Figure 1.** Example of COP movement of K2 bilateral TF amputee from initial assessment (A) and last assessment (B).

According to our analysis the Unilateral TF amputee missed less visual cues - a stepping stone (0.3m length and 0.15m width) after 15 minutes of practice of different tasks is presented in Fig 2.

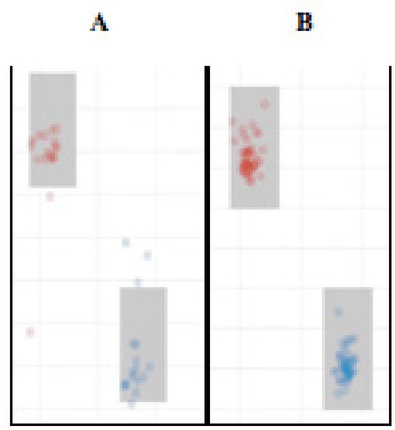


**Figure 2.** Example of missed stepping stones of K3 unilateral TF within treatment session. Beginning of treatment (A). End of treatment (B).

## DISCUSSION & CONCLUSION

Our preliminary observations support previous results with projected visual context in amputees (2). We believe that using a C-Mill offers a wider scope and higher level for gait training and evaluation for amputees during their rehabilitation period. It offers a more standard and precise protocol and better management of the amputee. As this method improves the learning process we suggest adopting it for routine use.

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# GEOGRAPHIC VARIATION IN THE INCIDENCE RATES OF LOWER LIMB AMPUTATION IN AUSTRALIA FROM 2007-2012.

Michael Dillon

## BACKGROUND

In Australia, little is known about how the incidence rate (IR) of lower limb amputation (LLA) varies across the country. Studies in countries with similar economic and health development, have shown considerable variation in the IR-LLA given that common risk factors are not equally distributed across populations, but rather geographically clustered. Factors such as age, sex, diabetes, socioeconomic- or Indigenous-status as well as remoteness may explain part of the variation between regions. Mapping variation of the IR-LLA is an important first step to identify geographic regions in greatest need and support the development of regional specific hypotheses for in-depth examination.

## AIM

The aim of this investigation was to describe the geographic variation in the IR-LLA across Australia and whether this has changed over time. Given our hypothesis that there would be significant geographic variation in the IR-LLA across Australia, we also sought to understand the influence that sex, age, diabetes and time had on the relative risk of amputation in each region.

## METHOD

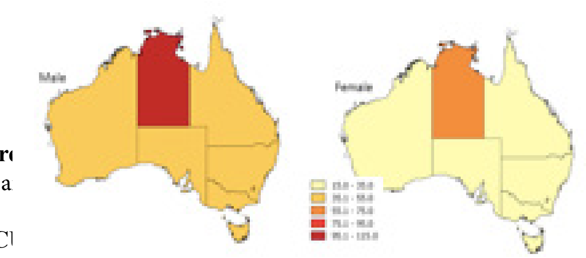
Using data from the Australian National Hospital Morbidity database and Australian Bureau of Statistics, the crude IR-LLA were calculated by dividing the number of LLA in a geographic region by the total population in that geographic region and expressed per 100,000 population. To enable comparisons between geographic regions without the confounding influence of different population structures, an age-standardised IR-LLA was calculated by the direct method for both men and women using the Australian Standard Population (June 30, 2001). Data were reported for the nation as well as each state and territory for the 2007/8 to 2011/12 financial years. To understand which factors influenced geographic variation in the crude IR-LLA, Generalised Linear Models were developed assuming quasi-Poisson distribution and an interaction term was fitted for the presence of type 2 diabetes and sex when significant ($p<0.05$).

## RESULTS

Across the time series, there were 35,306 LLA procedures nationally. The mean age at amputation was 63±15 years with 62% of people over 60 years of age. 67% of amputations occurred in males and 50% of people had a flag for type 2 diabetes. Most amputations were of the toe/s (43%) or other partial foot levels (29%). Transtibial (16%) and transfemoral amputation (12%) occurred in similar proportions.

Nationally, the crude IR-LLA was 32.4 per 100,000 population. The age-standardised IR-LLA was twice as high in males (40.3 per 100,000 population; 95%CI 39.8-40.8) as it was in females (19.9 per 100,000 population; 95%CI 19.5-20.2).

The age-standardised IR-LLA in males and females were very similar across most regions of Australia (Figure 1). The effect of older age, being male and the presence of type 2 diabetes was associated with an increase of IR-LLA in most states and territories. In the Northern Territory, the age-standardised IR-LLA in both males and females were higher than other regions (Figure 1). The younger age at time of amputation in the Northern Territory confounded the influence of sex and type 2 diabetes.




**Figur** lower
limb a

## DISC

The crude and age-standardised IR-LLA in males and females were similar across regions except for the Northern Territory. While age, sex, type 2 diabetes and time all had a significant effect on the relative risk of LLA, their influence varied across regions and as such, it is important that regional specific hypotheses can be developed to better understand what influences the relative risk of LLA.

Previous investigations have highlighted that the IR-LLA is often disproportionately high in regions with a large proportion of Indigenous people1 and this may, in part, explain the higher IR-LLA in the Northern Territory. It is likely that being an Indigenous Australian is a proxy for various determinants of health that, in turn, impact the risk of amputation2.

These observations are similar to that of Moxey et al. 3 whose investigation was the only other study that included all above- and below- ankle amputations irrespective of the cause of amputation and expressed the IR-LLA relative to 100,000 population. While many studies have shown larger variations in the IR-LLA across countries (3-10 fold), direct comparison was inappropriate given differences in the method design that affected the numerator or denominator, as an illustrative example.

To correctly interpret these results, it is important to note that each case reflects a hospitalisation with one or more surgical procedures, not an individual person. This approach artificially inflates the number of people affected by about 25% given the rate of repeat amputations. The IR-LLA reported in this study will also be overestimated relative to other investigations that only count first or major (i.e., above ankle) amputation.

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# HOW WELL CAN THE AMPUTEE MOBILITY PREDICTOR AND PATIENT DEMOGRAPHICS PREDICT THE MEDICARE FUNCTIONAL CLASSIFICATION LEVEL (K-LEVEL) IN PEOPLE WITH TRANSFEMORAL AND TRANSTIBIAL AMPUTATION? A PILOT STUDY.

Michael Dillon

## BACKGROUND

The Amputee Mobility Predictor (AMP) is frequently used to quantify mobility and aid categorization of people with lower limb loss into mutually exclusive K-levels. The assigned K-level influences the type of prosthesis that is considered medically necessary and the funding available for that prosthesis. While research has shown differences in the average AMP score between K-levels1, the known groups analysis does not demonstrate that the AMP can accurately predict K-level nor does it provide discrete cut-scores that would allow people with limb loss to be classified into mutually exclusive K-levels. There is considerable variability in AMP scores between K-levels1 that indicates the AMP is unlikely to be an accurate predictor of K-level. Given these concerns, and how widespread the AMP has become to categorize people into mutually exclusive K-levels, there is a pressing need to determine how accurately AMP score can predict K-level using more appropriate inferential analysis techniques.

## AIM

The aim was to determine how accurately the AMP could predict K-level. Given our hypothesis that the AMP is unlikely to accurately predict K-level, we also investigated whether including quantifiable patient characteristics (i.e., age, body mass, level and cause of amputation) would improve the accuracy of the prediction.

## METHOD

This retrospective review of data was exempted from Institutional Review Board oversight. Electronic medical records from Ability Prosthetics and Orthotics, Inc. (Exton, PA) were interrogated to identify all people with lower limb amputation (3.1.2013-7.31.2015) and obtain demographic and outcomes data recorded as part of routine clinical practice. A cumulative odds ordinal logistic regression model with proportional odds was used to determine how accurately the AMP, and the AMP in combination with other variables (i.e., age, body mass, level and cause of amputation) could predict the odds of being assigned to a particular K-level.

## RESULTS

The sample included 198 people with unilateral transtibial (TTA 70%) and transfemoral (TFA 30%) amputation described by: age (60±16 years), stature (1.74±0.12 m), body mass (86.5±23.4 kg) and K-level (K1, 3%; K2, 37%; K3, 51%; K4, 9%). Cause of amputation was dichotomized into dysvascular (75%) or non-dysvascular causes (25%). Used in isolation, the AMP significantly predicted K-level over the intercept-only model, $\chi^2(1)=148.70$, $p<0.000$ (Table 1). Each one-point increase in the AMP increased the odds of being in a higher K-level (OR 1.30; 95%CI 1.22-1.37). For those assigned to the K2 or K3 level by their treating clinician, the AMP predicted the same K-level a large percentage of the time which was not the case for people assigned to the K1 or K4 level by their treating clinician (Table 1, bold figures).Inclusion of additional variables into the model had little effect on the accuracy of the prediction; except for those assigned to the K4 level by their treating clinician where agreement between the predicted and clinician assigned K-level increased from 11% to 39%. The effect of the AMP remained unchanged by the additional variables. Each one-year increase in age reduced the odds of being in a higher K-level (OR 0.94; 95%CI 0.91-0.97). For people with TTA, the odds of being in a higher K-level were one-third that of people with TFA (OR 0.34; 95%CI 0.15-0.76). For people with non-dysvascular amputation, the odds of being in a higher K-level were larger than those for people with dysvascular amputation (OR 1.49; 95% CI 0.50-4.48), but highly variable and not significant. Increased body mass did not alter the odds of being in a higher K-level (OR 0.99; 95%CI 0.98-1.01).

| | | Predicted K-level | | | |
|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 |
| Clinician Assigned K-level | 1 | **20% (1)** | 80% (4) | 0% | 0% |
| | 2 | 2.7% (2) | **79.7% (59)** | 17.6% (13) | 0% |
| | 3 | 0% | 11.9% (12) | **88.1% (89)** | 0% |
| | 4 | 0% | 0% | 88.9% (16) | **11.1% (2)** |

**Table 1.** Proportion (and number) of cases where the clinician-assigned and predicted K-level agree (bold).

## DISCUSSION & CONCLUSION

Used in isolation, the AMP was a very good predictor of the K2 and K3 level assigned by the treating clinician. This was not true for people assigned to the K1 or K4 levels by their treating clinician. The inclusion of additional variables into the model had little effect on the accuracy of the prediction, except for those assigned to the K4 level, where agreement between the predicted and clinician assigned K-level improved. While the influence of age and AMP score were as expected (i.e., larger AMP scores and younger age were associated with a significant increase in the odds of being assigned to a higher K-level) this was not true for effect of cause and level of amputation.

While non-dysvascular amputation increased the odds of being assigned to a higher K-level, the effect was highly variable and therefore not statistically significant. The effect of amputation level may be biased by the study sample given that as K-level increased, so too did the proportion of people with TFA.
Further research is required to understand the true effect of level and cause of amputation as well as determine whether other factors (e.g., Charleston Comorbidity Index) can improve the accuracy of the prediction. Larger and more representative samples at the K1 and K4 levels are required.

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# MOTION RECOGNITION METHOD BASED ON EMG SIGNALS FOR INTELLIGENT LOWER LIMB PROSTHESIS CONTROL

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## BACKGROUND

The electromyographic (EMG) signal can directly reflect movement intentions and occur prior to movement, so become a good source for intelligent prosthesis control. EMG signals applied on the upper limb prosthesis has been mature [1,2], but the method for lower limb prosthesis control is still in exploratory stage[3]. The movement of traditional lower limb prosthesis mainly relied on residual limb, so user's energy consumption is high[4,5]. But for the powered prosthesis, the electricity supply is a problem.

## AIM

To research a motion recognition method based on EMG signals used for lower limb prosthesis control which run passively in normal walking and provide active power in strenuous action, so that to save both electricity and users' energy.

## METHOD

Several thigh amputees were selected as subjects and required to complete kinds of motions including flat walking, up stairs, down stairs, stand up and sit down. The surface EMG signals from six muscles of the thigh stump were collected from each subject, including rectus femoris, vastus lateralis, tensor fascia lata, biceps femoris, semitendinosus and gluteus maximus. After wavelet denoised and effective action extract, the integrated EMG (IEMG), root mean square (RMS), standard deviation (STD), wavelength (WL), average frequency (MPF) and median frequency (MF) were calculated and the motion modes were recognized based on the support vector machine (SVM).

## RESULTS

The data from one subject and several different subjects were respectively used for pattern recognition and all the EMG features of six muscles were used as feature vectors. Then the features were reduced to improve the operation speed by calculating the feature correlation. The recognition results showed in Table 1.

By further reducing the amount of muscle, two features of three muscles (RF□ST□GM) were eventually used for recognition. For the same subject, the accuracy for five modes reached 92%. During the lower limb motion, different movement modes can be recognized in real time so that the prosthesis can be controlled in different way. When walking, the prosthesis walks in passive way. When up or down stair, stand up or sit down, the prosthesis exercises in active way and provides power.

| | | 3 modes | 5 modes |
|---|---|---|---|
| same subject | 6 features | 98.33% | 94% |
| | 2 features | 96. 67% | 92% |
| different subjects | 6 features | 93.33% | --- |
| | 2 features | 95% | --- |

*3 modes(flat walking, up stairs, down stairs)
5 modes(flat walking, up stairs, down stairs, stand up, sit down)
6 features(IEMG, RMS, STD, WL, MPF, MF)
2 features(RMS, MPF)

**Table 1.** Recognition accuracy for different modes using 6 muscles

## DISCUSSION & CONCLUSION

Five kinds of lower limb motions including flat walking, up stairs, down stairs, stand up and sit down, can be recognized by the EMG signals of thigh stumps. According to different motions, the prosthesis uses different control modes, so that to save electricity in normal walking and provide active power in strenuous action. Next, the method of dividing different stages of the five action modes using EMG signals will be studied for finer control.

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# IMPLICATION OF UNLOADER BRACES IN GUIDELINE RECOMMENDED KNEE OA MANAGEMENT- AN EXPERT CONSENSUS

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## BACKGROUND

Guidelines for the treatment of knee osteoarthritis have been published by a number of expert groups. Recently, OARSI (Osteoarthritis Research Society International) published their recommendations for the non-surgical treatment of knee osteoarthritis. Besides core treatments including patient education, weight management and activity, biomechanical interventions such as insoles or unloader braces are recommended by these guidelines. .

## AIM

The goal was to provide a tool which helps medical professionals to select the right patient and to provide a guidance for when and how to use an unloader brace for different patient types

## METHOD

27 Experienced physicians discussed these questions in-depth and developed corresponding suggestions to achieve the best possible treatment outcome for the following patient groups: the younger knee osteoarthritis (OA) patient, the active & demanding knee OA patient and the older knee OA patient. Questionnaires on current practice of conservative management of symptomatic knee OA were used to prepare F2F OA experts from the US and Canada. The questionnaires were analyzed. Based on this feedback, a meeting was conducted and results of the questionnaires were discussed intensively. Within this discussion, the experts agreed patient group specific treatment recommendations, which have been consented thereafter in two Delphi rounds.

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## RESULTS

Recommendations have been made on how to manage patient´s expectations, which patients will most likely benefit from an unloader brace and how to implement an unloader brace in the management of knee OA. In order to be able to provide specific recommendations three different patients groups have been defined:

The younger knee OA patient, the active and demanding knee OA patient and the older knee OA patient. For those three patient groups the experts concluded on detailed recommendations on the how to treat knee OA the acute, subacute and chronic/ ongoing phase of knee OA (Table 1).

**Table 1.** Example Treatment recommendation for the active and demanding knee OA patients.

## DISCUSSION & CONCLUSION

The expert consensus approach was utilized to translate knee OA treatment recommendations and guidelines from international societies down to the patient´s needs in daily orthopedic and sports medicine practice. By dividing the patients in three different groups patient specific treatment recommendations have been established based on the existing clinical evidence and can be applied in daily practice. An expert consensus can be useful in order to support medical professionals in daily practice as they can offer a more practical patient centric treatment recommendation regarding the use of an Unloader Brace within knee OA management.

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# THE EFFECT OF USING A WERABLE SOFT-ROBOTIC GLOVE FOR GRIP STRENGTH SUPPORT IN DAILY LIFE PERFORMANCE

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## BACKGROUND

Elderly often suffer from reduced grip strength due to sarcopenia or age-related diseases. This can result in difficulties with activities of daily living (ADL). Therefore, elderly may need assistance in ADL to compensate for the loss of hand function. The ironHand (iH) system is a wearable assistive glove that supports grip during daily activities. The device is developed through a user-centred process and has already shown promising results regarding user acceptance [1].

## AIM

As a next step, the present study aims to evaluate the direct effect of the third iteration of the assistive iH system on functional task performance, in addition to user acceptance.

## METHOD

In this multi-centre cross-sectional study, 65 elderly (>55 years) who experienced reduced dominant hand function in daily life were included. After getting acquainted with the iH system, participants performed a maximal pinch grip test (3 attempts) and a standardized drinking task (1 attempt) both with and without the iH system. The order of glove use for both tests was randomized. At the end of the evaluation session, system usability was assessed by using the System Usability Scale (SUS). The difference between performance with and without glove was assessed with the paired sample t-test. The significance level was set at $\alpha \leq 0.05$.

## RESULTS

Maximal pinch grip was larger, while performance duration of the drinking task was higher with the glove compared to without the glove (see Table 1). Additionally, 61 participants completed the SUS, showing a mean score of 72.17 (SD=17.11). This indicates a good probability of acceptance of the iH system in daily life.

**Table 1.** Outcome measures (n=65)

| | without glove | with glove | significance |
|---|---|---|---|
| Pinch grip between thumb – index finger (kg)[a,b] | 3.95±2.44 | 4.39±2.46 | p=0.001 |
| Pinch grip between thumb – middle finger (kg)[a,b] | 3.38±2.13 | 3.84±2.07 | p<0.001 |
| Drinking task (seconds)[a,c] | 27.54±10.30 | 34.01±15.84 | p<0.001 |

aMean ± Standard Deviation; bMissing data of 2 participants; cMissing data of 3 participants

## DISCUSSION & CONCLUSION

The results of this study show that the assistive iH system improves grip strength. This didn't reflect in a better functional task performance in terms of movement duration, although participants did report a positive experience regarding support during those tasks. This is supported by a high score on usability, which is comparable to other studies [2,3]. Therefore, further analysis into more qualitative aspects of movement execution is ongoing. In addition, the current user input informs another round of design adaptations of the system.

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# DEVELOPMEN OF A GIAT SUPPORT ORTHOSIS WITH A LOWER THIGH ROTATION MECHANISM FOR PATIENTS WITH SEVERE OSTEOARTHTITIS

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## BACKGROUND

Knee osteoarthritis (knee-OA) has been estimated that approximately one of two people may experience it by the age of 85 [1]. Most cases of knee-OA lead to a gait problem due to pain during walking, with the result that knee-OA is a significant cause of reduced personal quality of life (QOL). One of the characteristics of knee-OA is rotation dyskinesia of the knee joint due to the degeneration of the system around the knee [2]. Patients with severe knee-OA who have some rotation anomaly generally cannot use any knee support orthosis because their pain may increase if there is any displacement of the orthosis.

## AIM

In the present study, we focused on the rotation of the lower thigh relative to the movement of the ankle joint during walking, and we developed a walking support orthosis of the new type of ankle-foot orthosis (AFO), which induces rotation of the lower thigh in conjunction with the movement of the ankle joint.

Figure 1. Proposed Walking Support Orthosis with Lower Thigh Rotation Mechanism.

## METHOD

In order to induce rotation of the lower thigh, we adjust the orthosis with a screw on the rod of the articulated ankle joint so that this mechanism creates different timing of the contact of the tip of the rod and the foot plate for the inside and the outside of the bars, respectively. The amount of inclination of each bar then creates a difference in conjunction with the movement of the ankle joint. Therefore, this mechanism induces rotation of the lower thigh. The walking support orthosis we developed is shown in Figure 1. This mechanism creates internal rotation of the lower thigh during flexion of the ankle joint upon heel strike, and then creates external rotation during extension of the ankle joint until toe off. In addition, we made a cuff (soft tissue) and a corrugation to the lower thigh, so that rotation power to the skin was improved. We verified the effectiveness of the developed orthosis by measuring the amount of rotation while a subject performed the stance phase.

## RESULTS

Our experimental results show that without orthosis, the lower thigh rotates externally until a standing middle period, and then rotates internally. With our developed orthosis however, the lower thigh rotates internally upon heel strike, then externally until toe off. That is, the rotation movement with our developed orthosis is consistent with normal movement.

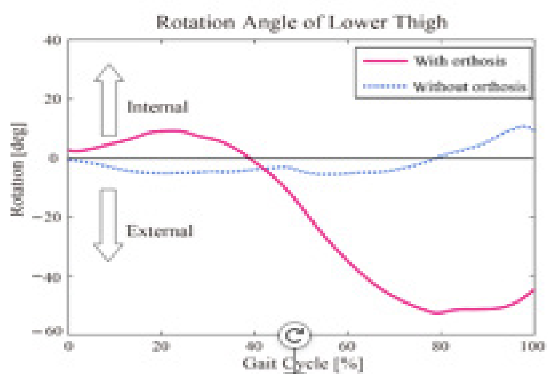


**Figure 2.** Rotation angle of the lower thigh during the stance phase, which begins at heel strike and continues until toe off.

## DISCUSSION & CONCLUSION

We confirmed that our proposed orthosis helps to induce correct gait motion, especially from heel strike to toe off. Moreover, this mechanism induces rotation of the lower thigh in conjunction with extension and flexion of the ankle joint, so that the developed orthosis requires no external forces, such as motors. In future research, we will verify the effectiveness of the developed orthosis by observing the behavior of the bone during walking.

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# WIRELESS and EMBEDDED CONTROLLER CARD DESIGN for ABOVE-KNEE PROSTHESIS with PNEUMATIC DAMPER

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## BACKGROUND

The robotic prosthesis control is a unit and associated method for ensuring the restoration of the mobility of amputee with loss of limb. In order to apply various heavy control strategies, one has to develop a capable controller card with good configuration and high computation ability. The control strategies could broadly be divided into two major categories, namely continuous time control and discrete event based control as presented in this paper. The studies over control strategies of knee prosthesis have been recorded around 1970's [1]. Impedance based control is an approach used to control the dynamic interactions between the environment and a manipulator. Zlatnik et. al. developed a nonanalytic (soft) finite state control method for a electronically controlled trans-femoral (TF) prosthesis. In the proposed prototype card sensing, microcomputer based electronics, and a servo controlled knee damper should be integrated and successfully tested in the clinic [2]. A finite-state control based above knee prosthesis with pneumatic cylinder was already designed and presented in our previous studies. Following this phase, an embedded controller card with a wireless data transfer unit, a floating point microprocessor and an inertial measurement sensing unit becomes an important design stage.

## AIM

The aim of the study is to develop a wireless, embedded microcontroller based data acquisition card with proper algorithms in order to gain an adaptive capability for coping with various control strategies for all phases of the gait.

## METHOD

The designed above knee prosthesis incorporates a microcontroller unit, a sensing unit and pneumatic cylinder actuator in order to adjust the stiffness of the gait according to relevant gait phases. Real time closed loop control mechanism, given in Figure 1, can conform to 2 phases, 3 phases and 5 phases scenario, that can be selected by the clinician based on verbal expression of the amputee and measured gait kinematics. The card developed for applying control scenarios is produced as a prototype as shown in Fig.2. These gait kinematics are derived by image based motion measurement system, developed in Biomedical Laboratory of Hacettepe University, Turkey.

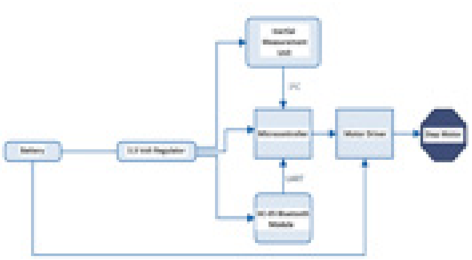

**Figure 1**. Real Time Closed Loop Control Mechanism

Electronically controlled knee is programmed to detect gait phases in order to achieve functional requirements such as preserving sufficient stability during stance phase, damping during swing phase, and flexibility just after heel strike to absorb the ground impact. Phase and speed estimation algorithm covers a dynamic normalization of the filtered gyroscope data and utilizes a 6-level non-uniform quantizer.

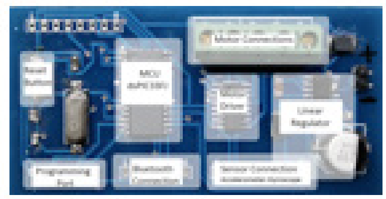

**Figure 2.** Developed Control Card (Top view)

## RESULTS

The performance test of the card and the algorithm embedded are conducted with five subjects by using image based motion measurement system. In Figure 3, knee angle results are given to show an example for the performance of the wireless embedded system in swing phase of the gait at one cycle.

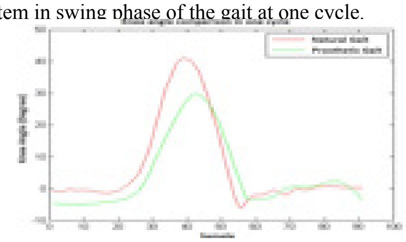

**Figure 3.** Knee angles derived from Motion Measurement System

The self-contained prosthesis can adapt itself to particular conditions, gait speeds and phases by means of impedance-adjustable pneumatic cylinder through a step motor controlled by microcontroller.

## DISCUSSION & CONCLUSION

In this study, wireless, embedded, electronically controlled above knee prosthesis control card design is presented and some gait performance analysis results are shared. The results show that developed prosthesis prototype reveals prominent results especially on the swing phase in various gait speeds.

## ACKNOWLEDGEMENT

This study is supported by the Scientific and Technological Research Council of Turkey by project number 112E316.

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# FEASIBILITY STUDY USING AN ORTHOSIS: AN APPROACH TO MEASURING THE RELATIVE MOVEMENTBETWEEN RESIDUAL LIMB AND PROSTHETIC SOCKET IN DYNAMIC GIAT SITUATION

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## BACKGROUND

The relative movement between residual limb and prosthetic socket is an important factor in quantifying socket fit. Little relative movement is used as an indicator for good socket control [1], and the occurrence of relative movement is further made responsible for skin irritation [2]. The measurement of the relative movement in dynamic gait situations poses a challenging task. In previous work, a sensor concept based on an optical 2D-motion sensor is presented [3] and its potential as well as useful sensor-liner configurations and sensor characteristics are assessed on a test-rig [4].

## AIM

The aim of this study is to assess sensor functionality during human gait, providing information about the feasibility of measuring the relative movement between residual limb and prosthetic socket with the sensor.

## METHOD

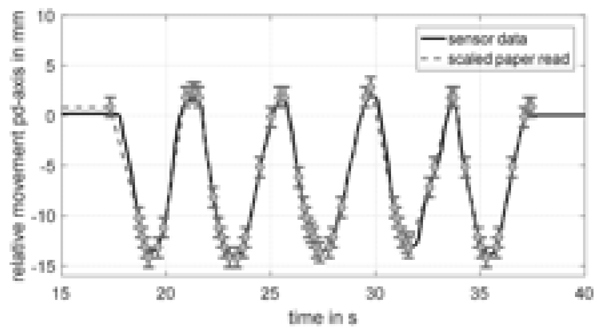
Two healthy subjects (male, 24.5 ± 0.7 yrs., 185 ± 22 cm, 75.5 ± 16.26 kg) perform tasks wearing a GO UP OPEN knee orthosis with an attached sensor unit. A cuff of MEDI LINER RELAX material is worn on the shank, serving as measurement surface for the sensor [4].

In a preliminary test, subjects perform unloaded knee bends. The sensor is attached elastically between the highest and lowest strap of the orthosis, performing a movement along the pd-axis of the shank. To assess sensor performance, scaled paper is attached to the shank next to the sensor and the movement is recorded with a PENTAX K5 camera. Data is evaluated offline via manual visual read of the scaled paper. The main test scenario is gait on a treadmill. To ensure a gaitinduced relative movement of the shank within the knee orthosis in early swing-phase, the knee joint is locked at 30° flexion. Each subject performs 100 gait cycles at three different treadmill velocities (0.85 ± 0.2 m/s).

The sensor is attached on the lateral splint of the orthosis, detecting movements in the sagittal plane of the shank within the orthosis.

## RESULTS

The results of one set of the first scenario (unloaded knee bends of subject 1, 0.25 Hz) are representatively shown in fig. 1 (top). To meet the accuracy of the scaled paper read an error bar of ± 1 mm is introduced. In the figure, the five knee bends of subject 1 can be assigned to the collected sensor data: showing a repetitive movement of 1.5 cm. The results of the main test scenario are summarized in a table (see fig. 1 (bottom)). Mean and standard deviation of peak-topeak relative movement as well as first harmonic of the Fourrier Transformation (FFT) of the sensor data (registered stride frequency) are given.




| Gait velocity in m/s | Movement in mm ap / pd direction | | Gait frequency according to FFT in Hz | |
|---|---|---|---|---|
| | Subject 1 | Subject 2 | Subject 1 | Subject 2 |
| 0.6 | 4.73±1.10<br>1.54±0.34 | 0.73±0.16<br>0.21±0.08 | 0.68 | 0.69 |
| 1.0 | 6.70±0.82<br>2.26±0.27 | 1.15±0.22<br>0.40±0.14 | 0.85 | 0.85 |
| 1.4 | 7.61±1.41<br>2.80±0.28 | 1.87±0.34<br>1.12±0.21 | 0.96 | 0.97 |

**Figure 1.** Results for described test scenarios: Representative plot of sensor data and video review for preliminary tests (top) and summary of sensor data (bottom).

## DISCUSSION & CONCLUSION

Sensor data match video data: sensor data remains within the error bar (see fig. 1 (top)). The induced relative movement exceeds the one expected between residual limb and socket. For treadmill gait, the sensor data show a tendency towards greater relative movement at higher frequency with increasing gait velocity, which is biomechanically plausible. Measuring reference values considering sensor performance was not applicable. Nevertheless, the combination of results for the different scenarios indicates the feasibility of measuring the relative movement of residual limb and prosthetic socket in dynamic gait situations with the assessed sensor unit.

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# A QUALITATIVE RATING SYSTEM OF COMPENSATORY MOVEMENTS IN UPPER LIMB PROSTHESIS WEARERS DURING WORK RELATED TASKS: RELIABILITY AND FEASIBILITY TESTING

Tallie M.J. van der Laan[1], Corry K. van der Sluis[1], Sietke G. Postema[1], Michiel F. Reneman[1], Raoul M. Bongers[1]

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## BACKGROUND

Musculoskeletal complaints (MSC) are twice as prevalent in persons with an upper limb defect compared to the general population. Overuse of the sound limb or compensatory movements of the affected limb may explain this difference.

## AIM

To develop 1) a qualitative scoring system for rating compensatory movements in upper limb prosthesis wearers during the performance of functional capacity evaluation tests adjusted for one handed individuals (FCE-OH), and to determine 2) the inter- and interrater reliability and 3) the feasibility of the scoring system.

## METHOD

The scoring system was developed in three subsequent steps following an international guideline for instrument development. Twelve (inter-) national FCE-experts, 6 physiotherapists, 12 upper limb prosthesis wearers, and 20 healthy controls were involved in the development. During reliability testing the raters scored videotapes of participating upper limb prosthesis wearers and controls, performing 4 FCE-OH tests two times (two weeks apart), using the developed scoring system. Feasibility was determined by using a questionnaire.

## RESULTS

Kappa value for intrarater reliability was 0.77. Kappa values for interrater reliability in the first and second rating sessions were $\kappa=0.54$ and $\kappa=0.64$, respectively. Feasibility was rated as good to excellent. Raters advised to provide a short training to improve rating further.

## DISCUSSION & CONCLUSION

A feasible scoring system was developed to assess compensatory movements in upper limb prosthesis wearers when executing FCE-OH tests. Intrarater reliability was good, interrater reliability was satisfactory in most instances. A training guide should be added to further improve rating. The standardized scoring system for assessing compensatory upper limb movements during performance of FCE-OH tests may provide clinicians with useful information for prevention and treatment of MSC in upper limb prosthesis wearers.

# CBR WORKER'S PERCEPTIONS OF WHEELCHAIR PROVISION AND USE IN UGANDA

Nicky Seymour, Motivation Charitable Trust

## BACKGROUND

Wheelchair provision in less-resourced settings face significant challenges. Global efforts to affect change include the WHO Guidelines on provision of manual wheelchairs in less resourced settings and the WHO wheelchair training resources. In contexts with shortage of professional wheelchair service providers and where community-based rehabilitation (CBR) is implemented CBR workers have a role to play. The exact nature and impact of their role requires further understanding.

## AIM

To determine what CBR workers in three areas of Uganda perceive as challenges with wheelchair provision and use; and the role they can play in overcoming this.

## METHOD

This qualitative, participatory study in the transformative paradigm gathered perceptions of twenty one CBR workers through three focus groups, in the north, west and central regions of Uganda. Purposive sampling was used to identify CBR workers, connected with community organisations in target areas with access to a wheelchair service. Data was transcribed and analysed using thematic analysis. Additional qualitative feedback was gathered via interview following implementation of recommendations.

## RESULTS

CBR workers provided rich observations reflecting domains of the International Classification of Functioning, Disability and Health (ICF). Limited availability of appropriate products and services; financial constraints of PWD and wheelchair services; and particularly historical and societal influences on attitudes are perceived to affect utilisation of services and mobility of PWD. Participation is further influenced by inadequate skills in wheelchair use and few role models; limited durability of products and environmental barriers. CBR workers suggested strategies consistent with the CBR matrix to increase referral, enhance use and care of a wheelchair and increase community inclusion. To strengthen implementation of their role training and closer partnership with wheelchair services was identified as a need. Positive change was reported by CBR workers following receipt of training and further challenges were however exposed.

## DISCUSSION & CONCLUSION

Contextual challenges to wheelchair provision and use in less-resourced settings would benefit from involvement of CBR workers. Historical approaches to wheelchair provision significantly impact community attitudes and require informed CBR input to increase uptake of services and optimal use of a wheelchair for participation. Training, collaboration with wheelchair services and financial resources would aid CBR workers in implementing their perceived role. Additional efforts are required to increase availability and accessibility of appropriate wheelchairs and services.

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## REFERENCES

This is optional, but necessary if you build on previous work. Very short style is common in abstracts, meaning:

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2. World Health Organization (WHO), 2010, Community based rehabilitation guidelines. WHO press. Geneva

# MUSCULOSKELETAL COMPLAINTS IN INDIVIDUALS WITH FINGER OR PARTIAL HAND AMPUTATIONS: PREVALENCE, IMPACT AND PREDICTORS

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## BACKGROUND

Inidividuals with major upper limb amputations (wrist disarticulation or more proximal) experience twice as much musculoskeletal complaints (MSC) in neck, back, unaffected limb and affected shoulder or elbow compared to able-bodied persons (1). For individuals with finger amputations or partial hand amputations there is no information on MSC following the amputation(s). Such knowledge is necessary to guide treatment of these patients in order to prevent the development of MSC.

## AIM

1. To compare the four-week and year-prevalence of musculoskeletal complaints (MSC) in individuals with finger or partial hand amputations (FPHA) with a control group. 2. To explore the impact of MSC on daily life. 3. To identify predictors of MSC in individuals with FPHA.

## METHOD

Cross-sectional study using a questionnaire including patient characteristics, amputation and prosthesis details, employment status, health status, health care consumption, musculoskeletal complaints, disability, hand function and cosmetic appearance. Previously collected data on MSC from individuals without upper limb amputation were used as a control group (1).

## RESULTS

In total, 104 individuals with FPHA and 108 controls were included. The response rate was 61%. No significant differences were found between individuals with FPHA and controls in the four-week-prevalence of MSC (33% vs. 27% respectively) or year prevalence (37% vs. 34% respectively). Individuals with FPHA experienced more pain compared to controls, they gave a higher rating to their pain and they consulted more health care professionals. Two clinically relevant predictors of presence of MSC in individuals with FPHA were found: limited range of motion (ROM) of the wrist of the affected limb presence and stump sensations.

## DISCUSSION & CONCLUSION

Prevention of MSC in individuals with FPHA does not seem to be specifically necessary, since the prevalence figures of patients did not differ from controls. However, special attention is needed for the risk of developing MSC in patients with limited ROM of the wrist of the affected limb or stump sensations. Future research in individuals with FPHA should focus on the role of wrist movements in the development of MSC.

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# EFFECT OF VARYING ANKLE FOOT ORTHOSIS STIFFNESS ON GIAT BIOCHEMICAL AND WALKING ENERGY COST IN PATIENTS WITH NEUROMUSCULAR DISORDERS EXHIBITING CALF MUSCLE WEAKNESS

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## BACKGROUND

Gait of patients with calf muscle weakness is often characterized by excessive ankle dorsiflexion and a reduced ankle push-off which may increase walking energy cost (EC). To compensate for calf muscle weakness, a spring-like ankle-foot-orthosis (AFO) can be provided. However, simulation studies have shown that the efficacy of spring-like AFOs to improve gait is stiffness dependent 1. Whether this also applies to patients with calf muscle weakness and how varying AFO stiffness affects gait in these patients is still unknown.

## AIM

The aim of this study was to determine the effect of varying the AFO stiffness on gait biomechanics and walking energy cost and speed in patients with neuromuscular disorders and subsequent calf muscle weakness.

## METHOD

Twenty-four neuromuscular disease patients exhibiting calf muscle weakness participated (13 male, mean age: 57±15, MRC calf strength: median 3 (range 0-5)). Participants were provided with a custom made footplate and calf shell in which five replaceable carbon leaf springs (CA7, Otto Bock, Germany) with a different degree of stiffness (k) could be placed, ranging from flexible (k1 = 2.5 Nm/degree) to stiff (k5= 6.2 Nm/degree). For each stiffness condition and for shoes only, a 3D gait analysis was performed to assess gait biomechanics (peak ankle dorsiflexion and ankle power during stance), and walking energy cost and speed was assessed during a 6-minute walk test at comfortable speed with simultaneous gas analysis.
Differences between the conditions were tested using a repeated measures ANOVA and t-tests with Bonferroni adjustments.

## RESULTS

Peak ankle dorsiflexion reduced compared to shoes-only when wearing the AFO, and it reduced more with increasing AFO stiffness. Peak ankle power also reduced with increasing AFO stiffness (both $p<0.001$, see Table 1 for post-hoc analysis). Walking with the AFO (all conditions) significantly reduced walking energy cost by at least 15% and increased walking speed by at least 18% compared to shoes only ($p<0.05$ for all conditions). However, no effect of varying AFO stiffness on walking energy cost or speed was found ($p=0.163$ and $p=0.132$, Table 1).

**Table 1**: effect of AFO stiffness on ankle dorsiflexion, ankle power and walking energy cost

| Stiffness (Nm/degree) | Ankle dorsiflexion angle (degrees) | Ankle power (W/kg) | Walking energy cost (J/kg/m) (%reduction compared to shoes) | Walking speed (m/s) (%reduction compared to shoes) |
|---|---|---|---|---|
| Shoes | 19.4±5.4$^{5}$ | 1.03±0.97 | 5.22±1.22 | 0.88±0.25 |
| K1 (2.5) | 17.4±4.9 $^{4,5}$ | 1.55±0.56 $^{4,5}$ | 4.32±0.88$^{s}$ (-17.6%) | 1.07±0.17$^{s}$ (+22.7%) |
| K2 (3.3) | 16.1±5.4 $^{4,5}$ | 1.51±0.53 $^{4,5}$ | 4.22±0.89$^{s}$ (-19.7%) | 1.07±0.17$^{s}$ (+22.7%) |
| K3 (4.2) | 15.6±6.7 | 1.43±0.56 $^{5}$ | 4.32±0.88$^{s}$ (-17.4%) | 1.06±0.20$^{s}$ (+20.5%) |
| K4 (5.1) | 14.2±4.8 $^{1,2}$ | 1.29±0.53 $^{1,2,3}$ | 4.41±0.84$^{s}$ (-15.9%) | 1.04±0.19$^{s}$ (+18.2%) |
| K5 (6.2) | 12.7±5.0$^{1,2,4}$ | 1.10±0.52$^{1,2,3,4}$ | 4.37±1.00$^{s}$ (-16.8%) | 1.04±0.17$^{s}$ (+18.2%) |

1= differs significantly from K1, 2= differs significantly from K2, 3= differs significantly from K3, 4= differs significantly from K4, 5=differs significantly from K5, s=differs significantly from shoe condition

## DISCUSSION & CONCLUSION

Increasing AFO stiffness reduced maximal ankle dorsiflexion but also negatively affected ankle power in patients with calf muscle weakness. Compared to shoes AFOs improved walking energy cost and speed but no effect of varying AFO stiffness was found, most likely because optimal AFO stiffness differs between patients and inadequate power. To maintain ankle power patients should be provided with the lowest sufficient AFO stiffness for normalizing ankle dorsiflexion. This stiffness may depend on patient characteristics like calf muscle strength, but further research into which characteristics determine this stiffness is needed.

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# A NEEDS ASSESSMENT FOR PROSTHETICS AND ORTHOTICS SERVICES IN LIBYA

Almissalati N[1], Badi A[1] ,Atetalla K[1], Fiasel Kubti[1], , Zada D[1], Zada A[1], Elgabaly F[1], Alzin K[1], Nagem M[1], Mangoush H[1], Sexton S[2], Figgins E[2].

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## BACKGROUND

Libya's health system infrastructure is weakened by conflict and disinvestment. This history has led to a growing burden of disability in the country. People with limb amputations or impairment are unable to exercise their human rights to access essential rehabilitation services. Tatweer Research, active in developing Libya's knowledge economy, identified this challenge as an area for development and commissioned a needs assessment study of the current situation about prosthetics in Libya.

## AIM

To understand development needs for prosthetics and orthotics services in Libya.

## METHOD

The study method involved nine researchers who, in partnership with the University of Strathclyde and St John's Innovation Centre Ltd, conducted a literature scoping review; interviews with key stakeholders, field visits; two face-to face workshops; and strategic analysis. A framework of analysis was developed based on work done by the World Health Organization on health systems strengthening [1] and the Global Cooperation on Assistive Technology. This framework considered the four elements of prosthetics and orthotics systems as being "the 4Ps", namely; policy, provision, personnel and product.

## RESULTS

A policy analysis found insufficiency in disability related Libyan law, causing more isolation for people with disability and subsequently a greater burden to the state budget, as a result of unfair regulation. Provision was uncoordinated with low coverage for at least 5,127 amputees and 20,215 people with limb impairments [2], and these numbers are projected to grow because of non-communicable diseases like diabetes [3]. Personnel issues included workforce shortages with an aging workforce profile with very limited development opportunities. Although staff worked in adequate facilities there were few products or materials available for them to work with. People with disabilities in Libya had inequitable access to prosthetics and orthotics services.

## DISCUSSION & CONCLUSION

Health systems strengthening [1, 4] is needed for all four pillars of service, namely: policy; provision; personnel and products. This study provides new information about the current situation in prosthetics and orthotics services in Libya and the associated need for service improvements. It provides a starting point for strategic planning and has the potential to stimulate interest from the international community to support access to priority assistive technologies.

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# SPRING-MASS BEHAVIOUR DURING UNILATERAL TRANSTIBIAL AMPUTEE RUNNING: EFFECTS OF VARYING BLADE STIFFNESS'

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## BACKGROUND

Spring-mass models are simple mechanical models that have been used to characterize and assess human running locomotion [1]. Studies have shown that the spring-mass behaviour of transtibial amputees (TTA) differs from that of able-bodied individuals [2], but it is not clear how prosthetic stiffness contributes to these changed dynamics. TTA use carbon fibre blade-type prostheses (CFP) for running, which are reported to return the strain-energy created during limb and prosthesis compression. Although the energy-return will be dependent upon blade stiffness, it is not clear whether TTAs are also able to acutely adapt their spring-mass behaviour in accordance with prostheses stiffness. An understanding of if and how TTAs might make such adaptations, will help establish evidence based standards for selecting prosthetic stiffness' in order to optimize running performance.

## AIM

The aim of the current study was to investigate how unilateral TTAs adapt vertical spring-mass behaviour in response to varying prosthetic stiffness' during running.

## METHOD

Eight unilateral TTAs (age 37.3±9.7years, height 1.75±0.07m and mass 73.4±13.8kg) performed overground running trials along a fifteen metre runway at self-selected speeds. All participants wore a Blade XT prosthesis (Chas A Blatchford and Sons, Basingstoke, UK) for testing, which they regularly used for dynamic physical activity. A nine-camera infrared motion capture system (Qualisys AB, Gothenburg, SE) and a single force platform (AMTI, Watertown, US) captured kinematics and ground reaction forces (GRF) at 200Hz and 1000Hz respectively. Three trials were repeated with participants' prescribed prosthetic stiffness (PRES, mean category 4.1±1.6), an increased prosthetic stiffness (+1 category) and a decreased prosthetic stiffness (-1 category) (categories 1-9, ~10kg per category. A modified six degrees of freedom marker model [3] with bilateral hip, knee and ankle functional joints was used for anatomically intact joints in order to define segmental properties of the head, trunk, pelvis, thigh, shank and foot/prosthetic foot.

| Variable | PRES | +1 | -1 |
|---|---|---|---|
| Running Speed ($m.s^{-1}$) | 3.36 ± 0.37 | 3.43 ± 0.28 | 3.44 ± 0.34 |
| Peak Vertical GRF (BW) | 2.32 ± 0.73 | 2.36 ± 0.69 | 2.30 ± 0.75 |
| Δ COM height (m) | 0.049 ± 0.007 | 0.048 ± 0.007 | 0.052 ± 0.008 |
| Vertical Stiffness ($kN.m^{-1}$) | 35.1 ± 13.4 | 36.6 ± 13.7 | 32.9 ± 13.5 |

**Table 1**. Group mean (±1SD) running speed, peak vertical GRF, Δ COM height and vertical stiffness for the three blade stiffness conditions.

$$k_{vert} = \frac{F_{peak}}{\Delta y}$$

Vertical stiffness (kvert) was defined as:
Where Fpeak is the peak vertical ground reaction force (GRF) and Δy is the reduction in the height of the centre of mass (COM), during limb compression, defined using the weighted averages of each segments COM location. Running speed was calculated as the first derivative of the COM A-P displacement. All data processing and analyses were performed in Visual 3D (C-Motion, Germantown, MD). Repeated measures ANOVAs statistically compared within-subject's effects, with multiple comparisons being corrected (Bonferroni) in IBM SPSS (IBM, Portsmouth, UK).

## RESULTS

There were no significant differences between prosthetic stiffness conditions in running speed ($F(2,14) = 0.64$, $p=0.54$, ES = 0.08), peak vertical GRF ($F(2,14) = 1.05$, $p=0.38$, ES = 0.13) or Δ COM height ($F(2,14) = 2.37$, $p=0.13$, ES = 0.25). However, vertical stiffness was lower (~7%) in the lower stiffness category (-1) compared to the PRES and higher stiffness categories (+1) although differences were only sig between +1 and -1 ($F(2,14) = 10.52$, $p<0.01$, ES = 0.60).

## DISCUSSION & CONCLUSION

The maintenance of peak vertical GRF and of change in COM height across CFP stiffness categories suggests that when using a more or less compliant CFP, TTAs are able to manage this additional compliance and maintain running speed. The change in vertical stiffness with a more compliant CFP and lack of change with stiffer CFP suggests that using a CFP with higher compliance (than recommended category) should be avoided. Further analysis is required to elucidate whether these changes in vertical stiffness are solely a result of local changes in CFP stiffness or whether joint level changes also contribute to such adaptations.

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# COMPENSATION STRATEGIES DURING GIAT IN PATIENTS WITH CALF MUSCLE WEAKNESS AND THEIR RELEVANCE FOR ANKLE-FOOT ORTHOSES

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## BACKGROUND

Gait in patients with calf muscle weakness is often hampered by reduced ankle power during push-off. To overcome this reduced push-off, patients have to compensate by producing more work elsewhere to maintain their walking speed1. Knowledge about which compensations are used by patients with calf muscle weakness is currently lacking, and may be useful to better define the required orthotic functions of ankle-foot orthoses in these patients.

## AIM

The aim of this study was to examine which compensatory strategies during walking are used by patients with unilateral calf muscle weakness.

## METHOD

Seventeen patients with unilateral calf muscle weakness who were indicated for an ankle-foot orthosis (10 male, age: 56.4±13.9 yrs, MRC calf: median 3; range 0-5) and 10 healthy controls participated (4 male, age: 32.5±14.9 yrs) were assessed with a 3D gait analysis, yielding joint kinematics, kinetics and powers, as a function of the gait cycle. Patients and healthy controls walked barefoot on a standardized non-dimensional walking speed (SWS), which was approximately 1.2 m/s. Positive and negative work (in J/kg) for the hip, knee and ankle joint were calculated over the entire gait cycle as well as added up for the whole leg for both the ipsilateral leg (leg with calf muscle weakness) and the contralateral leg. Differences in these parameters between the ipsilateral-contralateral leg and healthy controls were tested with an independent samples t-test.

## RESULTS

Ipsilateral positive leg work in patients with calf muscle weakness was equal to the control group (0.70 ±0.11 vs. 0.68 ±0.13 J/kg, p = 0.801), despite a reduced positive work at the ankle (0.19±0.10 vs. 0.31±0.04 J/kg, p< 0.001). This reduction was compensated for by an increased positive ipsilateral hip work (0.41 (0.09) vs. 0.27 (0.07) J/kg, p = 0.001). In the contralateral leg, positive leg work was increased in patients with calf muscle weakness compared to controls (0.92±0.14 vs.0.69±0.13 J/kg, p < 0.001), mainly because of increased positive knee work (0.21±0.07 vs 0.11±0.04 J/kg, p<0.001), and hip work (0.39±0.10 vs 0.27±0.07 J/kg, p<0.01). Negative work in the contralateral knee (-0.39±0.08 vs -0.31±0.04) J/kg, p<0.05) and hip (-0.23±0.08 vs -0.14 ±0.04 J/kg, p<0.05) were also increased compared to healthy controls. Further inspection revealed that negative work was mainly increased during the contralateral loading response.

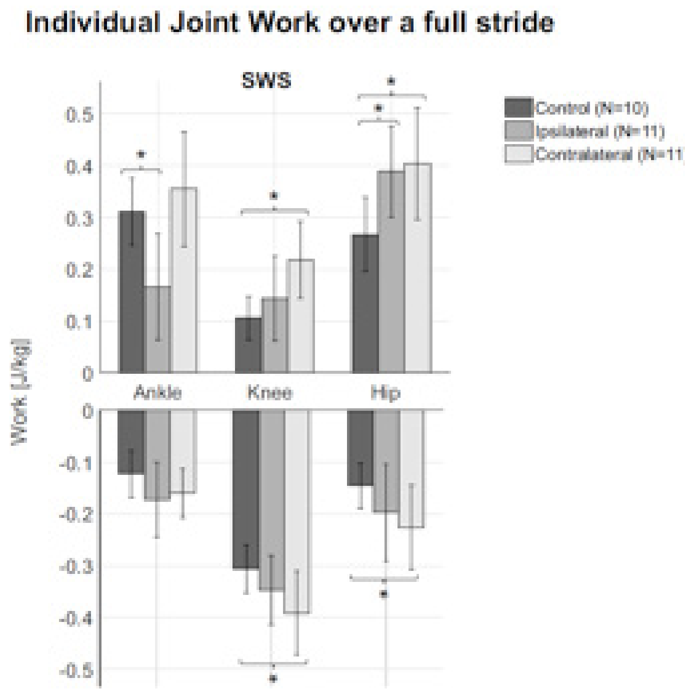


**Figure 1.** Positive and negative work for the separate joints during the gait cycle

## DISCUSSION & CONCLUSION

We showed that patients with unilateral calf muscle weakness compensate for a reduced push-off by increasing positive work at the ipsilateral hip and contralateral hip and knee. However, negative work in the contralateral knee and hip was also increased, mainly in the loading response, which seems to be caused by increased energy losses at contralateral heel-strike due to a reduced ankle push-off 2. This stresses the importance of an orthosis that assists ankle push-off power to reduce the energetic penalty caused by calf muscle weakness. Future research should study if a push-off assisting ankle-foot orthosis indeed reduces the need for compensations in patients with calf muscle weakness.

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# A LONGITUDINAL ANALYSIS OF THE RELATIONSHIP BETWEEN POSTURAL CONTROL, FALLS EFFICACY AND FALLING IN UNILATERAL TRANSTIBIAL PROSTHESIS USERS

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## BACKGROUND

Lower limb prosthesis users display altered balance strategies, are more likely to fall and have an increased fear of falling when compared to age-matched able-bodied individuals [1, 2]. Tests of postural control, such as the Limits of Stability (LOS) test, may be able to help identify prosthesis users that have an increased risk of and/or fear of falling. Although the validity and reliability of these tests in this population are currently being established [3], prospective investigations assessing the relationship between postural control and the fear of falling are lacking in the current literature.

## AIM

The primary aim of the current study was to investigate whether indices of postural control were related to and could predict the fear of falling in unilateral transtibial prosthesis users at a 6-month follow-up.

## METHOD

A group of 12 unilateral transtibial prosthesis users (PROS) (age 53.6±14.0, height 1.77±0.07m and mass 78.3±11.4kg) and a group of 12 matched able-bodied controls (CON) (age 53.6±13.4, height 1.77±0.07m and mass 81.5±10.5kg) completed three trials of the LOS test at baseline and at a 6-month follow-up with the final trial being used for subsequent analysis. The LOS test assesses postural control by requiring participants to voluntarily shift their centre of mass towards eight pre-determined targets, representing the theoretical maximum limits of stability in anterior-posterior and medial-lateral directions. Postural control indices such as reaction time (s), movement velocity (deg.s-1), maximum and endpoint excursion (%) and directional control (%) were extracted from the LOS test.

Participants also self-reported falls frequency and completed the Falls Efficacy Scale-International (FES-I) [4] questionnaire at baseline and at monthly intervals until a 6-month and 12-month follow-up to account for any seasonal variation in falls and/or falls efficacy.

## RESULTS

There were no statistically significant differences between groups in age, height or mass ($p>0.05$). Falls efficacy did not change significantly across the 12-month study period ($p>0.05$) although the PROS group showed a trend ($p=0.08$) towards increased FES-I scores (increased fear of falling) (Figure 1). The number of falls were similar between groups and did not change over the study period ($p>0.05$). Only 8% of indices of postural control from the LOS test were significantly different between baseline and the 6-month follow-up in both the PROS and CON groups. Regression analysis highlighted that indices of postural control were better at predicting falls efficacy in the PROS group when compared to the CON group. The maximum excursion possible in the backwards directions was negatively correlated to ($r=0.83$, $p<0.05$) and explained 69% of the variance in falls efficacy in the PROS group. Indeed, the top three most predictive indices of postural control in the PROS group were all in the backwards direction.

**Figure 1**. Season-normalised FES-I scores for both the PROS and CON groups across the 12-month study period. Baseline normalised to the month of January.

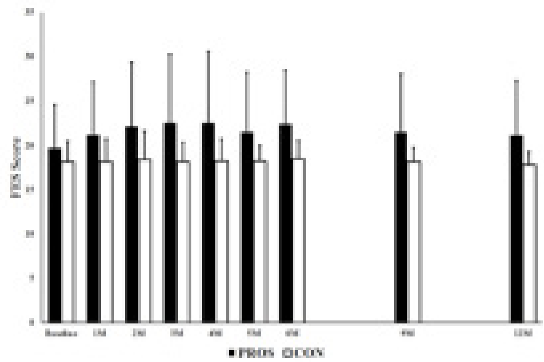
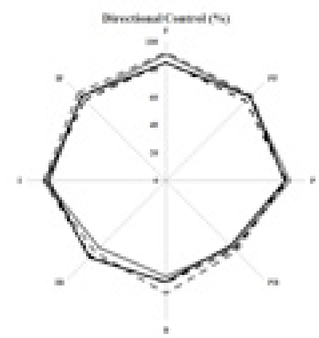


**Figure 2.** Directional control scores from the limits of stability test protocol for both the PROS (black) and CON (grey) groups at both baseline (solid) and 6-month (dashed) follow up). F-Forwards, B-Back, P-Prosthetic/Right, I-Intact/Left.



## DISCUSSION & CONCLUSION

Although not statistically significant in the current study, the trend for greater fear of falling in the PROS vs. CON group is consistent with previously research [2]. Results from the current study suggest that indices of postural control were related to falls efficacy in the PROS group and that the ability of these indices to predict falls efficacy was dependent upon the direction of the target goal. These results further highlight the inherent multi-dimensionality that underpins falls efficacy in prosthesis users. In conclusion, the predictive power indices of postural control are direction dependent and may help to identify those with increased fear of falling.

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# ROBOT ASSISTED GAIT TRAINING FOR SPINAL CORD INJURY - ONE YEAR FOLLOWUP

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## BACKGROUND

Powered exoskeletons are designed for robot assisted gait training (RAGT) in patients with spinal cord injury (SCI). It is believed that RAGT can enhance quality of life and reduce secondary health problems [1]. However, very few studies have been performed on long term effects. Therefore, we conducted a 12 month longitudinal study on the effects of RAGT, 1 or 2 times per week for approximately 60 minutes per session, on quality of life, bowel dysfunction and resilience.

## AIM

The aim was to investigate the feasibility and effect of 12 months of RAGT on quality of life, bowel function and resilience in participants with complete SCI.

## METHOD

7 participants with complete SCI were recruited, one female and 6 male. None had experience with RAGT. Average age at start was 44 +/- 16, injury levels ranging from C6/C7 to Th10/Th11, average time since injury 7.7 +/- 6.1 years. All participants completed 1 or 2 walking sessions weekly, taking about 1 hour, with 30 minutes walking time on average. The exoskeleton used was the Ekso GT (Ekso Bionics). Participants used crutches or a walking frame. Session were always accompanied by a specifically trained therapist. All participants filled in questionnaires on quality of life (WHO), neurogenic bowel dysfunction score and resilience scale at the start of the training period and after 3, 6 and 12 months.

## RESULTS

A summary of the results is presented in Table 1. None of the results show a significant difference (p>0.05). Quality of life as well as bowel dysfunction show a positive trend. No trend was found for resilience. Table 1. Mean (standard deviation) of quality of life, bowel dysfunction and resilience at start, after 3, 6 and 12 months follow-up.

| | Start | 3 months | 6 months | 12 months |
|---|---|---|---|---|
| Quality of life | 97 (10) | 97 (7.3) | 97 (7.6) | 101 (11) |
| Bowel dysfunction | 7.1 (2.7) | 11 (4.0) | 13 (5.3) | 13 (7.0) |
| Resilience | 94 (6.5) | 99 (6.7) | 94 (6.1) | 100 (11) |

## DISCUSSION & CONCLUSION

This study shows the long term feasibility of RAGT for complete SCI. Due to a limited sample size, no significant effects were found, although trends are positive for quality of life. It has to be taken into account that our participants scored very high on quality of life already at the start of the training period. Bowel dysfunction seems to increase; this might be due to the fact that gravity disturbs the scheme that participants were used to before the RAGT, according to what they reported to the therapists. More participants will be added to the analyses to further investigate the long term effects of RAGT. At this point we conclude that RAGT for complete SCI is most likely a valuable therapy, with a positive influence on quality of life.

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# TREATMENT OF PATIENTS WITH THUMB AMPUTATION USING OSSEOINTEGRATED PERCUTANEOUS IMPLANTS

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## BACKGROUND

One of the most common traumatic amputations is at the transmetacarpal level (1). A thumb amputation due to trauma or tumor can be treated either surgically (replantation, pollicisation, toe to thumb transplantation and lengthening procedures) (2) or conservatively by fitting a prosthesis. Conventional socket prostheses can be a particularly challenging due to short stumps. Osseointegrated (OI) treatment and rehabilitation for amputees has been used for transmetacarpal I (TMI) level since 1990 (3).

## AIM

The aim of present study was to report on adverse events, cumulative success rate and outcome measures in TMI amputees fitted with osseointegrated prostheses.

## METHOD

This was a retrospective study (1990-2014) including pre- and post-operative data collected from 13 unilateral TMI amputees (10 males, 3 females) treated with osseointegrated prostheses. Reasons for amputation were trauma (85%) and tumour (15%). Patients were followed up for a mean of 8.6 years (0.25-22), and their mean residual extremity length was 4 cm (3-5). Patients were treated with an experimental implant 1990-2004 (7 patients), and with a standardized treatment protocol 2005-2014 (6 patients). Postoperative tests were performed using monofilaments for sensation (4), Jamar grip test, B&L pinch and lateral pinch tests (5) and Sollerman test for function (6).

## RESULTS

One patient was withdrawn from the study for unrelated reason. Two implants were removed due to loosening, one due to a deep infection and one patient choose not to use a prosthesis despite having an implant. Eighteen complications were reported, the most common were: change of an abutment (8 in 3 patients) and superficial infection (6 in 4 patients). A total of 7 patients had no adverse events. The cumulative success rate was 57% and 100% for patients with experimental implant and standardized treatment protocol, respectively. Hand function was tested in 8 of 13 TMI amputees with OI thumb prostheses. All patients were able to feel sensation with their OI prosthesis (2,83- 6,65). Patients had 70 % of grip and pinch-strength compared with unaffected hand and their hand function was 95% of normal function measured with Sollerman test.

## DISCUSSION & CONCLUSION

The experience from the experimental implant design and treatment protocol led to standardized treatment with considerable higher implant survival. Patients had 70% of grip-strength compared with unaffected hand, 95% of hand function and measurable sensation via the OI-prosthesis. Osseointegrated TMI prostheses can offer a valuable treatment option for patients with thumb amputation.

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# PATIENT-SPECIFIC MUSCULOSKELETAL MODELLING OF FOOT ORTHOTICS EFFECT ON RHEUMATOID ARTHRITIS PATIENTS ANKLE JOINT LOADING

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## BACKGROUND

Rheumatoid arthritis (RA) is an autoimmune disease often causing foot problems and pain. In RA, synovitis, effusion, and eventually erosive arthritis are thought to cause clinically recognizable valgus heel or pes planovalgus deformity. These symptoms cause changes in the locomotion of RA patients. With the intention to stabilize and align the foot to allow normal locomotion, foot orthotics are often prescribed to this patient group.

## AIM

The aim of this study was to investigate the effect of patient-specific foot orthotics (FO) on ankle joint loading during gait. This was accomplished by developing patient-specific (PS) musculoskeletal models (MS) capable of estimating the detailed ankle joint mechanics with and without the orthotics.

## METHOD

Four early stage RA patients were recruited for this study. A pair of FO was developed for each patient using a weight bearing casting technique. PS bone geometry was obtained from magnetic resonance imaging (MRI) images and segmented in an image analysis package (Mimics 19, Materialse, Belgium). Motion capture was performed with an eight-camera setup (Qualysis, Sweden) with reflective markers together with three force plates (AMTI, USA) sampling at 100 and 1000 Hz respectively. The gait trial consisted of two conditions: one with the PS FO and one with a control insole (C).
PS MS models of each patient was developed using the AnyBody modeling system (AnyBody Technology, Denmark), Figure 1B.

Muscle attachments were made PS based on the Twente Lower Extremity Model version 2.0 dataset using advanced morphing to customize a generic cadaver-based model with respect to PS morphology acquired from MRI [1]. Accurate joint centres and axes were calculated with analytical surface fits to the segmented MRI bones.

## RESULTS

Ankle plantar flexion moments (APFM) are presented in figure 1 for the control and orthosis. Overall, the FO causes decreased ankle plantar flexion moment during the stance phase. Peak values before toe off are also lower with the FO.

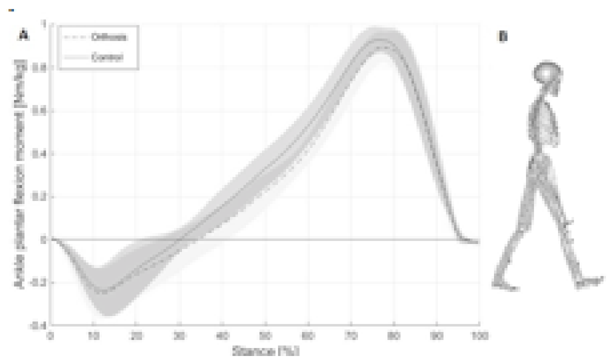


**Figure 1**A: Mean ankle plantar flexion moment during the stance phase of gait. The shaded areas show ± one standard deviation. 1B: Patient-specific AnyBody model

## DISCUSSION & CONCLUSION

The result of this study indicates that the orthosis decreases APFM during stance. A decreased APFM indicates that the ankle-flexors muscles (E.g. gastrocnemius, soleus and flexor hallucis longus) are less active during the stance phase. This will affect muscle recruitment pattern [2] and potential decrease pain [3].

## ACHNOWLEDGEMENT

The study is financially supported by The Danish Rheumatism Association [R142-A4113].

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# ON THE BIOMECHANICAL RELATIONSHIP BETWEEN APPLIED HIP, KNEE AND ANKLE JOINT MOMENTS AND THE INTERNAL KNEE COMPRESSIVE FORCES

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## BACKGROUND

Medial knee osteoarthritis is often treated using a valgus brace [1], which has the purpose of shifting the internal joint load from the damaged medial cartilage and meniscus laterally. Many studies claim a medial load reduction based on a reduced knee adduction moment [2,3] even though this correlation has been shown to be fairly low [4] and, even if the load shift succeeds, this approach does not reduce the total compressive knee load.

## AIM

To investigate how internal knee joint loads depend on applied moments during gait and hereby gain insight into how to reduce the total compressive knee load.

## METHOD

Musculoskeletal (MS) models (see Figure 1), from a previous study [5], were used, including ten healthy subjects (8 males and 2 females, age: 25.7 ± 1.5 years, height: 180.8 ± 7.4 cm, weight: 76.9 ± 10.4 kg) who performed three gait cycles (GCs) each. The models were developed in the AnyBody Modelling System (AMS) and driven by full-body 3D kinematics based on trajectories from 35 surface-mounted reflective markers (29 placed on the skin and three on each shoe). The AMS was used to compute muscle and joint forces while applying joint moments in the lower extremity at the hip, knee and/or ankle, in both sagittal and frontal plane, which completely balanced the internal moment, to investigate which moment(s) potentially contribute the largest reduction of the total compressive knee joint load.

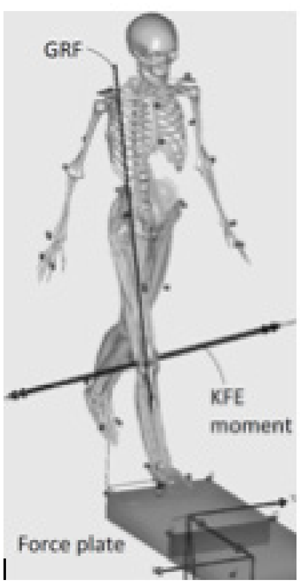


**Figure 1.** The used MS model in AMS applied with an ideal knee flexion-extension (KFE) moment to counteract the internal moment. The person steps on force plates measuring the ground reaction force (GRF).

## RESULTS

Figure 2 shows the mean knee compressive load during stance phase (0-70% GC) for each combination of applied moments in the sagittal plane and also varus-valgus moment for comparing with a valgus brace.
Our results indicate the highest internal knee load reduction when applying moments in the sagittal plane and when combining these, the reduction increases. All mentioned reductions are with respect to normal gait, which represents the compression load when no moment is applied (Normal).
When combining flexion-extension (FE) moments in hip, knee and ankle (Hip+Knee+Ankle), the first peak (~13% GC) and second peak (~50% GC) were reduced 52% and 60% respectively. Hip+Knee reduces both the first and second peak significantly with 56% and 30% respectively, whereas Knee+Ankle performs better at second peak with a reduction of 35%.

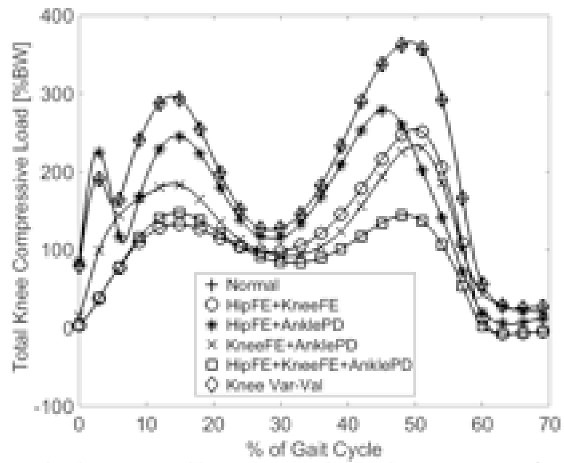


**Figure 2.** The mean total knee compressive load as percentage of bodyweight (BW) during stance phase for each combination of applied moments in sagittal plane and varus-valgus moment, which overlaps Normal. FE=flexion-extension and PD=plantar-dorsi flexion

## DISCUSSION & CONCLUSION

The study indicates that the total compressive knee load is not affected by a varus-valgus moment whereas applied moments in the sagittal plane contribute more effectively to this reduction due to reduced muscle forces. The applied moments in this study completely balance the internal moments which is not feasible in practice. However, the results show which approach, of the investigated moments, most efficiently reduces internal joint loads. This can be used as guiding for improving current knee braces.

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# NOVEL UPPER-LIMB OUTCOME MEASURE FOR BI-DIRECTIONAL UPPER-LIMB NEURAL PROSTHESE

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## BACKGROUND

Several groups are developing new bi-directional neural interfaces to use with upper-limb prostheses (e.g., [1]). These prostheses independently control the digits of multiarticulating prosthetic hands and provide sensory feedback regarding proporioception and grasp force. New outcome measures are needed during this development phase to evaluate the effectiveness of these interfaces, and to provide guidance regarding any bottlenecks in performance.

## AIM

We aimed to develop two outcome measures: the Peripheral Incorporation (PIC) test and the Control Bottleneck Index (CBI). PIC quantifies the degree of tool incorporation into the body schema, and CBI measures the bottleneck in performance between control, feedback, and internal learning on the part of the user.

## METHOD

PIC uses a variant of the cross-modal congruency test [2]. It tests a subject's ability to make a rapid discrimination between two sensory stimuli in the presence of visual distractors.CBI uses computational motor control theory [3] to isolate the effects of control noise, sensory feedback, and user experience on a person's prosthesis performance.

## RESULTS

The PIC and the CBI assessments have been packaged as stand-alone clinically-feasible test packages. Several able-bodied subjects and persons with an amputation have been tested using these outcome measures. Currently we are conducting a systematic validation of these tests where different known and controlled parameters are being tested.

Figure 1. PIC training phase using bypass prosthesis.

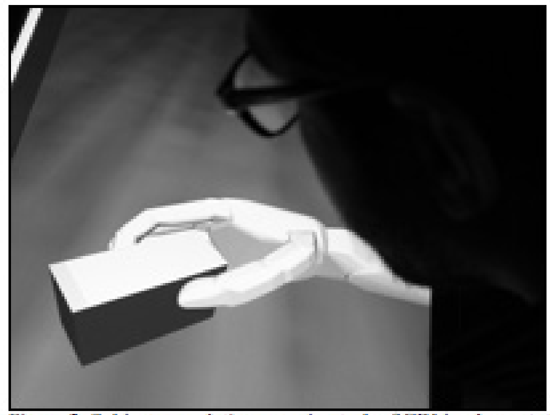

Figure 2. Subject completing grasping task of CBI implementation.

## DISCUSSION & CONCLUSION

These outcome measures are relevant for all upper-limb prostheses, including body-powered and conventional myoelectric devices. Complete validation of these metrics is ongoing. So far the PIC and CBI tests show promise in providing informed assessments that can be used by clinicians and engineers to direct further prosthetic system improvements.

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## ACKNOWLEDGEMENT

The authors thank Wendy Hill, Greg Bush, and Steve Blazeski for their clinical insight and support, as well as Ahmed Shehata for his insight on the control bottleneck index. This work was supported by the New Brunswick Research Health Foundation, the National Sciences and Engineering Research Council of Canada, the US Defense Advanced Research Projects Agency, and the US National Institutes of Health.

# APPROPRIATE SENSORY FEEDBACK IMPROVES PERFORMANCE

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## BACKGROUND

Persons with upper-limb amputation have reduced sensory feedback, and it is likely that this contributes to reduced performance in daily activities [1]. Despite many attempts to improve performance by providing sensory substitution, few succeeded in the presence of vision [2]. Recent computational motor control research suggests that the most useful augmented feedback depends on 1) existing feedback (such as vision), 2) control vs. task uncertainty, and 3) whether the feedback is in a local or global reference frame [3]. This research suggests local joint-based velocity feedback improves prosthetic arm control, even with unaffected vision.

## AIM

The aim of this study was to see if local joint-based velocity feedback improves performance, even when vision is present, during control of a 2 degree of freedom (DOF) myoelectric interface.

## METHOD

Four able-bodied subjects controlled a two DOF myoelectric interface with virtual dynamics (shoulder and elbow), after giving informed consent in a study approved by our local ethics board. They were asked to perform center-out reaches to one of four targets within 1.5 seconds. Subjects were provided audio feedback, where amplitude corresponded to joint speed, with a different frequency for each joint. After the subjects became familiar with the task, the damping of the virtual prosthetic arm was unknowingly decreased. Subjects were then assessed to see how quickly they could regain performance, as well as how accurately this control generalized to targets to the right and left.

## RESULTS

We found a significant improvement in subject's ability to respond to perturbed dynamics when they were provided with audio feedback that corresponded to the speed of each joint (Figure 1).

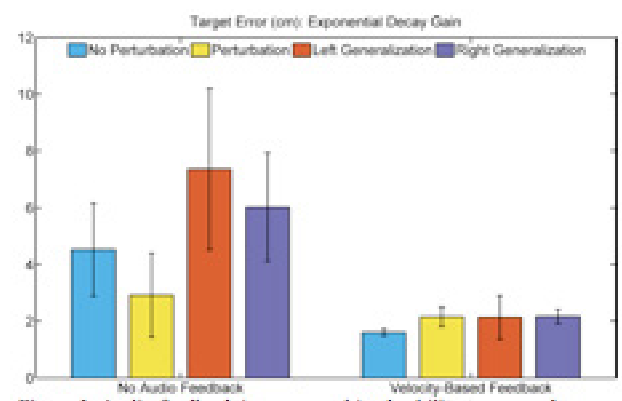


Figure 1. Audio feedback improves subject's ability to respond to disturbances in control

## DISCUSSION & CONCLUSION

This preliminary study suggests that joint-based speed feedback can play an important role in improving performance, even in the presence of vision.

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## ACKNOWLEDGEMENT

This work was supported by the U.S. National Science Foundation, the US National Institutes of Health, and the National Sciences and Engineering Research Council of Canada.

# THE EFFECTS OF A SUPPORTED AND INDIVIDUALISED 12-WEEK EXERCISE PROGRAMME IN MAXIMISING GAIT PERFORMANCE IN LOWER LIMB AMPUTEES

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**BACKGROUND**

Exercise programmes for elderly populations have been successful at improving gait and reducing fall incidence [1]. Asymmetric gait in lower-limb amputees (LLAs) has been widely reported [2], and may be as a consequence of limb loss, muscle weakness and mechanical limitations of the prosthetic foot and/or knee. These factors also increase the risk of falling. However, no study has yet examined the effects of an exercise programme on maximising gait performance in LLAs.

**AIM**

The aim of the study was to investigate the biomechanical effects of a 12-week supported exercise programme on gait biomechanics in a cohort of lower-limb amputees.

**METHOD**

Fifteen participants [Exercise: n=7, (mean age(SD): 59.7(12.7) years; TTA: n=2; TFA: n=5), and Control: n=8, (mean age (SD): 64.9(16.4) years; TTA: n=3; TFA: n=5)], with a range of amputation aetiologies were recruited into the study. Groups were matched by age, gender and level of amputation. 3D kinematic and kinetic data were collected (Qualisys, Sweden) at baseline (PRE) and at post-intervention (POST), 12 weeks later. Participants completed 10 level gait trials along a 10m runway, with two force plates (Kistler, Switzerland) embedded in the floor. The Exercise group engaged in a twice-weekly, supervised group exercise session and a once-weekly, progressing to twiceweekly individualised home-based exercise programme. The exercise programme consisted of flexibility, strength, balance and cardiovascular fitness exercises. The Control group were asked not to change their activity levels during the intervention period. A repeated measures general linear model was used to indicated whether significant differences existed between, or within, groups over time (P<0.05). Standardised effect size is reported as Cohen's d.

**RESULTS**

Temporal-spatial and kinetic data are presented in Table 1. Two participants from the Control group were not included in the kinetic data analysis due to an inability to correctly strike the force plates. Compared to the Control group, the Exercise group demonstrated a large (d=0.91) increase in walking speed and a significant Group*Time interaction (P=0.002) was observed. Significant Group*Time interactions were also observed for A2 and H3 joint powers on the intact and affected limbs, respectively (Table 1). In the Exercise group, there was a significant increase in power absorption and generation on the intact limb at A1 (P=0.021, d=1.28) and A2 (P<0.001, d=2.97), respectively; whilst no significant (A1 P=0.217; A2 P=0.772) changes were seen in the Control group. H3 power generation increased significantly for the intact (P=0.023) and affected (P=0.009) limbs, with large effect sizes (d>0.8).

**DISCUSSION & CONCLUSION**

These results are the first to demonstrate the benefits of a 12week exercise intervention on LLA gait performance. Mean gait speed increased by 0.21m/s (P<0.001) in the Exercise group, a value which exceeded the clinically meaningful threshold (0.1 m/s). The Exercise group significantly improved power generation, with large effect sizes, at the intact ankle, hip and affected hip joints; conversely the Control group demonstrated a large decline (d=1.21) in H3 power generation.

These results may indicate that common activities of daily living, undertaken by the Control group, are insufficient for maintaining concentric hip flexor pull-off strength. In the absence of affected ankle plantarflexor muscles, hip flexor strength is important for adding energy to the swinging limb in pre-swing. In conclusion, LLA gait performance can be maximised with a supported multidimensional 12-week exercise programme, with wider implications on patient functional mobility and well-being.

| | [illegible] | | |
|---|---|---|---|
| | PRE | POST | EFFECT SIZE (d) |
| Speed (m/s) | 0.77 (0.25) | 0.98 ([illegible] | 0.91 |
| | | | |
| Intact GRF Fz2 (N/kg) | 0.93 (0.09) | 1.06 (0.12) | 1.24 |
| Intact GRF Fy2 (N/kg) | 0.17 (0.04) | 0.22 (0.04) | 1.25 |
| | | | |
| Intact A1 (W/kg) | -0.56 (0.22) | -0.86 (0.25) | 1.28 |
| Intact A2 (W/kg) | 1.49 (0.60) | 2.81 ([illegible] | 2.97 |
| | | | |
| Intact H3 (W/kg) | 0.60 (0.33) | 0.99 (0.32) | 1.20 |
| Affected H3 (W/kg) | 0.36 (0.19) | 0.87 ([illegible] | 1.34 |
| | CONTROL | | |
| | PRE | POST | EFFECT SIZE (d) |
| Speed (m/s) | 0.84 (0.31) | 0.82 ([illegible] | 0.07 |
| | | | |
| Intact GRF Fz2 (N/kg) | 1.02 (0.08) | 1.11 (0.15) | 0.78 |
| Intact GRF Fy2 (N/kg) | 0.18 (0.09) | 0.17 (0.09) | 0.11 |
| | | | |
| Intact A1 (W/kg) | -0.63 (0.19) | -0.79 (0.07) | 1.23 |
| Intact A2 (W/kg) | 1.72 (0.60) | 1.79 ([illegible] | 0.10 |
| | | | |
| Intact H3 (W/kg) | 0.70 (0.34) | 0.74 (0.35) | 0.12 |
| Affected H3 (W/kg) | 0.72 (0.30) | 0.40 ([illegible] | 1.21 |

* indicates a significant (P<0.05) Group*Time interaction.
GRF = Ground reaction force. Fz2 = peak vertical force at push-off; Fy2 = peak propulsive force; A1 = ankle plantarflexor power absorption in terminal stance; A2 = ankle plantarflexor power generation in preswing; H3 = hip flexor power generation in pre-swing.

**REFERENCES**

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[2] Kaufman et al.; 2012 Clin Biomech

# ACHIEVING CADENCE RESPONSIVE PROSTHETIC KNEE JOINT SWING-PHASE CONTROL WITHOUT THE USE OF HYDRAULICS OR PNEUMATICS

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## BACKGROUND

Prosthetic swing-phase control plays an important role in allowing individuals with transfemoral amputation to achieve effective and efficient mobility. For individuals capable of high-level ambulation (K3 and K4 mobility levels), advanced prosthetic knee joints having fluid-based (hydraulic or pneumatic) swing-phase control are commonly prescribed. These devices allow for gait at multiple speeds (slow to fast); however, due to cost and maintenance these sophisticated systems are not accessible for most individuals around the world, especially those living in low resourced countries. In low resourced countries the most commonly accessible knee joints utilize simple constant friction-based controllers. However, conventional friction-based controllers only allow users to walk comfortably at one speed, otherwise resulting in significant gait deviations and inefficient mobility, as well as musculoskeletal problems over the long-term [1].

## AIM

The aim of this work has been to design and evaluate a simple non-fluid-based variable cadence controller (VCC) that provides good function over a range of walking speeds.

## METHOD

The VCC is based on a variable friction-spring system that can be programmed to provide torques closely matching those of hydraulic knee joints [2]. The performance of the VCC was assessed through a combination of computational modeling (gait model) and empirical testing. A 7-segment gait model was developed in Matlab and SimMechanics. The model was optimized using empirically based gait data of transfemoral amputees and able-bodied individuals, using a cost function. A number of configurations of the swing-phase controller were modelled and simulated to assess performance during gait. Constant friction was compared to the VCC. Performance evaluation was based on the ability of the controller to execute a step over three walking speeds (slow at 1.04 m/s; medium at 1.11m/s; and fast at 1.37m/s). A failed step was considered if the foot did not clear the ground, or if the knee did not extend in time for weight-bearing.

## RESULTS

A single spring system with constant friction (as typically used in knee joints) was able to provide control only at the slow speed. Applying variable friction (instead of constant friction) allowed control at slow and medium walking speeds. Using a dual spring with variable friction (VCC) allowed control over all three walking speeds. The dual spring and variable friction controller also produced swing-phase knee joint kinematics that most closely matched normal values across the range of walking speeds (Figure 1). This system also produced the lowest terminal impact velocities, even at fast walking speeds.

## DISCUSSION & CONCLUSION

Using a combination of dual springs and variable friction (VCC) shows promise for achieving swing-phase control across a range of functional walking speeds. Clinically, the VCC could significantly improve the performance of non-fluid-based prosthetic knee joints and provide an affordable option for many amputees around the world. The limitations of the modelling include the use of generic data for the anthropometrics and target kinematics. Also, the model used able-bodied gait kinematics which may not adequately capture the compensatory strategies used by amputees. Future work is focused on developing user-specific models based solely on amputee gait data.

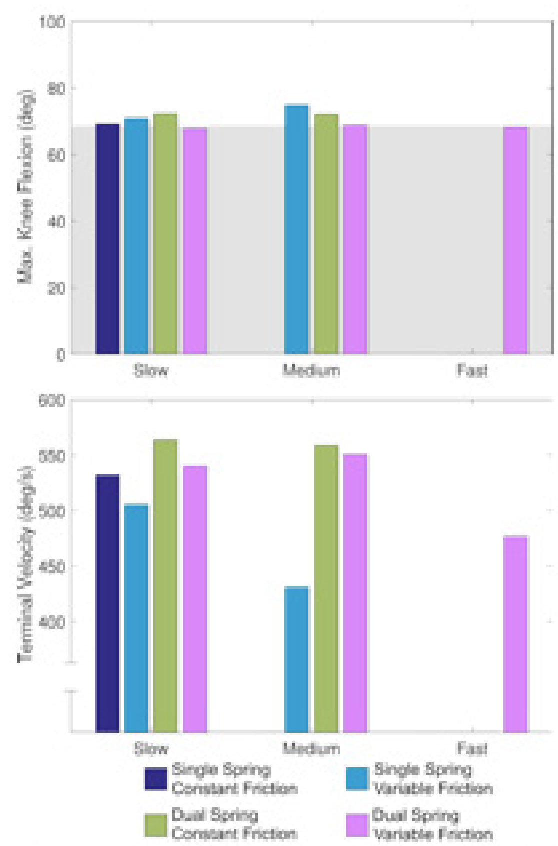


**Figure 1**. Model-generated maximum knee angles and terminal velocities for each walking speed. The shaded area in the Max. Knee Flexion plot represents able-bodied knee angles. The results from failed steps are not shown.

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# AN INSTRUMENT FOR MONITORING THE PERFORMANCE OF PROSTHETIC STANCE-PHASE CONTROL

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[1]Holland Bloorview Kids Rehabilitation Hospital, Toronto, Canada [2]LegWorks, Toronto, Canada

## BACKGROUND

For individuals with transfemoral amputations, the stance-phase control function of the prosthetic knee joint is important for achieving safe and efficient mobility. Stance-phase control helps to stabilize the prosthetic knee joint during weight-bearing, without impeding the natural movements associated with the swing-phase of gait. The AutoLock system is a promising new technology for prosthetic stance-phase control, that has demonstrated advantages over braking mechanisms and geometric stabilization in terms of safety and efficiency [1,2]. Understanding stance-phase controller function of the AutoLock system under relevant mobility and usage conditions can assist in more effective design and clinical utilization of stance-phase controlled knee joints leading to improved overall patient outcomes.

## AIM

The aim of this work is to develop and evaluate an instrument to monitor and quantify the function of the AutoLock system in out-of-the-lab environments, and assess the influence of prosthetic alignment on the AutoLock stance-phase control function.

## METHOD

An external instrumentation system, consisting of three light-weight, portable, and inexpensive sensors, was constructed to measure knee lock engagement, identify knee hyperextension, and provide kinematic context for the operation of the AutoLock mechanism. Kinetic and kinematic data were recorded during walking trials with one transfemoral amputee who was a user of the AutoLock based knee (All-Terrain Knee, LegWorks Inc.), and eight able-bodied participants wearing a prosthetic simulator. The prosthetic leg setup included an AutoLock knee prosthesis instrumented with the external sensor system and a high-precision six-degree-of-freedom load cell. Participants were asked to perform a series of walking trials under different prosthetic alignments.
Data from the sensor system and load cell were collected simultaneously and analyzed to identify loading events and evaluate AutoLock function throughout the gait cycle. The sequence and timing of these events and AutoLock responses were compared between alignment conditions.

## RESULTS

The AutoLock system provides stance-phase control by engaging a mechanical lock to resist the knee's natural tendency to flex following weight-acceptance until a hyperextension moment is applied at the knee axis in late stance. The results indicate that changes in translational alignment of the prosthesis have a measureable effect on AutoLock stance-phase control function and demands. Translating the foot posteriorly with respect to the knee joint caused the knee lock to disengage prior to knee hyperextension, on average, suggesting that the knee is more likely to become unstable in this alignment. Conversely, shifting the foot anteriorly caused the lock to remain engaged until a hyperextension moment was applied. In addition to stabilizing the joint throughout this mid-stance transition, results indicate that anterior foot translation is an intrinsically more stable condition based on a comparison of lock engagement duration as a fraction of stance-phase. The shorter duration of lock engagement in the anterior translation condition implies that a larger proportion of stance-phase is spent in hyperextension, rather than depending on the knee lock for stability (Figure 1).

## DISCUSSION & CONCLUSION

The effects of prosthesis alignment on the performance of the AutoLock stance control mechanism provide insight into how the prosthesis may be setup to increase or decrease knee stability according to the user's needs. The developed system also has the proven potential for use in larger biomechanical studies to inform AutoLock design iterations and to optimize patient-specific alignment protocols. Future work is focused on developing the instrument into a standalone, easy to use module.

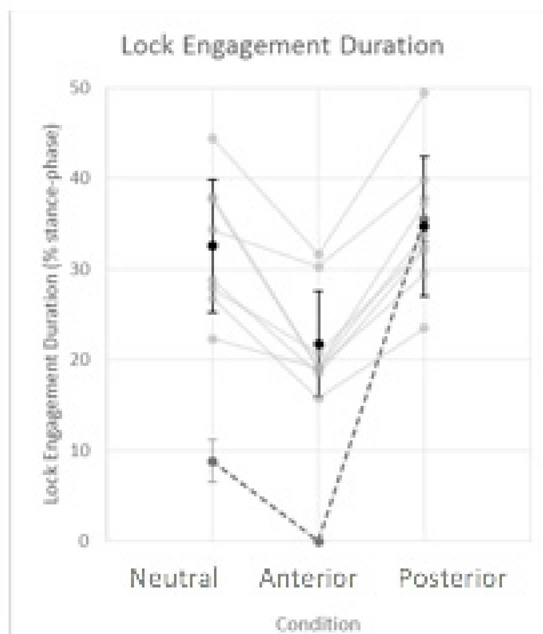


**Figure** 1. Average and standard deviation of lock engagement duration for all able-bodied participants (black), individual able-bodied participants (light grey), and the above-knee amputee (dark grey, broken lines).

REFERENCES

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# THE IMPACT OF THE MPO VS SCO VS KAFO ON THE FUNCTIONAL MOBILITY OF INDIVIDUALS WITH LOWER EXTREMITY WEAKNESS DUE TO NEUROLOGICAL OR ORTHOPEDIC INJURY OR DISEASE

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## BACKGROUND

The current standard orthosis for people with severe quadriceps weakness is the "locked" knee-ankle-foot-orthosis (KAFO); it is relatively inexpensive and available but causes abnormal gait patterns contributing to chronic pain, decreased mobility and a high physiological energy cost. The state of the art Stance Control Orthoses (SCO) allows users to flex the knee during the swing phase to improve gait patterns, but is still limited by the lack of controlled knee flexion or extension. A micro-processor controlled orthosis (MPO) could provide more control during the swing and stance phases allowing for independence in walking on uneven terrain, stairs and self-correction during a stumble.

## AIM

The aim of the study is to evaluate the potential of the microprocessor controlled orthosis (MPO) to improve the functional mobility and quality of life in individuals with lower extremity impairments as compared to the SCO and conventional KAFO.

## METHOD

20 individuals using a KAFO were randomized to either SCO or MPO. Following an instructional acclimation period of one month, participants were evaluated on device use in their home for another month. Following which, participants crossed-over to the other device group (SCO or MPO) and received a month of acclimation followed by home trial. Standard patient reported and performance-based measures of function and metabolic cost during ADLs and walking were assessed. In addition, advanced wearable sensors, GPS tracking and machine learning techniques were applied to quantify device use at home, community mobility and quality of life.

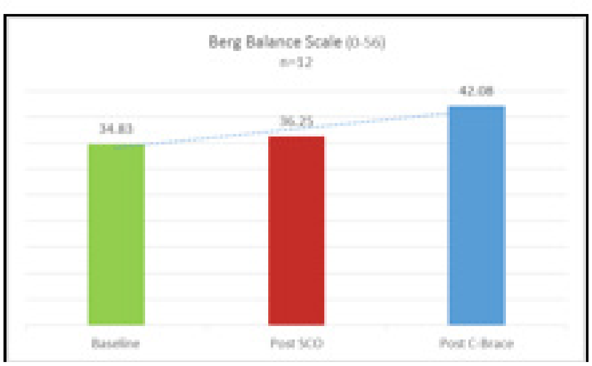


**Figure 1**. Balance Measure Scores

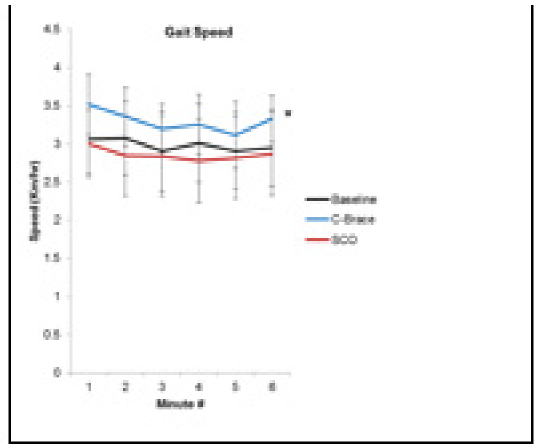


**Figure 2.** Gait Speed Measure

## RESULTS

Results of reported falls and balance testing demonstrate a lower number of falls using the MPO versus the SCO and KAFO and a significant difference in balance testing of the MPO versus the SCO and KAFO, exceeding the minimal clinically important difference of 5 points. In addition, the energy cost of walking is not significantly different between devices when measured at fast velocity on a 6 minute walk test, but the distance and speed are significantly improved using the MPO versus the SCO and conventional KAFO. Furthermore, the community mobility and step count measured with wearable sensors and GPS was higher in the MPO users compared to SCO and KAFO.

## DISCUSSION & CONCLUSION

The reduction in falls during use of the MPO indicates improved safety at home and in the community. The increased walking speed and distance by users of the MPO versus the SCO during a 6 minute walk test with equivalent oxygen cost shows the ability for the user of the MPO to improve cardiovascular conditioning and the potential for general health benefits. Although these results are from a small sample of orthotic users, the MPO does show potential to improve the functional mobility in the clinic and community for the user of a KAFO. These benefits may contribute to improved health and quality of life. However, not all users enjoyed the benefits of an MPO. Further sub-group analysis is required to identify optimal users vs. non optimal users.

# ADAPTIVE VACUUM SUSPENSION TO PROMOTE LIMB HEALTH AND OPTIMAL FUNCTION

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[1] The Ohio Willow Wood Company, [2]The Ohio State University

## BACKGROUND

Achieving a "proper" prosthetic socket fit can be a significant challenge as currently there are no methods to quantify fit, and therefore the experience of the prosthetist dominates the decision. Prosthetists goals are typically to maximize comfort and minimize movement between the limb and socket, but there are no indicators of what is ideal. Apart from socket shape, the prosthetist must also chose the most appropriate form of suspension, taking into consideration many factors including lifestyle, comorbidities, and mental capabilities. Here, we report the latest efforts to provide quantitative analysis of the quality of socket fit and suspension including factors such as limb health1 and movement between the limb and socket2. We suggest that adaption of socket conditions to optimize limb health and functional performance are possible.

## AIM

The purpose it to report the impact of socket suspension methods on residual limb health, demonstrate how suspension can be used to adjust the amount of movement between the limb and socket, and propose how these two can be used to generate an ideal socket environment.

## METHOD

Two sets of methods were used depending on the outcomes tested. Limb health measurements were collected from 10 lower extremity amputees. Measurement devices include Hyperspectral Imaging, Transepidermal Water Loss, Laser Doppler Flowmetry, and Transcutaneous Oxygen Measurement. A prospective longitudinal study design was used where subjects wore a non-vacuum or vacuum suspension for 16 weeks before switching to the other condition. Measurements were collected at 0 and 16 week time points and compared for differences. Data points were collected before, during, and after an activity period. In socket limb motion data was collected from 10 lower extremity amputees. Each of the subjects wore an elevated vacuum suspension socket. An inductive proximity sensor was mounted to the distal end of the socket and tracked the position of an aluminum target on the distal end of the liner. Subjects walked on level ground at several different vacuum pressure settings while movement data was recorded. Socket comfort score was collected and compared to the movement data.

## RESULTS

The limb health results found that long-term use of an elevated vacuum suspension system improved transepidermal water loss values, higher tissue oxygen content during activity, and a reduction in reactive hyperemia. These results suggest improved epidermal barrier function and a more stable supply of nutrient rich blood while wearing a vacuum suspension system, possibly due to a more stable socket interface allowing the limb to adapt. The limb motion results indicate that as the vacuum pressure increases, there is a transition point where there is a significant increase in stiffness at the interface. The maximum stiffness achieved varied among individual subjects, suggesting differences in soft tissue compliance and the fit of the prosthesis. The patients with a firmer tissue type displayed higher pressure fluctuations than the patients with medium tissue type for a given amount of distal displacement. As in-socket movement decreased, socket comfort score increased.

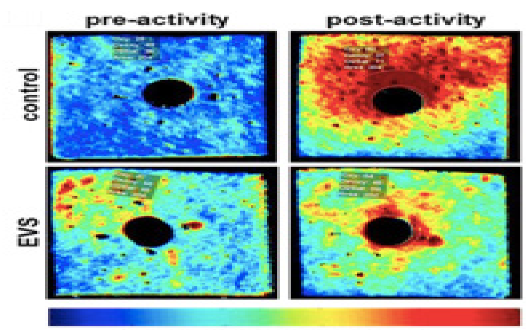


**Figure 1**. Representative Hyperspectral Imaging data. Notice the large difference in tissue oxidation for the control condition before and after activity. This change is not present when wearing elevated vacuum suspension suggesting better perfusion.

## DISCUSSION & CONCLUSION

This study found that limb health and in-socket movement are dependent on the quality of socket suspension, a variable which can be controlled. Initial results indicate higher comfort is achieved by minimizing movement at the interface, yet it remains unclear what is optimal for the health of limb tissues. Future work will look into the optimal suspension and socket fit by investigating the relationship between limb health and in-socket movement. From these results it is possible to create an adaptive vacuum system to optimize limb health and functional performance to ensure a proper prosthetic socket fit or provide objective reasoning for why a new socket is needed.

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# A PROTOCOL TO TEST DURABILITY OF TRADITIONAL AND ADDITIVE MANUFACTURED AFOS: PRELIMINARY RESULTS

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## BACKGROUND

AFOs are orthotic devices that are widely used to manage amongst others spasticity and weakness of the muscles of the lower limbs. With the introduction of additive manufacturing (AM) production techniques, the question rises if the so-called printed AFOs have the same lifetime expectancy as traditional AFOs. Several test benches are already developed to test the rigidity of AFOs [1]. For the new production techniques to be acceptable in the clinical practice, it is necessary that the durability is high enough to compete with AFOs produced in the traditional way.

## AIM

The first objective of this study was to objectively quantify the durability of both traditionally manufactured and printed AFOs with the final aim being the improvement of the printed AFO design so that the additive manufactured AFOs have at least the same lifetime than the traditional polypropylene (PP) solid AFOs.

## METHOD

Up to now, 2 PP traditionally made AFOs were tested. The AFOs were designed for the same test subject. The AFOs were submitted to both static and dynamic testing in two different test benches (Fig 1). In the dynamic tests, the AFOs were attached to a prosthetic limb, tailored to the size of the test subject's leg. The ankle was rotated to 10° dorsiflexion and 15° plantarflexion for 5 000 000 cycles. After every 500 000 cycles the AFO was tested in the static test bench, to measure the stiffness. A resting period of at least 24 hours was introduced between the dynamic loading and the static testing to let the AFO recover [2].

## RESULTS

When inspecting the evolution of the stiffness over time of both PP-AFOs, no substantial change in stiffness was observed. AFOs produced with the laser sintering technique in polyamide-12 (PA-12) will be tested with the same measurement protocol. To be able to objectively compare the AFOs, they are also designed for the same subject, and with the same stiffness (100 N.m/rad). The stiffness of the AFO design is first verified using an FE-analysis.

**Figure 1**. Static test bench (left), and dynamic test bench (right).

## DISCUSSION & CONCLUSION

Producing AM AFOs with the same or better properties compared to AFOs produced in the traditional way is not trivial. Despite the advantages of digital design and AM techniques, also the lifetime expectancy should be high enough to compete with traditionally produced AFOs. In this study we aim to identify the stiffness and lifetime expectancies of AFOs. However, further testing of different designs is needed.

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# MULTI-MODALITY SENSORY FEEDBACK

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## BACKGROUND

Prostheses for clinical use restore the lost motor function of the hand, but not the sensory function. Implementing sensory feedback (SF) in prostheses can increase the grasping capability, introduce a feeling of embodiment of the prosthesis, and reduce phantom limb pain [1], [2]. The current non-invasive SF systems normally only incorporate one-modality (electrotactile, mechanotactile, or vibrotactile). By integrating multi-modality (MM) SF more information about the object and the manipulation itself can be provided to the user.

## AIM

The aim of this study is to test the hypotheses that a multi-modality sensory feedback device, incorporating mechanotactile and vibrotactile feedback can increase the subjects' performance in localization and intensity discrimination.

## METHOD

Eleven subjects participated in the study: two amputees, one with a referred phantom sensation (A1) and the other without (A2). Remaining nine subjects were non-amputees (N1-N9). Incorporating eccentric rotating mass (ERM) and linear DC servomotor, the hybrid stimulation device sequentially expresses vibrotactile and mechanotactile modalities. The stimulation array was arranged according to A1's map of referred sensations (MoRS), while for the others the stimulation array was evenly distributed around the forearm (A2 and N1-N3) or V-shaped (N4-N9) placed on the dorsal side of the arm. The subjects were given 74 stimuli and were required to report the location (D1 to D5) and the intensity (level 1 to 3).

## RESULTS

High detection accuracy was shown when applying stimuli on the MoRS (A1) and a lower accuracy in the case of A2 and H1-H9 (Figure 1). The figure, also shows that the V-shaped array has better performance with respect to the evenly distributed array. This was assumed since the V-shaped array has better correspondence with psychological attributes and, therefore, easier for users to distinguish the position of each actuator.
Figure 1 shows that MM stimulation has comparable performance to mechanotactile stimulation, but in this study the vibration provides an extra dimension. The subjects spontaneously reported that the extra feature relieved the mental load, since the vibration made them alert to the upcoming mechanotactile stimulation.

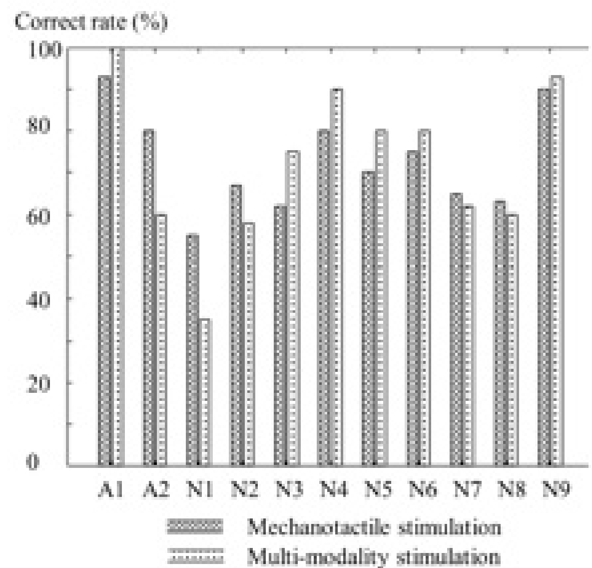


Figure 1. Individual detection performance during mechanotactile and multi-modality stimulation.

## DISCUSSION & CONCLUSION

To the best of our knowledge, this is the first attempt combining mechanotactile and vibrotactile into a single SF device. For persons without MoRS, the localization of the stimulations has to be memorized and predicted from previous stimulations. The outcome of this study shows that the hybrid stimulation relieves the mental load, but in future work activating both modalities simultaneously could increase haptic vocabulary. Hybrid stimulation also improves the performance for subjects with MoRS,

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# PRELIMINARY FINDINGS OF USING A WEARABLE SOFT-ROBOTIC GLOVE ASSISTING IMPAIRED HAND FUNCTION AT HOME

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## BACKGROUND

Older adults suffering from low handgrip strength due to age-related loss of muscle mass and/or diseases often experience reduced ability to perform daily activities. Assistive technology may compensate for a decline in hand function. An assistive soft-robotic glove, ironHand (iH), can assist grip strength directly during a wide range of daily activities. By enabling increased use of the impaired hand(s) in daily activities, assistive support might also seamlessly transition into therapeutic support to maintain or improve health status.

## AIM

The aim of this ongoing multi-centre clinical study is to explore the preliminary outcomes of both orthotic and therapeutic impact of using the iH system for 4 weeks during activities of daily life (ADL) at home and/or work.

## METHOD

In this ongoing study, so far 9 elderly (>55 years) with self-reported decrease in hand function and with experienced difficulties in performing ADL were included. They were advised to use the glove for 180 minutes/week for 4 weeks during ADL at home. Before and after the intervention period, participants performed a maximal pinch grip test and Box and Blocks test (BBT) with and without glove. Furthermore, the System Usability Scale (SUS) was completed after the intervention period. The Wilcoxon signed ranked test ($\alpha \leq 0.05$) was used to evaluate whether performance with glove PRE and without glove POST differed from performance without glove PRE (Table 1).

## RESULTS

Orthotic effect mainly represented in pinch grip strength improvement instantaneously, but not reflected in increased number of blocks transported during the BBT. Remarkably, after 4 weeks of assistive glove use, both pinch grip strength and BBT score increased substantially when performing those tasks without the glove (Table 1). Additionally, system usability was scored high (mean 73.1 (SD=18.9) on SUS).

Table 1. Outcome measures (n=9)

| | Without glove PRE | With glove PRE | Without glove POST |
|---|---|---|---|
| Pinch grip test between thumb – index finger (kg)[a] | 3.00±1.64 | 3.86±1.77* | 3.64±1.61* |
| Pinch grip test between thumb – middle finger (kg)[a] | 2.86±1.53 | 3.28±1.80 | 2.95±1.41 |
| BBT (amount of blocks)[a] | 34.11±17.11 | 34.78±16.70 | 41.22±16.75* |

aMean ± standard deviation; *$p \leq 0.05$

## DISCUSSION & CONCLUSION

The results indicates an orthotic effect on pinch strength mainly. This orthotic effect has apparently improved unsupported hand function in itself, in both strength and BBT. This implies a therapeutic effect of using an assistive glove supporting daily activities, to the extent that performing (more) ADL with the impaired hand serves as a training environment. These study results are promising but a larger sample size is needed for better interpretation of the results.

# FORMAL TRANSLATION OF THE PROSTHETIC LIMB USERS SURVEY (PLUS-M) AND QUANTITATIVE TESTING ON A POPULATION OF NORWEGIAN PROSTHETIC USERS

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## BACKGROUND

The massive rise in diabetes mellitus cases and cardio vascular disease worldwide is making lower limb amputees (LLA) a rapidly growing patient group requiring multidisciplinary rehabilitation. One of the most important factors of quality of life among lower limb amputees is mobility. Today only one tool for measuring of self-perceived mobility is available in Norwegian, and there exist no data on the self-reported mobility of Norwegian LLA.

## AIM

The aim of this study is to translate an American instrument for measuring self-perceived mobility (PLUS-M) of lower limb prosthetic users, to test the internal consistency of the Norwegian version and conduct a survey of mobility of Norwegian LLA.

## METHOD

A formal translation of the PLUS-M questionnaire (version 1.2, www.plus-m.org) using the FACIT translation methodology, was followed by qualitative and quantitative testing of the Norwegian version. For qualitative testing a strategic sample of five prosthetic users participated in cognitive debriefing interviews. For the quantitative testing, the Norwegian 12-item PLUS-M questionnaire was sent by mail to about 1000 Norwegian LLA. Internal consistency analysis was tested using Cronbach´s alpha and descriptive statistics on the Norwegian sample and the American development sample were compared to assess transferability of the scores for Norwegian use. In the present preliminary analysis, only data on the T-score in relation to amputation cause is presented.

## RESULTS

A total of 359 persons responded to the survey. The reasons for amputation were: vascular n=109, traumatic n=149, cancer n=31, dysmelia=15, other causes n=55). The Norwegian version of PLUS-M show excellent internal consistency (□= 0.96). The Norwegian sample report similar level and distribution of mobility as the American sample, making the standard score and the percentiles available valid for the Norwegian prosthetic user population. The PLUS-M T-score is related to the ethology of amputation with vascular LLA having the lowest T-scores.

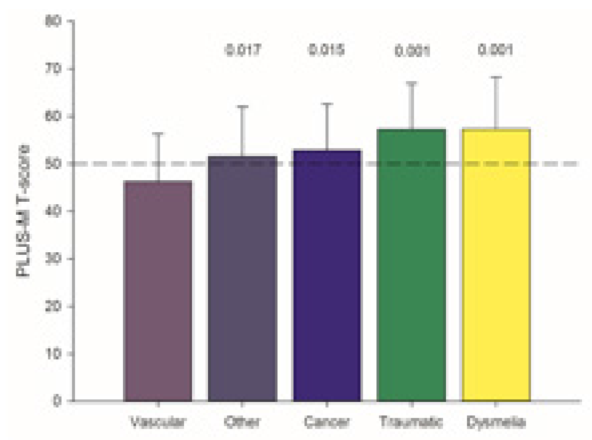


Fig 1. PLUS-M scores in relation to amputation cause. One-way Anova with Bonferroni correction show significant differences in mobility when comparing Vascular to all other causes. A T-score of 50 represents the mean mobility reported by the development sample.

## DISCUSSION & CONCLUSION

The Norwegian translation of PLUS-M show excellent internal consistency and is a valid measure of self-reported mobility for Norwegian lower limb prosthetic users. The present study is the first investigation of prosthetic user mobility in Norway. One of the most important factors of quality of life among lower limb amputees is mobility and it is important that reliable and valid instruments for self-reported mobility of prosthetic users is available.

# INVESTIGATION OF WRIST AND HAND FUNCTION FOR THE IMPROVEMENT OF UPPER LIMB PROSTHETIC DEVICE DESIGN

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## BACKGROUND

The development of upper limb prostheses faces many different challenges. Specifically, improvements in device design are urgently required, together with increased personalisation of devices according to patients' needs and overall device ease of use and affordability. This investigation is part of a project entitled Anthropomorphic Design for Advanced Manufacturing (ADAM) which aims to develop a new Design System for personalisation of upper limb prosthetics using additive manufacturing technology. Here, a novel procedure for acquiring data on the movement features of the sound and prosthetic upper limb will be presented, as input for those design requirements.

## AIM

The aim of this study was to develop a procedure to consistently investigate the relationship between prosthetic and sound upper limb function over specific tasks, in order to improve upper limb prosthesis design.

## METHOD

For the first phase of this study, able-bodied volunteers performed a clinically validated hand function test – the Southampton Hand Assessment Procedure (SHAP) – whilst kinematic data was recorded for all the tasks using a Vicon camera system, as well as electromyography and inertial data. Specific data acquisition and analysis procedures were developed, namely for the full kinematic analysis of the arm and hand. In a second phase, transradial amputees using various types of prostheses underwent the same procedure. Additionally, 3D-printed concept demonstrators were also tested.

## RESULTS

Following data collection, data was analysed and structured to build a benchmark of a range of behaviours and conditions which form the base of a novel Design System. Data obtained for the able-bodied subjects provided a baseline for normal hand function as the ideal prosthesis design. Specifically, SHAP scores and kinematic data were assessed in parallel and used to quantify the differences between sound limbs and prosthetic devices when performing the same tasks under the same conditions. Subsequently, data obtained with the concept demonstrator developed as part of this project was compared with the benchmarked data and points for improvement were identified.

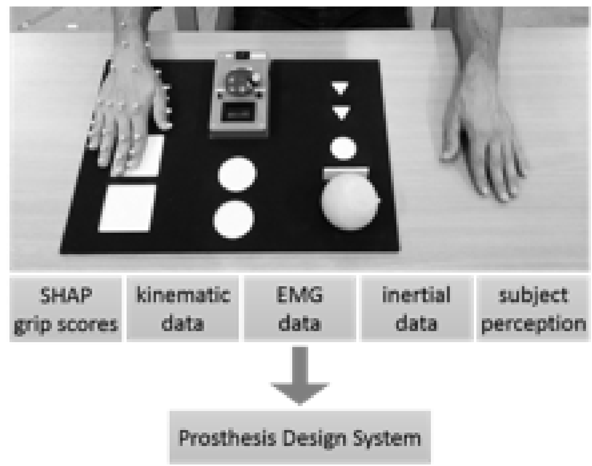


**Figure 1.** Photograph of the experimental setup and schematic of the types of data obtained with the developed procedure, which are inputs for a novel prosthesis design system

## DISCUSSION & CONCLUSION

In this work, kinematic, EMG, inertial and hand function data were obtained for able-bodied subjects. Additionally, kinematic and hand function data were obtained for transradial amputees wearing different types of prostheses. Using a clinically validated procedure allowed for a wide range of hand functions to be assessed. The obtained information set provides valuable input to any prosthesis design system and can be used to gauge the performance of existing and new devices. Additionally, the procedure can be adapted for use with different levels of amputation.

Overall, the developed procedure is a novel combination of techniques which can be used to create structured databases, constituting the base for new personalised prosthesis design systems, with great potential especially for additive manufacturing applications.

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# EMBEDDED CONTROLLER FOR PATTERN RECOGNITION AND NEURAL STIMULATION VIA OSSEOINTEGRATION

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, Max Ortiz-Catalan[1,2]
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## BACKGROUND

Although the development of bioelectrically controlled upperlimb prosthesis started in the 1970's, the majority of amputees do not use this technology due to its poor functionality, reliability, and comfort. This study is based on previous work conducted by OrtizCatalan,
Håkansson, and Brånemark, who developed a permanent bidirectional interface into the human body,
namely the Osseointegrated Human-Machine Gateway
(OHMG) [1][2].

## AIM

We developed an embedded system to exploit the advantages of the OHMG technology. Our Artificial Limb Controller (ALC) was designed as a self-contained wearable unit capable of decoding motor volition and provide direct neural sensory feedback (Fig. 1).

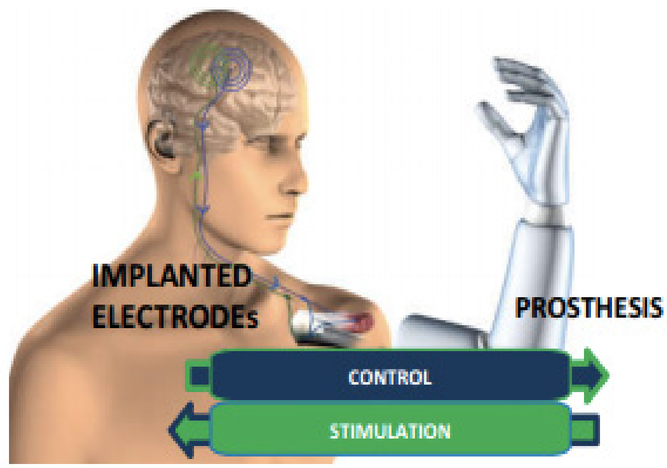


Figure 1. Artificial Limb Controller: overall view.

## METHOD

The ALC allows for bioelectric signals acquisition, processing, decoding of motor volition, and prosthetic control. Standard myoelectric threshold control was
implemented as well as two robust pattern recognition
algorithms. Inertial sensors are included in the system and used to improve motor prediction. The ALC also includes a neurostimulator to elicit direct neural feedback aimed for restoration of tactile sensations. In addition, a SD card is also included to continuously keep track of all relevant processes in order to better understand prosthetic use and the potential sources of errors. Wireless communication with external devices is be achieved via Bluetooth dongle pluggable on the ALC.

## RESULTS

Battery life was found to be 15 to 18 hours using a standard prosthetic device battery with capacity of 800 mAh. Real-time functionalities were proven with time characterization of all embedded routines. Onboard pattern recognition algorithms showed average accuracy around 97% in offline test. Realtime predictions were tested with state-of-the-art test and resulted in average accuracies around 65%. The effectiveness of the neural stimulation was proven by asking the pilot patient to blindly grasp delicate objects such as eggs or grapes. The ALC is no used by the patient in daily life.

## DISCUSSION & CONCLUSION

An embedded digital controller was implemented in this work aiming to exploit the advantages of the OHMG
technology. Hardware was thoroughly bench tested and
validated in terms of real-time tasks characterization and power consumption. Pattern recognition accuracy was tested, both offline and real-time. This ensemble provides a clinically viable solution for the control of upper limb prostheses, as well as a research platform for further investigations on prosthesis usage and
training, machine learning techniques and neural stimulation paradigms.

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percutaneous prosthetic system for treatment of patients with transfemoral amputation: A prospective study of 51 patients," Bone Jt. J. [2] M. Ortiz-Catalan et al; 2014; "An osseointegrated human-machine gateway for long-term sensory feedback and motor control of artificial limbs," Sci. Transl. Med.

# LOAD DISTRIBUTION BETWEEN FOREARM BONES IN TRANS-RADIAL OSSEOINTEGRATED PROSTHESES

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## BACKGROUND

Osseointegrated trans-radial prostheses have the potential to preserve the natural range of wrist rotation by allowing controlled freedom of motion between the forearm bones, and thus improve prosthetic function. Since this is the first time that loads are can be applied independently to the forearm bones, no literature regarding the safety and comfort of the patient is available.

## AIM

The aim of this work was to investigate how loads are distributed between the two forearm bones when a trans-radial osseointegrated prosthesis is used to preserve natural forearm rotation.

## METHOD

A custom test rig was produced that accommodates dummy implants in several different configurations, simulating different patients and forearm rotation angles. The implants were instrumented with strain gauges. A device that preserves natural forearm rotation was attached to the implants and subsequently a fixed load was applied to this attachment device. Strain in the implants was measured during different alignments of the implants, configurations of the attachment device and rotation angles of the rig.

## RESULTS

Depending on the alignment of the implants, the configuration of the attachment device, and the rotation angle of the test rig, the measured distribution of loads over the two implants varied. The attachment device allows one of the holders of the implants to move more freely than the other. Generally, the implant attached to the more constrained holder received a higher portion

of the load, measured between 55 and 90 %. The difference between the strains in the implants increases as the rig is positioned more vertically, which is illustrated in Figure 1. Horizontal positioning of the rig resulted in an equal distribution of the loads over the two implants (as expected).

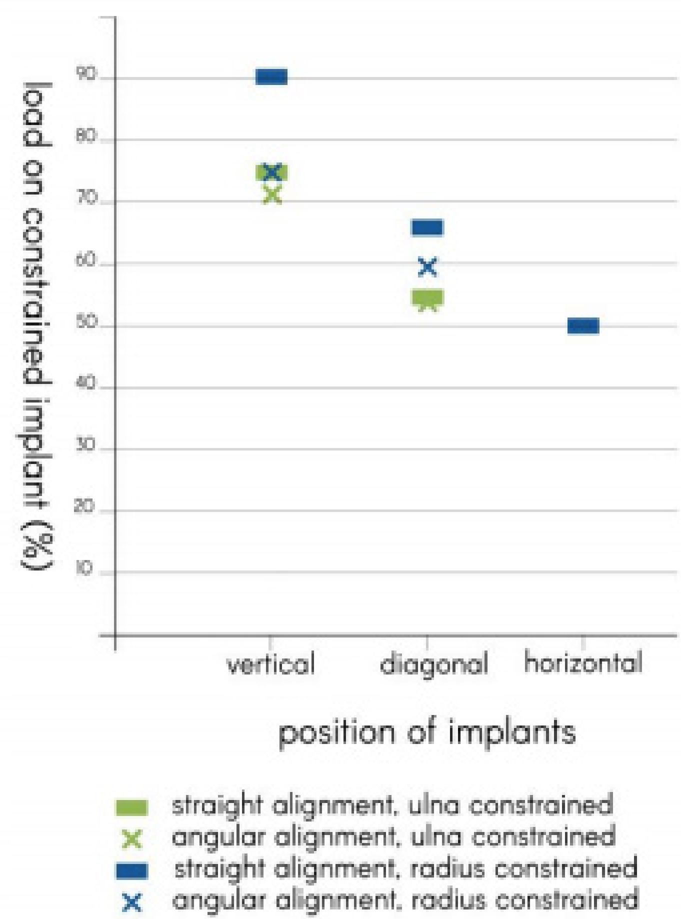


Figure 1. Percentage of load of the constrained implant when varying alignment and rotation angle of the set-up.

## DISCUSSION & CONCLUSION

The distribution of loads over the forearm bones depends on several factors when using an osseointegrated prosthesis with an attachment device that allows natural pronation and supination, but can be predicted to some degree. This information can be used to present guidelines for the use of this type of prosthesis and assess its long-term safety. Future research should be conducted on how the load distribution impacts comfort of the patient.

# THE TRUNK CANNOT BE SEEN AS ONE RIGID SEGMENT FOR ORTHOSIS DEVELOMENT

Laura Peeters

## BACKGROUND

The trunk is important for performing daily activities, as its movements interact closely with arm movements. The trunk is part of the kinematic chain, but also provides a stable base. Current trunk orthoses often (partly) restrict trunk movement, since they are (semi) rigid and do not take into account the multi-segmented nature of the trunk. Getting insight in the contribution of individual trunk segments to performance of daily tasks, can be used to develop a trunk orthosis for children with neuromuscular disorders, that assist the users rather than restricting them.

## AIM

The aim of the study was to evaluate trunk movements during daily activities in healthy children and young adults and to deduct possible implications for trunk orthosis design.

## METHOD

Twenty-five healthy children and young adults between 6 and 20 years old participated in this study. A 3D motion analysis system (Vicon) was used to record 23 single markers on pelvis, trunk and arms. The trunk was divided in four segments: upper and lower thoracic, and upper and lower lumbar. While seated, participants performed maximal trunk range of motion tasks in three directions and several daily activities, like reaching, drinking and writing. Kinematics of the trunk segments, pelvis and the arms were calculated in three dimensions, so individual trunk segment movement and relative contribution of each segment could be determined. Movement of the pelvis was described globally (relative to the world), while movement of the other segments were described locally (relative to a more caudal segment).

## RESULTS

Results show that contribution of individual trunk segments to the overall movement, varies in different movement planes. Rotation between the lower thoracic segment relative to the upper lumbar segment contributed most to rotation, both in maximal movement and in daily tasks. The main contribution to lateral bending was either from the pelvis or from both thoracic segments. During maximal trunk movement, participants chose different strategies (e.g. either moving more with the thoracic segments or pelvis segment), whereas in daily tasks lateral bending was mainly due to movement of both thoracic segments. When flwexing and extending the trunk in daily activities, the contribution of all segments was about equal. However, when performing maximal trunk movement or maximal reaching movements, the contribution of the pelvis was highest, followed by lumbar segments.

## DISCUSSION & CONCLUSION

Individual trunk segments contribute in different movement directions to the performance of daily activities. Thus it is important for development of a new type trunk orthosis to consider the trunk as multi-segmented instead of a rigid segment. Restricting certain trunk movements may result in less comfort, adaptation or avoidance when performing daily activities. In future research we will study how daily life performance is influenced by restricting certain trunk movement.

# CRITICAL OUTCOME VARIABLE FOR UNRAVELING THE UPPER EXTREMITY WORKING MECHANISM IN DUCHENNE MUSCULAR DYSTROPHY: A BIOPHYSICAL MODEL

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## BACKGROUND

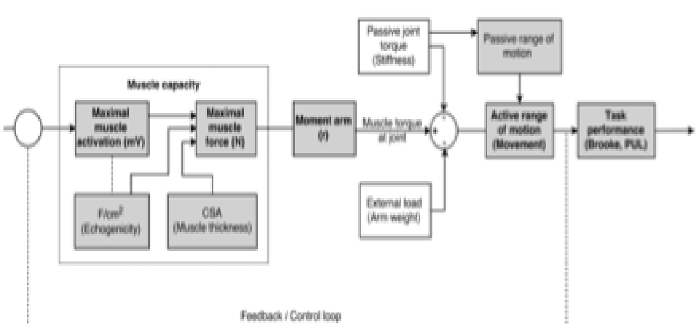
Duchenne Muscular Dystrophy (DMD) is a neuromuscular disorder which limits upper extremity (UE) function. UE activity scales are currently used as the golden standard for defining UE limitations. These scales, however, are not able to explain the biophysical working mechanism behind these UE limitations. Yet, for choosing appropriate and effective interventions, knowledge on the upper extremity working mechanisms is very important.

## AIM

The aim of this study was to identify critical physiological outcome variables underlying reduced UE task performance in DMD. These critical variables were used to propose an explanatory biophysical model of the UE working mechanism in DMD.

## METHOD

Twenty-three DMD patients (8-21 years) participated in this study. We used both physiological outcome measures (maximal muscle torque, maximal surface electromyography (sEMG) amplitude, echogenicity, maximal passive and active joint angles) and functional scales (Brooke scale and the Performance of Upper Limb (PUL) scale). Critical physiologic outcome variables were determined based on their Spearman correlations with functional scales (Brooke and PUL scale) and multivariable linear regression analysis using functional scales as dependent variables.




## RESULTS

Correlations with Brooke scale and PUL score were very high (rs > 0.80) for maximal active joint angle sum score, high (rs = 0.60-0.79) for maximal muscle torque and maximal sEMG amplitude sum scores, and moderate (rs = 0.40-0.59) for mean echogenicity Z-score and maximal passive joint angle sum score. Multivariable regression analysis showed that maximal active joint angle and maximal muscle torque sum scores were significantly associated with Brooke score (R2=0.91). Maximal active joint angle, maximal passive joint angle and maximal muscle torque sum scores were significantly associated with PUL score (R2=0.94).

## DISCUSSION & CONCLUSION

Based on the most critical physiologic outcome variables, we were able to construct an exploratory biophysical model of the working mechanism, leading to limitations in UE task performance (figure 1). Although this model should still be validated, it could be used as a basis for understanding the working mechanism leading to upper extremity impairments. Better insights in this working mechanism could support clinical management of UE limitations and facilitate the development of appropriate interventions. In addition, the model could form the basis for new composite outcome measures for clinical trials.

# RELIABILITY OF THE SELF-EFFICACY FOR ASSESSING, TRAINING, AND SPOTTING TEST FOR MANUAL WHEELCHAIR USERS

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## BACKGROUND

The Wheelchair Skills Program is an effective, evidence-based wheelchair skills testing and training program for manual wheelchair users,1 Despite knowledge translation efforts, including clinician workshops and multi-faceted interventions, the program is underutilized. Clinician confidence may influence its use in practice, however no measure has been available to assess confidence to implement the Wheelchair Skills Program. The Self-Efficacy for Assessment, Training, and Spotting test – Manual Wheelchair Skills (SEATS-M) was developed to assess clinician confidence following knowledge translation interventions.

## AIM

To establish the retest reliability and responsiveness of the SEATS-M for use in knowledge translation or clinician training contexts.

## METHOD

Participants were occupational or physical therapists working in a provincial rehabilitation centre, with a minimum of six months experience in clinical practice, who treated 5 or more wheelchair users/month. Participants completed the SEATS-M twice, approximately two weeks apart, during which no clinician training was provided. Percentage scores for each subscale (assessment, training, spotting, and documentation) were calculated by adding all reported subscale scores, dividing by total possible score (# applicable scores x 5), and multiplying by 100. Intraclass Correlation Coefficients (ICC 1, 1, 95% Confidence Interval) were calculated for within person scores (T1-T2) for each subscale. Minimal detectable change established using a calculation for Smallest Real Difference (SRD).

## RESULTS

Participants included sixteen Occupational and Physical Therapists working in a Canadian Rehabilitation Centre. ICCs for all subscales of the SEATS-M were excellent, ranging from 0.80 to 0.95 (Table 1). The SRD for the SEATS-M for assessing, training, spotting, and documentation ranged from 6.24 to 8.13 (Table 1). These reflect the minimal amount of change required for each subscale to exceed measurement error.

| | SEATS for Manual Wheelchair Users | | | |
|---|---|---|---|---|
| | Assess | Train | Spot | Document |
| Median (%) | 70.08 | 62.29 | 85.63 | 44.00 |
| Retest ICC (1,1) | 0.81 | 0.95 | 0.87 | 0.89 |
| SRD (%) | 7.95 | 6.24 | 8.18 | 7.12 |

Table 1. SEATS-M Re-test Reliability and Responsiveness

## DISCUSSION & CONCLUSION

We found excellent reliability for all subscales of the SEATS-M. Overall, median scores for documentation were lower than for assessing, training, and spotting. This is consistent with clinical observations and represents an opportunity for clinical education and training.

The SEATS-M is a self-report measure of confidence for assessing, training, spotting, and documentation of manual wheelchair skills which can be used to assess the effectiveness of education provided to clinicians to support implementation of the Wheelchair Skills Program in practice.

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# KNOWLEDGE TRANSLATION OF THE WHEELCHAIR SKILLS PROGRAM IN A CANADIAN REHABILITATION CENTRE

Paula W. Rushton[1], Emma M. Smith[2,3], William C. Miller[2,3], R. Lee Kirby[4], Louise Demers[1], åLinda Boronowski[3], Sarah Rowe[3], Sarah Sinanan[3]

## BACKGROUND

Among the 197,560 Canadian manual wheelchair users over 15 years of age,1 only 11-55% receive wheelchair skills training.2,3 Training which is provided is mostly basic skills, rather than the more advanced skills required for community mobility.4 Without adequate wheelchair skills training, wheelchair users may experience decreased participation in daily activities and reduced quality of life. The Wheelchair Skills Program (WSP) is an evidence-based program that can be used for this purpose.5

## AIM

This project evaluated the feasibility of implementing a WSP as a knowledge translation (KT) intervention.

## METHOD

Rehabilitation clinicians working at a Canadian rehabilitation center were recruited to participate in this study. During the 20-week WSP KT intervention, each participant attended an 8-hour educational workshop, had regular access to clinical champions, access to the WSP website, and increased organizational support (i.e. approval of site specific forms, time to attend training). Feasibility indicators assessing process, resource, management and intervention outcomes were measured at 4 time points (baseline and 1 week, 6 months and 12 months post-intervention). These data were supplemented with participant logs, chart audits, and qualitative interviews with participants, clinical champions, and managers.

## RESULTS

Sixteen physical (n=11) and occupational (n=5) therapists participated in this study. Our parameters for success for process outcomes were met for clinician recruitment (i.e., ≥ n=15) but not for retention (i.e., ≥ 80% retention). For resource outcomes, we achieved success in terms of clinician attendance at the workshop (i.e., 100%), clinician website use (≥ 4x), and qualitative interview completion (≥ 30%). The parameters for success were not met for use of clinical champions (i.e., ≥ 80%) or completion of logs (i.e., ≥ 80%). In terms of management outcomes, we recruited and retained two clinical champions for the entire length of the study. Finally, for the intervention outcomes, participants demonstrated a statistically significant improvement in their knowledge of wheelchair skills and self-efficacy for wheelchair skills assessment and training.

## DISCUSSION & CONCLUSION

Study findings indicate that a WSP KT intervention for manual wheelchair use is feasible, but there is room for improvement. Specifically, we recommend additional time for knowledge use, increased structure during clinical champion sessions, variability in the timing of clinical champion sessions, and improved communication strategies. This work will ultimately help to enhance clinical outcomes by bridging the gap between evidence and practice.

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# TOP COMPARE THE OBJECTIVE AND SUBJECTIVE COMPLIANCE OF THE MILWAUKEE BRACE WEARING SCHEDULE IN ADOLESCENTS WITH HYPER-KYPHOSIS

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## BACKGROUND

Orthoses are the most known method for conservative management of adolescents with hyper-kyphosis [1]. To achieve the best results brace needs to be worn 23 hours daily[2]. Most of the studies in the field either considered that patient have worn the brace as advised or measured the time in brace (i.e. compliance) subjectively. This might be one reason for the current controversy in the available evidence.

## AIM

To compare the objective and subjective compliance of the brace wearing schedule in adolescents with hyper-kyphosis.

## METHOD

Study participants were 18 adolescents with hyper-kyphosis (7M &11F). Actual time in brace was measured using a miniature temperature sensor, thermochron which was embedded underneath padding in the brace. Patients and their families were blinded to the mounted sensor. For subjective evaluations of brace compliance, two methods were used. First, a questionnaire was provided to the patients to record quantity of hours in brace daily.Second method was the routine question that usually the therapist asks from a patient and/or the parents i.e. how many hours the brace has been worn on average.

## RESULTS

Comparison of data for the thermochron, questionnaire and general average brace wear time were evaluated. All were distributed normally expect general average time.Comparison between thermochron recording and questionnaire data was carried out employing paired sample t-test and wilcoxon non-parametric for the average brace use.The compliance measured by the thermochron (16 hrs) was significantly lesser than that reported by patients whether in questionnaire (19.61hrs) ($p<0.001$) or in general average time (21.18hrs) ($p=0.001$).There was no correlation between age, gender and BMI with brace the difference in compliance.

## DISCUSSION & CONCLUSION

Wearing schedule in orthotic treatment of spinal deformity is an important factor that affects the treatment results and might be affected by a several factors including appearance, quality, and comfort of brace, parents' support, life style, and etc. Evaluating the effectiveness of any brace without objective measurement of compliance should be considered with caution.Difference between objective and subjective compliance was present in all patients and was not limited to any age category, gender, or particular body mass index.

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# A TRAINING EXPERIENCE OF BENCH WORKERS IN SUDAN

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National Authority of Prosthetics and Orthotics (NAPO) [1], International committee of the Red Cross (ICRC) [2]

## BACKGROUND

There is a huge demand of Prosthetics and Orthotics services in Sudan and due to lack of trained Bench Workers (BW), the limited available professionals had to practice the entire process of fabricating devices, resulting in limited output. The International Committee of the Red Cross (ICRC) working in partnership with the National Authority for Prosthetics and Orthotics (NAPO) for more than 25 years in Sudan made an attempt to design a short-term course for BW.

## AIM

To share Sudan's experience in contextual BW's training from its inception to execution and evaluation. The training package developed through the process may help others in similar context.

## METHOD

An estimation was made for the needs of the BW's in the country following guidelines for training personnel in developing countries *, a curriculum was designed for the most practiced devices and in this case, ICRC polypropylene technology for lower limb prosthetics and orthotics. The duration 12 weeks and the content of the training (Basic Anatomy, Workshop technology, Health & Safety, Manufacturing guidelines, etc.) was decided considering sustainability of the training, cost effectiveness and quick outcome. The careful selection of the students and their employment was ensured prior to the training and evaluation made at each batch of the training.

## RESULTS

Two batches of the training conducted and 24 BWs are ready to work under the supervision and guidance of qualified prosthetics and orthotics professionals, this will allow the qualified professionals (P&O) to concentrate more on service users while BWs are involved in fabrication of devices inside workshop. The BWs practicing fabrication of devices and having scientific background are the best choice for selection of student for Diploma in Prosthetics and Orthotics. NAPO developed local trainers for sustainability and continuity of the training with gradual reduction of the support from the ICRC.

- 3.0 % of countries' required BWs were secured in short period (two batches)
- Built capacity of existing BWs and trained new BWs at NAPO centres throughout Sudan.
- 20% of trainees with disabilities included

## DISCUSSION & CONCLUSION

Overall, the BWs training in Sudan was successful considering the outcome in the short period. Moreover, the formal training of BWs are neglected in most of the developing countries especially in Africa and a contextual design of the training could help to boost production qualitatively and quantitatively. The duration of the training is still under discussion and perhaps refresher /upgradation training may be required if the technology and scope of services changed. Recognition will be another challenge.

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# INTEGRATED MOBILITY DEVICE SERVICES: SAMOA'S EXPERIENCE

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[1] Motivation Australia

## BACKGROUND

Mobility impacts upon all aspects of life. Being mobile has a significant impact on health, social and economic life; and enables access to education and employment.
According to the World Health Organisation (WHO) approximately 1% of any population require a wheelchair, and 0.5% require a prosthetic or orthotic device. In the small island nations of the Pacific Region, this equates to approximately 150,000 people.

Very few people with a mobility disability in the Pacific Region have access to the mobility devices that they need. When devices are available, there is not always a service system in place to provide those devices appropriately.

A chronic reliance on donated wheelchairs, handed out by NGOs or faith based groups in the absence of a service delivery system has perpetuated a lack of awareness of the impact that an appropriate mobility device can have on a person's mobility, health, self-esteem and overall independence.

The WHO promotes integrated wheelchair, seating, prosthetic and orthotic services as a way of addressing the need for mobility device services in less resourced settings. Integrating the provision of wheelchairs, walking aids, prosthetic and orthotic services means:

•more cost effective services to establish (compared to separate services)
•lower on-going running costs for health providers
•well suited to smaller, more dispersed island populations
• simpler referral system

## METHOD

The Samoan Integrated Mobility Device Services (SIMDES) project is a four year (2014 - 2018) collaboration between the Samoa National Health Service (NHS), NOLA (Nuanua O Le Alofa) and Motivation Australia; working to create consistent, equitable and sustainable access to appropriate mobility device provision for women, men, girls and boys with a mobility disability in Samoa.

The project has seen the development of the Mobility Device Service (MDS) within the Tupua Tamasese Meaole (TTM) hospital in Apia, integrating services for wheelchairs, supportive seating, Prosthetics & Orthotics (P&O) and walking aids into one mobility device department. Prior to this project there was no pre-existing mobility device services available in Samoa.

## RESULTS

Mobility device provision requires a combination of:

• Appropriate mobility devices
• Services that people can reach
• Training for local people
• Policy and awareness that support and guide

The Samoan MDS was built progressively to allow for the varied range of training, devices, tools and materials required for an integrated service. Walking aid and basic wheelchair services were introduced first, with intermediate wheelchair and prosthetic and orthotic services following. Building the service progressively allowed for each element to be adequately developed and supported.

The lessons learnt from the establishment of the Samoa Integrated Mobility Device Services are relevant for all small – medium service development. In order to build the Samoan MDS into a sustainable, appropriate mobility device service there were four core components that needed to be strengthened:

• Human resources
• Technical Resources
• Service systems
• And Organisational culture

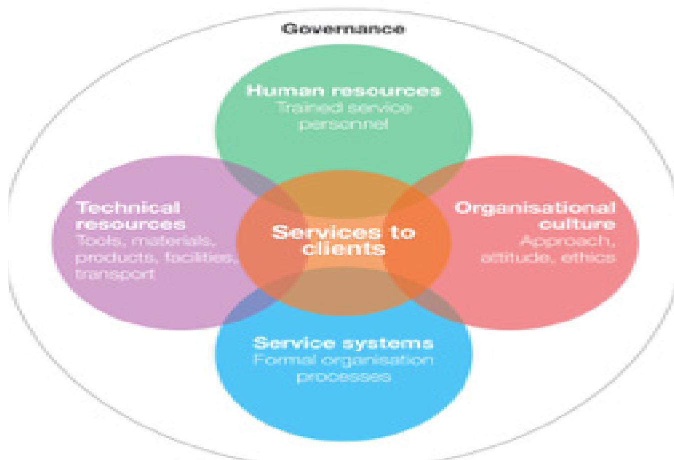


Figure 1. Motivation Australia's 'Capacity Assessment Matrix' for service provision organisations.

## DISCUSSION & CONCLUSION

The development of the Samoa MDS has highlighted the importance of addressing capacity holistically, rather than focusing on single elements in isolation. The scale of the inputs that can be made is always funding dependent. However, taking a long term view enabled the planning and implementation of services which complement each other and contribute strategically to the bigger picture.

# WHICH ROCKER OUTSOLE DESIGN IS MOST EFFECTIVE FOR DIABETIC PATIENTS?

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## BACKGROUND

Plantar foot ulceration and gait abnormality are two serious complications in diabetic patients (1). There are a number of conservative modalities to decrease the incident of plantar foot ulceration. Irrespective of the type, the primary role of all these modalities is mechanical offloading of the high risk areas of the foot. While the therapeutic extra-depth shoe with a rocker outsole is the most common prescription for offloading diabetic foot (2), there is an obvious paucity of research about the most effective design of the rocker outsole in diabetic patients.

## AIM

As forefoot is the most common site of the diabetic foot ulceration, we aimed to investigate the effects of three different designs of toe-only rocker outsoles on several kinetic and kinematic gait characteristics.

## METHOD

Ten female participants with diabetes aged 45-65 years, with no history of previous ulceration were recruited to the study after ethical approval was granted by the local university. Three different designs of rocker outsole (with 10°, 15° and 20° rocker angle) which were previously shown to be most effective in plantar pressure reduction in diabetic patients (3), were used. Kinetic and kinematic data were synchronously collected while subjects walked either barefoot or with each of the rocker outsole shoes with a controlled self-selected speed over a 10-meter walkway. Qualisys motion capture system and a Kistler force plate were used to measure the spatiotemporal gait parameters and the ground reaction forces (GRFs), respectively. Repeated measures ANOVA followed by Bonferroni Post Hoc statistical analysis was performed with a confidence interval of 95% using SPSS software (Version 22, 2014).

## RESULTS

Summary of results is shown in Figure 1. There was no significant difference among the test conditions for the first peak of GRFs ($p>0.05$). Although the second peak of GRFs was decreased by increasing the rocker angle respectively, this decrease was only significant for 20° rocker outsole in comparison to the both barefoot ($p=0.003$, effect size=0.45) and 10° rocker outsole ($p=0.007$, effect size=0.41); with no significant difference between 20° and 15°. There was an increase in mean step-width from barefoot to 20° rocker angle, but it was statistically significant only between barefoot and 20° rockers ($p=0.0$, effect size=0.58). The mean step-length was significantly increased with all the three rocker outsole designs in comparison to the barefoot ($p<0.05$, effect size>0.8). Although, mean of the cadence was increased by increasing the rocker angle respectively, this increase was only significant for 15° ($p=0.02$, effect size=0.37) and 20° ($p=0.0$, effect size=0.58) rocker outsoles in comparison to the barefoot.

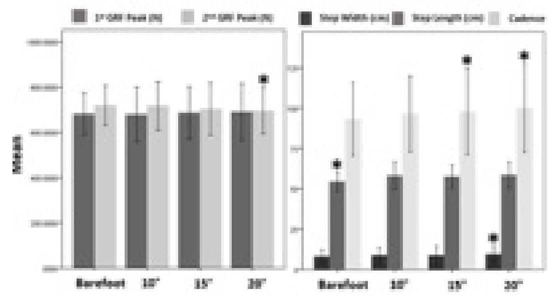


**Figure 1**. Left: First and second GRF peaks (a significant difference between 20°and barefoot, 20°and 10°; Right: Step width (a significant difference between 20°and barefoot), Step length (barefoot is significantly different from 10°, 15° and 20°) and Cadence (a significant difference between barefoot and 15°, barefoot and 20°). Standard error bars show +/- 2 SD.

## DISCUSSION & CONCLUSION

Results of this pilot study showed that 20° toe-only rocker outsole shoe imposes more kinetic and kinematic changes to the diabetic gait. There is a global consensus on the altered gait pattern of diabetic patients which could be either a compensatory or a conservative strategy. Any shoe modification can affect this specific gait pattern thus must be considered carefully. It was previously shown that the toe-only rocker significantly increases cadence and decreases step length while significantly changing the kinematics and kinetics of lower limb joints in healthy subjects. However, there was no report of the specific design of the toe-only rocker used in that study (4). To our knowledge, there is only one study in which the effects of systematically changing the toe-only rocker outsole characteristics on peak plantar pressures have been investigated (3). Though it was found that increasing rocker angle decreases plantar pressures particularly from 15° to 20°, 66% of participants with diabetes experienced sufficient offloading with a 15° rocker outsole shoe (3). For a conclusive result, further studies with a bigger sample size containing both genders are warranted.

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# CUTTING COSTS WHILE IMPROVING CARE: SAMOA'S DIABETIC FOOT CLINIC

Katrina McGrath [1], Marjolein Weigman [2]

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## BACKGROUND

In June 2015, Motivation Australia, in partnership with the Samoa National Health Service (NHS), established a Diabetic Foot Clinic (DFC) at the Tupua Tamasese Meaole (TTM) hospital in Apia, Samoa.
Treating diabetic foot ulcers is costly due to long treatment times and high rates of amputations. Evidence from developed countries shows that treating diabetic foot ulcers in a diabetic foot clinic with guideline-based care and a multidisciplinary approach is cost-effective compared with usual care (Sumpio et al. 2010). There is limited research, however, outlining the costs and benefits of similar clinics in less resourced settings such as Samoa.

## AIM

The aim of this research was to outline the costs and benefits of treatment within the NHS DFC compared to treatment received at the NHS in the 2 years prior to the DFCs implementation.

## METHOD

In Samoa the only recognised and measurable intervention for clients with diabetic foot ulcers prior to the DFC was inpatient treatment. As a result the costs and benefits of the DFC were compared to acute hospital care and amputation within TTM Hospital. Medical records were reviewed for clients who were admitted at TTM Hospital for a diabetic foot ulcer for a two-year period between June 2013 and June 2015, and for clients who were treated for a diabetic foot ulcer at the DFC for the period from June 2015 until May 2016.
DFC costs were calculated using the mean costs of offloading materials per client who received offloading and the mean salary costs per visit multiplied by the average number of appointments.

Hospital costs were calculated using the Eurodiale study as a guideline (Prompers et al. 2008). A percentage of amputation costs, intervention costs, diagnostic intervention costs and the costs of antibiotics were calculated from available data on total hospital running costs.

## RESULTS

From June 2013 to June 2015, 563 clients were admitted to TTM Hospital with diabetes related circulatory complications a total of 667 times. The average length of stay was 11 days per admission. No ulcers healed during admissions and 30% of clients had an amputation. Average cost per admission was WST$7,239 (USD$2,909).

From June 2015 to May 2016, 46 clients with non-infected foot ulcers were treated at the DFC. Clients attended an average course of treatment of 10 appointments; 70% of clients received ulcer offloading. By May 2016, 50% of clients seen at the clinic had their ulcers healed; average healing time was 105 days. Average cost per course of treatment was WST$924 (USD$371).

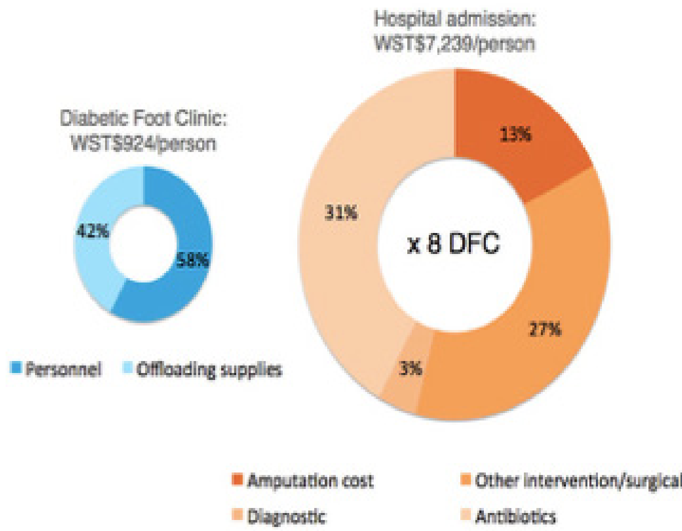


**Figure 1.** Breakdown of treatment costs for clients with diabetic foot ulcers seen at the DFC compared to those admitted to TTM Hospital.

## DISCUSSION & CONCLUSION

Along with the economic benefits of the DFC over hospital admissions, outcomes for clients were also much improved. DFC clients were more likely to heal their ulcers, prevent infection and avoid amputations. The diabetic foot ulcers of clients admitted to the TTM Hospital, when compared to those seen at the DFC tended to have the added complication of infection. Within this study an assumption was made that treatment at the DFC prevented infection and the need for hospitalisation, and therefore the associated costs. This is supported by the fact that only one of the 46 clients receiving treatment at the DFC required admission to TTM with foot sepsis in the one-year period. The study indicates that the DFC could save costs for the National Health Service and improve outcomes for clients. Savings would increase and more people would benefit if the capacity of the service was expanded and Samoans were encouraged to seek treatment earlier at services closer to their communities. The results show that the implementation of a dedicated Diabetic Foot Clinic both reduces costs and improves outcomes when compared to acute care, hospital admission and amputation. It is hoped that these findings can be used to encourage the establishment of more multi-disciplinary Diabetic Foot Care services within Samoa and throughout the Pacific.

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# INCIDENCE OF LOWER LIMB AMPUTATION IN KPK AND FATA, PAKISTAN

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## BACKGROUND

The incidence of amputation has been well reported in developed countries around the world [1]. This has enabled them to provide effective services to support people with disabilities around the entire country. A lot of work needs to be done in a developing country like Pakistan due to lack of required data and accessible clinic for vulnerable people with disabilities [2].

## AIM

To determine the trend in the incidence of lower limb amputation over a six-year (2009-2014) period in KPK and FATA.

## METHOD

All patients with Lower Limb Amputations (LLA) used in this study reported at the PIPOS Rehabilitation Service Program (PRSP) centers between 2009 and 2014. Patient's age at amputation, gender, level of amputation, and cause of amputation were recorded. The site of amputation was classified into partial foot amputation, ankle disarticulation, transtibial amputation, knee disarticulation, transfemoral amputation and hip disarticulation. Prosthetic assessment was recorded into the Patient Management System. The causes of amputation were classified as trauma, diabetes mellitus, disease, congenital and others.

## RESULTS

The average population of KPK and FATA between 2009-2014 was 5209486 [3] and the incidence of LLA per 100,000 population per year was 27.3 overall (22.1 for male and 5.2 for female). A total of 4340 amputees were provided with prosthesis, including 3540 (81.6 %) males and 800 (18.4 %) females. The male to female ratio was approximately 4:1, and the average age at amputation was 39.1 ± 17.2 years.
The most frequent levels of amputation were transtibial amputation (63.8 %) and transfemoral amputation (25.5 %) (Fig. 1). The major causes of LLA was trauma (76.6 %) and diabetes mellitus (14.1 %) (Fig. 1). Disease (7.5 %) and congenital disorders (1.5 %) were the least causes of amputation (Fig. 1).

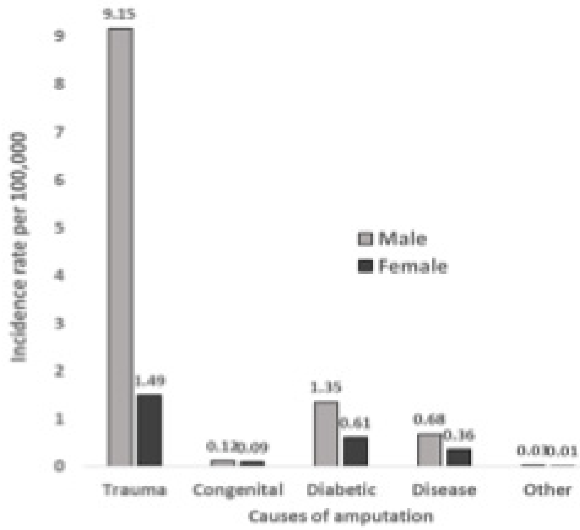


**Figure 1.** Variation of incidence rate with causes of amputation for male and female amputees in KPK and FATA between 2009 - 2014

## DISCUSSION & CONCLUSION

This study has attempted to study the incidence of LLA at two strategic regions in Pakistan (KPK and FATA). The outcome of which has established a large gender variation between male and female amputees (≈ 4:1). In contrast to other studies which reported that diabetes was the leading cause of LLA [4, 5], our results proved otherwise. Trauma was the major cause of LLA, accounting for over three-quarter of the cases reported. The outcome of this study will provide a platform towards the planning and distribution of services according to the needs of patients with disabilities.

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# AN INTERNATIONAL, MULTI-CENTER CLINICAL STUDY: GAUGING PATIENT EXPERIENCE WITH DIGITALLY DESIGNED, 3D TRANS-TIBIAL PROSTHETIC DEVICES COMPARE TO COMPARE TO MANUALLY PRODUCED PROSTHETIC DEVICES

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## BACKGROUND

Current manual manufacturing techniques to produce trans-tibial prosthetic sockets require extensive labour and time. These factors limit the throughput of orthopaedic workshops, particularly in resource-limited contexts. The use of a digital toolchain, including 3D scanning, design and printing, reduces the total manufacturing time for a single device, enhancing clinician and workshop productivity. How prosthetic users would regard the use of a digitally designed, 3D printed device is currently unknown.

## AIM

The aim of this research project is to compare the efficacy of digitally designed, 3D printed trans-tibial prosthetic sockets to manually produced sockets made with ICRC methods.

## METHOD

In partnership with clinics and orthopedic workshops in Uganda, Cambodia and Tanzania, Nia Technologies Inc. is conducting a large-scale clinical study. Seventy trans-tibial device users between the ages of 5 - 25 are being recruited to use a 3D printed trans-tibial socket for four weeks. At the end of four weeks, patients complete a 27-question survey (modified Prosthesis Evaluation Questionnaire) to gauge their user experience. Next, a new manually produced prosthetic device is manufactured for the patients. After four weeks of using the manually produced device, patients complete the same survey to assess their user experience with this device.

## RESULTS

Currently, 38 trans-tibial prosthetic users from Uganda, Cambodia and Tanzania have reported back after having used their 3D printed device for four weeks. Of the 38 patients, 27 have returned and provided feedback for the manually produced device. With regard to the patient's ability to walk, the average Likert score was 4.00±0.39 and 3.89±0.77 out of 5 for manually produced and 3D printed devices respectively. With regard to the overall fit of the device, the average Likert score was 3.85±0.76 and 3.97±0.72 for manually produced and 3D printed devices respectively. Finally, when asked about their happiness with the device, the average Likert score was 3.85±0.39 and 3.94±0.61 for manually produced and 3D printed devices respectively.

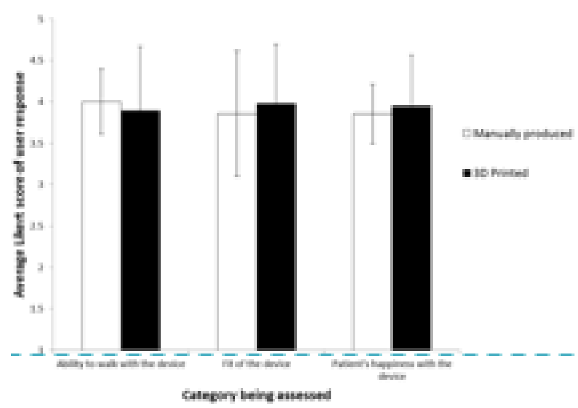


**Figure 1.** Average Likert score of responses from patients regarding their ability to walk, overall fit and satisfaction with their manually produced or 3D printed trans-tibial prosthetic. Error bars are ±SD.

## DISCUSSION & CONCLUSION

To our knowledge, this is the first study of its kind and scale to compare the efficacy of 3D printed devices with manually manufactured prosthetics. While acknowledging the subjectivity of data derived from patient interview methods, preliminary results indicate that 3D printed devices are performing comparably to manually produced prosthetics. This supports our hypothesis that a digital manufacturing toolchain is a viable alternative to current manual methods and may ultimately be more desirable given the time savings involved.

# COMPARISON OF TWO METHODS TO CALCULATE AMPUTEE BODY MASS INDEX: SELF-REPORTED VERSUS CLINICIAN ADMINISTERED

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## BACKGROUND

Weight gain is typical following lower limb amputation, with the likelihood of obesity increasing the more proximal the lower limb amputation at a rate of 37.9% and 48.0% for those with unilateral transtibial and transfemoral amputation, respectively.1 Body Mass Index (BMI) is a measure of weight adjusted for height (kg/m2) and has been found to be a surrogate measure of body fat, predictor of obesity, and indicator of type 2 diabetes, hypertension, and cardiovascular disease in adults.2,3 More than one-third (35.7%) of American adults are considered obese (BMI > 30).3 For persons with lower limb amputation this calculation factors in the weight and length of the missing limb using a mathematical formula. The Amputee Coalition and members of the Scientific and Medical Advisory Committee (SciMAC) developed a BMI Calculator for People with Limb Loss. The tool is available online and can rapidly generate a BMI score.

## AIM

The purpose of this study is to determine the validity of using self-reported height and weight and an estimated residual limb length for BMI calculations when compared to clinician measured anthropometric values.

## METHODS

A convenience sample of 72 lower limb amputees were recruited at the 2016 Amputee Coalition National Conference in Greensboro, North Carolina. Eligible subjects were between 18-80 years of age, with unilateral transtibial, knee disarticulation, or transfemoral amputation. Subjects completed the online Amputee Coalition BMI Calculator (BMIs) at intake using self-reported height, weight, and level of amputation. The formulas to calculate BMIs with this tool are:

$$BMIs = [We(lb) / height(in)2\ ] \times 703$$
$$We = W0 / (1-P)$$

**Figure 1**. BMIs Formulas. Where We = self-reported weight, W0= weight without the prosthesis, and p= percentage of total body weight of missing limb (TTA = 3.26, TFA= 9.96).

The research staff then measured height, weight, residual limb length, and sound limb segment length using standard equipment and calculated BMIc:

$$BMIc = [We(kg) / height(m)2\ ]$$
$$We = Wwp - Wpro / (P- (RL/intact)$$

**Figure 2.** BMIc Formulas. Where We = weight, Wwp= weight with the prosthesis, Wpro= weight of the prosthesis, and P= percentage of total body weight of missing limb (TTA = 0.985, TFA= 0.941).

The two methods of calculating BMI were compared using correlation analysis and paired t-tests.

## RESULTS

The average BMIc was 29.95 (range 15.4-55.8). Three subjects had calculated BMI < 18.5, indicating underweight status. Fifteen subjects had a calculated BMI in the normal range (18.5-24.9 kg/m2). Eighteen subjects (25%) were classified as overweight (BMI 25-29.9), and 36 subjects (50%) were classified as obese. The two methods of calculating BMI were highly correlated $r = 0.95$, $p<.001$. There was no significant difference in calculated BMI between the self-reported value and the clinician administered measurements (paired t-test, $p=0.36$). The clinician administered BMIC calculations were an average of 0.25 kg/m2 higher.

## DISCUSSION & CONCLUSION

The BMI equation developed by the Amputee Coalition using self-reported height, weight, and level of amputation produced similar BMI for unilateral lower limb amputees when compared to traditional methods. The clinician measured calculations required significantly more time to administer. Surprisingly, the rate of obesity in this sample of unilateral lower limb amputees is much higher (50%) than the prevalence in the US adult population (35.7%).3 The Amputee Coalition BMI Calculator is a quick and valid method for calculating BMI in unilateral lower limb amputees. Healthcare providers can use the Amputee Coalition BMI Calculator to generate valid BMI calculations for unilateral lower limb amputees while saving valuable clinical time.

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# COMPARING THE TASK JOINT MOTION BETWEEN ABLE-BODIED AND TRANSRADIAL PROSTHESIS USERS DURING ACTIVITIES OF DAILY LIVING

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## BACKGROUND

There are many health issues associated with amputation [1] but the connection is not always clear. Individuals who have undergone amputation surgery will perform tasks by employing different motions than persons without an amputation [2, 3]. Upper limb prosthesis users may compensate for the lack of joints while completing activities of daily living. As a result, amputees move significantly different than able-bodied, even for simpler tasks. This affects the strain of the musculoskeletal system with a potential to develop chronic injuries [4, 5].

## AIM

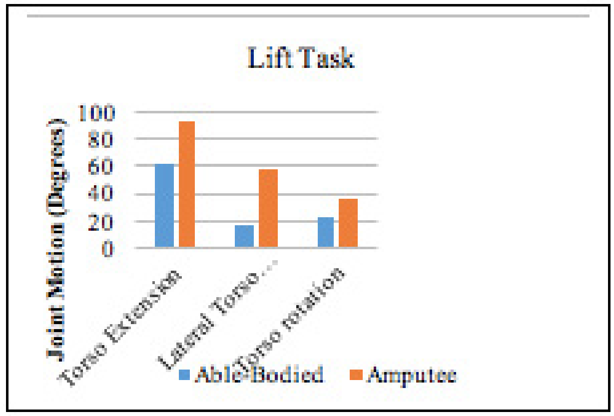
The goal of this study was to describe how much variation in the total use of joint motion exist between amputees and able-bodied, in order to optimize prosthetic design and training.

## METHODS

Fourteen (14) able-bodied individuals and eight (8) left transradial prosthesis users participated in the study. The amputees used a body-powered, voluntary opening prosthetic device. They performed activities of daily living (ADL) tasks while their motions were recorded using a marker-based motion capture (MoCap) system (Vicon, Denver, CO). The joint angles were calculated and compared using custom software written in Matlab (Mathworks, Natick, MA). Subjects performed each of the following ADL tasks at least three times: brushing hair, drinking from a cup, opening a door bilaterally lifting a laundry basket, and simulating cutting and eating using a fork and knife. The anatomical range of motion, the task joint motion (maximum joint angle –minimum joint angle during the task), were calculated and compared to give an insight of the overarching strategy able-bodied and amputee individuals use. The torso motions of the "Lift" task is shown because they showcase the differences between able-bodied and amputees better.

## RESULTS

For the able-bodied group the "Lift" task had an average torso extension of 61.0o with a standard deviation of 18.0o. Average Lateral torso extension was 16.3o ± 12.9o and average torso rotation was 23.1o ± 10.0o. For amputees, average torso extension joint motion was 92.7o ± 3.2o, lateral torso flexion ROM was 57.2o ± 1.7o, and torso rotation joint motion was 35.8o±1.8o. The amputees tend to move their torso more than able-bodied for all the tasks. The "Drink", and "Eat" tasks had shown higher joint motion for the amputee group, due to the need of compensation for the missing wrist, but the differences are not significant. For the "Open" task, torso extension was 12.5o ± 7.7o, lateral torso flexion was 8.8o± 4.6o, and torso rotation was 14.9o ± 6.8o. The amputees during the same task had an average torso extension was 12.3o ± 4.6o, lateral torso extension was 16.2o ± 3.2o, and torso rotation had an average 8.3o ± 1.7o. All tasks showed similar results. The standard deviation was lower for amputees. This was also consistent throughout all the tasks. The "Brush" task had slightly higher average joint motion for the able-bodied group. Indeed, torso extension was 15.0o ± 12.0o, lateral torso flexion was 9.3o± 6.1o, and torso rotation was 13.8o ± 7.1o. The amputees during the "Brush" task had an average torso extension of 10.3o ± 4.7o, lateral torso extension was 3.2 ±




v 3.1o, and torso rotation had an average of 6.7o ± 2.6o.

Fig.1 Torso movement ROM during the "Lift" task.

## DISCUSSION & CONCLUSION

Amputees tend to use their torso more to compensate for their missing joints. Interestingly, even though they were missing only their left wrist, their torso was affected greatlyThis is consistent with the previous literature. Another note needs to be made about the standard deviation. Amputees showed more consistency than able-bodied. This doesn't imply that the amputees will move similarly with each other, but rather that they will use consistently more of their ROM during tasks. Indeed, existing literature [5] says that the amputees will not converge to a similar kinematic solution. This happens due to differences among length of the residual limb and prosthetic device that is being used. However, amputees are more likely to use more joint motion consistently. Interestingly, during the "Brush" task, the amputee population had lower joint motion compared to the able-bodied, and the standard deviation was lower. This is because this specific task required the head to be held up.This exaggerated the motions of the already compensating joints, eliminating the need for the torso to move at all.

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# USING THE COMPONENT TIMED-UP-AND-GO TEST (CTUG) FOR FALL RISK ASSESSMENT IN PEOPLE WITH LOWER LIMB LOSS

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## BACKGROUND

The Timed-Up-and-Go (TUG) test is a commonly used performance-based outcome measure to assess mobility in people with lower limb amputation1-4, with the Centers for Disease Control (CDC) citing a 12 second performance threshold on the TUG as a prediction of elderly who may be at increased fall risk. Examining the TUG by its component subtasks allows for greater insight into basic prosthetic mobility5, and potentially into fall risk in amputees.

## AIM

The purpose of this study was to investigate basic prosthetic mobility with the cTUG, and to determine variables that may contribute to increased fall risk in community ambulating lower limb amputees.

## METHOD

A convenience sample of 131 (72 males, 59 females) people with unilateral lower limb loss was recruited for the study. Participants performed the cTUG, where a total time plus 5 component times were recorded: 1) sit to stand, 2) walk to turn, 3) 180° turn, 4) walk exiting turn, 5) turn to sit. The number of steps to perform component 3 was also collected. Demographic, anthropometric and amputation specific variables were collected, along with single limb balance, and hip motion and strength. All data was recorded using custom mobile software applications. Descriptive statistics were calculated, with group comparisons performed using Mann Whitney U tests. Logistic regression analysis was used to determine the contribution of specific variables to fall risk.

## RESULTS

Participants were categorized into low fall risk (LFR) and increased fall risk (IFR) based on the 12 second threshold. Sixty-six percent of people with LLA were classified as LFR, and 34% categorized as IFR. Within the IFR cohort, 36% (n=16) were amputated at the transtibial level and 64% (n=28) were transfemoral. Additionally, 69% of the IFR cohort had dysvascular etiology of amputation. There were significant differences between groups on all measures except hip motion. Overall, the IFR group was older, weaker, had poorer balance, and performed mobility tasks slower than the DFR cohort. Backward logistic regression modelling found that, the time required to complete the 180º turn remained the only significant identifier of increased fall risk (OR=35.6, p<.001), with a concordance statistic = .923.

| Variable | Increased Fall Risk (n=44) μ ± SD | Decreased Fall Risk (n=87) μ ± SD | p value |
|---|---|---|---|
| Age (yrs) | 54.8 ± 14.0 | 46.3 ± 12.8 | <.001 |
| Waist (cm) | 110.4 ± 18.5 | 98.6 ± 14.1 | <.001 |
| Comorbidity Score | 3.4 ± 3.6 | 1.8 ± 1.6 | <.001 |
| Hip Extension ROM (degrees) | | | |
| Sound | -2.5 ± 10.4 | -.4 ± 10.6 | .2 |
| Residual | .61 ± 8.9 | 1.0 ± 9.4 | .5 |
| Hip Extension Strength | | | |
| Sound | 34.4 ± 7.3 | 38.3 ± 3.6 | <.001 |
| Residual | 27.5 ± 11.3 | 35.65 ± 7.5 | <.001 |
| Single Limb Balance (sec) | | | |
| Sound | 12.8 ± 13.1 | 22.7 ± 10.8 | <.001 |
| Prosthetic | 1.1 ± .92 | 1.8 ± 1.2 | <.001 |
| cTUG test | | | |
| Total time (sec) | 15.5 ± 5.3 | 9.83 ± 1.4 | <.001 |
| Component 1 (sec) | 2.5 ± 1.6 | 1.5 ± .33 | <.001 |
| Component 2 (sec) | 2.6 ± .8 | 1.7 ± .3 | <.001 |
| Component 3 (sec) | 4.2 ± 1.2 | 2.8 ± .5 | <.001 |
| Component 4 (sec) | 2.3 ± .6 | 1.6 ± .3 | <.001 |
| Component 5 (sec) | 3.9 ± 1.7 | 2.3 ± .5 | <.001 |
| Number of steps component 3 | 6.6 ± 1.5 | 3.2 ± .8 | <.001 |

**Bolded values indicate statistical significance

**Figure 1**. Comparison of subject characteristics and cTUG performance

## DISCUSSION & CONCLUSION

This is the first study to categorize lower limb amputee fall risk analogous to able bodied persons. Although the subjects were community ambulators, 34% are at risk for falls according to CDC standards. The identification of increased odds for fall risk with difficulty performing the 180º turn of the cTUG lends insight to the potential dangers of common turning tasks and the importance of incorporating turn training into prosthetic gait training and rehabilitation. In conclusion, the cTUG presents potential of identifying fall risk during basic prosthetic mobility tasks.

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# APPLICATION OF AUDITORY BIOFEEDBACK FOR GAIT TRAINING OF UNILATERAL TRANSFEMORAL AMPUTEES IN THE COMMUNITY

Vibhor Agrawal[1], Christopher Bennett[2], Ignacio Gaunaurd[3], Jennifer Lucarevic[1], Sheila Qualls[1], Adam Finnieston[4], Ian Fothergill[5], Allison Symsack[5], Brooks Applegate[6] and Robert Gailey[1]

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## BACKGROUND

Unilateral lower limb amputees have an asymmetrical gait pattern, which can be improved through a standardized prosthetic training and exercise program.1,2 However, upon completion of the training program, amputees have a tendency to revert to their habit of asymmetrical walking in the community. In order to improve retention and reinforce therapeutic intervention in the community, a novel auditory biofeedback system was developed to measure gait parameters and provide corrective biofeedback.

## AIM

The purpose of this study was to determine the efficacy of auditory biofeedback in improving temporal-spatial gait symmetry of unilateral transfemoral amputees (TFAs) in the community.

## METHOD

The biofeedback system consisted of inertial measurement units (IMUs) for collecting motion data and iPad for processing data and providing feedback. 21 unilateral TFAs (mean age 53.5±13.7 years) were fit with test microprocessor knee and divided into four groups: no exercise & no feedback (controls); exercise only (Ex); feedback only (FB) and exercise with feedback (Ex+FB). At initial visit, subjects were trained on using the system at home for 4 weeks. They were assigned home exercises and/or were asked to practice walking with auditory biofeedback, depending on their group assignment. Temporal-spatial parameters were assessed with a gait mat in the clinic at initial and final visits.

## RESULTS

Figure 1 shows the changes in walking speed between initial and final visits. The symmetry of single limb support (SLS) time, stance time and step length was calculated and the change in symmetry between visits was determined. Table 1 shows the effect size for the average change in these parameters between different groups. Based on Cohen's interpretation of effect size,3 the combination of exercise and audio feedback had a large effect on SLS time and stance time, and a medium effect on walking speed compared to the control group. Neither exercise nor feedback had any effect on step length.

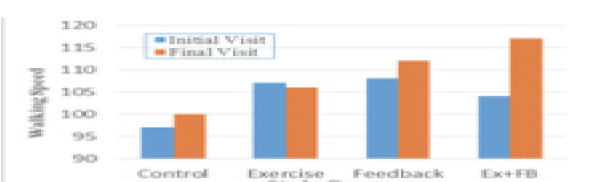


**Figure 1.** Walking speed (m/s) at the initial and final testing sessions for the four study groups

| | SLS Time | Stance Time | Step Length |
|---|---|---|---|
| Control vs. Ex+FB | 0.99* | 1.3* | 0.09 |
| Control vs. Ex | 0.84* | 0.94* | 0.31 |
| Control vs. FB | 0.96* | 1.03* | 0.05 |

**Table 1:** Comparison of effect size between groups for selected temporal spatial gait parameters. * large effect

## DISCUSSION & CONCLUSION

Auditory biofeedback was designed to provide verbal cues if gait asymmetry was detected by IMUs. Subjects receiving auditory feedback were able to modify their gait pattern and thus improve temporal-spatial gait symmetry. As subjects were not listening to the feedback during data collection, auditory biofeedback appears to have a long term improvement in gait symmetry. A combination of home exercises and auditory biofeedback could be employed for community based rehabilitation of unilateral TFAs.

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# USE AND USABILITY OF CUSTOM MADE ANKLE-FOOT ORTHOSES FOR CALF MUSCLE WEAKNESS IN POLIO SURVIVORS

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## BACKGROUND

Dorsiflexion-restricting ankle-foot orthoses (DR-AFOs) are often prescribed in polio survivors with calf muscle weakness to improve gait and to reduce walking and standing related problems such as instability and fatigue. However, in clinical practice the DR-AFO does not always result in adequate satisfaction and use [1], which may compromise the effectiveness of the AFO as experienced by the patient.

## AIM

The aim of this study was to assess the use of prescribed custom made DR-AFOs in polio survivors, and to investigate whether usability of the orthosis differed between users and non-users.

## METHOD

We sent a questionnaire to all polio survivors (n=57) prescribed with a DR-AFO at our department between 2004 and 2015. The questionnaire consisted of the validated questionnaires D-QUEST (measuring satisfaction with, and services related to the provision of DR-AFOs) and SF-36 (measuring perceived health status). These were complemented with self-designed questions on use and the components within the usability framework 'context of DR-AFO use', 'goals to be achieved with the DR-AFO' and 'perceived DR-AFO effectiveness' as defined in the 'Guidance on Usability' [2]. Differences in the questionnaire outcomes between users and non-users were tested with Mann-Whitney U tests or Fisher's exact tests (for binary data).

## RESULTS

Of the 57 polio survivors, 40 filled out the questionnaire. Five patients were excluded for further analysis because there was no DR-AFO indication anymore (e.g. became wheelchair bound). From the remaining 35 patients, 26 (74%) used their DR-AFO (median [interquartile range]) 9.3 [3.9-13.0] hours/dag and 9 (26%) did not. Most frequently named DR-AFO goals were improving stability (77%), improving walking distance, speed, duration (53%), and reducing fatigue (44%) during walking. Goals were similar between users and non-users. Non-users were significantly more often female, first time DR-AFO users and also they fell more often per year (Table 1). Non-users were significantly less satisfied with aspects related to the DR-AFO, particularly on comfort. Also, they experienced less effectiveness on problems indicated as DR-AFO prescription goals (Table 1). There were no significant differences between users and non-users in satisfaction with the services related to DR-AFO provision, the patient's physical status and plantarflexion strength (Table 1).

| | Users (n=26) | Non-users (n=9) | p-value |
|---|---|---|---|
| Gender (male/female) | 16/10 | 0/9 | 0.001* |
| First orthosis (yes/no) | 6/20 | 6/3 | 0.038* |
| Number of falls (per year) | 1 [0-10] | 5 [3-29] | 0.049* |
| Plantarflexor strength (0-5) | 3.0 [0.0-4.5] | 3.5 [0.0-4.0] | 0.915 |
| SF-36 physical component (0-100) | 34 [28-44] | 43 [31-44] | 0.626 |
| Satisfaction of DR-AFO (0-5) | 3.8 [3.6-4.3] | 2.9 [2.0-3.8] | 0.011* |
| Satisfaction of services (0-5) | 4.0 [3.6-4.8] | 4.3 [3.8-4.9] | 0.347 |
| Effectiveness of DR-AFO (-6-6) | 2.5 [1.1-3.6] | 0.7 [-1.8-1.6] | 0.006* |

**Table 1.** Differences between DR-AFO users and non-users
Median [interquartile range] or frequencies, a higher median score is considered a better outcome, *: p<0.05.

## DISCUSSION & CONCLUSION

Our study shows that 74% of the prescribed DR-AFOs were used and 26% not. A low satisfaction and perceived effectiveness, mainly in woman, particularly related to comfort and a lack of improvement on prescription goals may be associated with non-use of the DR-AFO. These findings are in line with recent studies on other types of AFOs in other patient groups [3,4]. To promote satisfied use, and possibly to reduce risk of falling, we recommend monitoring use, satisfaction and perceived effectiveness after DR-AFO provision, and, when indicated, adjusting the DR-AFO to improve these outcomes.

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# THE CONTRIBUTION OF VESTIBULAR SENSORY INTEGRATION TO MOBILITY IN UNILATERAL LOWER LIMB AMPUTEES

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## BACKGROUND

The vestibular system provides critical information regarding the position of the body in space. The ability to receive and process that information is known as Vestibular Sensory integration (VSI). People with lower limb amputation have a significant loss of afferent somatosensory information due to loss of proprioceptors within the limb; therefore utilizing the information from the visual and vestibular system becomes more critical during static and dynamic activities. Previous work has shown a relationship between VSI and performance-based mobility1 but this relationship has not been explored in the limb loss population.

## AIM

The purpose of this study is to determine the relationship of VSI on mobility in unilateral lower limb amputees (LLA).

## METHODS

A convenience sample of 130 healthy community ambulators with unilateral transtibial and transfemoral amputation were recruited to participate in a study conducted at the 2015 and 2016 Amputee Coalition National Conferences.  Procedures: The participants answered questions regarding history of vestibular symptoms. Visual acuity and sound protective sensation were assessed and the Modified Test of Sensory Interaction and Balance (mCTSIB) was performed and used to classify groups based on sensory integration. Mobility was assessed using the Timed Up and Go (TUG) test: time intervals were recorded for each functional subtask: sit to stand, walk to turn, 180º step turn (toward the prosthetic limb), walk exiting turn, and turn to sit.

The total TUG time was also measured. Chi-Square, Odds Ratio, and univariate ANCOVA were performed to determine differences between the normal sensory integration (NSI) and impaired VSI cohorts (IVSI), as classified by mCTSIB performance.

## RESULTS

The 130 LLA subjects included in the study were classified into cohorts based on pass/fail performance on the mCTSIB: visually dependant (n=6, 5%), impaired vestibular sensory integration (IVSI) (n=29, 22.3%), and normal sensory integration (NSI)(n=95, 73%).  Statistically significant differences were found between the NSI and IVSI groups: the IVSI group had lower balance confidence (mean difference 7, p=0.003), a greater distribution of TFA (X2=5.92, p=.02) and  hypertension (HTN) (X2=8.29, p=.004).  Subjects with a positive history of HTN were four times more likely to have IVSI (95%CI 1.5-10.8).

**Table 1**. Univariate ANCOVA TUG intervals based on NSI or IVSI while controlling for level of amputation. Statistically

| TUG Interval | IVSI (n= 29) | NSI (n= 95) | Univariate ANCOVA Model Results F | p-value | η2 |
|---|---|---|---|---|---|
| Sit to | **2.1** ± 1.5 | **1.6** ± 0.9 | 3.19 | .05* | .05 |
| Stand | **2.5** ± 1.8 | **1.9** ± 0.5 | 6.51 | .002** | .10 |
| Walk to turn | | | | | |
| 180º Step | **3.8** ± 1.3 | **3.1** ± 0.9 | 9.38 | <.001^ | .13 |
| Turn | **2.1** ± 0.7 | **1.8** ± 0.4 | 6.61 | .002** | .10 |
| Walk Exit Turn | | | | | |
| Turn to sit | **3.4** ± 1.8 | **2.7** ± 1.1 | 4.98 | .008** | .08 |
| Total TUG | **13.9** ± 6.3 | **11.2** ± 3.6 | 7.43 | .001^ | .11 |

significant at *p≤.05, **p≤.01, ^p≤.001.

When controlling for amputation level, the IVSI group had slower times on every TUG interval (Table 1). Medium to large effect sizes (η2) were found with walk to turn, 180° step turn, walk exiting turn, turn to sit, and total TUG time

## DISCUSSION & CONCLUSION

This is the first study to examine the contributions of VSI to mobility in those with LLA. The LLA were community ambulators that performed the TUG faster than previously reported.2 Classifying sensory integration based on mCTSIB performance showed a difference with the IVSI group performing the TUG an average of 2.7 seconds slower than the NSI group. These results suggest that a strong relationship exists between IVSI and mobility limitation in people with LLA.

Screening tests such as the mCTSIB should be part of the prosthetic rehabilitation standard of care for individuals with lower limb loss. The capacity to identify contributing factors for balance will promote targeted rehabilitation and prosthetic treatments that will maximize mobility and prosthetic performance.

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# A COMPARISON OF PROSTHETIC MOBILITY IN AMPUTEES WITH OSSEOINTEGRATION VERSUS TRADITIONAL AMPUTATION AND SOCKET

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## BACKGROUND

The Osseointegration (OI) limb reconstruction surgical procedure for people with lower limb amputations (LLA) has been performed in numerous countries. Presently, there are variations with the two-stage surgical procedure. Published outcomes for people who have had OI reconstruction report improvements within subjects when comparing pre to post-surgical mobility or quality of life. 1,2,3 To date no studies have compared prosthetic mobility in people with LLAs who use an osseointegration prosthesis (OIP) to a traditional socket prosthesis (TSP).

## AIM

The aim of this study is to determine the differences in mobility of those with transtibial amputation (TTA) and transfemoral amputation (TFA) fit with a Osseointegration prosthesis versus a traditional socket prosthesis.

## METHOD

Subjects: A convenience sample of 28 community ambulators with unilateral LLA, 14 who had an OIP and 14 age and level of amputation matched LLA with TSP with a mean age of 44 ±13 and 46 ±13 years respectively, were recruited. All OIP subjects had the same surgeon, Munjed Al Muderis, MD, with their surgery performed in Sydney, Australia. Procedures: Subjects completed Prosthetic Limb Users Survey of Mobility™ (PLUS-M) short form. In addition, subjects performed 2 trials of the 10 meter walk test (10MWT), component Timed Up and Go (cTUG) test at self-selected and fast walking speeds. A custom mobile software application was used to capture all data. Paired t-tests were performed to compare differences in group performance.

## RESULTS

Significant differences in residual limb length was found between the OIP and TSP group with the OIP group presenting with significantly shorter residual limbs (4.7 cm difference, p = 0.04). Although those with OIP were found to have better self-perceived mobility as measured by the PLUS-M, it was not significantly different (p = 0.06). No other differences in mobility were detected as measured by the 10 MWT, TUG and TUG-fast when comparing the entire sample.

| Measures | OIP M ± SD (n=14) | TSP M ± SD (n=14) | p |
|---|---|---|---|
| Age (years) | 44.1 ± 12.5 | 45.8 ± 12.9 | .07 |
| Time amp (mths) | 94.2 ± 28.2 | 107.0 ± 36.3 | .56 |
| PLUS-M12 (t-score) | 60.4 ± 6.4 | 54.5 ± 8.6 | .06 |
| 10 MWT (m/sec) | .89 ± .13 | .91 ± .23 | .82 |
| TUG (sec) | 10.9 ± 2.1 | 11.5 ± 2.3 | .55 |
| TUG –Fast (sec) | 8.7 ± 1.7 | 9.4 ± 2.2 | .30 |

| Measures | TTA-OIP M ± SD (n=4) | TTA TSP M ± SD (n=4) | Mean Diff 95%CI | p |
|---|---|---|---|---|
| PLUS-M12(t-score) | 62.5 ± 8.0 | 57.7 ± 10.5 | -12.7-22.4 | .44 |
| 10MWT (m/sec) | 1.0 ± .14 | .75 ± .17 | 0.06-0.43 | .02 |
| TUG 5(sec) | 9.0 ± 1.7 | 12.5 ± 2.9 | -6.4-(-0.6) | .03 |
| TUG -fast (sec) | 7.3 ± 1.8 | 10.2 ± 3.1 | -6.4-0.6 | .07 |
| | **TFA OIP M ± SD (n=10)** | **TFA TSP M ± SD (n=10)** | **Mean Diff 95%CI** | **p** |
| PLUS-M12(t-score) | 59.4 ± 5.8 | 53.1 ± 7.9 | -1.9-14.6 | .11 |
| 10MWT (m/sec) | .85 ± .09 | .99 ± .22 | -0.32-0.43 | .13 |
| TUG (sec) | 11.8 ± 1.7 | 11.0 ± 1.9 | -.89-2.57 | .30 |
| TUG -fast (sec) | 9.4 ± 1.2 | 9.2 ± 1.9 | -1.5-1.9 | .80 |

## DISCUSSION & CONCLUSION

Osseointegration surgical procedures are currently indicated for LLAs who have difficulty or cannot wear a traditional socket and are relatively healthy. Prior published research has reported significant differences between TSP versus OIP when using within subject designs comparing their mobility prior to OI surgery in their existing prosthesis to their post-surgical capabilities.1,2,3 This small study found that the LLA with OIP were able to demonstrate mobility similar to LLA with TSP and were similar to previous reports post-OI surgery.1,3 Moreover, the subset of TTAs with OIP had significantly better mobility with short distance activities. Further research with a larger sample and other measures of mobility would provide greater insights to similarities and differences between the two groups.

In conclusion this study suggests that osseointegration surgical procedure enables people with LLA to have mobility equal to those LLAs who are comfortably fit in a traditional socket.

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# VALIDATION OF TEMPORAL-SPATIAL ALGORITHMS FOR THE DETECTION OF GAIT DEVIATIONS IN LOWER LIMB AMPUTEES USING WIRELESS IMU SENSORS

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## BACKGROUND

Observational gait analysis is commonly used in the clinic as a means of assessing gait deviations for those with lower-limb amputation (LLA). A wireless sensor system that utilizes inertial measurement units (IMU) enables the collection of motion data in a non-laboratory setting with the ultimate goal of providing clinicians with a portable system that performs automatic gait deviation (GD) detection. The IMUs use a combination of sensors to collect raw motion data and can be mounted on different parts of the body including the prosthesis.

## AIM

To determine the ability of wearable IMU sensors to detect differences in measurable gait parameters (GP) and classify common prosthetic GD.

## METHOD

IMU data were collected on 27 transtibial amputees (TTA) and 28 transfemoral amputees (TFA) (n= 55) while performing three 10-meter walk tests (10MWT) at self-selected walking speed. All subjects wore five custom IMUs, one above and below each knee of each lower limb, and one on the waist. Temporal and spatial GP were calculated using proprietary algorithms. Decreased balance over the prosthesis, decreased knee flexion, and decreased prosthetic toe load were the primary GD and confirmed by a team of five physiotherapists (PT) reviewing video recordings of the walk trials. All subjects were community ambulators who attended a national conference. Subjects were classified into four groups based on the number of GDs present during the 10MWT: zero, one, two, or three. The GP data were analyzed using one-way analysis of variance (ANOVA) and post-hoc Tukey tests to identify differences between those who presented with zero, one, two, or three GDs.

| Gait Parameters | Number of Gait Deviations | | | | Significant Differences Between Gait Deviations |
|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | |
| Sound SLS [%] | 38.0 (3.6) | 37.3 (5.2) | 36.9 (5.3) | 33.3 (4.9) | 3 < 0,1,2 |
| Prosthetic SLS [%] | 31.80 (4.7) | 32.5 (3.3) | 31.5 (4.0) | 28.6 (4.8) | 3 < 0,1,2; 2 < 1 |
| Double Limb Support [%] | 13.38 (3.7) | 14.0 (4.5) | 15.4 (4.7) | 18.2 (5.7) | 3 > 0,1,2; 2 < 0, 1 |
| Sound step length [m] | 0.67 (0.15) | 0.64 (0.13) | 0.61 (0.10) | 0.50 (0.13) | All Gait Deviations |
| Pros. step length [m] | 0.78 (0.14) | 0.74 (0.18) | 0.70 (0.15) | 0.56 (0.13) | All Gait Deviations |

Table I results show the mean (standard deviation) values for each gait parameter measured by the wireless IMU sensor system classified by the number of GDs. Significant differences were found between GPs and number of GDs ($p < 0.05$).

## RESULTS

The 55 subjects participated in this study and presented with the following GDs: 4 (7%) with zero GDs, 18 (33%) with one GD, 19 (35%) with two GDs, and 14 (25%) with three GDs. Decreased toe load was the most prevalent GD (detected in 49 subjects or 89%), while 32 (58%) had decreased balance and 17 (31%) exhibited decreased prosthetic knee flexion.

Table I results show the mean (standard deviation) values for each gait parameter measured by the wireless IMU sensor system classified by the number of GDs. Significant differences were found between GPs and number of GDs ($p < 0.05$).

## DISCUSSION & CONCLUSION

In this study, the wireless IMU sensor system was found to be a valid measure for assessing GD using common temporal-spatial GPs calculated by proprietary algorithms. The majority of LLA subjects (60%) presented with at least two GDs. Those who presented with three gait deviations spent statistically less time on their prosthetic limb, greater amount of time in double limb support, and shorter step lengths bilaterally. The identified GPs showed significant differences across groups and are the most useful for automating the GD detection process using IMU data.

The ability to accurately quantify the presence of one or more GDs is an important tool for assessing gait both within and outside of the clinic. This could help guide clinical decision making when determining the need for rehabilitation and/or prosthetic intervention, ultimately improving quality of life and mobility for those with LLA.

# THE RELIABILITY AND VALIDITY OF THE PROSTHETICS SOCKET SURVEY: A MEASURE OF STABILITY, SUSPENSION, COMFORT AND APPEARANCE

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## BACKGROUND

The literature frequently discusses prosthetic socket fit and comfort as an important measure for the determination of successful fitting. To date the only objective measure is the Socket Fit Comfort Score, which is a 10-point analog scale that asks amputees to rate the comfort of their socket. If a low score is received there is no indication to the cause of the socket dissatisfaction with the exception that it is "uncomfortable".1 There is a need for an outcome measure that can quantify the multiple constructs that influence user satisfaction of a prosthetic socket. This will provide prosthetists a method to evaluate and guide clinical decisions.

## AIM

The aim of this study is to determine the reliability and validity of the Prosthetic Socket Survey (PSS).

## METHOD

The PSS is a Likert-scale questionnaire comprised of 24 items with four constructs 1) Stability, 2) Suspension,3) Comfort and 4) Appearance. The PSS takes less than five minutes to complete. To determine the test-retest reliability of the PSS, the questionnaire was administered twice within a 48-hour period. It was completed by a convenience sample of 47 lower limb amputees (LLA); either unilateral transfemoral or transtibial. Intraclass Correlation Coefficient (ICC) values with 95% confidence interval (95% CI) were calculated for each item. Cronbach alpha was used to determine the internal consistency of each of the four constructs, and for item analysis. Mann-Whitney U test was used to determine known group validity.

## RESULTS

Overall, the PSS demonstrates excellent test-retest reliability (r=0.89, 95% CI: 0.74-0.92) and good internal consistency for each of the constructs. Following item-analysis, 5 questions were removed, improving the internal consistency as presented in Table-1. The Final PSS was scored out of a possible 70 points. The average overall socket satisfaction of the PSS administered to 47 LLA is 83.1% (58.17±9.11, 37-70). The average satisfaction score for each of the four constructs: Stability 86.7% (13.6±2.6), Suspension 85% (□=13.6±2.6), Comfort 81.8% (13.0±2.7) and Appearance 77.3% (□=9.3±2.0). No statistical significant difference was found in PSS score based on amputation level (p=0.08) or gender (p=.054). However, there was a significant difference in the appearance construct based on gender (female=8.6±2.1, male=10.3±1.5, p=.005).

| | Original PSS | | Final PSS | |
|---|---|---|---|---|
| Sub-category | Items | α | Items | α |
| Stability | 5 | 0.843 | 4 | 0.882 |
| Suspension | 5 | 0.897 | 4 | 0.926 |
| Comfort | 5 | 0.880 | 4 | 0.919 |
| Appearance | 5 | 0.792 | 3 | 0.850 |

| Sub-category | Lowest Mean Score (4 points) | | Highest Mean Score (4 points) | |
|---|---|---|---|---|
| Stability | Exercise | 3.0 | Sitting | 3.6 |
| Suspension | Exercise | 2.9 | Standing | 3.5 |
| Comfort | Exercise | 2.8 | Standing | 3.3 |
| Appearance | Tight pants | 2.8 | Sitting | 3.3 |

**Table 1.** Cronbach α values present the internal consistency of the PSS constructs before and after item-analysis.

## DISCUSSION & CONCLUSION

The final version of the PSS is a self-report measure of socket stability, suspension, comfort and prosthetic appearance, with excellent test-retest reliability and internal consistency. Validity tests showed that the overall PSS is not gender-biased and can be used for individuals with LLA. Socket appearance has been found to be an important issue for women with LLA and the PSS allows clinicians to assess both current perception and potentially change in perception due to a prosthetic intervention. In summary, the ability to determine where a socket issue occurs and how the prosthetist can remedy the problem is important for the quality of life and overall function of the LLA.

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# ENERGY MANAGEMENT OF PASSIVE PROSTHETIC FEET DURING GAIT

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## BACKGROUND

Recent studies of the mechanical performance of lower limb prostheses consider both the timing and magnitude of energy during activity. Of particular interest is deformation power of the foot, which is influenced by both the structural properties of the device as well as the ground reaction and joint kinematic profiles of the user [1]. Foot deformation power profiles are expected to be practical measures of energy management and will facilitate comparison among designs

## AIM

The objective of this study was to describe passive energy management in three designs of prosthetic feet using measures of power that account for foot deformation.

## METHOD

Ground reaction forces and limb segment kinematics were recorded during level ground walking for three transtibial prosthesis users each using three prosthetic foot conditions: their prescribed device and two stiffness levels of the Niagara Foot™ (Standard NF and Reduced NF). For all subjects, the prescribed devices were carbon fibre designs.
Data were analyzed using two approaches to describe energy management in the foot; each describes a different aspect of lower limb energy involving the foot segment. Prince et al. defined compliant power, PC, to isolate power due to elastic deformation of the device [2], while Takahashi et al. defined unified deformable segment (UD) power, PUD, to include power from foot deformation as well as rigid body motion effects in the shank/foot complex [3].

## RESULTS

PC and PUD are shown in Figure 1 for one subject (67kg) using three prosthetic foot conditions. Results indicate that both methods are sensitive to device design.

The prescribed foot PC displays a magnitude of -9W in early stance and a peak of 47W in late stance, while power from 30% to 70% stance is minimal. For both NF conditions, Pc magnitude is approximately -12W in early stance and peaks at ~27W in late stance. Differences in PC trends across subjects were most evident in the first and last 10% of stance. PC captures power due to structural deformation and trends are consistent with a deformable heel and forefoot design which provides stability (minimal deformation) during midstance.

The prescribed foot showed PUD peaks of -91W in early stance and 145W in late stance, with additional peaks of 33W and -63W in the transitions into and out of midstance, respectively. NF conditions displayed PUD peaks of approximately -69W in early stance and ~74W in late stance, with minimal PUD in the transition into midstance and -23W in the transition out of.

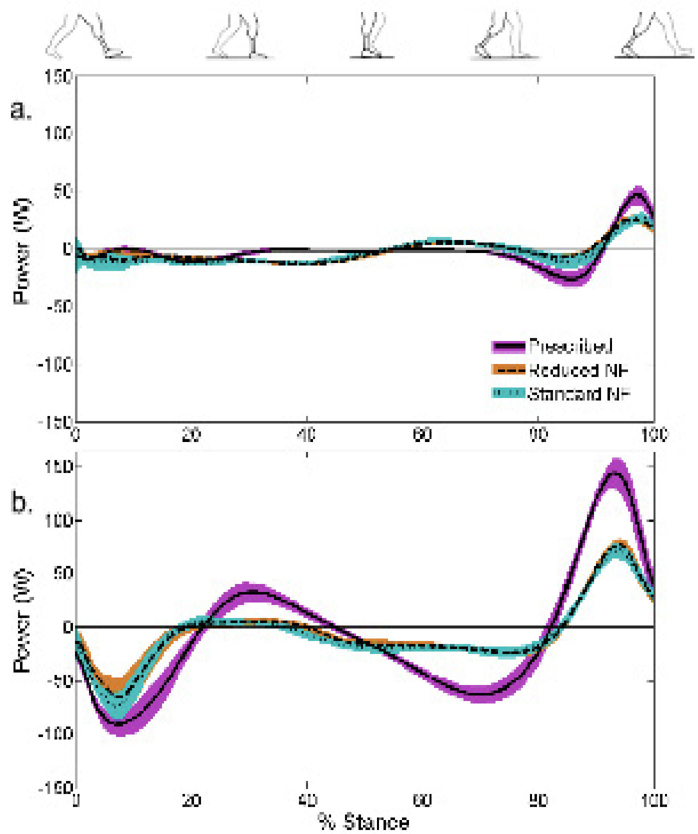


**Figure 1**. Typical power profiles for one subject and three foot conditions: a. Compliant Power, PC, and b. UD power, PUD. Ensemble averages (n=9) and 95% confidence intervals.

## DISCUSSION & CONCLUSION

Conceptually, the measure of PC isolates power due to deformation of prosthetic foot structures, while PUD represents the combined effect of power due to deformation and motion. However, both measures are limited. PC requires the definition of an "ankle" joint and includes energy dissipation as well as elastic deformation. PUD is limited in that deformation power cannot be isolated from rigid body motion effects.
Both approaches are sensitive to prosthetic foot design and reveal differences between devices in the magnitude and temporal features of energy management.

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# RESIDUUM VOLUME AND SHAPE ASSESSMENT AFTER LOWER LIMB AMPUTATION: VALIDITY AND RELIABILITY OF A NEW STRUCTURED LIGHT 3D SCANNER

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**BACKGROUND**

Objective assessment methods to monitor residuum volume are required after lower limb amputation to aid decision making in determining when the amputee can start wearing a prosthesis and to enable design of new prosthetic sockets that can improve fit and comfort [1]. Many techniques have been described and computer aided systems, including 3D scanners, present numerous advantages, but currently no definitive clinical method is available. The recent Artec Eva scanner (Artec, Luxembourg) based on laser free technology, can capture geometry and colour (for anatomical landmark identification) without the need for reference targets [2], and it could potentially be a more effective solution compared to the current methods used in clinical practice.

**AIM**

The aim of this study is to analyse variation in measurements of transtibial and transfemoral residuum model volumes and shapes, using the Artec Eva scanner, and to validate it against a high precision and resolution laser scanner (Romer - Hexagon, UK).

**METHOD**

In this study, ten residuum models (5 transtibial and 5 transfemoral, of both foam and plaster construction) were scanned by three operators, on three occasions each, using the Artec and Romer scanners. Three 4 mm diameter markers were placed on each model to identify anatomical points that determine a plane used as the proximal end of the scan. Each Artec scan, exported as an stl file, was manually aligned with the respective Romer scan using the anatomical references to compare the two volumes (Geomagic - 3D Systems, USA and Artec Studio 9.2 - Artec Group Luxembourg, Luxembourg).
Validity of the Artec scan was assessed using the Bland-Altman method [3], and repeatability coefficients were calculated using one-way analysis of variance [3, 4]. In addition, root mean square error (RMSE) was calculated to observe differences in the residuum model shape.

**RESULTS**

Volume recorded in this analysis ranged from between 885 ml and 4400 ml. Results for the validity analysis of the Artec scanner against the Romer scanner are shown in Fig. 1 as percentage of the original volume. Mean bias was 1.4% (Confidence limits: 1.3, 1.5%), R2 = 0.99. Coefficient of variation (CV) was 0.34%. The average RMSE value calculated in three dimensions between Artec and Romer scan ranged from 0.23 to 0.65 mm, with Artec scanner presenting slightly higher values than the Romer scanner. Intra-rater volume variability (repeatability coefficient) was 13.94 and 5.90 ml for the Artec and the Romer scanners respectively. Inter-rater variability (reproducibility coefficient) was 18.55 ml and 6.39 ml for the Artec and the Romer scanners respectively. Interclass correlation coefficient was 0.99 for both the coefficients.

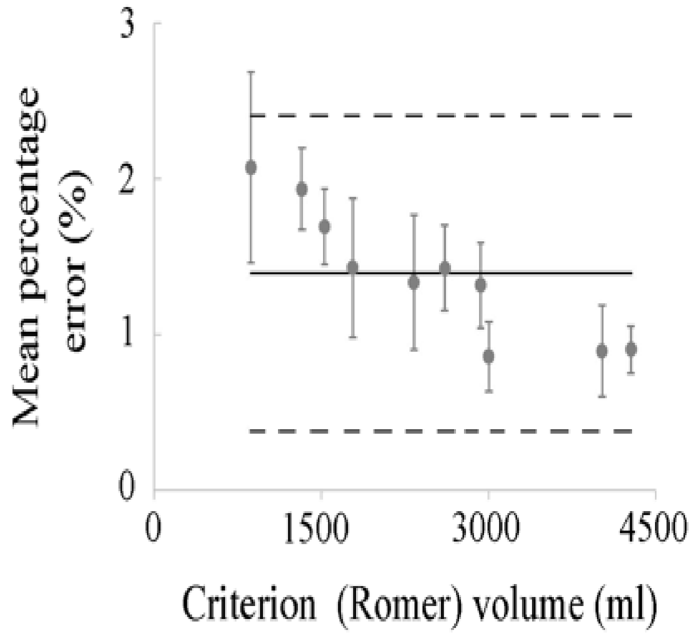


Figure 1. Modified Bland-Altman plots displaying the error of the volume (bias) measured with the practical (Artec Eva) scanner expressed as a percentage of the Romer scanner original volume (average between trials). The dashed lines indicate the upper and lower 95% limits of agreements.

**DISCUSSION & CONCLUSION**

The use of the Artec scanner showed a high degree of accuracy (<2%) in volume measurements and a very small magnitude for RMSE. Artec maximum average RMSE was 0.69 mm, with the highest differences highlighted at any severe prominences of the models. Repeatability coefficients for the Artec scanner increased when different operators performed the scans. However these coefficients were were 55% (for inter-rater coefficient) and 66% (for intra-rater coefficient) lower compared to the ones reported for the Omega

Tracer scanner (42 ml), considered as the most reliable scanner for residual limb volume monitoring in clinical practice [4]. In conclusion, the Artec scanner has been shown to be a promising alternative for objective assessment of the residuum volume and shape change in lower limb amputees. This process will be repeated in vivo on amputees to collect information for prosthetic design purposes.

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# DOES PROSTHETIC SPRING STIFFNESS HAVE AN EFFECT ON THE BIOMECHANICS OF A START-STOP MOVEMENT IN UNILATERAL TRANS-TIBIAL AMPUTEES WHEN USING A RUNNING-SPECIFIC PROSTHESIS?

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## BACKGROUND

Running-specific prosthesis (RSP), have spring-like properties which aim to replace the loss of musculature and soft tissues and optimise dynamic movement biomechanics of amputees. No research is available investigating the variation in prosthetic stiffness to changes in lower body stiffness to the authors' knowledge. Little is understood of the biomechanical adaptations undertaken by amputees in dynamic activities which are common in many sporting situations such as tennis, basketball and volleyball. Most analyses are conducted on walking1, running2 and sprinting3, as the RSP were designed to enable forward movement and are at their most effective at steady state running on the straight. The start-stop movement (Fig.1) analyzed in this study is common in court-based sports.

## AIM

The present study aimed to determine whether a change in prosthetic stiffness has an effect on the biomechanics of a start-stop movement in trans-tibial amputees.

## METHOD

Eleven male unilateral trans-tibial amputees performed a start-stop movement with an RSP using two different stiffness – Prescribed and Stiffer. Kinematics and kinetics was collected by a twelve-camera motion capture system (Vicon, UK) synchronised with a Kistler force platform. Stance time, flight time, touchdown (TD) and take off (TO) angles and velocities, ground reaction forces (GRF), impulses, and lower body stiffness were compared between intact and prosthetic limbs, and against prosthetic stiffness using ANOVA and effect size.

## RESULTS

No main effect of prosthetic stiffness except for TD angles and vertical impact GRF peaks. A moderately longer loading phase on the prosthetic limb compared to the intact limb was seen in the prescribed RSP condition (Intact: 47.2% ±7.1; Prosthetic: 52.1% ±9.4; Effect size: g=0.55), but not in the stiffer RSP condition. Amputee participants demonstrated lower TD and TO LEG-G angles on the prosthesis side, compared to the intact limb in both conditions (g=0.60-0.67), which indicates a more horizontal movement. Vertical impact GRF peaks were significantly higher in the prosthetic limb when bounding with the prescribed RSP compared to the stiffer RSP (P=0.034, g=0.33). Loading rates of intact limbs were higher than prosthetic limbs (Prescribed: g=0.75; Stiffer: g=0.90). There is no main effect of prosthetic stiffness on lower body stiffness of either the intact or prosthetic limb.

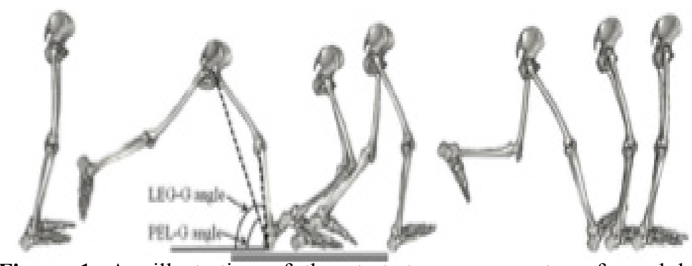


**Figure 1**. An illustration of the start-stop movement performed by participants in this study. . Initial take off occurred at a distanced normalized to the participant's leg length (1.3*LL). A minimum distance of 0.80 m from the force platform was set for the final landing, since some study participants struggled to achieve a distance normalized to leg length. The LEG-G and PEL-G angles at touchdown are shown.

## DISCUSSION & CONCLUSION

A main effect for prosthetic stiffness was found in impact GRF peaks of the prosthetic limb and TD angles of the intact limb, which were higher and more horizontal respectively when using the prescribed RSP. Results indicate that amputees have a more horizontal approach to a forward bounding movement onto the prosthesis regardless of prosthetic stiffness. Amputees' more horizontal movement may reflect difficulty in movement initiation with a RSP. Higher impact forces and loading rates of the intact limb suggest increased chronic injury risk. Prosthetic stiffness caused no statistical difference in lower body stiffness contrary to expectations. This suggests that compensation via modulation of knee and hip joint stiffness in the absence of an active biological ankle joint4 to maintain a constant lower body stiffness throughout movement performance regardless of the change in prosthetic stiffness. Thus, dynamic movement performance analysis in amputees should focus more on movement technique to allow efficient dynamic movement and prevent injury, rather than prosthetic stiffness.

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# UPPER EXTREMITY PROSTHETIC TRAINING AND REHABILITATION WITH THE USE OF VIRTUAL REALITY

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**BACKGROUND**

Approximately 10 million people live with a limb loss worldwide, with around 30% being an upper extremity amputee [1]. The sudden loss of a hand or arm causes the loss movements and several limitations, all which can be improved with the use of a prosthetic [2]. To ensure patient success with the prosthesis, the training and rehabilitation phase significantly important.

**AIM**

The present study describes a virtual reality (VR) environment system to facilitate an effective training and rehabilitation process for amputees to return patients to the highest level of independence and functioning possible.

**METHOD**

The patient population of this study included four subjects without an amputation and three subjects with a unilateral transradial amputation who regularly used a myoelectric prosthesis. All subjects participated in a 2-hour session to test range of motion (ROM), activities of daily living (ADL), and return to duty (RTD) tasks with and without the use of VR visualization provided by a Computer Assisted Rehabilitation Environment (CAREN).

CAREN is a multimodal system consisting of 10-motion- capture cameras, 6-DOF hydraulic base, instrumented treadmill, and a 180-degree cylindrical projection screen. The VR visualization included a real-time model of the subject's body segments, and a character avatar animating an optimal goal motion. This is shown below in Figure 1.

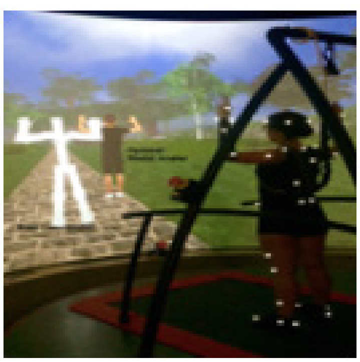

**Figure 1**. Amputee subject on the CAREN system.

Anatomical measurements along with forty reflective markers attached to specific joints on the subject, accurately animated the real-time model. The user's motion and joint angle measurements were recorded and calculated throughout all trials. Observations were also considered, and patient feedback was collected through a post-testing survey.

**RESULTS**

The interim results of this study suggest that the use of VR visualization allowed for improved joint positioning, movements, motivation, and overall a better performance of the tasks tested. Observation revealed subjects to execute the motions overall closer to the optimal motion shown with the VR. Without the visualization, subjects performed the tasks unbalanced, and unsymmetrical.

The patient feedback collected through the post-testing survey revealed that subjects enjoyed performing the tasks more with the feedback provided by the VR. Subjects stated they felt more motivated since they were able to visualize their motions in real-time along side the optimal model. With the VR visualization, subjects were able to quickly adjust and perform the movements alike the optimal motion shown.

The interim analysis data has shown differences in joint angle ROMs while performing the same task with and without VR. While performing the tasks with VR, subjects demonstrated improved positioning, joint angle ROM, and overall a smother path of motion. Looking specifically at the pelvis angle of one of the amputee subjects during the unilateral lift task, greater pelvic tilt was demonstrated when preforming the task without the VR feedback (Figure 2). This shows that with VR, subjects were able to adjust their positioning to be closer to the optimal positioning of little to no pelvic tilt when performing the unilateral lift.

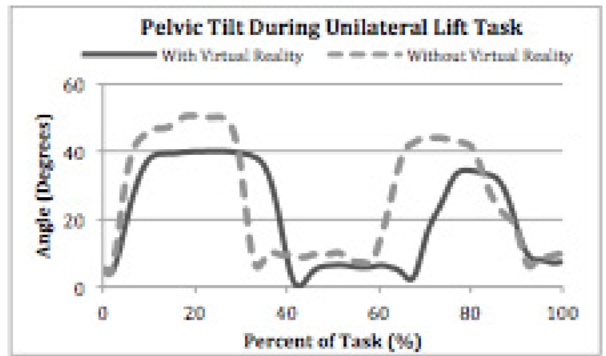


**Figure 2.** Pelvic tilt of one amputee subject during the unilateral lift task, with and without the use of the virtual reality visual feedback.

**DISCUSSION & CONCLUSION**

The provisional and anecdotal results suggest that the use of virtual reality enhances upper limb prosthetic performance with the thought that a more extensive biomechanical analysis will further support the findings. The visual feedback provided by VR allowed for the subjects to adjust and correct their motion to perform tasks without compensating with other joint movements. The visual feedback, along with the quantitative data collected, allows for the patient and operator to know where improvements must be made while providing an accurate assessment of the patient's developments.

The results from this study intend to introduce a way to significantly improve upper extremity prosthetic training and rehabilitation while providing useful parameters for an adaptable system for clinics and at home use. This will be clinically significant to upper limb prosthetic training and rehabilitation programs by introducing an adaptable way to increase effectiveness and greatly impact the future of prosthetic users.

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# EFFECTS OF TUNED AND UNTUNED POSTERIOR SHELL RIGID ANKLE FOOT ORTHOSIS ON BALANCE, MOBILITY AND SELF-EFFICACY IN ADULT PATIENTS WITH HEMIPLEGIC STROKE: A PILOT STUDY

Jemiah Faye Guillermo

## BACKGROUND

Stroke constitutes a major countrywide burden in the Philippines thus healthcare providers focus on implementing appropriate interventions for hemiplegic stroke patients. Ankle foot orthoses (AFOs) are known to account for improvements in biomechanical deficits including spatiotemporal and kinematic parameters of hemiplegic gait such as speed, step length and cadence. However, few studies support functional effects of AFOs. Moreover, treatment effects of tuned AFOs using clinically available objective scales are scarce.

## AIM

Prospective cohort study was used to investigate the effects of tuned and untuned posterior shell rigid AFO (PSRAFO) on functional outcomes such as balance, mobility and self-efficacy in stroke patients.

## METHOD

14 subjects were from the pool of patients from a local clinic in the Philippines with >6 months post-stroke with controlled vital signs, age range of 35-60 and able to walk with shoes or without AFO. Subjects were allocated into treatment (tuned) and control (untuned) groups. Subjects' balance, mobility and self-efficacy were measured with and without tuned and untuned PSRAFO using Berg Balance Scale (BBS), Timed Up and Go test (TUG) and Activity-Specific Balance Confidence Scale (ABC). BBS and TUG were performed with 1 practice session and 3 trials while ABC was answered twice. $P<0.10$ value was accepted statistically significant.

## RESULTS

Tuned PSRAFO only displayed statistically significant changes on balance ($p=0.08$) and mobility ($p=0.02$) while untuned PSRAFO showed significance only in self-efficacy ($p=0.01$) compared to with shoes alone. Mean scores from between group comparison favors tuned PSRAFO in balance (52.43, $p=0.63$) and mobility (12.81, $p=0.49$) but it was not statistically significant. Mean score for self-efficacy was 87.28% ($p=0.64$) in favor of untuned PSRAFO but still not statistically significant.


**Figure 1**. With Shoes, With Untuned PSRAFO and With Tuned PSRAFO

## DISCUSSION & CONCLUSION

TPSRAFO only extracted significance on balance and mobility while self-efficacy improved significantly using UPSRAFO. Nevertheless, tuning is still preferred due to its biomechanical advantages as supported by previous studies. But since its biomechanical effects do not translate significantly in terms of functional outcomes, we cannot totally discard one of them in favor of the other in providing treatment among adult hemiplegic stroke patients.

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# EFFECTS OF PROSTHETIC REHABILITATION ON THE FUNCTIONAL MOBILITY OF PATIENTS WITH UNILATERAL TRANS-TIBIAL AMPUTATION: A PILOT STUDY

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## BACKGROUND

The Philippines School of Prosthetics and Orthotics has adapted an interdisciplinary approach in prosthetic rehabilitation. With the school and the prosthetics profession being relatively young in the country, objective measures of rehabilitation outcomes can provide useful guides for further improvement of its services. Functional mobility is an important outcome in the rehabilitation of amputees with the transtibials (TT) being the most prevalent case.

## AIM

This study aimed at determining the changes in the functional mobility of patients with unilateral TT amputation undergoing prosthetic rehabilitation using a performance-based assessment tool called Amputee Mobility Predictor (AMP).

## METHOD

This is a single center study that utilized longitudinal time series design. Eight unilateral TT patients of 18-55 age range were recruited. Five primary patients (PP) underwent prosthetic initial evaluation, fittings and 12 sessions of physiotherapy (PT) while five established patients (EP) completed fittings only. AMP scores were collected in three periods of their rehabilitation: during prosthetic initial evaluation (AMP1), after final prosthetic fitting (AMP2) and after completion of PT sessions (AMP3). Friedman test was utilized to determine changes across AMP1-3 scores within group. Descriptive statistics were used to report changes in sub-aspects of functional mobility in each group.

## RESULTS

Significant changes were observed in AMP1 and AMP3 scores of PP ($p=0.05$). Chair to chair transfers, standing balance, sitting down and variable cadence were sub-dimensions which showed marginally significant changes. Significant improvements were observed from EP in AMP1 to AMP2 scores ($p=0.043$) with better performance in 14 out of 20 AMP tasks.

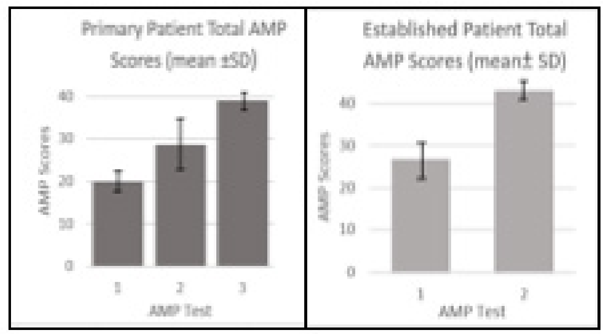


**Figure 1**(a). Mean of Total AMP scores of Primary Patients (n=3). (b). Mean of Total AMP scores of Established Patient (n=5).

## DISCUSSION & CONCLUSION

The results provided support that prosthetic rehabilitation can significantly improve functional mobility especially for primary patients. Furthermore, this study could be a useful guide in the practice of prosthetic rehabilitation services in the country. Future studies can be geared towards including larger populations, extending data collection to long-term observations and comparison between both the groups.

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# AFYA: A DESCRIPTIVE STUDY OF A LONG-TERM REHABILITATION PROJECT IN POST-EARTHQUAKE HAITI

Sarah Schuyler, Elisabeth Bahr OTR, Nohora Guzman OTR, Kristie Patten Koenig PhD, OTR, Danielle Butin, OTR, MPH

The Afya Foundation, New York University

## BACKGROUND

International rehabilitation professionals who provided relief in Haiti noted insufficient facilities, scarce quantities of health care professionals, and a growing need for services [1]. The current body of literature highlights the immediate influx of international aid and relief but there is little literature about long-term rehabilitation and its impact. The Afya Foundation (NY, USA) developed the first model for homecare and local access to rehabilitation medicine in Port au Prince. The program included the training of Haitians to become Rehabilitation Techs or Adaptive Builders.

## AIM

The following presentation aims to 1) Provide a description of patients, interventions and goals that Afya addressed in their long-term rehabilitation program. 2) Investigate the preliminary impact of rehabilitation on intervention pain and functions using a retrospective analysis of patient records provided by The Afya Foundation.

## METHOD

This study was conducted on a data set comprised of 987 patients, collected over a period of 3 years. Patients were given 10 questions in which qualitative data was collected about the clinic they attended, medical history, diagnosis, goals of treatment, equipment needed, and reason for discharge. Additionally, a sample of 67 patients were asked to fill a self-reported questionnaire containing 19 questions that included level of pain and function prior to and after treatment. Questions and results were coded to generate statistical analysis by SPSS. Paired sample t-test, Pearson correlations and crosstabs were used for the analysis.

## RESULTS

Most patients had no prior medical history (n = 274), second most reported was Cardiovascular/Diabetes (n = 133), and third was Aches and Pains (n = 78). The most common diagnosis seen in this data set was pain (n = 366). Overall, the survey data subset was representative of the overall data set. Generally, patients reported improvement between pre-treatment and post-treatment pain and function as can be seen in Table 1. Increasing length of treatment had a positive effect on outcome measures, with significant correlations in pain ($r = .279$, $p < .05$) and function ($r = .474$, $p < .05$).

| | Pre-Treatment | | Post-Treatment | | | | |
|---|---|---|---|---|---|---|---|
| | *M* | *SD* | *M* | *SD* | *t* | *df* | P (2- tailed) |
| Pain (n=53) | 4.09 | 1.06 | 2.3 | 1.46 | 9.47 | 52 | .000*** |
| Function (n=26) | 4.04 | 1.18 | 2.35 | 1.36 | 6.26 | 25 | .000*** |

M= mean; SD= standard deviation; df= degree of freedom.
*** p- value is significant at the .001 level
Figure 1. Paired Samples T- Test for Pre and Post-test Pain and Function Scores

## DISCUSSION & CONCLUSION

Afya's model of post-disaster long-term rehabilitation improved patient outcomes of function and pain. The t-test determined that the difference in pain and function from pre- treatment to post-treatment was significant. The Pearson's correlation analysis showed that the longer patients received treatment, the more their function improved and their pain decreased. Choosing to train Haitian individuals to provide treatment instead of deploying foreign professionals continues to build capacity and adds to the long-term sustainability of the project. Conclusion Training local rehabilitation technicians was an effective method to build local capacity of healthcare professionals.

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# DIABETIC FOOT CARE IN LESS RESOURCED SETTINGS

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[1] Motivation Australia

## BACKGROUND

Every 20 seconds, somewhere in the world, a lower limb is lost due to diabetes. The World Health Organisation (WHO) estimates that 50% of all hospital admissions and amputations as a result of diabetes can be prevented with appropriate foot care. This has been supported by the 40-60% decrease in amputation rates during the last 10-15 years seen in countries with strong diabetic foot management services. Unfortunately the same reductions are not being seen in low to middle income countries, where, in most cases, amputation rates are steadily increasing.

In 2014 Polynesia and Micronesia had the world's highest age-standardised diabetes prevalence rate -- nearly 25% -- with Melanesia not far behind. This data highlights the growing burden of diabetes within the Pacific Region. With high rates of diabetes also comes a high prevalence of diabetic foot complications and resultant hospitalisations and amputations. This is evident with any visit to a Pacific Island hospital, where in many cases entire wards are full of clients with diabetic foot sepsis.

## AIM

In June 2015, Motivation Australia, in partnership with the Samoa National Health Service (NHS), established a Diabetic Foot Clinic (DFC) at the Tupua Tamasese Meaole (TTM) hospital in an attempt to reduce the numbers and impact of diabetic foot wounds within Samoa.

## METHOD

The DFC was established with a core team comprising of a podiatrist, nurse and orthotist, with support from doctors from the TTM medical ward. The clinic's multi-disciplinary approach focuses on primary wound care, orthotic offloading, provision of ongoing diabetes and foot care education, and referrals to appropriate allied services.

A review of the service was conducted at three and six months post implementation.

## RESULTS

In its first six months, the NHS DFC was held two mornings per week, for a total of 276 half-hour appointments. A total of 42 clients were seen multiple times in this period. At each appointment clients received diabetes and foot care education, wound care and orthotic offloading if required.

Key findings at the six month review included:

- Enhanced wound healing for clients,
- The value of orthotic offloading for wound healing,
- Improved multi-disciplinary co-operation between NHS staff involved in diabetic care,
- High client attendance rates,
- Anecdotal evidence from the surgical team reporting fewer bilateral amputations.
- Improved self care behaviour of clients
- Wound healing with lower cost, basic style dressings

One unexpected but very promising outcome of the DFC was the demonstration of behaviour change in the clients who attended the clinic. Many clients presented with very high blood glucose levels. For various reasons, these clients were eating poorly, not taking medication as directed, not attending medical appointments and not undertaking appropriate self-care. The consequences of these behaviours greatly affected the ability of their wounds to heal. The DFC team noted that these behaviours changed markedly as the clients' treatment continued. Clients' blood glucose levels continued to decrease over time and reported self-care behaviours improved. These changes coincided with improved healing rates and general health and well-being.

## DISCUSSION & CONCLUSION

The DFC was developed to integrate treatment from key health specialties in order to improve outcomes for clients with diabetes. A number of the DFC clients presented with very serious foot wounds and infections, which affected the length and number of appointments. It is hoped that as awareness of the clinic improves, clients will present earlier for treatment, improving potential client outcomes and reducing both the time required for healing and treatment, and the materials and resources required by the DFC.

The implementation of a DFC in a less resourced setting is complicated by reduced access to dressings, materials, and medical specialties often recommended in best practice guidelines. The DFC within Samoa shows that with the right personnel and training it is possible to achieve successful outcomes for clients whilst using lower cost materials.

When establishing a DFC in a less resourced setting it is important to implement treatments that can be sustained long term. The use of higher cost donated items can be beneficial, however treatment options must also be developed utilising locally available dressings and materials to ensure services are sustainable. In a similar way the use of international volunteers can assist with a clinics implementation and development of local personnel, however to ensure sustainability, well trained, qualified local staff are essential. Much of the success of the Samoa DFC is due to the training and competency of the local staff.

During the feasibility period, medical personnel noted difficulties in communicating with clients and translating medical terms into local language. Focusing on allocating longer consultation times and clear language within the DFC, along with follow up calls to increase attendance rates anecdotally has contributed to the behavior changes experienced. The importance of client communication cannot be underestimated within this type of setting.

The establishment of the DFC within the Samoan NHS has provided many positive outcomes. It is hoped that the lessons learned from this clinic can help to influence the development of similar clinics across the Pacific.

# MODULAR ACTIVE ORTHOSIS FOR LOWER EXTREMITIES WITH ONE DEGREE OF FREEDOM FOR PARAPLEGICS

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## BACKGROUND

If the main propose of a device is to assist individuals with paraplegia to walk in an upright posture, without a need to precisely adapt normal gait patterns, then such device can be fairly simple. HALO is passive orthosis for paraplegic individuals (Genda et al., 2004) with locked knees and contralateral linkage between medial hip joint and ankles, this linkage maintains the position of the foot always parallel with the ground to avoid stumbling and in addition assists swinging the leg.

## AIM

Users have to usually undergo long training periods, before using HALO orthosis. Walking is not very smooth, even after training. The main goal is to develop compact and lightweight active orthosis using HALO mechanism. New orthosis will be characterised by smoother forward movement and increased safety and stability which is closer to the stability of normal walking. Such device should be moreover modular to provide the users with the possibility of easy conversion between passive and active setting.

## METHOD

In order to keep weight and price of device low, so it can be affordable and attractive for all users, there was introduced just single actuated degree of freedom (DoF) in the new orthosis. In order to test main objectives, stability and safety, there were 20 one-stride trials conducted by 3 able-bodied subjects (age 21-29). Subjects were equipped with markers using Helen-Hayes marker-set and recorded by the motion capture system MAC3D. Variability in velocity and displacement of the center of gravity (CoG) of the body were further examined as the stability factors, (Shinoda at al. 2008). Results were compared with normal walking.

## RESULTS

There was designed new compact active orthosis @halo, see Fig.1. The first active orthosis for lower limbs with just one actuated DoF, which can generate the safe walking patterns.

The orthosis is equipped with new @halo joint consists of right-angle gearbox with pulleys connecting hip and ankle using steel wire rope in Bowden. One DC motor with simple velocity feedback is connected to this gearbox. Forearm crutches, with a switch in the grip for motor activation, have to be used during walking. Compact prototype weights less than 7 kg.

Velocity and displacement of CoG of the body were evaluated. Total mean velocity with standard deviation (S.D.) was 0.26±0.031 m/s and coefficient of variation (C.V.) was 11.9 %. Displacement of CoG of the body in mediolateral direction was 9.5±0.6% of body height (%BH) and in the vertical direction was 1.28±0.21%BH. The trajectories of CoG of the body in sagittal and horizontal planes during one gait cycle using @halo orthosis are in Fig. 2


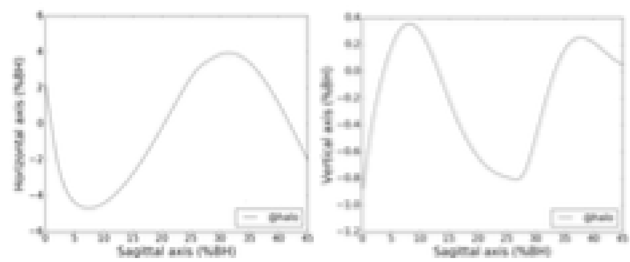


**Figure 2.** Trajectories of CoG in horizontal plane and sagittal plane

## DISCUSSION & CONCLUSION

S.D. and C.V. of velocity were smaller in comparison with data reported by Öberg et al. Such findings can be interpreted such as stability of walking with @halo orthosis evaluated from velocity variations is better than slow walking of able- bodied individuals. This is due to the programmed walking pattern of @halo with constant actuated periods and design constraints of the orthosis. Vertical elevation of COG and its S.D. were close to normal slow walking according to results from the study by Orendurff et al. Only way how to avoid excessive vertical elevation due to locked knees is to increase waddling. Mediolateral displacement was exceeding normal state nearly thrice. The impact of this result on stability is eliminated by crutches. S.D. in mediolateral direction is comparable to normal slow walking.

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# WHAT CHARACTERISTICS ARE ASSOCIATED WITH FASTER WALKING SPEED IN LOWER LIMB AMPUTEES?

Heather Batten

## BACKGROUND

Walking speed has been shown to be a predictor of functional ability, future health status, institutionalization and death. However, there is a paucity of literature examining patient and clinical characteristics associated with walking speed in the lower limb amputee population. By determining these characteristics, we may be better able to predict an amputee's prosthetic walking ability.

## AIM

To investigate which patient and clinical characteristics were associated with faster walking speed in a cohort of unilateral lower limb amputees (transtibial or higher) at discharge from inpatient rehabilitation.

## METHOD

A cohort study was conducted (n=111) among patients prescribed a lower limb prosthesis during inpatient hospital rehabilitation. Generalised linear mixed modelling was conducted to examine factors associated with walking speed at discharge from hospital. This included a model fitting exercise to determine the most appropriate model parameters (using Akiake Information Criterion as an indicator of model fit with penalty for complexity). The most parsimonious model included discharge walking speed (dependent variable), and eight characteristics of interest (K-level, aetiology, cognition (measured using Modified Mini-Mental State Exam (MMSE)), discharge Functional Independence Measure- Motor (FIM-M), gender, age, whether the patient used an indoor mobility aid prior to amputation and amputation level).

## RESULTS

Walking speed was positively associated with K-levels. People with aetiology of trauma (coeff=0.090, p=0.006), tumour (coeff=0.080, p=0.014) and infection (coeff=0.080, p=0.001) walked faster than people with lower limb amputation of dysvascular aetiology. Higher discharge FIM-Motor was associated with faster walking speed (coeff=0.006, p=0.044). Younger people walked faster than older people (coeff=0.003, p=0.007). Males with lower limb amputation walked faster than females (coeff =0.148, p=0.003). Transtibial amputation level walked faster than knee disarticulations (coeff=0.372, p=<0.001)) and transfemoral amputations (coeff=0.176, p=0.009). MMSE (p=0.55) and prior mobility aid (p=0.25) were not associated with prosthetic walking speed.

## DISCUSSION & CONCLUSION

This was the first investigation to investigate associations between walking speed and K-level as well as walking speed and FIM-Motor score. More distal amputation levels have been previously associated with walking ability. The impact of aetiology and gender has varied across previous studies. Cognition and prior mobility have previously been found to be associated with faster walking speed; however, this was not the case in the present study.

Whilst amputee rehabilitation should include walking speed training, rehabilitation teams need to better understand characteristics specifically associated with amputee walking speed, to more accurately set goals and predict prosthetic walking ability. Further prospective studies are required to confirm predictive characteristics associated with faster amputee walking speeds.

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# FEASIBILITY OF A SELF-EFFICACY ENHANCED PEER-LED WHEELCHAIR TRAINING PROGRAM FOR OLDER ADULTS

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## BACKGROUND

Although an effective wheelchair skills program exists, a need was identified for alternative approaches to manual wheelchair (MWC) training for older adults that can be administered in the community.1 Self-efficacy, an important psychological factor, is just as, or more important than, skill in predicting behavioral outcomes (i.e., wheelchair use).2 Low wheelchair use self-efficacy is prevalent in older adults.3 According to the tenants of Social Cognitive Theory,4 a Wheelchair training 'Self-Efficacy Enhanced' for Use (WheelSeeU) peer-led program was developed. A feasibility evaluation is a prudent step to understanding issues related to process, resources, management and safety.

## AIM

The aim of this study was to evaluate the feasibility of the WheelSeeU study protocol for older manual wheelchair users according to process, resources, and management issues.

## METHOD

A two-site randomized controlled trial (RCT) was administered with community-living older adults (age >50 years) who had MWC mobility goals. Participants in the intervention completed 6 x1.5 hours of peer-led WheelSeeU training in pairs. Participants in the control group completed 6 x 1.5 hours of didactic sessions on general wheelchair use in pairs. Feasibility indicators assessed process (e.g., recruitment rates, consent rates, retention), resources (e.g., burden, adherence), management (e.g., processing, protocol administration), and treatment issues (e.g., safety). Feasibility indicators were treated as binary (successful/unsuccessful).

## RESULTS

Forty participants were allocated to the experimental group (n=18) or the control group (n=22). Five participants were lost to follow-up. Participants were 64.5±8.0 years of age, predominantly male (60%), with variable diagnoses (amputations =28%; SCI =20%; other =52%) and 7±11.3 years of previous experience using a MWC

| Feasibility indicator | Outcome measure | Parameter for success | Results | Feasible | Suggested modifications |
|---|---|---|---|---|---|
| **Process** | | | | | |
| 1. Recruitment rate | # of subjects recruited/ time | 2 subjects/month/site | 2 participants/m | N | Other recruitment strategies |
| 2. Consent rate | % of subjects consenting | < 10% subject refusal | 49% | N | Relax parameter for success |
| 3. Retention rate | % of subjects with complete data collection (T2, T3) | Complete T2 & T3 with ≥ 80% of subjects | T2 = 93% T3 = 87.5% | Y | |
| 4. Perceived benefit | Post-intervention Participant Questionnaire | > 85% will perceived benefit of WheelSeeU | 100% | Y | |
| **Resources** | | | | | |
| 5. Adherence | | | | | |
| WheelSeeU group | Attend 6 WheelSee sessions | > 85% of subjects | 95% | Y | |
| Control group | Attend 6 iWheel sessions | > 85% of subjects | 90% | Y | |
| 6. Subject/tester burden | | | | | |
| T1 | Data collection time T1 | > 85% of subjects complete in ≤ 2 h | 141 (36) min | N | Reduce the number of outcome measures collected; relax parameter for success |
| T2 | Data collection time T1 | > 85% of subjects complete in ≤ 1.5 h | 119 (43) min | N | |
| T3 | Data collection time T1 | > 85% of subjects complete in ≤ 1.5 h | 118 (36) min | N | |
| 7. Trainer adherence | Recruit and retain a peer trainer | Attend 6 x 5 training sessions/ site | 98% | Y | |
| 8. Translations | Translate and administer study materials | No/minimal issues | 0 issues | Y | |
| **Management** | | | | | |
| 9. Combining data | Combine data (English, French) | No issues with combining English and French Data | 0 issues | Y | |
| 10. Intervention fidelity | Observe and score peer-trainer and expert trainer administer the intervention. | A score of > 90% on the WheelSeeU Administration Rating | 90% | Y | |
| 11. Processing time | Time from initial contact to enrolment | Mean time is < 10 days | | N | Relax parameter for success |
| 12. Treatment admin | Treatment protocol checklist | Modifications can be made without substantial changes to protocol | 1 minor change required | Y | Allow for individual training if one participant drops out |
| **Treatment** | | | | | |
| 13. Safety | | | | | |
| Intervention | # of adverse events | No adverse events | 0 adverse events | Y | |
| Data collection | # of adverse events | No adverse events | 0 adverse events | Y | |

**Table 1.** Feasibility indicators and suggested modifications.

## DISCUSSION & CONCLUSION

Success was achieved on 9 of 13 feasibility indicators confirming the feasibility of the peer-led WheelSeeU training program for older adults. Minor modifications to the number of assessments in the study protocol should lessen tester and participant burden. Alternative recruitment strategies may address recruitment issues and may better target older adults living in the community who don't necessarily require rehabilitation services. Lower than anticipated consent rates and longer than expected subject processing times highlight the importance of providing training at optimal times.

For example, basic training during initial rehabilitation is important, but is likely not the best time for intermediate or advanced training. New MWC users need time to experience using the wheelchair use to better understand the task demands. Moreover WheelSeeU may provide training options for older adults in the community who procure their wheelchairs independently (e.g., directly from vendors, purchase second hand). With minimal modifications, WheelSeeU is a feasible approach to community-based MWC training for older adults. WheelSeeU may address issues related to just-in-time training with additional social benefits and reduced clinician burden.

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# ANALYSIS OF INTERFACE FORCE DISTRIBUTION & BALANCE IN SUBJECTS WITH ADOLESCENT IDIOPATHIC SCOLIOSIS (AIS) USING BOSTON BRACE

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## BACKGROUND

The update definition of scoliosis (AIS) is a three dimensional (3-D) deformity of the spine caused by lateral curvature and vertebral rotation. Effectiveness of spinal orthosis for AIS is still controversial.

## AIM

To find the interface forces & balance in subjects with adolescent idiopathic scoliosis using Boston brace.

## METHOD

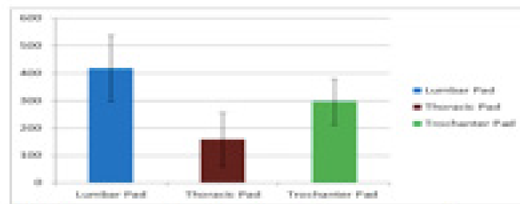
This is pre-post experimental study design. 10 AIS subjects using Boston brace. Study by convenience sampling method. Group (N=10, M-5, F-5, age-12.9000 ± 2.51 year; weight-35.6940±12.294kg, height-142.800±24.4895cm, Cobb's angle-30.800±3.1903). Pre-post data were taken with electronic force measuring instrument, Pressure measuring system for force data of Boston brace. & COP data for balance were taken with .Kistler force Plate (Type- 9260AA6, dimension- 600 X 500 X 50 mm, weight- 8.6 kg). The comparison of the various variables between pre-brace and post in brace was done for statistical analysis.

## RESULTS

Several parameters are analysed. These are force of trochanter force, lumber pad force and thoracic pad force in various posture, COP Parameters – Range (AP &ML), Mean distance (AP& ML), COP range, COP RMS , Romberg Ratio.

## DISCUSSION & CONCLUSION

M. S. WONG et.al.(1998) et al. state that the corrective force the curve have an effect on correctional forces1. Eshaghi et. al (2012);states that the displacement of the




Graph-1- Mean corrective force Vs various pressure pads.

| Group | Mean | SD | P-value |
|---|---|---|---|
| LumbarPad | 418.0760 | 119.7517 | <0.0001 |
| ThoracicPad | 98.1465 | 89.9474 | |
| TrochanterPad | 83.5269 | 132.0323 | |

Table 1- Mean corrective force (Newton) in standing position

| | Group | Mean | ±SD | t-value | p-value | Pearson Correlation |
|---|---|---|---|---|---|---|
| Fy average | Pre eye close | .6023 | .4487 | 2.8193 | 0.0114 | 0.8579 |
| | Post eye close | .8989 | .3427 | | | |

Table-2, Mean value of COP-Fy.

COP is maintains stability2. Both are accordance with this study. Boston brace with stranded force application is effective in curve correction and improvement of balance in Adolescent idiopathic scoliosis. The Boston Brace provides an actual force system resulting in improvement of balance.

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# THE MODULAR SOCKET SYSTEM AS RURAL SOLUTION IN INDONESIA

Anthony Francis

## BACKGROUND

In many low-income countries, the majority of the people who need assistive technology do not have access to prosthetic devices1. Solutions like the Modular Socket System (MSS, Össur®) could be delivered faster compared to conventional methods, with fewer visits and without needing any heavy machinery2. This could make it suitable for application in a Community Based Rehabilitation (CBR) setting.

## AIM

The aim of this study was to evaluate the technical feasibility of the MSS for implementation in a CBR setting in terms of required tools, skills and required production time.

## METHOD

The study was performed at the Department of Prosthetics & Orthotics of the Jakarta I Polytechnic School of Health Science (JSPO). Four students of the JSPO received a three- days training to produce the MSS. Lower limb amputees were recruited to participate in this study from the region of Jakarta (n = 5) and Bali (n = 10). Performance and satisfaction were measured using standardized instruments like the two minutes' walk test (2MWT) and Prosthesis Evaluation Questionnaire (PEQ). To evaluate technical feasibility the prosthetists filled out production and maintenance logbooks.

## RESULTS

Both the score of the 2MWT and the PEQ were comparable to that of studies with other lower leg prostheses which suggests the students were able to reach sufficient quality. The amount of time to fit a MSS to a patient ranged between 3.5 and 10.5 hours (mean socket production time 2.0±0.6 hours and mean prosthesis assembly and fitting time 4.1±2.6 hours).

The only non-portable machine needed for the production of the prosthesis was a grinding machine (router). Smaller portable machines used were a cast cutter/jigsaw, Icecast® Compact and resin injection tool.

## DISCUSSION & CONCLUSION

Patients who normally have to travel long distances to access prosthetic services were only required to make one visit to the health facility in order to receive a prosthesis. If the grinding machine will be replaced by a handheld tool, production of the MSS could be performed on site, making it suitable for use in a rural setting. Whilst feasible from a technical and quality perspective, high costs remain an issue.

## REFERENCES

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# RESPIRATORY POWERED ASSISTIVE TECHNOLOGY FOR PRECISION CONTROL

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## BACKGROUND

The input required to control an assistive device greatly defines the subsequent precision that can be achieved. Robust mechanisms that are low-cost often use musculoskeletal motion for control. However, applicability issues can arise when the system that is augmented also generates the power and drives the control. A device that is powered and controlled by breathing could expand the product options for patients and address certain requirements that are difficult to meet with the currently available solutions.

## AIM

The aim of this study is to explore the utility of a breathing powered technique for precision control of a gripping device.

## METHOD

The proposed system was virtually prototyped [1] to determine if the the concept could meet the minimum requirements for functional application. The virtual prototype consisted of modelling the human respiratory airflow, turbine performance, torque transmission and pinch force of the terminal device (Figure 1). Two models were used to virtually prototype the turbine [2, 3] and the force output range was determined. The physical device was tested to determine repeatability (precision) of control. An airpump (Tetra APS 300) was used to provide a consistent input (300 l/h) comparable to the exhalation of breath. Published results, as well as experimental data that was obtained with a digital anemometer (HoldPeak HP-866A) were used to ascertain that the airpump would create a relevant "physiological" input. The revolutions per minute (RPM) at which the turbine operated was used to determine the repeatability of the system, as it could accurately be measured using an optical tachometer (DT-6236B). The maximum difference and the Root Mean Square Deviation (RMSD) were computed based on 12 measurements obtained over a 30 minute interval.

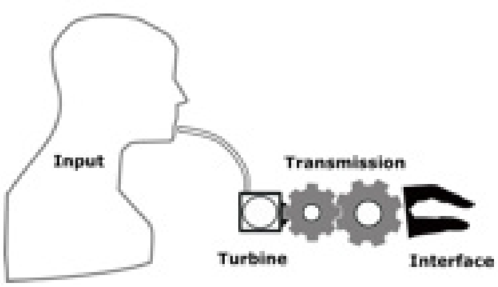


**Figure 1**. Modular breakdown of parts that were virtually and physically prototyped. The prototype consist of an input, turbine, transmission and terminal module [1].

A physical representation was constructed with an additive manufactured turbine (Figure 2).

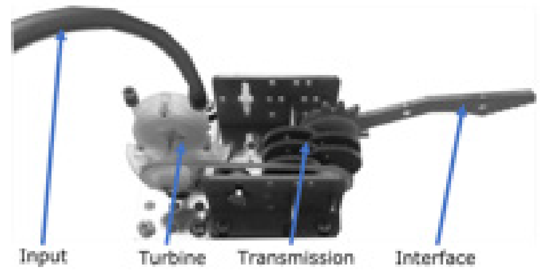


**Figure 2**. Initial physical prototype for proof of concept

## RESULTS

A gripping force of 50.3-126.9 N was generated by the virtually prototyped assistive device. The mean RPM recorded across the measurements was 11490 with a RMSD of 66 (0.6% of the average value). The largest difference between measurements was 239, which represents 2.1% of the average RPM that was recorded.

## DISCUSSION & CONCLUSION

The prototype results indicate that a breathing powered prosthetic could generate enough force and create a sufficient repeatable output to complete certain precision activities of daily living. More work is needed to determine what the exact precision is of the control during real-world situations. The air-powered assistive technology should be able to tolerate harsh working environments and provides a new conceptual method for control and power of assistive technology. The presented explorative device uses a Tesla turbine to power the gripping mechanism. This turbine can reverse the direction of rotation of the shaft creating the opportunity to drive the system in both directions.

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# OPTIMISING CLINICAL OUTCOMES FOR AFO USERS:

Prototype development of a clinical tool to report AFO stiffness

Anthony Francis

## BACKGROUND

Achieving measurable and optimised clinical outcomes in the provision of Ankle Foot Orthoses (AFO) requires a patient-focused approach and the careful specification of the functional and material design characteristics of the device. A key design characteristic of a successful AFO design is its flexural stiffness. Flexural stiffness is used by AFOs to affect control on the transition of the human body through the gait cycle and is increasingly the focus of research and clinical practice. Previous studies in the area have identified links between AFO stiffness and the effect on energy return (Bregman et al. 2011), ankle kinematics (Kobayashi et al. 2011) and muscle activity (Harper et al. 2014). Previous conceptual work in this space explored the need for developing the ability of P&O clinicians to observe, report and specify the characteristics of AFO design. This is required for optimising individual goal-focussed outcomes for clients, and in addition, the accurate specification of material characteristics required for progressive manufacturing techniques such as additive manufacture.

## AIM

To prototype an AFO Stiffness Quantification Tool in a clinical environment and evaluate the impact of adjusting the stiffness of an AFO on gait characteristics of a client.

## METHOD

A custom AFO with a variable stiffness joint was fitted to a single participant. Gait characteristics were manipulated through varying the AFO stiffness until an ‘optimal’ gait was achieved. Gait was captured using a two-camera video system and lower limb kinematics analysed using movement analysis software and scored with using the Edinburgh Visual Gait Score.

Walking trials were conducted with a range of AFO stiffness conditions as measured by the prototype AFO Stiffness Qualification Tool.

## RESULTS

Clinical optimisation of gait quality was achieved for the client using a dorsiflexion stiffness of 6.8Nm/deg and plantarflexion stiffness of 3.5 Nm/deg (Figure 1). This can be expressed as a plantarflexion:dorsiflexion (Pf:Df) stiffness ratio of 0.51. Stiffness characteristics of commonly used AFO conditions vary considerably though largely have smaller variations in Pf:Df stiffness ratio.

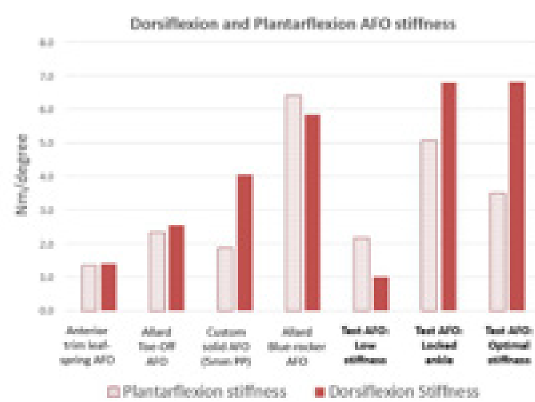


**Figure 1**. Stiffness characteristics of AFO designs.

## DISCUSSION & CONCLUSION

The ability to accurately manipulate, quantify and report flexural stiffness is demonstrated through the use of a prototype clinical tool. This development provides a basis for further work to better understand the clinical importance and prescription of flexural stiffness to improve clinical outcomes.

## REFERENCES

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# TARGET ORIENTED - LASER ILLUMINATION DEVICE TRAINING IN IMPROVING HEAD CONTROL, SITTING AND STANDING BALANCE IN CHILDREN WITH CEREBRAL PALSY

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## BACKGROUND

Children with cerebral palsy (CWCP) often lack balance to maintain their head on the shoulders thereby making it difficult for them to stand or sit. This becomes accentuated after Single Event Multilevel Lever Arm Restoration Anti Spasticity Surgery (SEMLARASS). Laser illumination device is an indigenously developed device for improving sitting, standing balance, and head-trunk control in CWCP. LID works by giving visual feedback through active and passive correction.

## AIM

This study evaluated the effectiveness of a LASER illumination device (LID) on head and trunk control, sitting and standing balance in CWCP after SEMLARASS.

## METHOD

Prospective experimental study was conducted among 50 CWCP after SEMLARASS and were randomly assigned to Group A(n=25) which received the LID with conventional rehabilitation(CR) and Group B(n=25) which received only CR. The study duration was 5 weeks with 1 hour of intervention per day for 6 days per week. The intervention comprised 15 minutes training with LID on a targeted screen with a few minute rest periods in between. Paediatric balance scale (PBS), Trunk Impairment Scale(TIS) and Clinical Scale for Head Control(CSHC) were the primary outcome measures performed at baseline, 5weeks after treatment and follow- ups after 1month and 3months.

## RESULTS

Participants in Group A had mean age of 9.23±3 years and Group B 9.68±3.45 years. Group A showed a significant difference in the scores of TIS ($P<0.01$) and CSHC ($P<0.05$) when compared to group B. PBS scores were not significant in both the groups. comparatively PBS scores showed better results in Group A than Group B. The obtained outcomes were maintained at follow up of 1 month and little deterioration in 3 months for Group A. outcomes were not maintained for Group B.

**Figure 1.** Gender distribution among Group A and Group B

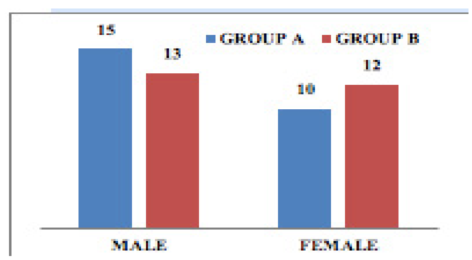
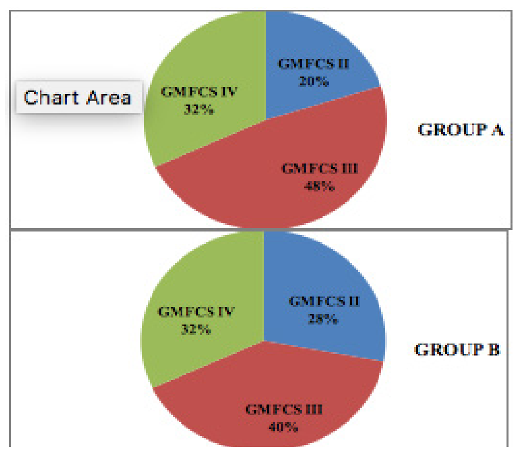



Figure 2. GMFCS Distribution among Group A and Group B




## DISCUSSION & CONCLUSION

HHLID can be a useful tool during rehabilitation after SEMLARASS for the improvement of head control, trunk control, standing and sitting balance in children with CP. A Laser-pointer attached to the head or pelvis and target is to focus on the screen. The participants were encouraged to perform the focussed trajectory exercises. The results were favourable to the use of LID for rehabilitation purpose post SEMLARASS.

# MUSCULOSKELETAL PAIN, FUNCTION, AND QUALITY ASPECTS OF LIFE IN ADULTS WITH CONGENITAL UPPER LIMB DEFICIENCIES USING PROSTHESES OR NOT

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## BACKGROUND

In Norway babies born with limb deficiencies are offered follow up through life by regional multidisciplinary teams. For those with below-elbow deficiencies, fitting of passive prostheses will be advised from the age of 6 months, based on the idea that growing up with an asymmetric body will increase the risk of musculoskeletal disorders in adulthood, and that daily use of limb prostheses can reduce this risk (1).

## AIM

The aim was to study presence of musculoskeletal pain, function, and quality of life in adults with congenital upper limb deficiencies compared to controls, and whether the use of prosthesis had influenced these aspects.

## METHOD

All patients 18 years or older with an ICD-X-diagnosis of Q71.*, congenital Reduction defect of upper limb, but not Q72.*, Reduction defect of lower limb, in our hospital records, received a questionnaire including demographic factors like gender, age, level of education, marital status, work participation, use of prostheses and/or orthoses, active exercise, pain in neck, shoulders, lower back, and upper extremities, health-related quality of life (EQ-5D-5L), satisfaction with life (SWLS), and practical arm function (Quick-Dash). The same questionnaire was sent to 1092 controls, randomly picked by the national folk register.

## RESULTS

See tables and figure for results on function, quality of life and pain.

**Table 1**: Arm function and quality of life in patients and controls

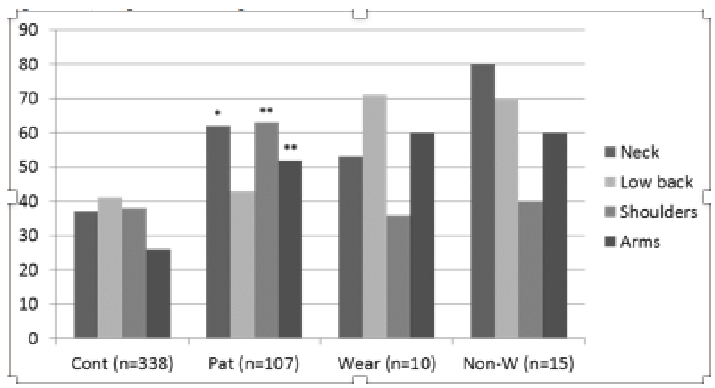
| Table 1 | Patients (n=107) MD(IQR) | Controls (n=338) MD(IQR) | P Value |
|---|---|---|---|
| Arm function (QuickDash) | 14(20) | 2(9) | <0.01 |
| Life satisfaction (SWLS) | 5 (2) | 5(1) | 0.9 |
| Health-related quality of life (EQ-5D-5L, VAS) | 80(20) | 80(20) | 0.2 |

107 (58%) who fit the inclusion criteria (Pat) answered. 338 controls (Cont) (31%) did so. Mean age in Pat was 31(13), 47(15) in Cont. Demographic characteristics and work participation were similar. 46% of all Pat had prostheses fit at least once, and all with diagnosis Q71.2, below-elbow deficiencies (n=25), had. 40% of these were still daily users (Wear). Median age for quitting (Non-W) was 11 years.

**Table 2**: Arm function and quality of life in wearers and non-wearers

| Table 2 | Wearers (n=10) MD(IQR) | Non-W (n=15) MD(IQR) | P Value |
|---|---|---|---|
| Arm function (QuickDash) | 14(14) | 10(17) | 0.3 |
| Life satisfaction (SWLS) | 6(2) | 6(1) | 0.5 |
| Health-related quality of life (EQ-5D-5L, VAS) | 80(17) | 88(18) | 0.4 |

**Figure** 1: Musculoskeletal pain in % of each group for four locations *p<0.01, **p<0.001 in patients compared to controls




## DISCUSSION & CONCLUSION

There was more musculoskeletal pain in neck, shoulders, and arms, but not in the lower back, as well as lower arm function in adults with congenital upper limb deficiencies compared to controls. The health-related quality of life and life satisfaction were similar in patients and controls. Daily use of prostheses in below-elbow deficient patients did not seem to have made any difference for function or presence of pain, although there was a tendency towards more neck pain in the non-wearer group. The patient group was diverse, and on average younger than controls. Splitting up in age-groups would increase the value of comparing. Studying only the Q71.2-group focused on one main question, but the patient groups became too small for some statistical comparisons. Larger patient groups are needed to study this further

## REFERENCES

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# LIGHTWEIGHT PROSTHETIC KNEE WITH STAND-UP ASSISTANCE

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## BACKGROUND

For amputees with an above knee (AK) amputation it is hard to stand up when being seated. This is especially true for the elderly amputee. They have difficulties with independently standing up and sitting down, e.g. on a chair or a toilet. A prosthetic leg with an actuated knee could provide assistance during daily standing up activities. Unfortunately current active knees are heavy. In general they are too heavy to be used by a large group of elderly people.

## AIM

The aim of our study was to develop a prosthetic knee, which provides active support during standing up. This active prosthesis should be lightweight.

## METHOD

Current active knees use electric actuators and batteries to provide the standing up support. Electric actuators are heavy. Furthermore the battery has substantial weight, as the total energy for multiple stand-up motions needs to be pre-stored in the battery. In order to make the knee lightweight, we took another approach. We regenerate the energy of the sitting down motion and store it in the device. In this way only the energy of one standup-motion needs to be stored in the device. When the amputee wants to stand up, this energy is used to actuate the knee and provide support during standing up. To achieve this, we use a pneumatic actuator. Pneumatic actuators have a high force-to-weight-ratio.

## RESULTS

We developed a prototype of a prosthetic knee that uses a pneumatic actuator to actuate the knee during standing up. By using pneumatics, we can use the actuator as a generator regenerating energy during sitting down (Figure 1). The regenerated energy is restored in an accumulator and can be used for actuation during the standing up motion. As a result the device is much lighter than current active devices. The device weighs less than 1.5 kg (from knee to ankle). The current prototype is intended for amputees with a very low activity level. Therefore we use a knee that is fixed during walking. The devices uses sensors and a micro-controller to detect when the amputee wants to stand up. This prevents unwanted actuation, while the amputee is being seated.

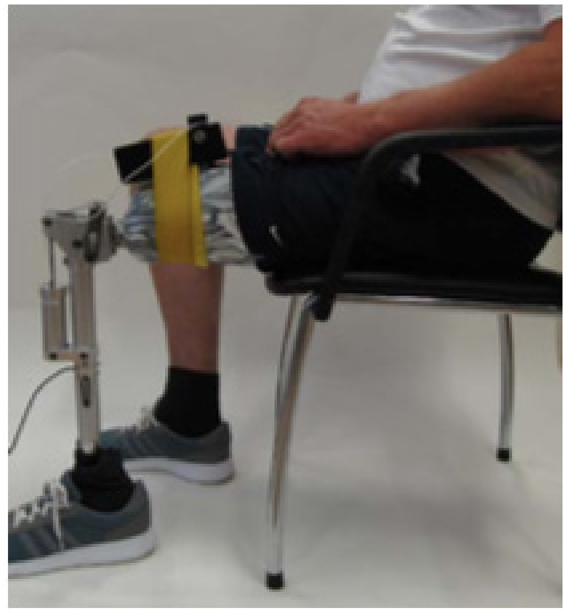

**Figure 1.** The prototype of the prosthetic knee regenerates and stores the energy of the seating down movement. This energy is used to provide standing up support.

## DISCUSSION & CONCLUSION

A first step was made in the development of a lightweight powered prosthetic knee. The study showed that pneumatics can be used to regenerate energy during sitting down, allowing for enough energy to be stored and used for standing up at a later moment. The first prototype that was built, showed the feasibility of the concept. A lightweight powered

knee answers to the need of a large group of elderly AK- amputees with a low activity level. Further studies are planned to further evaluate the principle. The current system works for a simple knee joint, which is fixed during walking. These type of knees are commonly used by elderly people. Further studies will investigate how the principle can be used for other types of knees as well.

# ACTIVE ASSISTIVE DEVICES; CARE IN THE FUTURE?

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## BACKGROUND

In the coming decades, there will be a growing need for care for people with chronic diseases. At the same time, people coping with disabilities strive for autonomy and social participation. This strive is, in turn, one of the core fundaments of rehabilitation Medicine as it aims to improve functions and skills of patients with disabilities caused by congenital or acquired disorders, to optimize their self-management and to maximize their autonomy and ability to participate in social activities.

## AIM

In this abstract we would like to share the view of the Netherlands Society of Rehabilitation Medicine and the Dutch Society for Rehabilitation Physiotherapists on the field of Rehabilitation Medicine and assistive technology.

## METHOD

Not applicable

## RESULTS

Rehabilitation Medicine works actively to improve the quality of care offered to patients based on knowledge derived from scientific research, the application of technological and other innovations and networks within the healthcare system. Achieving the greatest possible autonomy and participation for these patients is one of our core aims. In this context, the proposed new definition of health by M. Huber: The ability to adapt and self-manage in the face of social, physical and emotional challenges of live, fits very well into the vision of rehabilitation medicine.
Supportive technical devices like prostheses, orthoses and wheelchairs can help to regain and remain functional skills and tasks. They can actually improve the persons abilities to stay independent. The interaction between the adaptive capabilities of a person and the adaptive capacities of the assistive device will define the level of functional ability. Indeed in the face of social, physical and emotional challenges of live. Technical improvements in sensing, actuation and artificial intelligence in these assistive devices makes them more and more functional embedded to the human body. Will it be possible to improve the original?

## DISCUSSION & CONCLUSION

Based on the new definition of health we feel that the field of Rehabilitation Medicine should shift it's paradigm from treating the consequences of the disease to achieving the highest levels of functioning and self-management. This new paradigm should also be the base of the evaluation of assistive devices: does this (new) device enable people to adapt to and self-manage in the face of the challenges of life? In the end it is not the technological complexity of an assistive device that matters, but what matters is whether the assistive device contributes to functioning in daily life.

## REFERENCES

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# A SATISFACTION FEEDBACK SURVEY OF PEOPLE RECEIVING PROSTHETIC SERVICES IN THE GAZA STRIP

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## BACKGROUND

Artificial Limb & Polio Center (ALPC) is the only service providing comprehensive prosthetic & orthotic rehabilitation since 1978 in the Gaza Strip. It works in partnership with ICRC to improve quality, accessibility and sustainability of its services and to provide opportunities for social inclusion of people with disabilities. Feedback from service users (SUs) provides an opportunity to understand where improvements can be made. A third party, Azhar University was engaged to complete a satisfaction survey.

## AIM

For ALPC to have relevant information about the perceptions and satisfaction of SUs amputees in order to plan improvements.

## METHOD

100 prosthetic SUs were randomly selected and interviewed by 8 physiotherapy students from Azhar University. The survey consisted of general information, feedback on accessibility, interpersonal manner and communication with ALPC staff, perceptions of prosthesis' quality (prosthetic fit, comfort, self-reporting of mobility) and socio-economic impact. Interviews were conducted face to face or by phone. Care was taken to ensure confidentiality, allow a safe environment and avoid bias. Data analysis was completed using (SPSS). The sample included 12 upper-limb and 88 lower-limb SUs, 14 bilateral, 97 adults, 3 children, average age was 36.3 years (Range 12-70).

## RESULTS

The survey found 58.6% SUs had a comfortable fit of their prosthesis, 42% walk over 500 meters a day with their prosthesis, 54% can wear their prosthesis more than 10 hours a day. 79.8% indicate that the prosthesis is easy to wear. 48% rate themselves with a very high ambulation capacity using their prosthesis. 84.7% said that prosthesis is very important for their interaction with community. 81.6% indicate the prosthesis suits its purposes. Overall satisfaction on the prosthesis expectation shown in the figure. Reasons of dissatisfaction were also collected. 92.9% of respondents indicate that ALPC staff are friendly, 98% indicate that level of privacy during the treatment was very appropriate. Results reveal that 96.9% of respondents will recommend and refer another person with a disability to ALPC for its services.

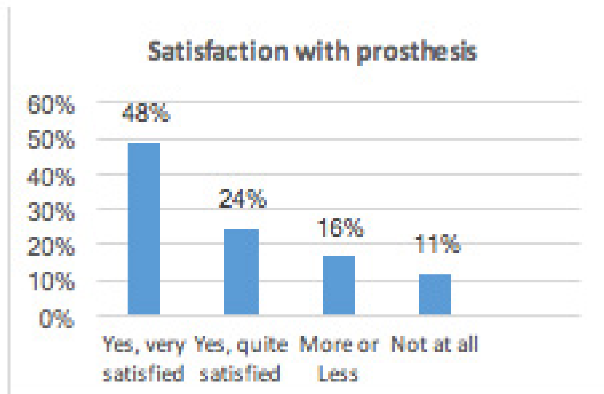


**Figure 1.** Title (SUs' Satisfaction with prosthesis)

## DISCUSSION & CONCLUSION

Satisfaction of patients with prosthetic therapy is multi-dimensional. It depends on general health, psychological status, level of independence in performing of daily activities, social relationships and the possibility of realization of basic goals (Wetterhahn 2002). Whilst some of these aspects are out of service provider's control, possible areas of improvement have been identified through this survey such as improvements to prosthesis comfort and a focus on performing functional activities of daily living. This survey has provided useful information that will inform planning to further improve outcomes.

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# HEALTH LITERACY IN VASCULAR SURGERY PATIENTS

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## BACKGROUND

Health literacy (HL) is the degree to which individuals have the capacity to obtain, process and retain basic health related decisions. Studies have proposed an association between poor health literacy and negative patient outcomes. For patients, an understanding of long term management, lifestyle changes and secondary prevention are essential in optimal vascular disease treatment because compliance with disease management, and therapeutic, orthotic and prosthetic goals rely on comprehension, recall and the ability to process and act upon information provided.

## AIM

To determine vascular surgery patients' health literacy and preferred information gathering method; verbal, written or a combination.

## METHOD

The primary HL measure was the Newest Vital Sign (NVS) which has favorable validity and utility in a clinical setting (Rowlands et al 2013). It scores health literacy on a scale of 0-6.

| | |
|---|---|
| 0-1 | High likelihood of limited health literacy. |
| 2-3 | Possibility of limited health literacy. |
| >4 | Almost always indicated adequate health literacy. |

Patients admitted to a vascular surgery ward for either elective or emergency intervention were approached during their hospital admission (July 2016 - September 2016). Surgeries ranged from angioplasty to major amputation, capturing the full spectrum of interventions expected in this population. Exclusion criteria were a confirmed diagnosis of dementia, cognitive or visual impairment.

| | |
|---|---|
| No. of patients | 52 |
| Age range (mean) | 32 – 85 (62) |
| Smoking : Ex : Non | 13 : 33 : 6 |
| Co morbidities (0-1 : 2-5 : <5) | 8 : 31 : 13 |
| Age left formal education | 14=3 15=30 16=12 17=2<br>18=3 >18=2 |
| Preferred communication style | Verbal 33: Written 4<br>Verbal and written 15 |

Demographic data included; age, intervention, no of co-morbidities, school leaving age and the patient's preferred information gathering strategy. Patients who chose not to participate or who abandoned the tests comments were recorded.

## RESULTS

Fifty seven patients were approached with 52 included in analysis of communication style and demographics, and 47 in HL.

Most (33) patients expressed a preference for verbal information in the first instance. In contrast, 15 preferred a verbal/written combination, with 4 preferring only written information (Table 1). The majority (35) of patients were observed to have a high likelihood of poor health literacy (Table 2). Of patients who did not complete the NVS (10), verbal reasons included; "are you trying to trick me", "I don't do words", "the question doesn't make sense" and "I'm too tired to do it".

The vast majority of patients left school after secondary education and prior to accessing any form of higher qualification.

**Table 1**|: Demographics and preferred communication styles

**Table 2:** Health literacy scores.

| | Patients | Meaning |
|---|---|---|
| 0 | 34 | High likelihood of limited literacy |
| 1 | 1 | |
| 2 | 4 | Possibility of limited literacy |
| 3 | 1 | |
| 4 | 4 | Almost always indicates adequate literacy |
| 5 | 2 | |
| 6 | 1 | |
| Refused | 5 | Declined to continue after starting test |
| Refused | 5 | Declined to participate after explanation |

## DISCUSSION & CONCLUSION

Health literacy is a developing area with little research in the vascular and amputee population. Our results provide evidence of a population with limited health literacy and a preferred communication style of verbal interaction. The results were unsurprising as our clinical work often includes examples of patients who lack understanding of what has happened to them surgically, express minimal self-awareness that their lifestyle choices are likely to have been causative factors in their health status, and expect to recover without fully engaging with therapists and other healthcare professionals.

Vascular patients have poor health literacy which may explain some of the difficulties therapists encounter in patient understanding, learning, post-surgical expectations, and their engagement in rehabilitative regimes. Improved therapist insight will support better strategies to be adopted.

## REFERENCES

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# FIRST EVALUATION OF NOVEL MYOELECTRIC HAND PROSTHESES USING DIGITAL FABRICATION TECHNOLOGY

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## BACKGROUND

Conventional industrial manufacturing method can achieve mass-production. However products in the field of P&O need fitting-process for individual users. Recently digital fabrication technology reduces the production cost for individual objects. Applying this new technology can renew the P&O manufacturing process. Several communities of the open-source prostheses grow up. One of appropriate target using this technology is hand prosthesis. We develop the novel myoelectric hand prosthesis by using a laser cutting machine (LC) [1]. The hand prosthesis has adaptive grip function and passive wrist function.

## AIM

The aim is checking the grip functions of the hand prosthesis with a cosmetic silicon glove (LC-prosthesis) through a clinical evaluation.

## METHOD

The LC-prosthesis consists from skeletal structure of hand (made by LC), a silicon glove (Sil-glove: Sato Giken Corp.), servo-motor (MP91SMKII: Japan Remote Control Co., LTD.), microcontroller (Arduino pro mini 328: SparkFun), two EMG-amplifiers (13E200=60: Otto Bock Health Care GmbH) and battery (5V-charging battery for a Handy-Recharger).
The thumb of the LC-prosthesis is capable of posing manually with the healthy side hand of a user. Another four fingers are controlled by the servo-motor. The servo-motor is controlled by the microcontroller according to the strength of EMG-signals, which are acquired by the EMG-amplifiers. The control method of the fingers is a proportional control.

A skillful test-user of the myoelectric hand prosthesis is participated for this first evaluation. The user has amputated right side of the forearm. A fitted socket of the LC-prosthesis is made for his residual limb (Fig. 1). The user is known all function of the LC-prosthesis, before the evaluation. The LC-prosthesis can be controlled similar with the MYOBOCK system. While the evaluation, the user adjusts the direction and the rotation of the hand with an adjustable wrist for an object.

**Figure 1**. The LC-prosthesis. The size of thumb is shorter than an evaluated LC-prosthesis (ref. Figure 2).

The user tried to grasp various objects on a desk. While the user controls the LC-prosthesis to open/close, the four fingers of the LC-prosthesis fit the shapes of the objects automatically and wrap the objects. Whole grasping movements while the evaluation was recorded by video camcorders.

## RESULTS

The user-evaluation showed the four fingers are fitted to the shapes of the objects. The grip form of these adaptive fingers looks like real. The user perceived the LC-prosthesis lightweight and the finger-movements speedy. The grip power is weak, however the LC-prosthesis hold the various objects through the adaptive grips (Fig. 2).

**Figure 2**. The user-evaluation and tested six grip forms.

## DISCUSSION & CONCLUSION

The control scheme of the LC-prosthesis is similar to the MYOBOCK system, which the test-user uses daily. This control method made him easy to control the LC-prosthesis. While the evaluation, he adjusted the direction and rotation of the LC-prosthesis with the adjustable wrist function, so he can reach the LC-prosthesis with the best orientation for the holding objects. Although the output power of the servo-motor losses through bending the silicon glove while closing the finger, the adaptive grip mechanism makes up for the weak grip force and could hold the objects.

We have evaluated the LC-prosthesis, which is made by digital fabrication technology. The adaptive grip function and the passive wrist function made the hand-forms of the LC-prosthesis more naturally, while holding objects. However the grip-force should be increased in order to use the LC-prosthesis in daily tasks. The servo-motor is easy to use as a tool of the early evaluation, but it consumes electric energy from the battery constantly. We will change the servomotor to another actuator in order to reduce energy consumption.

## REFERENCES

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# "HOT" – THE HEIDELBERG OBSTACLE TRAIL FOR ASSESSING MOBILITY IN PERSONS WITH LOWER LIMB AMPUTATION

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**BACKGROUND**

One of the foremost aims in the rehabilitation of people with a lower limb amputation (LLA) is to enable them to actively participate in daily live again. A prerequisite for that is to be able to move free within the community. This includes to overcome obstacle e.g. slopes and stairs. The commonly used K-Level scale, described e.g. by Gailey et al. [1], might give an insight if a person with LLA is e.g a limited community walker. However, a better differentiating method for functional classification is needed, to detect problems and individualize therapy. The Heidelberg Obstacle Trail (HOT) is an attempt to collect objective gait data, mainly temporal, spatial, parameters (TSP), in different gait conditions (level ground, stairs and slope), in a reasonable time following the example of Meier et al.[2].

**AIM**

The aim was the development of a tool for clinical use which delivers information of patients function in addition to questionnaires. The results will become a part of the hospital registry for persons with amputations.

**METHOD**

10 unimpaired reference subjects (73.8±16.7kg; 179.8±8.9cm; 27.5y±4.4y), 13 trans-femoral amputees (TFA / 71.6±21.6kg; 171.0±10.4cm; 48.1y±19.2y) and 14 trans-tibial amputees (TTA/ 91.7±16.2kg; 180.7±7.8cm; 49.1y±12.4y) were included in this study. The HOT protocol includes a 12m walkway, two slopes (5° and 10°) and a 5 step stair case (Figure 1). Markers were attached to the subject's feet, shanks; pelvis and trunk. A 12 camera system (Vicon) is used to track markers. Subjects walked with self-selected speed, starting with level walking, followed by walking up and down the ramps and ended with ascending and descending the stairs. TSP and kinematics (trunk tilt and obliquity range of motion) were calculated.

**RESULTS**

Results for the TSPs, gait speed, cadence and step width, as well as for kinematics, trunk range of motion in the coronal (tilt) and sagittal plane (obliquity) are displayed in Table 1. TFA walked the slowest, had the lowest cadence, had the widest step width and showed the largest trunk movements, in both the sagittal and coronal plane.

**Figure 1:** The extended lab setting for HOT

| | Speed [m/s] | Cadence [steps/min] | StepWidth [cm] | Trunk Obliquity Range in deg. 0-100%GC | Trunk Tilt Range in deg. 0-100%GC |
|---|---|---|---|---|---|
| **TFA** | **0.92** | **90.5** | **12.6** | **6.9** | **5.2** |
| **(N=13)** | *(0.36)* | *(21.7)* | *(5.6)* | *(3.3)* | *(1.8)* |
| **TTA** | **1.10** | **99.5** | **11.1** | **5.7** | **2.8** |
| **(N=14)** | *(0.21)* | *(9.7)* | *(2.9)* | *(2.4)* | *(0.6)* |
| **Ref.** | **1.54** | **113.8** | **10.4** | **2.6** | **2.2** |
| **(N=10)** | *(0.12)* | *(4.0)* | *(2.2)* | *(0.7)* | *(0.6)* |

**Table1:** Selected HOT results
(TFA = trans femoral amputees; TTA = trans tibial amputees; GC = gait cycle)

**DISCUSSION & CONCLUSION**

With the results shown here individual differences of functional levels could be differentiated and this more sensitive as by K-level classification alone. It is planned to associate results to an observational gait score, e.g. as proposed by Hillman et al. [3]. They critically remark that repeatability of this particular score was moderate, even when observers follow a structured approach. By combining HOT with a gait score, its sensitive could be increased and the results would be coherent for clinicians instead of reporting rather non-intuitive numbers.

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# WIRELESS INTRAMUSCULAR MYOELECTRIC SENSORS ALLOW HIGH FIDELITY SIGNAL TRANSMISSION AFTER COGNITIVE NERVE TRANSFERS FOR ADVANCED PROSTHETIC CONTROL: A PROSPECTIVE CASE SERIES

Stefan Salminger[1,2], Christian Hofer[3], Agnes Sturma[2,4,5], Melissa Evangelista[6], Mike Perrin[6], Konstantin D Bergmeister[2], Aidan D Roche[2,7], Hans Dietl3, Dario Farina[8], Timothy Hasenoehrl[5], Oskar C Aszmann[1,2]

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## BACKGROUND

Prosthetic control in above elbow amputees is challenging. Conventional 2-signal control limits speed and intuitivity of movements. Targeted muscle reinnervation (TMR) can expand the biotechnological interface, however due to limited space in the arm there is significant crosstalk with standard transcutaneous pick-up electrodes thus limiting applicability. Here we present for the first time transmission of signals after multiple cognitive nerve transfers via fully implanted myoelectrical sensors (IMES) with long term functional outcome measures.

## AIM

Evaluating the applicability and benefit on prosthetic outcome of implantable myoelectric sensors in transhumeral amputees.

## METHOD

In three transhumeral amputees multiple IMES were implanted while undergoing routine TMR surgery to demonstrate feasibility and functional benefits of intramuscular recorded EMGsignals in prosthetic control. Global prosthetic function was evaluated using the Southampton Hand Assessment Procedure (SHAP), the Clothespin-Relocation Test (CPRT) and the Box and Blocks Test (BBT) which monitor hand and extremity function closely related to activities of daily living both pre- and postoperatively.

## RESULTS

In all three patients precise placement of sensors could be performed at the time of nerve transfer surgery. Depending on the number of available target muscles 5-6 sensors were implanted. Signal transmission was monitored very closely and revealed excellent prosthetic function as early as 4 months postoperatively. Follow-up of 1.72 ± 0.25 years is available. The patients showed a mean improvement in SHAP from 33 ± 7.94 to 39.67 ± 3.21, in CPRT from 84.45 ± 33.88 to 37.03 ± 17.74 seconds and in BBT from 7.67 ± 5.13 to 12.22 ± 2.34.

## DISCUSSION & CONCLUSION

Targeted muscle reinnervation can extract neural information useful for prosthetic control after limb loss. Standard transcutaneous pick-up electrodes, however are unable to decipher high-fidelity signals in transhumeral amputees thus limiting translation into reliable prosthetic control. Here we present that a fully implantable system is able to reliably pick-up and transmit myosignals after cognitive nerve transfers and thus improve prosthetic control.

# SOUND SIDE SAGITTAL KNEE MOMENTS DURING STAIR CLIMBING WITH THE SKIPPING STRATEGY IN A PERSON WITH A TRANS-FEMORAL AMPUTATION

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## BACKGROUND

The common gait pattern to climb stairs is the step over step strategy (SoS) [1], in which both limbs equally and alternating lift the whole body center of mass (CoM). It typically cannot be facilitated by people with a unilateral trans-femoral amputation (TFA). This is, due to the fact that almost all prosthetic knee joints do not provide a concentric knee moment or the user is unable to generate a sufficient hip extending moment. Therefore TFA use the step by step strategy (SbS, Figure 1a) where they roughly climb half as many steps in comparison to SoS. Therefore persons with TFA often use the skipping strategy (SKIP; Figure 1a). It is almost similar to the SbS, except one skips a stair step. In this study, kinematics and kinetics during SbS and SKIP of a person with TFA are compared to unimpaired individuals using the same strategies to climb stairs.

## AIM

The aim was to get an insight if there are increased sagittal plane knee moments of the sound side in TFA when utilizing the SKIP strategy.

## METHOD

15 unimpaired reference subjects (REF / 74.4±13.1kg; 175.9±8.7cm; 26.8y±4.5y) and one male subject with a trans-femoral amputation (TFA / 67kg; 186cm; 32y) were included in this study. Subjects were equipped with skin mounted markers according to Plugin Gait (Vicon, Oxford, UK). A 12 camera system (Vicon) is used to track markers. Subjects walked up an instrumented staircase of 5 steps (width 100cm, 16cm step rise and 27cm step run). The staircase was equipped with two force platforms (Type: BP400600-2K-Q2412, AMTI, Watertown, USA). All Subjects climbed the staircase with both the SbS and SKIP strategy, with self-selected walking speed. At least five repetitions for each participant were captured, averaged and normalized to the Stair climbing cycle [2].

## RESULTS

TFA showed a peak knee moment of the sound, leading side at opposite foot off, of 1.4 Nm/kg in SBS and 1.6 Nm/kg in SKIP and REF of 0.9 Nm/kg in SbS and 1.0 Nm/kg in SKIP. REF showed a vast increase in peak ankle power of the trailing limb 6.7 W/kg at the end of stance during SKIP in comparison to 2.3 W/kg in SbS.

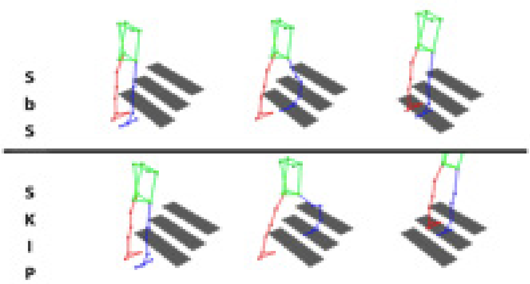


**Figure 1a:** Graphics of SbS and SKIP strategy

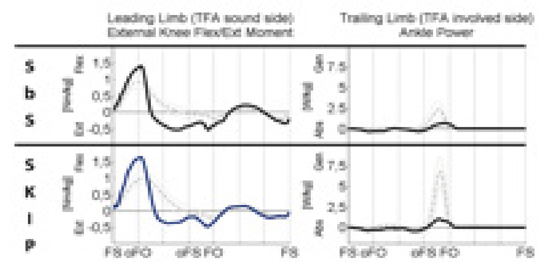


**Figure 1b:** Knee moments of the leading limb and ankle powers of the trailing limb, in SbS and SKIP Strategy
*(solid black line = TFA, dashed grey line = REF±SD; values are normalized to body weight; SbS = step by step strategy; SKIP = skipping strategy; FS= foot strike; oFO = opposite foot off; oFS= opposite foot strike; FO = foot off)*

## DISCUSSION & CONCLUSION

The results showed that the TFA showed higher peak external knee flexion moments of the sound, leading limb in comparison to REF. This could be led back to the missing ankle power burst of the trailing limb in TFA, which is present in REF. This burst in REF possibly helps to move their CoM to the aimed stair step and reduce external knee flexion moments of the leading limb. This Hypothesis is underpinned by the fact, that for both SbS and SKIP almost similar peak knee moments for the leading limb were detected in REF. The ankle power burst of the trailing limb in the TFA is of course absent, because the prosthesis cannot provide an active push off. A prosthesis which facilitates an physiologic SoS pattern could help to reduce knee loads in persons with a trans-femoral amputation. Further work has to confirm the results of this case and prove if there is a reduction of sound side knee loads in TFA when using SoS pattern by means of a specialized prostheses, e.g. as introduced by Bellmann et al.[3].

## REFERENCES

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# WHEELCHAIR SERVICE PROVISION EDUCATION FOR REHABILITATION PROFESSIONALS: CURRENT SITUATION, FACILITATORS AND BARRIERS & FUTURE DIRECTIONS

Nicky Seymour, Paula Rushton, Jon Pearlman

Motivation Charitable Trust[1], University of Montreal[2], International society of wheelchair professionals[1,2,3]

## BACKGROUND

Poorly fitting or inappropriate wheelchairs place a high risk for secondary injuries and participatory restrictions for the estimated 70 million people who need them. Wheelchair service provision from trained rehabilitation professionals can help to alleviate those risks. The World Health Organization (WHO) has proposed an 8-step wheelchair service provision approach.1 Regrettably, current practice is not consistently aligned with these 8 steps, partly because not all rehabilitation professionals receive adequate education.

## AIM

Aims of this research are to: (1) describe the global situation of wheelchair service provision education; (2) explore facilitators and barriers and; (3) develop partnerships with key rehabilitation professional organizations.

## METHOD

The International Society of Wheelchair Professionals (ISWP) recruited a convenience sample of university rehabilitation program representatives via a listserv and snowball sampling to complete a cross-sectional online survey. The survey questions gathered information regarding the current global situation of wheelchair service education. To obtain an in-depth understanding of barriers and facilitators to providing wheelchair service education semi-structured interviews were conducted with 10 targeted university representatives. As a follow-up, WHO hosted a meeting in February 2017 led by ISWP and including representatives of rehabilitation professional organizations i.e. ISPO, WCPT, WFOT and ISPRM to share results and ways to move forward with the initiative.

## RESULTS

A sample of 72 representatives from educational institutions in 21 countries completed the survey. Of these institutions, ~79% taught wheelchair-related content. However, there was great variability in the content itself, content sources, methods of teaching and evaluation. Time spent also varied greatly with the vast majority doing less than 50% of the WHO recommended standard. Findings from the semi-structured interviews emphasized barriers to integration of wheelchair-related content, such as lack of awareness of existing resources, lack of time, lack of 'in-house' expertise and lack of equipment. Outcomes of the meeting with rehabilitation professional organizations included commitment to support ISWP in their endeavour to enhance the integration of wheelchair content in rehabilitation professional programs world wide. A variety of strategies were identified, such as the development of a joint position paper and endorsing the WHO wheelchair training packages.

## DISCUSSION & CONCLUSION

The survey, interview and meeting findings have provided a more comprehensive understanding of the current situation regarding wheelchair service education in academic programs worldwide, facilitators and barriers to the provision of this education, as well as the relevance and commitment by key stakeholders. This research will inform the development of tools and strategies to guide educational curricula with the ultimate goal of improving the quality of wheelchair service provision worldwide.

## REFERENCES

This is optional, but necessary if you build on previous work. Very short style is common in abstracts, meaning:

# UNDERSTANDING THE POTENTIAL OF A VIDEO-BASED METHOD FOR IMPROVING STUDENTS' SELF-ASSESSMENT SKILLS

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[1]Mahidol University, [2]University of Glasgow

## BACKGROUND

Learning is a lifelong and iterative process that requires a teacher to identify suitable methods to best facilitate development of a students' learning skills. To be an effective lifelong learner, students must possess self-assessment skills that will prepare them for the constructive assessment of their tasks they will confront over their lifetime (1). The value of self-assessment skills has been well supported in the literature. Amongst several techniques for teaching self-assessment is a video-based method, which has shown significant advantages for enhancing students' self-assessment skills (2). However, the mechanisms that determine the outcomes of this method are still unclear.

## AIM

The aim of this research was to evaluate the potential of a video-based method for improving self-assessment skills in prosthetic and orthotic (P&O) undergraduate students. Specifically, the aim was to undertake a realist evaluation (3), in which the focus was on the factors that might have influenced whether, and why, the video-based model was or was not effective in the P&O context.

## METHOD

Participants & Design A realist evaluation was used, because the aim was to explore the factors (mechanisms) affecting the outcome (self-assessment ability) in the particular context of P&O education. Ethical approval was obtained from the College of Medical, Veterinary & Life Sciences Ethics Committee, the University of Glasgow; and the Siriraj Institutional Review Board. All Year 3 students (n=15) and their teachers (n=5) in the academic year 2015-2016 were invited to participate. The ability of students' to self-assess was measured by calculating the congruence between scores given by students themselves and those given by teachers, after each successive round of the intervention (below).
The views of teachers and students toward the application of video-based self-assessment for teaching this skill were explored by semi-structured interviews. Intervention
Video-based self-assessment was facilitated by teaching staff without interference by the researcher. Steps included: i) video recording the students while they practiced performing measurement and casting; ii) the students were then asked to review the video of their performance at a later time, and; iii) during the students video review step, the students performed self-assessment by completing a self-assessment form. The intervention was not specific to the research, but a standard aspect of clinical skills teaching.

## RESULTS

This research does not focus on the outcome of implementing the video method per se; rather it aims to determine the nature of factors that may help or hinder students to develop self-assessment skills using the video-based self-assessment method, particularly in a context of P&O education. The analysis of the interview data is ongoing. In general, all participants expressed satisfaction with video-based self-assessment. However, comparison of student-teacher ratings showed that there was no significant correlation between students' and teachers' assessments. However, it is difficult to conclude that the students lack the ability to self-assess, as the number of participants is small, and there were few opportunities for student-teacher comparisons. Exploring perspectives on self-assessment, and the video-based method in particular, may suggest reasons (mechanisms) to explain the actual outcome (lack of self-assessment ability) in the specific context. Preliminary analysis shows that P&O teachers and students understand the concept of self-assessment; however, its importance in routine practice is not well appreciated. Possible mechanisms to explain the outcome include an inadequate orientation to the activity; students viewing self-assessment as an option; students having difficulty seeing themselves from an external perspective; and students possibly benefiting from external feedback on their performance.

## DISCUSSION & CONCLUSION

The video-based self-assessment method has been successfully implemented in other educational programmes (2), and it seems to be a good teaching method to be applied in P&O education, particularly in clinical skills teaching. The self-assessment skill is widely accepted as a key requisite for lifelong learning. However, in P&O education, the practice of self-assessment in teaching programmes is not made explicit. From this preliminary analysis, it seems that students need to be offered guidance and opportunities to practice assessing themselves. Although this research is not generalisable, given the limited number of participants and the focus on a specific professional context, it suggests a means of improving the development of students' self-assessment skills in the local context, and potential issues that should be considered before a video-based method is implemented in a P&O curriculum.

## REFERENCES

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# WORLD'S 1ST P6-ISO-TESTED 3D-PRINTED PROSTHETIC FOOT

Manuel Opitz

## BACKGROUND

Digital prosthetics design offers the advantages to 3D-print patient specific feet even for special patients (e.g. pediatrics) and thanks to digital simulation with predictable durability. In 2015, the first 3D-printed prosthetic foot passed ISO 10328:2006 level P4/80kg [1].

However, industrial 3D-printing methods like selective laser sintering (SLS) are still mistrusted in prosthetics regarding their mechanical durability, despite being widely used in critical applications in aerospace (turbines, interior frames) and medical (joint replacements, dental implants).

## AIM

This study aims at proving the mechanical durability of a 3D-printed prosthetic foot according to ISO 10328:2016 level P6/125kg. In parallel, an FEA is used to predict potential material failure or design weaknesses.

## METHOD

Physical testing: DIN EN ISO 10328:2016 at load level P6, dynamic load 1.580N over 2 Mio cycles at 1.1 Hz, heel + toe load 4.880N (P6 Upper Level), 2 prosthesis samples with max length (300mm) + min width (97mm, 1:3)Simulation of ISO 10328: Finite Element Analysis (FEA) using ANSYS, high density mesh, simplified material behavior Patient evaluation: 2 males/ 2 females, age 3-62 years, 2 amputated since birth (pediatrics)/ 2 amputated when grown-ups (15-20 years ago), high mobility levels (K3/ K4), attended by 4 different CPOs across Germany, weight 10-90kg Prosthetic foot design: Laser sintered body made from PA12 ("Nylon", EOS PA2200), glass fiber element for higher energy return (heel 88.0%/ toe 84.8%), SACH adaptor, 2 damper elements

## RESULTS

Physical testing: In a pre-test, forefoot was tested up to Fmax at 6.000N (P8) with no visible or internal signs of material failure. In main test, 2 prosthesis samples showed no visible sign of damage after dynamic testing. Both samples were then tested up to P6 Upper Level, still no material failure visible. Simulation: Temporary deformations of the heel and forefoot were simulated correctly (cf. Figure 1). However, FEA predicted a material failure before reaching P8 (pre-test), but samples was more durable than simulated. Patient evaluation: Supervised by 4 independent CPOs, 4 patients evaluated the foot. No visible material failure. Field testing still continues with longest duration of use currently standing at >6months.

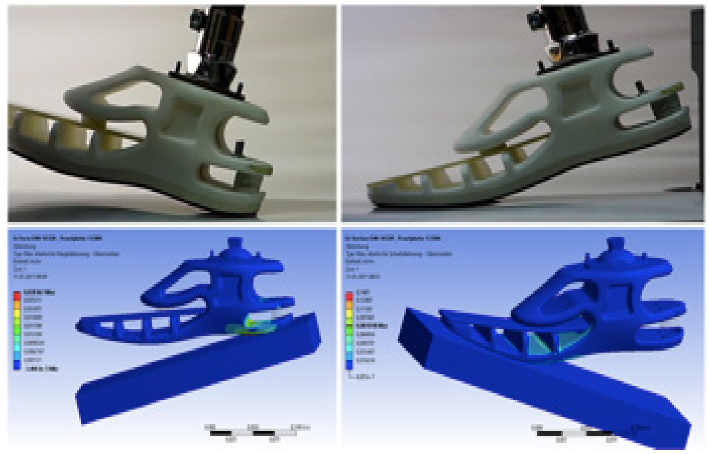

Figure 1. Physical Testing (top) vs. FEA (bottom), Heel (left) vs. Toe (right)

## DISCUSSION & CONCLUSION

In conclusion, the study confirms and adds to Fraunhofer's results from 2015 and proofs that laser sintered prosthetic feet fulfil the requirements of ISO 10328 level P6. Temporary deformations can be predicted using FEA, however exact critical failure not yet.

In outlook, these results need further investigation like:

- Test up to P8 (static and dynamic) or ISO 22675
- Validate simulation to predict material failure
- Long-term patient evaluation (>1year)
- Maximum prosthetic foot size (norm: 320mm)

## REFERENCES

1.Fraunhofer Institute for Manufacturing Engineering and Automation IPA, Stuttgart

# KINEMATIC EVALUATION OF DIFFERENT TYPES OF HAND PROSTHESES IN COMPARISON TO ABLE-BODIED PARTICIPANTS

Barbara Pobatschnig

## BACKGROUND

Assessment tests are the gold standard to measure the functionality of hand prostheses, but they evaluate how fast a patient is able to perform a specific task and do not assess quality of movement. The wide range of UL movements leads to a big challenge to assess and interpret data. Therefore, UL 3D motion analysis is a difficult task in clinical practice, thus there is still a major lack of published data. Hence, further research is needed to understand the effectiveness of medical treatments.

## AIM

The aim of the study is to highlight compensatory movements of trans-radial amputees using different hand prostheses in comparison to normative subjects.

## METHOD

Kinematic, electromyographic (EMG) data and arm profile scores (APS) are compared to able-bodied participants (N= 20, 26.3 years ±2.17, BMI: 23±1.44 kg/m2) during eight daily tasks. The electrodes are placed on the dominant hand of the normative subjects and the affected side of the prosthesis users, as well as on both sides of the back. Five valid trials are measured and they are normalized into sub phases. The EMG signals are bandpass-filtered (4th order butterworth, 30–500 Hz). The use of 30Hz eliminates ECG contamination [1] and the root mean square(80ms) is estimated for linear enveloping.

## RESULTS

Figure 1 exemplifies the movement pattern of a prosthesis user compared to a normative group for the clavicle elevation and the elbow joint in transversal plane. Corresponding, electromyographic data of the trapezius (pars descendens) and major pectoralis muscles are shown in Figure 2. The three lines (prosthesis 1: green line, prosthesis 2: blue line: prosthesis 3: red, grey band: norm) represent different types of hand prostheses and the vertical dashed lines define sub phases for the normalization process of the curves. The blue line shows increased clavicle elevation in the second and third phase and increased supination during the whole movement. The EMG signal (blue line) presents higher activation of the trapezius muscle and reduced activation of the major pectoralis muscle in the second and third phase. Prosthesis 2 (blue) shows an APS of 27.2°, prosthesis 1 11.0° and prosthesis 3 15.3° (norm group: 4.4°).

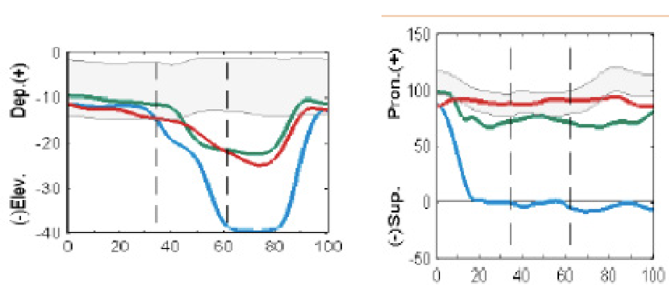


**Figure 1**. Kinematic data (mean of five trials) of a user with 3 prosthetic devices and a normative group (grey band): left: clavicle elevation / depression, right: elbow pronation / supination

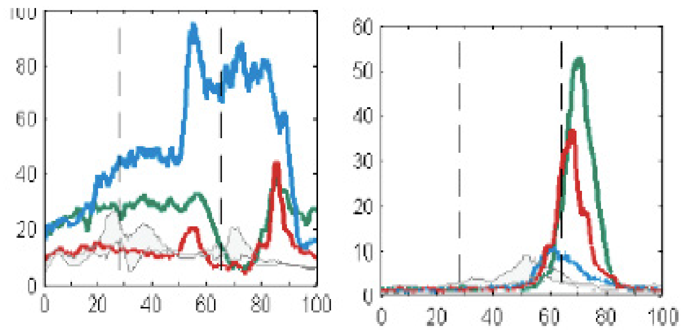


**Figure 2**. EMG data (mean of five trials) of a user with 3 prosthetic devices: left: trapezius pars descendens, right: pectoralis major

## DISCUSSION & CONCLUSION

The kinematic example data in combination with electromyography highlights the different amount of compensatory movements between the three devices, and the differences to the normative group. Prosthesis 2 shows increased elbow supination, clavicle elevation and higher APS compared to the others.
This is also clearly visible in the ectromyographic data, which show an increased activity of the trapezius muscle and a reduction in the major pectoralis muscle. Hence, the presented example elucidates the potential to kinematic and electromyographic data in clinical application for prosthesis users.

## REFERENCES

1. Willigenburg, 2012, J Electromyog Kines: 22:485-493.

# POLICY, REALITY, AND EXPECTATIONS; THE DELICATE BALANCE BETWEEN GOVERNMENT, ORGANIZATIONS, AND PROFESSIONALS IN THE QUEST TO DELIVER QUALITY O&P PATIENT CARE IN THE U.S.

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[1] NCOPE Chairman, [2] AAOP President, [3] NCOPE Executive Director, [4] AOPA Board

## BACKGROUND

The orthotic and prosthetic (O&P) education, credentialing, and research organizations in the United States include the American Academy of Orthotists and Prosthetists (AAOP), The American Board for Certification in Orthotics, Prosthetics and Pedorthics, Inc. (ABC), the American Orthotic and Prosthetic Association (AOPA), and the National Commission on Orthotic and Prosthetic Education (NCOPE).

These organizations are dedicated to providing educational pathways, from instruction in entry-level basics and continuing education, to funding and disseminating advanced cutting edge research that pushes the boundaries of our imagination. Specifically, the credentialing organizations have the responsibility of evaluating and monitoring O&P compliance of educational and professional standards with government policy guidelines, which helps keep the delicate balance between the U.S. government and the O&P professionals and organizations in our country.

Although these organizations serve differing roles in the grand scheme of health care, they agree that the issues of care versus coverage and quality versus quantity are best discussed from a “patient-centric viewpoint.” Dr. William J. Mayo (1861-1939), a co-founder of Mayo Clinic, Rochester, Minnesota, U.S.A., described a patient-centric paradigm when he said, “The best interest of the patient is the only interest to be considered.” Private insurers combine with state and federal governments to provide the majority of coverage for healthcare costs, with regulatory strings attached. These regulations may include state licensure, federal coverage restrictions, and qualification standards that are currently in a state of flux. It can seem to be an old-fashioned notion and quite altruistic an endeavor to put aside the impositions of government policy and financial realities to only focus on the patient. If only it were that simple.

One can, however, keep the patient’s best interest as an overarching objective, with the expectation of a positive patient outcome in spite of bureaucratic control.

## AIM

Our goal is to examine and share the external forces influencing U.S. O&P patient care from various viewpoints of individuals involved in differing leadership roles in the industry. It includes: a review of public policy administered, and/or research influenced by federal and state government agencies including the Veterans Administration (VA), the Department of Defense (DoD), the Centers for Medicaid and Medicare Services (CMS), the National Institutes of Health (NIH), and state licensure boards; a description of education and credentialing standards organizations including ABC and NCOPE; a view from a practitioner-member organization such as AAOP; and a view from the business/manufacturing-member organization such as AOPA.

## METHOD

The distinct viewpoints are represented by the four authors, and will highlight the difficulties and hurdles encountered in the U.S. when trying to provide quality patient care. It includes the transition and tumult caused by repeal/replace Affordable Care Act and discusses the importance of “Essential Health Benefits” to O&P coverage. The authors are leaders in the O&P industry and have wide ranging experience and immersion in several aspects of accreditation of facilities, establishment of O&P educational pathways and lobbying for patient care concerns at the state and federal levels. Their collective experience includes two career O&P practitioners, two O&P business owners, two national organization sitting Presidents, one national organization Executive Director, one attorney and one ABC facility accreditation surveyor. Together they present expert observation and opinion of a wide variety of forces influencing the delivery of O&P care in the U.S.

## RESULTS

As the authors maintain various roles in the profession, and represent a diversity of O&P organizational leadership, some conclusions are easily drawn, while others remain obscure and can be left to the attendee’s interpretation. A panel discussion period could prove to be stimulating and lively. There may be some questions that we leave unaddressed and suggest questions that help prompt a relevant answer.

## DISCUSSION & CONCLUSION

O&P facilities in the U.S. have become increasingly aware of the need for proactive patient management and positive patient outcomes. With increased insurance and governmental oversight and reimbursement restrictions, the successful clinical practitioner has developed unique ways to provide effective patient care while maintaining costs. This paradigm shift has been possible through the collaborative efforts of O&P professional organizations and through open lines of communication in the extended U.S. health care industry. Working together to educate those in our government has been paramount to any and all progress made. Continuing to foster this dialogue and maintaining an understanding of how this delicate balance works, has resulted in improved care to the O&P patients we continue to have the pleasure to serve.

# EFFECT OF PASSIVE DYNAMIC PROSTHETIC FEET ON THE IMPROVEMENT OF GAIT IN ADULT UNILATERAL TRANSTIBIAL AMPUTEES AS COMPARED TO SACH FEET:

# A SYSTEMATIC REVIEW

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[2] Human Mobility Research Centre, Queen's University and Kingston General Hospital, Kingston, Canada

## BACKGROUND

While multiple passive prosthetic foot options are available for patients with transtibial amputation, few reports in the literature provide scientifically based clinical guidelines to aid in prosthetic foot selection [1], [2]. Although numerous studies have evaluated prosthetic componentry using gait analysis, the literature is unclear as to whether the data consistently shows increased biomechanical function of dynamic feet compared to conventional options. [3], [4].

## AIM

A systematic review was completed to determine if passive dynamic prosthetic feet, defined using the AOPA guidelines, improve the biomechanics of gait in adult unilateral transtibial amputees as compared to SACH feet.

| Biomechanical Gait Parameters | Outcome Measures | | |
|---|---|---|---|
| Stride Characteristics | *Velocity* | *Cadence* | *Stride Length* | *Step Length* |
| | NC | NS | NC | NC |
| Temporal Characteristics | *Percent Gait Cycle* | | | |
| | NC | | | |
| Kinematics | *Ankle Range of Motion* | *Knee Range of Motion* | *Hip Range of Motion* | |
| | ↑ | NS | NS | |
| Kinetics | *Vertical Ground Reaction Forces* | *External Ankle Moment* | *External Knee Moment* | *External Hip Moment* |
| | SL ↓ | PL DF ↑ | NC | NS |
| Muscle Activity | *EMG Output* | | | |
| | NS | | | |
| Energy Expenditure | *Energy Cost/unit Distance (mLO2/kgm)* | *Energy Cost/unit Time (mLO2/kgs)* | *%APMHR* | |
| | NC | NC | NC | |

Table 1. Summary of overall conclusions based on pooled significant data, with all results reported as difference in dynamic feet compared to SACH feet (NC = non-conclusive based on contradicting results, NS = non-significant, ↑ = significant increase, ↓ = significant decrease, SL = sound limb, PL = prosthetic limb, DF = dorsiflexion)

## METHOD

A literature search using keywords identified in the aim was performed using ten databases. Two reviewers independently assessed all identified study abstracts for inclusion. Publications that met the following criteria were included. The article was available in English from a peer reviewed journal. Study participants were adults (17-72yrs) with unilateral transtibial amputation caused by traumatic, oncologic, or congenital etiologies. The intervention compared a conventional SACH foot (L5971) and a passive dynamic prosthetic foot (L5980, L5981, or L5987), defined based on AOPA guidelines [5]. Outcome measures assessed biomechanical gait parameters including: stride and temporal characteristics, kinematics, kinetics, muscle activity, and energy expenditure.

## RESULTS

The initial keyword search produced 387 articles of which 15 qualified for final inclusion. Outcome measures data were extracted and pooled for comparison, with overall conclusions presented in Table 1. The dynamic feet showed an increased ankle range of motion (ROM) during late stance dorsiflexion of 52-94% as well as a 54% increase in external ankle joint moment as compared to SACH feet. Although results for self-selected walking velocity (SSWV) were inconsistent, the increased ankle ROM and moments correlate with improved forward progression.

Results also indicated that dynamic feet decreased vertical ground reaction forces of the sound limb by 19%, indicating increased use of the prosthetic limb. This was further supported by the increased prosthetic limb mid-stance duration reported for dynamic feet by two studies.

## DISCUSSION & CONCLUSION

Statistically significant improved gait outcomes that contribute to forward progression and reduced vertical ground reaction forces resulted when using dynamic feet. Dynamic feet with L-code 5980 displayed the most improvement in gait, however not all designs within this classification were studied. It remains to be determined whether biomechanical differences between these dynamic feet and SACH feet are clinically significant.

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# THE ROLE OF UNIVERSITIES IMPLEMENTING THE GATE INITIATIVE IN LATIN AMERICA

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## BACKGROUND

According to the Pan American Health Organization there are 85 million people with disabilities in Latin America [1]. Only 5 – 15% has access to assistive technology (AT) [2]. WHO Global Disability Action Plan 2014 – 2017 [3] identifies improving access to AT as one of its fundamental components. Access to AT is a complex problem requiring funding, product design, pricing, distribution, service delivery models and paradigm changes in health systems as well as professional training and empowerment of persons with disabilities and their organizations. As a first stage implementing a global commitment to improving access to AT, the GATE initiative has launched the Priority Assistive Product Lists. What role can Latin American universities play in improving access to AT?

## AIM

The aim of this project is to implement a network of AT centers where AT will be available for demonstration, AT courses will be taught to a variety of audiences and new and appropriate AT devices would be designed, fabricated and delivered to individuals with disabilities. Achieving these activities will align the centers with the GATE initiative

## METHOD

The Rehabilitation Engineering and Technology Center (CITeR in Spanish) was established at a major university in Mexico City. Presently CITeR has affiliated programs in Colombia, Ecuador and Peru. All the centers are located at universities and require formal relationships with clinical facilities. Since its beginning CITeR has designed AT appropriate to the needs and conditions of Latin America and has developed novel service delivery models for the region. Presently, we are initiating formal training in AT recommendation for a variety of audiences including teachers and therapists. CITeR has acquired the full collection of devices included in the Priority Assistive Products List (APL) and it is presently developing online training materials for these devices. Through the CITeR Network, AT development, demonstration and service delivery will support the GATE initiative of training the local health workforce.

## RESULTS

Multiple AT devices have been designed, fabricated and delivered to children and adults with disabilities. Devices include contoured seating systems, customized wheelchairs, augmentative and alternative communication software, wheelchair recommendation software, as well as special formulation foam to reduce the probability of acquiring pressure ulcers. Most of these technologies have been transferred between affiliated centers. Technology exchanges are made at no cost to the participating members. All affiliated centers are located at universities and all have close working relationships with clinical facilities. Cross training between the centers has been successful.

## DISCUSSION & CONCLUSION

New and innovative forms of providing AT are needed in order to supply AT to adults and children with disabilities in Latin America. CITeR and its affiliated network have provided, in concert with clinical personnel, AT incorporated on the APL of the GATE initiative.

Including how to recommend all the devices listed on the APL as part of a national AT certification process, will add value to the GATE initiative.
Increasing the number of affiliated centers throughout Latin America could facilitate the successful implementation of the GATE initiative in the region.

Universities throughout Latin America could play a major role implementing the GATE initiative while promoting empowerment of people with disabilities Duplicating or adapting the CITeR-Network in universities of low resource countries could also facilitate implementing the GATE initiative AT will be in greater demand as the population grows and ages. Public health care systems that are presently struggling to provide quality health care will have a difficult time including AT as part of their benefits. Universities have the opportunity to play an important role in developing AT and adapting new forms of service delivery that empowers people with disabilities.

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# INVESTIGATING A METHOD OF SUSTAINABLE FABRICATION OF ORTHOTIC JOINTS

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[1]University of Pittsburgh

## BACKGROUND

The orthotics and prosthetics (O&P) industry has one of the largest carbon footprints of any medical professions. Contributing to this is the comparably large percentage of material waste that is associated with the manual fabrication methods of customized devices [1], as well as the energy intensive transport and shipping requirements of an industry that is signified by widely dispersed businesses of comparable small size. Those factors are especially burdensome in lower income regions of the world, where access to health care is limited [2, 3] and where manufacturers of O&P devices often rely on foreign imports for needed componentry. As the need for O&P care is rising due to aging populations, war, and lack of resources, it becomes ever more important to explore sustainable solutions in this field.

## AIM

This research had the aim to develop and test a method of producing a versatile orthotic joint using materials and fabrication methods that are universally available anywhere orthoses can be made.

## METHOD

In addressing the research aims, a method was developed to fabricate orthotic joints from scrap plastic as it accrues in O&P workshops in substantial quantities. The basic design of the joints was adopted from the long established “Oklahoma” style joints, and respective 2-part molds were produced. In order to produce a joint, scrap plastic – preferably copolymer – is cut to size and heated. It is then transferred to the mold. The mold is closed and the plastic is allowed to cool under vacuum. After the plastic cools the joints (Figure 1) can be cut out, smoothed and installed in articulated orthoses. Fabrication protocol and step by step instructions on the use of the device are intended to be translated in different languages in order to facilitate effective and widespread use of this technique.

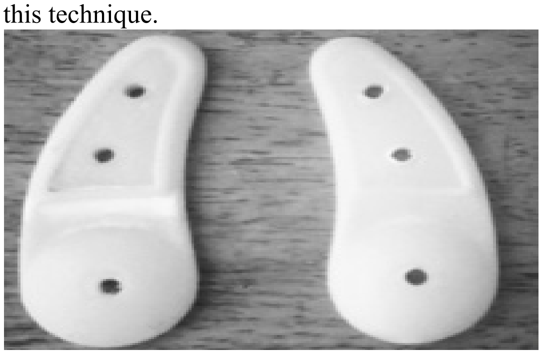

**Figure 1**: Sample Oklahoma style joints produced with the described method

## RESULTS

Initial results demonstrate the feasibility of the developed fabrication method. Using a standard O&P shop grade oven, vacuum system and router, a pair of joints could be produced in about 20 minutes’ time. Preliminary strength testing suggests sufficient durability. Each joint was subjected to a force pushing each beyond its functional limit (Figure 2).

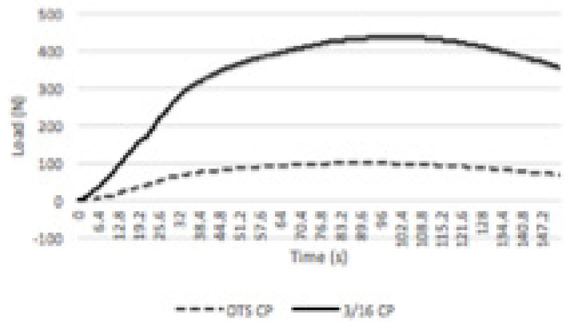


Figure 2: Comparison of mechanical properties between conventional and self-fabricated Oklahoma style joints

## DISCUSSION & CONCLUSION

While initial assessment of the sustainably produced orthosis joints is promising, additional standardized stress and fatigue testing is needed to determine if the locally fabricated orthotic joints are an effective alternative to the off-the-shelf Oklahoma joints. This will generate evidence to inform whether the fabricated joints are safe and effective alternatives to the off-the-shelf version.

The here described method, pending the results of standardized testing, provides an inexpensive alternative to industrially fabricated orthotic joints for people in low income or remote areas. The mold can be fabricated entirely onsite. It allows for onsite recycling reducing both environmental and financial costs. The device has the potential to be accessible at minimal cost all over the world, while lowering the environmental impact of the orthotic industry.

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# EVALUATING THE BENEFITS OF STUDY EXCURSIONS ABROAD FOR PROSTHETICS & ORTHOTICS MASTER STUDENTS

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## BACKGROUND

It is conventional knowledge that travel is educational and that a study stay in a foreign country contributes to a student's personality formation and well-roundedness. The benefit of such experiences on attitudes that shape professional aptitude and career success may, however, be debated. It could be argued that exposure to experiences that are irrelevant to a student's chosen profession may have no sizeable impact – thus not justifying the invested time and money – or, in an extreme case, may even be detrimental to career success if the wrong conclusions are drawn. Examples for such occurrences may include the adoption of inappropriate belief systems, educational priorities, or work habits.

## AIM

In this study, it was investigated how a short term study stay abroad was reflected in the self-efficacy [1] of students and graduates of a professional Master of Science program, hypothesizing that such a study excursion would increase the professional confidence in the short and long term.

## METHOD

A cohort of students of Prosthetics and Orthotics at an U.S. American University who had participated in non-compulsory study excursions to Germany and a comparable cohort of their peers who had not participated in such trips were asked, by way of a 10-question survey, to state their confidence in mastering specific hypothetical situations of daily work life. About half of the subjects of each group had already graduated and were in residence at the time of the survey, whereas the remaining half was still in their first year of the study program. Answers were statistically compared using a two- way analysis of variance to investigate main and interaction effects of professional experience and short term stay abroad.

## RESULTS

Nineteen of targeted 32 students responded to the survey for an average response rate of 59%. Significant differences between travel group and non-travel group were found for some, but not all of the questions. All of the differences were in favor of the travel group (Fig. 1). Averaged across all questions there was a trend to higher confidence in the travel group, but no significant effect ($p = 0.128$).

Qualitative analysis of provided responses showed generally positive assessments of the travel experience by travelers. None of them drew a negative or even neutral conclusion. A representative sample response by one student was "This experience helped broaden my knowledge of the P&O field both technically and theoretically. … I gained a more encompassing understanding of the P&O field and feel prepared to work with international companies/clients."

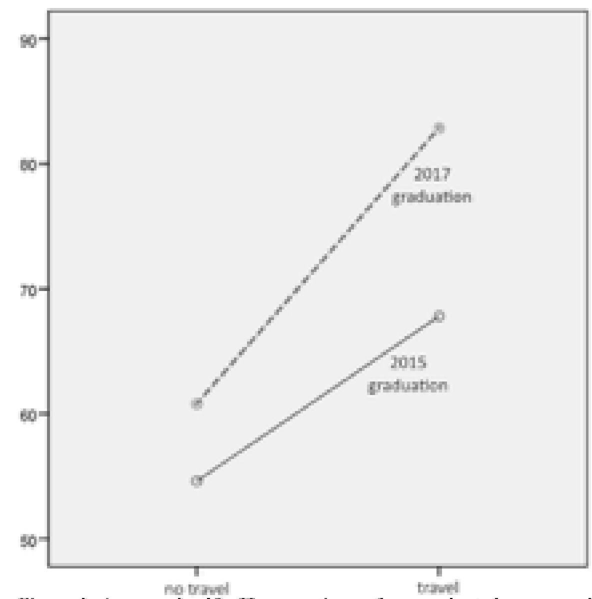


**Figure 1.** Averaged self-efficacy ratings of respondents by year and group allocation

## DISCUSSION & CONCLUSION

Quantifying the effects of study abroad programs can help justify the allocation of appropriate private and institutional resources to respective course offerings. Our results seem to indicate a tendency that the experience was beneficial, thus agreeing with previously published work involving different populations [2, 3]. Limitations of our study include the small sample size, although it may be argued that in the context of the very small total target population (an estimated 350 students per year enroll in US based programs), the response rate is acceptable. It should also be noted that the used modified self-efficacy scale was not formally validated, which may limit comparability of findings across comparable studies.

In conclusion, our investigation yielded no indication of negative effects of the study abroad experience. This, and the beneficial effects that were noted by the participants, makes it recommendable to offer international experiences within the curriculum of P&O masters education.

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# EFFECT OF COSMETIC COVERS ON DEFORMATION VELOCITY COMPONENTS OF PROSTHETIC FOOT SYSTEMS

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## BACKGROUND

The prosthetic foot system is comprised of a keel, and removable cosmetic cover. Previous work has shown the effects of covers on stiffness of the system under loading conditions representative of gait [1]. However, the influence of kinetic and kinematic properties on these effects is unclear. Stiffness is an amputee independent property used to describe prosthetic foot system mechanical characteristics [2], and can be represented by the predicted rate at which the system deforms during stance. This deformation velocity can be described in terms of force and angle components, which can be used to isolate the effects of structural stiffness and kinematic effects due to component shape and orientation.

## AIM

The objective is to determine the effects of three cosmetic covers on prosthetic foot system performance based on isolated force and angle deformation velocity characteristics.

## METHOD

Mechanical testing was performed on an unmodified Niagara Foot™ [3] and three Axtion™ keels with a SACH Foot for reference. The Niagara Foot and Axtion samples were tested bare and with three different commercially available cosmetic covers. The testing protocol is based on a previously reported method [4], and produces force-deflection curves taken at specific shank angles from the ISO22675 waveform.

Total deformation velocity was defined as the sum of deformation rate due to loading and shank angle (Equation 1).

$$\text{1)}\quad \underset{\text{Velocity}}{\overset{\text{Total}}{\text{Deformation}}} = \underset{\text{due to Force}}{\overset{\text{Deformation}}{\text{Velocity}}} + \underset{\text{due to Angle}}{\overset{\text{Deformation}}{\text{Velocity}}}$$

$$\frac{dz}{dt} = \frac{\partial z}{\partial F}\frac{\partial F}{\partial t} + \frac{\partial z}{\partial \theta}\frac{\partial \theta}{\partial t}$$

The deformation velocity components were calculated using ISO force and angle time derivatives, and change in displacement data measured across angle and force values from mechanical tests. The process is shown in **Figure 1**.

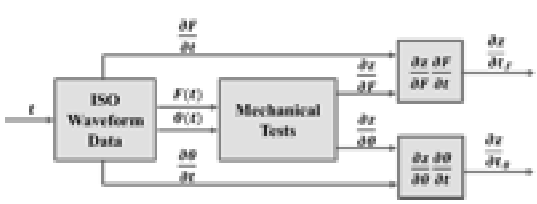


**Figure 1.** Deformation velocity component flow chart

Niagara Foot deformation velocity under bare and covered conditions are plotted against percent stance in **Figure 2**.

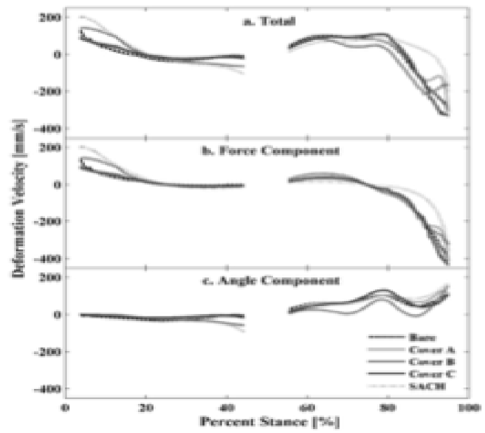


**Figure 2**. Niagara Foot™ deformation velocity profiles under bare and covered conditions: a. Total Deformation Velocity b. Deformation Velocity due to Force c. Deformation Velocity due to Angle.

## RESULTS

An increased rate of deformation due to force was observed during initial heel and forefoot loading of 122% and 65% respectively for Cover B compared to the bare condition as seen in Figure 2 b. These differences indicate increased compliance for this cover design during compressive loading, while minimal differences were observed between cover conditions during unloading. Large variations in deformation velocity due to shank angle can be observed throughout stance between cover conditions, with the largest effects again seen for Cover B in Figure 2 c. The maximum decrease in rate of deformation due to angle observed for Cover B was -1024% during heel unloading into midstance, and -117% during forefoot loading and unloading compared to the bare keel.

## DISCUSSION & CONCLUSION

Isolated measures of deformation velocity provide insight into the contribution of loading and shank angle on prosthetic foot system mechanical performance. The variations observed for the Niagara Foot with different cosmetic covers indicate that the shape and structural stiffness interact to affect the system’s rate of deformation. Therefore it is necessary to consider the effects of both components in the design and prescription of keel and cover pairings to achieve desired performance.

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# UNILATERAL vs. BILATERAL JUMP LANDINGS IN TRANSTIBIAL AMPUTEES

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## BACKGROUND

Unilateral amputees have altered lower limb mechanics and favor the intact limb during gait, making them prone to develop OA at the intact knee and hip (Lloyd et al., 2008). Previous research has shown asymmetrical and high forces onto the intact limb during bilateral vertical jump landings in physically active amputees (Schoeman et al., 2012). The high landing forces onto the intact limb was mainly attributed to compensatory mechanisms in response to the constraints from the prosthetic limb. It was unknown whether the landing forces would be decreased and the impact absorption mechanics different when the constraints from the prosthetic limb were removed in a unilateral jump landing onto the intact side only.

## AIM
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To assess and compare the vertical loading forces and sagittal kinetics and kinematics associated with unilateral and bilateral countermovement jump landings in unilateral transtibial amputees (TTAs).

## METHOD

Six TTAs (age 40±5 years, height 1.86±0.05m, mass 85±13kg) participated in the study. Amputees were included if they had a traumatic amputation with no secondary pathology, were recreationally active and at least 1 year post-amputation. All TTAs wore rigid pylons with their own prescribed prostheses and personal footwear. Ten maximum effort unilateral (intact) and bilateral countermovement jumps were performed of which the jump with the greatest flight height were chosen for analyses. Differences between the unilateral and bilateral data were assessed using Cohen's d tests and 95% confidence intervals of the raw mean differences.

| | UNILATERAL | | | BILATERAL | | | d [CI] |
|---|---|---|---|---|---|---|---|
| | $Q_1$ | Median | $Q_3$ | $Q_1$ | Median | $Q_3$ | |
| FH (m) | 0.06 | 0.11 | 0.14 | 0.11 | 0.15 | 0.19 | **0.91** [-0.13 ; 0.01] |
| $F_2$ (N.kg$^{-1}$) | 29.19 | 31.91 | 34.51 | 21.46 | 26.78 | 29.09 | **1.51** [1.16 ; 14.51] |
| LR (BM.s$^{-1}$) | 38.98 | 57.62 | 86.21 | 31.64 | 36.83 | 54.80 | **0.22** [-40.13 ; 57.03] |
| **Ankle** | | | | | | | |
| $TD\theta_{(ankle\_plantarflex)}$ (°) | -13 | -9 | 3 | -7 | 13 | 20 | **0.73** [-30.57 ; 8.43] |
| $RoM_{(ankle\_dorsiflex)}$ (°) | 17 | 21 | 43 | 25 | 31 | 41 | **0.04** [-23.02 ; 24.43] |
| $M_{(ankle\_plantarflex)}$ (Nm.kg$^{-1}$) | 1.56 | 2.13 | 2.82 | 1.78 | 1.99 | 2.24 | **0.29** [-0.63 ; 0.99] |
| **Knee** | | | | | | | |
| $TD\theta_{(knee\_flex)}$ (°) | 16 | 18 | 20 | 13 | 21 | 29 | **0.29** [-13.42 ; 8.42] |
| $RoM_{(knee\_flex)}$ (°) | 33 | 35 | 38 | 16 | 19 | 23 | **1.74** [5.50 ; 36.50] |
| $M_{(knee\_ext)}$ (Nm.kg$^{-1}$) | 1.60 | 1.78 | 2.11 | 1.59 | 2.05 | 2.51 | **0.36** [-0.78 ; 0.44] |
| **Hip** | | | | | | | |
| $TD\theta_{(hip\_flex)}$ (°) | 22 | 27 | 34 | 25 | 32 | 35 | **0.04** [-16.56 ; 15.56] |
| $RoM_{(hip\_flex)}$ (°) | 16 | 18 | 25 | 3 | 7 | 13 | **1.27** [-0.24 ; 33.57] |
| $M_{(hip\_ext)}$ (Nm.kg$^{-1}$) | 3.50 | 3.73 | 4.18 | 1.92 | 2.13 | 4.62 | **0.11** [-2.30 ; 2.75] |

**Table 1.** Vertical loading forces and sagittal kinetics and kinematics during unilateral and bilateral jump landings

## RESULTS

The TTAs achieved similar flight heights (FH) when jumping from the intact only and both limbs. Compared to the bilateral jump landings, the maximum vertical ground reaction forces (F2) experienced were higher for the unilateral jumps while loading rates (LR) to F2 were similar. Touch-down (TD) kinematics were comparable for the intact ankle, knee and hip. However, increased ranges of motion (RoM) from TD to the end of landing were seen at the knee and hip in the unilateral jump. There were no noteworthy differences in the sagittal plane moments (M) at the ankle, knee and hip between the unilateral and bilateral jump landings.

## DISCUSSION & CONCLUSION

The TTAs landed from similar heights during the unilateral and bilateral jumps. Despite the higher F2 forces experienced in the unilateral jump landings, the loading rates to F2 were similar compared to the bilateral jumps. This may be attributed to the larger knee and hip RoMs seen in the unilateral jump when the physical constraints from the prosthetic limb were removed. While the sagittal data and vertical ground reaction forces in isolation seem to suggest that unilateral jump landings onto the intact limb holds no clear advantage over bilateral jump landings, frontal plane forces and mechanics should be investigated before conclusions related to OA can be made to inform rehabilitation guidelines and training programmes for active TTAs.

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# PATIENT SPECIFIC CERVICAL ORTHOSIS GENERATED BY CT DATA AND SELECTIVE LASER SINTERING

Anja Fischer

## BACKGROUND

Cervical fractures are an increasing problem due to demographic change. Nearly all patients, regardless if treated surgically or conservatively, are provided with standard neck braces, potentially inducing partially severe side effects. Up to 44% of the patients suffer remarkable pressure ulcers[1], 59% suffer from dysphagia [2] and 35,8% experience a rise of ICP [3]. This increases the complication rate, noncompliance and costs in the health care systems induced by longer hospital stays and avoidable surgery.

## AIM

Design a patient-specific neck brace, adjusted to patients' and medical staff's evaluated needs, which lowers the complication rate and combines stabilization with high comfort due to perfect fit and test the orthosis on healthy and affected volunteers.

## METHOD

The concept uses the patient's imaging data in a CAD process, in order to align the orthosis to the patient's anatomy. Eventually, this enables the surgeon to verify the design, add features and eliminate spots of peak pressure. After approval, the orthosis is laser sintered (3D printed) and delivered to the patient. For objective evaluation, a Polaris Spectra tracking system was used to quantify range of motion when compared to standard orthoses (Miami J advanced, Philadelphia brace) and an Arduino based system allowed rough pressure measurement on a healthy volunteer. The patient in this study acquired an instable C2 fracture. As surgical treatment had to be interrupted twice due to circulatory failure and obese body shape did not allow standard orthotic treatment, he was finally treated with a laser sintered patient specific neck brace after informed consent.

## RESULTS

We found a significantly reduced ROM ($p < 10^{-9}$) in mean rotation ranges when comparing the new design to the standard orthoses. Five comparisons between orthosis models were each performed for the six rotation directions. Overall, the mean rotation range was reduced by 4.4°($p < 10^{-4}$) from Philadelphia to Miami J model, and further reduced by 13.1°($p < 10^{-9}$) from Miami J to the 3D fitted orthosis. The average values for high and low pressure values were 4.99 N/cm² (Miami J), 5.44 N/cm² (Philadelphia) and 6.33 N/cm² (laser sintered orthosis). The higher values are attributed to the fact that the quite rigid Polyamide 12 ("Nylon", EOS PA2200) was used for sintering the trial orthosis. The pressure is expected to be lower when changing partially or completely to a more flexible material (e.g. PA11, TPU). Accordingly, the patient treatment was finished after 14 days due to pressure peaks.

**Figure 1**. Patient after treatment with 3D-printed cervical orthosis

## DISCUSSION & CONCLUSION

Once completely developed, the technology could also be used for other orthoses and casts, enabling hospitals to provide individual treatment for each patient and optimizing their quality of life during and after treatment.

The fit is perfect and after further trials to optimize material and cushioning, this technology can be expected to lower complications related to standard size braces, improve the outcome of cervical trauma patients at any age and lower hospitalization time and overall treatment cost significantly.

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# DIGITAL CAMERA BASED MOTION ANALYSIS ALGORITHM FOR KINEMATIC GAIT ANALYSIS

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## BACKGROUND

Human Gait analysis is the systemic study of human locomotion by observation as well as by the use of different instruments that measure body movements (distance, velocity, and acceleration). Gait analysis is used as a quantitative as well as an interpretive method to asses, plan, and treat individuals with conditions affecting their ability to walk. The existence of an economic gait analysis system can represent a strong tool for low income countries.

## AIM

The aim is to build an economic gait analysis system, which can provide accurate information about the gait kinematics with affordable price for small clinics with low budget.

## METHOD

Light-based digital cameras are used to capture film of a moving body, and the film is upload to a software for the analysis. For this project, the software is developed using Open CV open source library. The system is designed to recognize up to 25 colored markers and give as an output the position for each of them, in each frame of film nearby the velocity and acceleration. The position can be then plotted to show the motion of each individual marker. The required tools include a digital camera, printable colored markers, good lighting, dress code (e.g. black colored clothes).

## RESULTS

The new proposed gait analysis system was able to detect the motion with acceptable accuracy (at this stage +/- 2mm). The software and algorithm were able to recognize 25 markers with a detection accuracy of 50-80% using a video rate 30frames/sec. The process was based on utilizing the RGB values of colored images. Changing the background colors, the contrast, and the lighting conditions influenced the results highly. However, the time to do the gait analysis compared with professional systems (VICON) was reduced due to the limited setup preparation time. The videos used in the algorithm varied from cell phone camera videos to digital cameras with higher resolution. Figure 1 shows a sample result of one marker on the ankle joint.

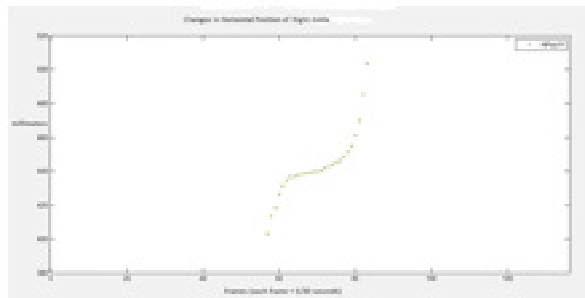

**Figure 1**. Sample result of the right ankle position.

## DISCUSSION & CONCLUSION

The software is capable of identifying the colors as part of its calibration, and then tracking them, in the gait phase. However, the algorithm relies heavily on the environment, where the video capture is being undertook. Lighting, frame rate, type of color modelling, size of the marker are all factors that affect the gait analyzers accuracy. The cost of the system is reduced to the cost of a digital camera and the combined software.

# RELIABILITY OF PRESSURE REDUCING CAPABILITIES OF INDEPENDENTLY CONSTRUCTED WHEELCHAIR CUSHIONS FOR LOW-RESOURCED SETTINGS

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## BACKGROUND

The Tuball cushion is an accessible option for low-income wheelchair users in developing countries, as it is constructed using inexpensive and locally-sourced materials. In a single study of 30 individuals, no statistically significant difference between the pressure-reducing properties of the Tuball cushion and the ROHO cushion was found. The ecological validity of utilising the Tuball cushion for its pressure-reducing properties depends upon the consistency of its construction. Presently, it is unknown whether the Tuball cushion can be constructed reliably by different individuals, given the same set of instructions and access to the same materials.

## AIM

To assess the reliability of pressure-reducing capabilities across multiple independently constructed Tuball cushions.

## METHOD

Six occupational therapy independently constructed a Tuball cushion using the same set of instructions and materials. Force Sensitive Application pressure mapping values were obtained and compared for five other students, each of whom sat on each of the six constructed cushions. FSA data were analysed for a primary outcome measure, dispersion index, and three secondary outcome measures, peak pressure index, contact area-quartile, and seat pressure index. Intraclass correlation coefficients and 95% confidence intervals were calculated for each outcome measure to evaluate the reliability of construction across six individuals.

## RESULTS

We expect the Tuball cushion will be constructed reliably across individuals when supplied with equivalent materials and instructions. Good reliability ($ICC \geq 0.60$) is anticipated between the various cushions constructed by each of the students.

## DISCUSSION & CONCLUSION

Provision of a reduced-cost, locally-sourced solution addresses a critical health care gap for wheelchair users in developing countries. An understanding of the reliability of the Tuball cushion construction may inform areas of improvement, such as instruction manual revisions, to ensure consistency among clinicians in creating these cushions in low-resource settings. This study will contribute to seating and mobility literature by expanding our understanding of the pressure-reducing qualities of a wheelchair cushion created from inexpensive and accessible materials.

## REFERENCES

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# VALIDATION OF THREE MEASURES OF BALANCE, MOBILITY, AND PARTICIPATION IN OLDER ADULTS WITH LOWER LIMB AMPUTATION

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[1] University of British Columbia, [2] Western University, [3] University of Alberta

## BACKGROUND

Lower limb amputation is a disabling condition that affects an individual's balance, mobility, and participation. It is important to use valid and reliable outcome measures to evaluate rehabilitation outcomes and track progress, determine the effectiveness of specific interventions, and optimize clinical decision-making. There is a lack of validated outcome measures for individuals with lower limb amputation. Further, using measures validated in other populations does not transfer confidence in the precision and stability of evaluation estimates in those with lower limb amputation. Balance, mobility, and physical activity represent key outcomes that are validated in other populations but not in individuals with lower limb amputation.

## AIM

The aim of this study was to determine the validity of the Four Square Step Test (FSST), Physical Activity Scale for Elderly (PASE), and Life Space Assessment (LSA) in older adults with lower limb amputation. The FSST is a balance test for identifying fall risk; the LSA is a tool for assessing mobility, and the PASE is a measure of frequency of participation in physical activity and metabolic activity for older adults.

## METHOD

This study used a cross-sectional design with a sample of 59 community-living older adults (≥50 years old) with unilateral trans-femoral or trans-tibial amputation. In addition to the the FSST, PASE, and LSA, participants completed the 2-Minute Walk test (2MWT) and Activities-specific Balance Confidence Scale (ABC) in a random order. We derived Spearman's rho coefficients to assess the magnitude of pairwise correlations between the measures and the 2MWT and ABC.

We hypothesized that there would be a moderate negative correlation ($r \geq 0.3$) between the FSST, and the 2MWT and the ABC. For the LSA and PASE, we hypothesized moderate positive correlations ($r \geq 0.3$) with the 2MWT and the ABC.

## RESULTS

Moderate negative correlations between the FSST and the 2MWT ($\rho=-0.640$, $P<0.0001$) and the FSST and the ABC ($\rho=-0.425$, $P<0.01$) were observed. In addition, a moderate positive correlation was observed between the PASE and ABC ($\rho=0.408$, $P=0.053$). The correlation between the PASE and the 2MWT was moderate and statistically significant ($\rho=0.380$, $P<0.01$). The LSA and ABC had a fair positive correlation ($\rho=0.383$, $P<0.01$) and the LSA and the 2MWT had a moderate positive correlation ($\rho=0.548$, $P<0.0001$).

## DISCUSSION & CONCLUSION

The FSST, LSA, and PASE scores correlated with the 2MWT and the ABC in a priori hypothesized direction and magnitude, indicating support for validity. Our results are generalizable to older, experienced, community living adults and may not be generalizable to younger, new amputees. Additionally, bilateral amputees were not included. Future research is required to investigate the validity of these measures in bilateral, younger, and new lower limb amputees. Further, we recommend considering the reliability of data in this population.

## REFERENCES

• Bita Imam; 2013 and SAGE Open Medicine

# EFFECT OF PROSTHETIC FOOT DESIGN ON FOOT CENTRE OF PRESSURE PROGRESSION SYMMETRY IN TRANSTIBIAL GAIT

Alexandria Tsimiklis [1, 3, 5, 6], Stacey R. Zhao [1, 3, 5, 6], Martin Robertson [2, 4, 6], Matthew Faris [2, 5, 6], Tim Bryant [1, 3, 5, 6]

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## BACKGROUND

During lower-limb amputee gait, reliance on the sound limb is commonly observed in greater intact limb stance times, ground reaction forces, joint moments, and prosthetic step length [1] as well as centre of pressure progression [2]. Recently, Klenow et al., developed a method of quantitatively identifying the "dead spot" phenomenon (DSP), described as an interruption to the forward progression of a prosthetic foot during stance in amputee gait [3]. The presence of DSP has been noted to be clinically significant as it reduces energy efficiency [3]; however, it is recognized that some patients prefer this DSP feature as they perceive it as the presence of increased stability during this phase of gait.

## AIM

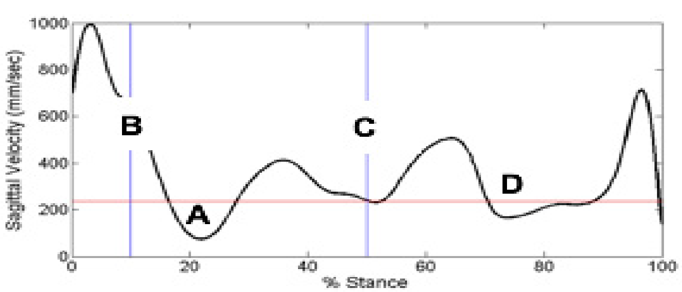
The aim of this study is to quantify DSP for intact and affected limbs of lower-limb prosthesis users across a number of prosthetic foot designs. It is hypothesized that differences in contralateral DSP patterns will indicate patient-specific adaptations to prosthetic design features.

## METHOD

Centre of pressure (COP) data were collected for three transtibial prosthesis users during over-ground self-selected walking speed trials on a walkway instrumented with 4 AMTI™ force plates. Four prosthetic foot devices were evaluated for each subject: the prescribed (dynamic carbon fibre) foot and three stiffness levels of the Niagara Foot™ [4]. Data were processed using the methods of Klenow et al. [3]. Data displayed DSP if the derived COP sagittal plane velocity fell below 60% of the COP mean sagittal velocity and within the target timeframe of 10-50% stance (Figure 1). In addition, 60-80% of stance was analysed for evidence of "toe-lever inflection" [3], termed Forefoot DSP in the current study. Initial analysis of both DSP patterns were completed by graphically comparing COP velocity profiles of sound and affected limbs. Subsequent analyses compared three metrics derived from these data: total dead spot time, dead spot magnitude, and total dead spot area [3].

## RESULTS

Two DSP patterns were evident. In the first, DSP was mainly observed in the affected limb conditions, with little occurrence of DSP in the intact limb in two of the three subjects. A typical example of the second pattern is shown in Figure 1. This displays the presence of DSP in the intact limb while fitted with one of the three Niagara Foot™ conditions (Figure 1a), and little or no DSP in the prosthetic limb (Figure 1b). However, consistent across all subjects, small or non-existent DSP values in the intact and affected limbs occurred when fitted with their prescribed prosthetic foot devices, showing more symmetrical patterns between limbs when compared to the other foot conditions. Lastly, across the four foot conditions, evidence of Forefoot DSP was observed in both intact and affected limbs for all subjects.



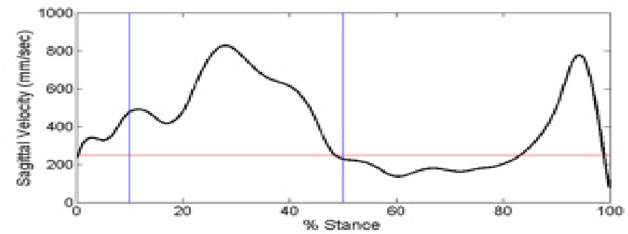




**Figure 1.** Typical second-pattern sagittal COP velocity and DSP profiles for one subject fitted with the softened Niagara Foot™ for the: a) intact limb, and b) affected limb. Visual analysis of this data indicates DSP is present for the intact limb, where the sagittal COP velocity (thick black line) passes below the threshold (A) within the target timeframe of B and C. DSP is not present for the affected limb, as the sagittal COP velocity (black line) does not pass below the threshold within the target timeframe. Forefoot DSP is present in both the intact and affected limb, as indicated by D.

## DISCUSSION & CONCLUSION

Two patterns of DSP were observed for these subjects, while fitted with Niagara Foot™ conditions, suggesting that the phenomenon varies among foot designs and users. In the first pattern, results are consistent with expectations, whereas the second pattern showed an interesting adaptation of the intact limb that may be present in some users. Across all subjects, DSP patterns were more symmetrical between affected and intact limbs when fitted with the prescribed dynamic carbon fibre foot conditions. Whether related to the user preference, familiarity of the device, or the device design, the reason for these differences is not yet clear and requires further research. Furthermore, it is still unclear whether the presence of DSP is a desirable or undesirable feature for all user groups and future work should consider developing appropriate rigorous nomenclature for this phenomenon.

## REFERENCES

1. Ventura; 2011 Clinical Biomech
2. De Asha; 2014 Clinical Biomech
3. Klenow; 2016 Clinical Biomech
4. Niagara Prosthetics and Orthotics International

# THE IMPACT OF COMORBID DIABETES MELLITUS ON OCULOMOTOR AND BALANCE PERFORMANCE IN TRANSTIBAL AMPUTEES: A PILOT STUDY

Lucarevic J[1,2], Gaunaurd I[1,2], Pasquina P[3], Symsack A[3,4], Ortiz A[1], Bennett C[1], Schubert M[5], Szczupak M[1], Hoffer M[1], Gailey R[1,2]

[1] University of Miami, [2] Miami Veterans Affairs Health Care System, [3]Henry M. Jackson Foundation for the Advancement of Military, [4]Walter Reed National Military Medical Center, [5]Johns Hopkins School of Medicine

## BACKGROUND

In the United States the prevalence of diabetes mellitus (DM) in the general population is estimated to be 9.3%, with diabetic complications account for over half of the lower limb amputations performed annually. Studies have found that people with DM have changes in vestibular and visual system as measured by oculomotor testing. DM has been associated with slower eye movements when tracking an object (smooth pursuit) and rapidly moving between two targets (saccade), and increased postural sway during balance.1,2

## AIM

The purpose of this pilot study is to determine if a cohort of transtibial amputees (TTA) with DM have differences in balance and oculomotor performance, and if there is a relationship between oculomotor and balance performance.

## METHODS

Subjects were recruited at the 2016 Amputee Coalition National Conference. Inclusion criteria unilateral TTA, more than 12 months post-surgery, with 3+ months experience on current prosthesis. Smooth pursuit tracking and saccade testing were assessed with the I-Portal® - PAS Goggle System (NKI, Pittsburgh) using a standardized protocol. Smooth Pursuit Velocity (SPV) Gain asymmetry will be calculated by comparing the ratios of eye velocity/target velocity for tracking rightward and leftward targets. Saccade latency will measure how quickly the eyes move between targets. The Modified test of Sensory Interaction and Balance (mCTSIB) which tests bipedal balance for 30 seconds in four different conditions (total maximal score out of 120): 1) floor, eyes open, 2) floor, eyes closed, 3) foam, eyes open, 4) foam, eyes closed. Balance performance was assessed on the trial duration of mCTSIB (bipedal balance) and single limb stance (SLS). Mann-Whitney U tests were used to determine a difference between groups, spearman correlations were used to determine the relationship between oculomotor and balance performance.

| | DM (n=6) | Non-Diabetic (n=30) | P-value |
|---|---|---|---|
| **Oculomotor** | | | |
| Saccade Latency (sec) | **0.17** ± .02 | **0.20** ± .035 | .02* |
| SPV Gain Asymmetry | **-2.9** ± 3.8 | **1.1** ± 6.6 | .04* |
| **Balance** (sec) | | | |
| mCTSIB | **109.5** ± 9.7 | **116.3** ± 7.1 | .11 |
| Prosthetic SLS | **0.89** ± 0.37 | **1.5** ± 0.69 | .04* |
| Sound SLS | **6.14** ± 11.7 | **20.9** ± 12.2 | .009** |

**Figure 1.** Comparison of Mean Oculomotor and Balance Performance in TTA with DM to non-diabetic TTA (Values displayed as Mean ± SD). Statistically significant at *p<.05 and **p<.01 levels.

## RESULTS

Of the 36 TTA who participated in the study, six (17%) had comorbid DM. Subjects with DM had statistically significant differences in oculomotor and balance performance (Table 1). Subjects with DM had smaller latencies before initiating saccadic eye movements, greater asymmetry in smooth pursuit eye velocities, and shorter balance trial durations. A moderate correlation was found in the DM cohort between prosthetic SLS and SPV gain asymmetry (rs=-.43, p=.20). Weak correlations were found in the DM cohort between mCTSIB time and oculomotor parameters of SPV gain asymmetry (rs=-.26, p=.31) and saccade latency (rs=.32, p=.27).

## DISCUSSION & CONCLUSION

In this small pilot study the prevalence of DM (17%) was almost twice the rate estimated in the general population (9.3%). Similar to other findings co-morbid DM is associated with differences in oculomotor and balance performance. The study is limited by the small sample size, based on results more research on the role of visual and vestibular system changes in diabetic amputees is indicated.

## REFERENCES

1. Virtaniemi; 1998 Acta Otolaryngol.
2. Nicholson; 2002 Neuroreport

# USING BODY WORN SENSORS TO ANALYZE POSTURAL CONTROL STRATEGIES OF LOWER LIMB AMPUTEES DURING THE MODIFIED TEST OF SENSORY INTERACTION AND BALANCE

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## BACKGROUND

Postural control has been defined as the act of maintaining, achieving, or restoring a state of balance during any posture or activity.1 Postural control relies on a complex interaction of sensory information from visual, somatosensory and vestibular systems. The modified test of sensory interaction and balance (mCTSIB) allows clinicians to evaluate postural control during four distinct sensory conditions that manipulate the accuracy of visual and somatosensory input. To remain upright the human body makes constant corrections by oscillating forward, backward, and/or sideways over the fixed base of support. These oscillatory movements, known as postural sway, can be quantified by body worn sensors, such as inertial measurement units (IMUs). The IMU sensors provide raw data (linear acceleration and angular velocity) that must be processed to provide meaningful parameters. Currently it is unclear if IMU-derived parameters can distinguish single segment (ankle) and double segment (hip) strategies in lower limb amputees (LLA).

## AIM

The aim of this study is to 1) describe postural control of LLA during the mCTSIB using IMU-derived measures, and 2) determine if IMU-derived measures of postural control could differentiate between observed movement strategies.

## METHODS

Subjects: A convenience sample of 71 unilateral LLA (TTA n=38, TFA n=33; female n=36, male n=35; mean age 47.5 ± 14) were recruited at the 2016 Amputee Coalition National Conference in Greensboro, North Carolina, USA. Subjects were included if they were 18-80 yoa, more than 12 months post-amputation surgery, and a current prosthetic user with > 3 months in current prosthesis. Procedures: Subjects wore an IMU sensor attached at the sacrum to approximate the position of the center of mass. Subjects were asked to balance for 30 seconds in each of the four mCTSIB conditions: 1) on the floor with eyes open, 2) floor, eyes closed, 3) foam, eyes open, and 4) foam, eyes closed. A licensed physical therapist observed and classified the movement as: single segment (ankle) or double segment (hip) strategy. Parameters of postural control were derived from the raw IMU data for: maximal excursion (AP and ML), sway area, jerk (the time derivative of acceleration), root mean square (RMS) of acceleration, and mean velocity. Data Analysis: Statistical analysis was performed using SPSS version 22 (SPSS Inc., Chicago, USA). Independent samples t-test was used to compare the IMU-parameters between subjects observed using a single segment (ankle) strategy to a double segment (hip) strategy.

## RESULTS

Movement strategies and IMU-derived spatial parameters varied across mCTSIB conditions. While sway area progressively increased from condition 1-4, the AP and ML increases were dependant on standing surface. When standing on the floor the vast majority LLA relied on a single-segment (ankle) strategy, and changes in AP excursion to control balance based on visual input. When standing on foam, LLA relied more on double-segment (hip) strategy and increasing ML excursion. IMU-derived Parameters of velocity, jerk, and RMS of acceleration were relatively constant across mCTSIB conditions. None of the IMU-derived measures of postural control were significantly different between LLA utilizing a single-segment and double-segment movement pattern.

| | mCTSIB Condition | | | |
|---|---|---|---|---|
| | 1.Floor, EO | 2.Floor, EC | 3.Foam, EO | 4.Foam, EC |
| **Sway Spatial Parameter** | | | | |
| AP (cm) | 1.2 ± 0.6 | 1.7 ± 0.8 | 1.3 ± 0.5 | 1.9 ± 1.0 |
| ML (cm) | 0.9 ± 0.4 | 1.0 ± 0.6 | 1.7 ± 1.0 | 2.4 ± 1.7 |
| Area (cm²) | 0.8 ± 0.8 | 1.2 ± 1.1 | 1.6 ± 1.5 | 3.6 ± 6.1 |
| **Observed Strategy** | | | | |
| Single Segment n (%) | 65 (92%) | 55 (78%) | 9 (13%) | 3 (4%) |
| Double Segment n (%) | 3 (4%) | 13 (18%) | 58 (82%) | 47 (66%) |
| Other n (%) | 3 (4%) | 3 (4%) | 4 (5%) | 21 (30%) |

**Table 1. Mean values for IMU-derived measures of sway spatial parameters and frequencies of observed strategies during mCTSIB.**

## DISCUSSION & CONCLUSION

The IMU-derived spatial measures of postural control utilized in this study could not differentiate movement patterns utilized by LLA. The IMU-derived spatial parameters could however be used to describe how LLA responded to increasing postural control challenges. The progressive results are similar to research in non-amputee populations, suggesting the mCTSIB is an appropriate tool for assessing postural control in LLA.

## REFERENCES

1. Pollock; 2000 Clin Rehabil
2. Shumway-Cook; 1986 Phys Ther

# MAJOR UPPER LIMB AMPUTATION IN AUSTRALIA: INCIDENCE AND AETIOLOGY

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[3] School of Public Health and Community Medicine, University of NSW, Australia

## BACKGROUND

There is no published literature on the incidence of upper limb amputation in Australia. Previous aetiological analysis has been based upon samples of clinic attenders or publicly funded prescriptions only.

## AIM

The purpose of this study was 1) to determine the incidence and time trends (if any) in major upper limb amputations in Australia and 2) to provide an aetiological analysis of a two-year sample.

## METHOD

The incidence and causes of major upper limb mputations were calculated based on the procedure and diagnosis data from the Australian Institute of Health and Welfare for 2003-2013 financial years.

## RESULTS

The absolute numbers of shoulder disarticulation, transhumeral and transradial amputations varied widely from a minimum of 39 in 2004 to a maximum of 64 in 2010, with an average of 53 amputations per year. The time trend did not change over the study period. The average incidence rate of major limb amputations was 2.45 procedures per million population. The two-year snapshot analysis of amputation aetiology showed that 41% of all major upper limb amputations were for treatment of neoplasm, 36% resulted from trauma, 12% were due to a disease of muscular skeletal and connective tissue system.

## CONCLUSIONS

Major upper limb amputation in Australia is rare with no significant change during the 10-year study period. Cancer exceeds trauma as a leading cause of major upper limb amputations, a finding at variance with published literature from overseas which consistently reports trauma to be the overwhelmingly leading cause.

## REFERENCES

Dillingham T.R. et al. Limb Amputation and Limb Deficiency: Epidemiology and Recent Trends in the United States. Southern Medical Journal Vol. 95, No8, 2002 pp 887-883

# EXTENDED DEVELOPMENTS IN THE ORTHOPAEDIC ENGINEERING CURRICULUM (B.SC.) IN THE NETHERLANDS.

## HOW TO EDUCATE THE NEXT GENERATION PROSTHETISTS, ORTHOTISTS AND PEDORTISTS.

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## BACKGROUND

Since 2000 the educational programme in prosthetics, orthotics and orthopaedic shoe making / pedorthics at a Bachelor level educate students to become orthopeadic engineer (P&O in the Netherlands) is located at the Fontys University of Applied Sciences, Eindhoven. Since 2009 it is also accredited as an ISPO Cat1 programme. Already from the beginning this programme has been performed in a very close collaboration with the Thomas More University, Belgium. From 2016 this programme will be performed fully at the Fontys University of Allied Health Professions (FPH) due to change of educational content and more specific in program organization as well as a change of view at Health in general.

## AIM

The aim of the abstract is to give the interested an overview of the extended developments in the Orthopaedic Engineering Curriculum (B.Sc.) in the Netherlands. Especially to give insight in professional and social forces that plays a role in curriculum content ad organization design and the choices made to educate the next generation Prosthetists, Orthotists and Pedortists.

## METHOD

A changing view on healthcare: “Health as the ability to adapt and implement their own control, in light of the physical, emotional and social challenges of life” as defined by Huber (2011), was the reason for a major change in thinking about healthcare education and also for the orthopaedic engineering education.
A new educationally design was introduced to be able to adapt, be more responsive and more effective and efficient on societal and technological changes. Professional knowledge, skills, business skills and internationalization and research need to be integrated throughout the whole programme.

## RESULTS

FPH changes the the education organization in a firm part (2,5 years) and a flexible part (1,5 years) of the 4 year full time programme. The first 2,5 years will focus on the basic knowledge and skills necessary solely for becoming a Prosthetist, Orthotist or Pedortist. The final 1,5 years of education enhance this knowledge and skills in this specific field of expertise and also expanse in the direction of Technology, Self-management or Interprofessional Collaboration. Internships and research are an integral part of the programme. These focus in the programme, or “profiling” makes the student develop skills to work in a constantly evolving care sector. It allows the student the freedom to shape their own study. Finally, the student will finalize the study in a research project in a specific ‘mobility’ issue connected with one of the three profiles mentioned.

## DISCUSSION & CONCLUSION

A thoroughly revised curriculum gives the opportunity to educate a next generation of students ready for their future and their clients.

## REFERENCES

Huber, M.; Knottnerus, J.A. ; Green, L.; Horst, H. van der; Jadad, A.R.; Kromhout, D.; Leonard, B.; Lorig, K.; Loureiro, M.I.; Meer, J.W. van der ; Schnabel, P.; Smith, R.; Weel, C. van ; Smid, H. (2011). How should we define health? BMJ. British Medical Journal, vol. 343, d4163

# ASSESSMENT OF AN ULTRASOUND-GUIDED ORTHOTIC DESIGN IN TREATMENT OF ADOLESCENT IDIOPATHIC SCOLIOSIS: A FEASIBILITY TEST OF WHOLE PROCEDURE FROM CASTING TO IN-BRACE CORRECTION)

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## BACKGROUND

To control the progression of moderate curves in patients with adolescent idiopathic scoliosis (AIS), spinal orthoses have been prescribed for decades. The key impact of initial in-brace correction on effectiveness of orthotic treatment necessitates the development of an objective real-time method of curve measurement during the casting and brace design to achieve the appropriate pad placement. Development of Clinical Ultrasound (CUS) as a non-invasive technology in scoliosis assessment facilitates the orthotic treatment potentially [1, 2].

## AIM

This purpose of this study is to evaluate a new approach of brace design in treatment of AIS patients by integrating an assessment frame, CUS, and CAD/CAM to mimic the optimum in-brace correction of curvature during the casting procedure.

## METHOD

This is an on-going pilot study. Five scoliotic subjects with moderate right thoracic and left lumbar curves were recruited. They were requested to stand inside a purpose-design assessment frame and several corrective pads were applied to the major curves with documented orientation and pressure level. The real-time curve measurements were conducted by application of CUS (scanning from C7 to L5) until an optimum correction (≥ 30%) was obtained. Subjects' trunk shape in corrected position was scanned for design and fabrication of orthoses using CAD/CAM system. Finally, CUS will be applied to assess the in-brace correction of curvature for comparison purpose.

## RESULTS

The feasibility of immediate curve correction in the assessment frame was evaluated in the previous project by using the reflective markers adhered to the spinous process of corresponding vertebrae which confirmed the curve reduction of 40% by applying the pressure pads set to 60 and 40 mmHg at the thoracic and lumbar regions accordingly. The Centre of Laminae (COL) method was used to estimate the Cobb angle in ultrasound (US) images. A comparison of US and radiographs in baseline and in-brace checking session were conducted.

## DISCUSSION & CONCLUSION

If the curve correction characteristics of this combined orthotic design could be confirmed, it will facilitate the verification of optimum pad placements in a more documented approach and less relying on individual judgments and experience of clinician. Compared to plain radiographs, a free-radiation US scanning can provide comprehensive 3D information; however the limitation of ultrasound in application of severe curves should be kept into consideration.

## REFERENCES

1. Lou E; 2015, Scoliosis
2. Li M; 2012, Eur Spine J

# AUTOMATIC PRESSURE-ADJUSTABLE SPINAL ORTHOSIS FOR ADOLESCENT IDIOPATHIC SCOLIOSIS

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## BACKGROUND

Full-time orthotic treatment is generally prescribed to the patient with adolescent idiopathic scoliosis (AIS). However, its treatment effectiveness may be influenced by the patient's compliance to orthosis prescription, including adequate wearing tightness and wearing time. Some previous studies suggested patients tended to wear the spinal orthosis with less compliance. Thus, to improve the treatment effectiveness, appropriate orthosis tightness and adequate wearing duration are essential.

## AIM

This study aims to develop an automatic pressure-adjustable spinal orthosis for AIS; to investigate its treatment effectiveness comparing to the conventional orthosis; and to study the correlation between the wearing duration and its treatment outcomes.

## METHOD

A device has been developed to be embedded inside spinal orthosis to monitor pressure and temperature, and it can also provide consistent interfacial pressure as to offset the inappropriate tightness. The device (Figure 1) is composing of a pressure sensor (SCCP05GSMTP model, Honeywell© International Inc.), a temperature sensor (MCP9701T-E/LT model, Microchip© Technology Inc.), an air bladder, a wireless micro-controller (CC2540 model, Texas© Instruments Inc.), and a smallest pump-valve which can generate 300mmHg of pressure. The net weight of the device is 35g and the dimension is 61x44x22 mm. The device can regulate the interfacial pressure by inflation and deflation of the air bladder embedded in the 3-point pressure area of the spinal orthosis.

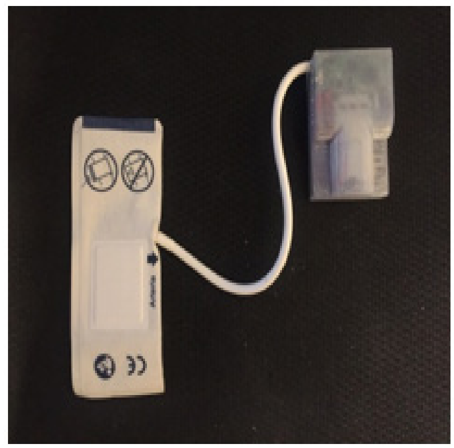
As a trial run, 2 normal subjects were recruited wearing this automatic pressure-adjustable spinal orthosis for 2 days. A randomized controlled trial study is being conducted for comparison between the automatic pressure-adjustable spinal orthoses and the conventional spinal orthoses. The same standard of orthotic and medical care for treating scoliosis is applied for both groups (25 subjects each). Assessments including radiograph, quality of life (QoL), anthropometric (including age, sex, height, weight, family history and menarche), and compliance is being conducted with 12-month follow-up after the first orthosis fitting.

## RESULTS

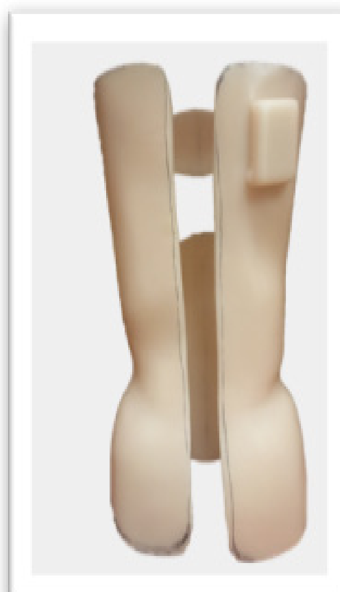
The two normal subjects wearing the pressure-adjustable spinal orthosis for two days (Figure 2) showed that both orthoses could maintain 10-40 mmHg of interfacial pressure in the trial test. In the analysis of compliance, both temperature and pressure data showed similar results. In the randomized controlled trial study, 12 subjects with AIS have been recruited and showed that no subjects had curve progression >5° with the pressure-adjustable orthosis; whereas 2 out of 6 subjects under the conventional method had unsuccessful orthotic treatment - one having 7° increment and the other requiring surgery. This study is under progress. The results of more patients will be presented in the conference.

## DISCUSSION & CONCLUSION

This automatic pressure-adjustable spinal orthosis is of pressure and temperature monitoring, and can maintain a prescribed range of interfacial pressure. It has good potential to provide better treatment effectiveness in comparison with conventional spinal orthosis. If it is proven effective, the automatic pressure adjustable spinal orthosis can be prescribed to patients with AIS, thus achieving better treatment outcomes.



*(Figure 1. The pressure-adjustable device)*



*(Figure 2. The posterior view of spinal orthosis embedded with the pressure adjustable device)*

# QUANTIFICATION OF ANKLE-FOOT ORTHOSIS RESISTIVE MOMENT TO CONTROL ANKLE AND KNEE KINEMATICS DURING GAIT IN INVIDUALS POST-STROKE

Toshiki Kobayashi

## BACKGROUND

Also called "Introduction", this section describes the study's relation to past research, rationale, and prepares for the aim. The Background starts with a general context and then leads towards the actual (clinical/technical/educational/...) problem that the study addresses. Also cite relevant previous works [#] (from one's own or from others) to further direct the reasoning towards the aim. This section is used by reviewers to assess "relevance".

## AIM

The aim (or: purpose; or: objective; or: research question) is a concise statement of the goal, phrased in a precise way, that was targeted by this study.

## METHOD

The method refers to how the study is designed and executed, by describing all the steps and selections that were made to fulfill the study's aim and to allow the reader to critically appraise the results. For most clinical studies, this includes participant selection criteria, agenda for each person who took part, measurements and interventions that were performed; how the data was processed into the concepts mentioned in the aim, and statistical evaluation. For non-clinical studies, the structure is less straightforward but relevant details must be provided, especially if the method is (technological) innovative.

## RESULTS

This section describes the actual results of your study. The main result should be presented in a manner that fits the way the aim of the study was phrased. It is encouraged to visualize the main results using a figure. Also, a table might be a concise way to present structured data.

To ensure readability for figures and tables, please consider minimizing amount of information included, avoid small font sizes, and no colours. Preferably, describe your results in numbers and add statistical significance (p-values) if appropriate.

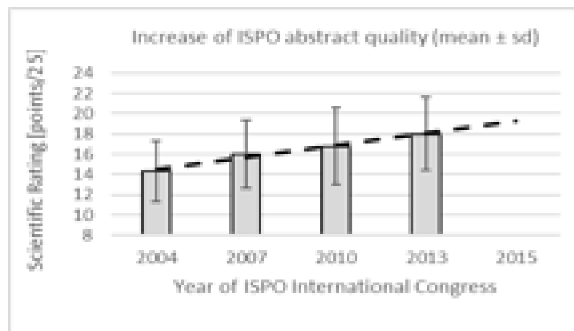



Figure 1. Title

## DISCUSSION & CONCLUSION

While the result sections presents focussed outcomes, the discussion provides interpretation of the results. Discussion relevant questions can include: "are there important study limitations?", "do the results confirm or conflict with previous results?", "are the result generalizable?" After all relevant considerations, a final conclusion must be written. This conclusion should relate to the aim and not overstretch the importance of the results.

## REFERENCES

This is optional, but necessary if you build on previous work. Very short style is common in abstracts, meaning:

1. First author's name; year and abbreviated journal only

# SMARTPHONE APPS TO ENHANCE CLINICAL WALKING TESTS

Edward Lemaire

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## BACKGROUND

The six minute walk test (6MWT), two minute walk test, and 10 meter walk rest (10MWT) are common clinical evaluations in prosthetics and orthotics that assess functional capacity and walking speed. While these tests can be easily implemented using a stop watch and measurement wheel, smartphone technology provides an opportunity to deliver the same outcome measures but also augment the test with additional movement-quality metrics [1].

## AIM

Create smartphone applications to run and augment the 6MWT, 2MWT, and 10MWT.

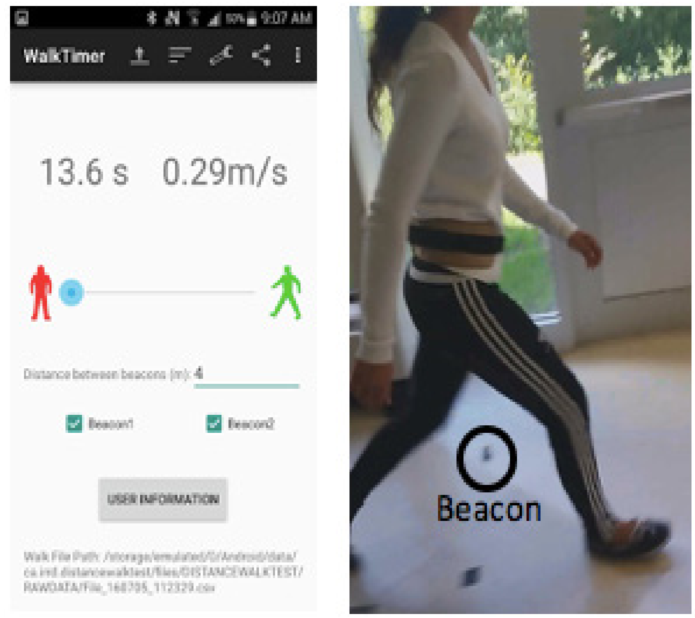
## METHOD

The 6MWT and 2MWT app [2] was originally programmed for BlackBerry 10 and then ported to Android. As reported in [1], signal processing methods identify steps, turns, stops and distance walked is calculated. If participant information is entered, a reference range is provided for test result context.

The 10MWT app [3] used the 6MWT code base, but an additional signal was necessary for analysis within a fixed distance. To enable cost effectiveness and accessibility, Bluetooth LE Beacons (iBeacons) were used to identify the measurement range's start and end (i.e., 2 and 8 m). Beacon signal processing involves filtering the RSSI (Received Signal Strength Indicator) using a 0.5 Hz cutoff frequency and then employing peak detection methods to determine maximum signal strength, which should correspond to the minimum distance between the smartphone and the beacon. The time to pass between 2 beacons is used to calculate walking speed, since the distance between beacons is preset. Phone location is standardized to the centre-posterior waist, using a belt clip or purpose built belt with a pocket for the smartphone. Since smartphones can contain accelerometers, gyroscopes, and magnetometers, enhanced biomechanical outcome measures can be provided to the clinician to better understand how the person moved during the test. Recent research has confirmed that the pelvis is a preferred site for overall movement evaluation [4]. The following measures are provided for each walkway length: number of steps, average speed, average step length, cadence, maximum and average acceleration for medial-lateral (ML) and anterior-posterior (AP) directions, maximum and average pelvic tilt and rotation and obliquity, average asymmetry. For research purposes, all sensor and step data can be saved to a data file.

## RESULTS

6MWT app evaluation was reported in [1], showing that accuracy of less than 1m can be achieved over the 6MWT period. Preliminary 10MWT app evaluation compared velocity from the app to velocity from video recordings (Figure 1). The average difference across three able-bodied participants was 0.088 m/s, which was within the 10MWT minimum detectable change of approximately 0.17.




## DISCUSSION & CONCLUSION

Initial evaluations of this smartphone approach to enhancing walking tests supported use for evidence-based practice. Since smartphone connectivity facilitates appropriate results transmission, written results do not need to be transcribed for analysis of patient performance over time or grouped analysis within a clinical practice. Since a consistent method is used for data collection, these apps could be more reliable than stopwatch-based measurements. A purpose-built belt is preferable for holding the smartphone since phone position is consistent between patients and unwanted movement is minimized. Further research is required to determine how the biomechanical output can be used clinically and how these results should be related to reference data to provide context on the participant's walking performance.

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# PERSPECTIVES AND EXPERIENCES OF AMPUTEES REGARDING THE USE OF MICROPROCESSOR PROSTHETIC KNEES

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## BACKGROUND

Technology is advancing rapidly, particularly in the development and use of microprocessor prosthetic knees (MPKs). There is however limited understanding of the experience and benefits of these types of prosthetics from a user perspective. A better understanding of user perspectives regarding perceived benefits and limitations of MPKs and the transition to this type of prosthetic is necessary to inform practice, policy and funding improvements within our service nationwide.

## AIM

To explore the perspectives of amputees fitted with a MPK regarding a) the perceived benefits and limitations of MPKs; and b) their experiences of transitioning to a MPK.

## METHOD

This was a qualitative descriptive study using semi-structured interviews. Participants (n=13) were adults (>18 years) with transfemoral amputation who had been fitted a MPK. Purposeful sampling was used to capture diversity on key characteristics including traumatic (n=6) vs. non-traumatic (n=7) amputation, time since fitted with first MPK (range: 3 months-12 years), gender (n=9 male; n=4 female), and age (range: 26-73 years). Phone interviews were conducted by fourth year physiotherapy students. An interview guide was used as a prompt to initiate discussion but allowed for flexibility to be responsive to the participant. Interviews were audio-recorded and transcribed verbatim. Data was analysed using thematic analysis.

## RESULTS

Findings highlighted a number of perceived benefits of using a MPK including that participants experienced a greater sense of normality and confidence to manage varied terrain without feeling anxious about risk of falling. Participants indicated the MPK had opened up their world, now being able to engage in a more diverse range of activities and enjoy the destination rather than focus all their energy on the journey. Participants spoke of a process of relearning to walk upon transition to a MPK requiring them to forget habits learnt while using a mechanical knee. This process took time and many would have valued additional support during that transition. Participant's expressed frustration over having to travel to a centralised limb centre for minor adjustments. Regardless, there was overwhelming agreement that the benefits of a MPK far outweigh any downsides.

## DISCUSSION & CONCLUSION

The benefits described by amputees fitted with a MPK are consistent with existing research. The qualitative approach used provides a more in-depth understanding of outcomes that matter to amputees which could inform more advanced cost-benefit modelling and funding decisions. Participant experiences of transitioning to a MPK provide us with valuable insight regarding service level improvements particularly relating to fitting and training processes, and models of service delivery.
Our study highlighted a number of perceived benefits of MPKs for amputees, and provided 'user' information to guide service improvements.

# DEVELOPMENT OF A WHEELCHAIR SERVICE PROFESSIONAL CERTIFICATION

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## BACKGROUND

The importance of credentialing is evident throughout health professions as it ensures education and service standards are upheld, while ultimately protecting the consumer (1,2,3). Despite these benefits, currently, there is no credential available for basic wheelchair service provision that is recognized internationally. Therefore, the International Society of Wheelchair Professionals (ISWP) proposed to develop an evidence-based Wheelchair Service Professional (WSP) certification that is accessible to a large audience of health care personnel around the world who service wheelchair users.

## AIM

The aim of this project is to develop a WSP credential that protects wheelchair users by ensuring service personnel do no harm, know the fundamentals of basic wheelchair service provision, and are kept abreast of evidence-based practice as science evolves through continuing education requirements.

## METHOD

The ISWP appointed an advisory panel (AP) of expert contributors to expand the current Wheelchair Service Provision Basic Test (WSPBT), a knowledge test administered by the ISWP, to a certification examination reflecting the knowledge, skills, and abilities aligned with the profession by following Downing's 12 steps for test development (4). The test was expanded to a certification by a) looking at the job tasks of all target health professional groups; b) developing an equitable certification process based on a review of related certifications; c) pooling together existing resources into a synchronous, online cohort-based preparatory course; and d) piloting a-c with a cohort of trainees.

RESULTS

Results include the extension of current WSPBT based on all job performance assets and the development of a) a job task analysis for the WSP credential, which was compared to all target groups' job roles, existing training content, formalcurricula, and the widely adopted World Health Organization's Wheelchair Service Training Package-Basic; b) a process by which to obtain the WSP credential through the ISWP; c) an online course consisting of pre-existing materials to prepare service providers for the certification examination (WSPBT); and d) a process by which to maintain the WSP credential through required continuing education. 20 trainees are being chosen for the pilot which will include participating in the prep-course focusing on wheelchair standards, policy, documentation, outcome measurement, standards of practice, and ethics and by sitting for the expanded WSPBT.

## DISCUSSION & CONCLUSION

The trainees who meet the requirements of the certification and pass the expanded WSPBT will be the first to be certified by ISWP as a Wheelchair Service Professional. After the pilot, it is anticipated that earning this credential and participating in the associated preparatory course will not only ensure a do no harm service to wheelchair users, but will be a valuable resource and pathway for volunteers, students, interns, entry-level clinicians, professional development, and a stepping stone for additional professional credentials in rehabilitation.

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# DEVELOPMENT OF A PROSTHETIC AND ORTHOTIC SCHOOL TO RECEIVE FULL ISPO CATEGORY 1 RECOGNITION

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**BACKGROUND**

Up until the year 2001 there was no bachelor degree program of prosthetics and orthotics in Southeast Asia (SEA) even though aapproximately 1 % of the population has suffered from physical disabilities. Certified Prosthetists and Orthotist (CPO) would elevate the quality of life for people with movement disabilities greatly.

**AIM**

To develop a Prosthetic and Orthotic (P/O) school to be recognized at the International Society for Prosthetics and Orthotics category 1 level for producing CPOs for South East Asian countries. A P/O school was established through collaboration between the Ministry of Public Health and a public university in 2001. The school has been developed as followed:

1. Responsible Institute. In the beginning, the school was under the Ministry of Public Health but later it was moved to be under the Mahidol University in 2006.

2. Financial Support. The Nippon Foundation, Japan had supported the school directly for the expense of expatriates since 2001 and international students since 2010 until 2015. The local government began allocating a special budget (~ 400,000 USD/year) for P/O education in 2010. The university also provided a grant for expense of local staff and permanent building.

3. Teaching Staff. Initially, the school had to invite many expatriates from various countries including Japan, France, Australia, Tanzania and others to help run the program. After the students accomplished the BSc in P/O, 2-4 graduates from each class were recruited and prepared to be future lecturers. At present, there are 19 local teaching staff and 3 expatriates (2 MD, 1 PhD, 10 master degree, 2 American Board of Certification in Pedorthics, 6 CPOs, 1 shoe specialist).

4. Curriculum. The domestic curriculum was adjusted in 2007 to follow the ISPO/WHO guidelines for training personnel of 2005. It was a 4-year program with 150 credits composed of general education subjects, basic medical science subjects, P/O subjects, research, and elective subjects. An international program was established in 2010. A Bachelor in P/O (blended distance learning, international program) through collaboration with an NGO from Germany for upgrading ISPO category 2 graduates was started in 2013.

5. Extracurricular Activities. Many extracurricular activities are arranged to enhance students' social skills for professional improvement.

6. Student Recruitment. Each year 24 domestic students, 12 international students and 10 students for the Blended Distal Learning international program are accepted.

7. Infrastructure. The university provided a building of 4,500 square meters with full equipment in 2012. The school also arranged a P/O clinic serving as a location to provide clinical experiences for students.

8. Quality Management System. ISO9001: 2008 was implemented in 2011.

**RESULTS**

The school has received yearly ISPO category 1 recognition since 2009 and received full recognition in 2013. Besides, the school also has been certified by ISO 9001:2008 since 2012. Within the last 15 years, our program has led to the production of 180 CPOs. 135 are domestic graduates and 45 are international ones. More than 80% of our graduates retain their work in the P/O field in both public and private sectors. 62 graduates from 10 different countries work for P/O schools in the South East Asia region. The Bachelor in P/O (blended distance learning, international program) has just been recognized as ISPO category 1 level in 2017. In August 2017, the school will start a Bachelor in P/O (BDL domestic program) for local technicians and a Master of Science in P/O (international program).

**DISCUSSION & CONCLUSION**

To produce CPOs are very expensive. It required a lot of resources including human resources, equipments and materials. The success of the school comes from good collaboration between local government, the local university, the Ministry of Public Health, and the sponsors. The strong determination of the teaching staff is another important factor of the success. In addition, good management system is also essential.

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# A MULTI-NATIONALLY VALIDATED MOBILITY ASSESSMENT TOOL USING INTERNATIONAL CLASSIFICATION OF FUNCTIONING, DISABILITY AND HEALTH CATEGORIES: THE IBMAT 10

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**BACKGROUND**

The International Classification of Functioning, Disability and Health (ICF) provides a universal language for rehabilitation professionals across the globe. To facilitate use of the ICF in clinical practice, a multinational collaboration has been working on developing and validating a mobility assessment tool based on ICF. The 22 item tool initially developed, required about 25 minutes to complete. This made the tool impractical for use in routine clinical practice and further refinement was required to develop a shorter version.

**AIM**

The aim of this study was to establish an ICF based Mobility assessment tool (IBMAT) and companion scoring instructions for individuals who had a lower extremity amputation. The assessment tool had to be short enough to be used in routine daily clinical practice yet remain sensitive to detect changes in mobility.

**METHOD**

191 lower limb amputees were assessed across 6 study centres using the 22 item assessment tool. Three methods were then used: (i) The concept retention method: to identify items which did not clearly measure mobility did not fit into the concept of the tool; (ii) the equi- discriminative item-total correlation and other statistical measures quantifying the contribution of an individual item to the overall range and sensitivity of the scale and (iii) Rasch modelling demonstrating the fit of each item and score distributions of each item related to the difficulty of the item. Based on these analysis items which could be removed were identified.

**RESULTS**

Maintaining standing balance conceptually was more a measure of falls and did not fit into a mobility scale conceptually. Driving and maintaining other body positions had very low discriminative values. Moving around buildings other than the home and moving around obstacles showed very high correlation and score agreement with other items of the scale and these items were therefore deemed to be redundant.
The resulting 10 item assessment tool (IBMAT10) includes squatting, standing, bending, lifting and carrying objects, walking short distances, walking long distances, walking on different surfaces, climbing, running and moving around outside the home/other building. The IBMAT 10 has a Cronbach's alpha of 0.92 This section describes the actual results of your study. The main result should be presented in a manner that fits the way the aim of the study was phrased. It is encouraged to visualize the main results using a figure. Also, a table might be a concise way to present structured data. To ensure readability for figures and tables, please consider minimizing amount of information included, avoid small font sizes, and no colours. Preferably, describe your results in numbers and add statistical significance (p-values) if appropriate.

| IBMAT Items | Median week 1 | Median week 6 |
|---|---|---|
| Squatting | 4 | 4 |
| Standing | 0 | 0 |
| Bending | 0 | 0 |
| Lifting and carrying | 3 | 1 |
| Walking short distances | 2 | 1 |
| Walking long distances | 4 | 4 |
| Walking on different surfaces | 4 | 1 |
| Climbing | 4 | 4 |
| Running | 4 | 4 |
| Moving around outside home/other buildings | 1 | 1 |

**Table 1** Showing IBMAT 10 items and change over a 6 week rehabilitation programme

**DISCUSSION & CONCLUSION**

The items of the IBAMT been validated in different cultures and settings as part of the 22 item assessment tool. Applying common statistical techniques to reduce the number of item has resulted in an ICF based assessment tool that can be applied in busy daily clinical practice. The items are sensitive over a broad range of the mobility spectrum. Further field testing is required to further validate the IBMAT 10, determine the time it takes to complete, and validate it as a self-rated instrument.

The IBMAT 10 could be a useful ICF based mobility assessment tool in a broad range of settings in rehabilitation for the person with an amputation.

# POSTERS

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# HEALTH PROFESSIONAL EDUCATION AND SKILLS DEVELOPMENT-ELEARNING

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KILIMANJARO CHRISTIAN MEDICAL UNIVERSITY COLLEGE (KCMUCo)

## BACKGROUND

WHO (2006), estimated shortage in the global health-care workforce to be approximately 4.3 million. ICT offers new modes for delivery of education, e-Learning and blended learning.
Both allow for the combination of hands-on, skills-based training, self-directed, knowledge-based learning. They help reduce the costs of delivering educational content and break down the geographical and temporal barriers that limit access and availability of education, improve access to relevant experts and novel curricula.
AIM (approx. 30 words, Times New Roman, 9pt)
To determine the strength of the use of ICTs in eLearning for education and training of the professional health workforce in the provision of health care services in the world.

## METHOD

Descriptive Retrospective/Prospective study was applied. Retrospectively the case series and trend of professional staff developed through Blended e-Learning at TATCOT identified, including challenges faced due to resources scarcity. Retrospectively, Literature reviewed to selected studies done of the same subject worldwide on staff knowledge and skills development through e-Learning while continuing at workplace. On Prospectively the studies aimed at identifying the views of staff on future plans towards staff development, despite of the minimal resources in place, rather ensure that staff knowledge is being boosted /developed. Motivation of staff through continuing development despite of staff shortage is among the key issues

## RESULTS

ICTs for eLearning initiatives study, 82% of the (n=125 Member States) participating in the survey reported using this teaching tool for the health sciences, while 91% acknowledged using distance learning to train health professionals.

Evidence on eLearning-mLearning: In any activity that allows individuals to be more productive when consuming, interacting with or creating information, mediated through a compact digital portable device that the individual carries on a regular basis, has reliable connectivity, and fits in a pocket or purse.
Total of 65 staff have been trained through Blended eLearning with hands-on at TATCOT since 2007. More could be trained, but to mention few is due to financial constraints. The number is still low due to multiple factors which includes; inadequate or absent of financial support to join the eLearning course.

## DISCUSSION & CONCLUSION

The process of institutionalizing and sustaining eLearning within an educational setting, and offers key strategies for organizational transformation and change. The successful institutionalization and sustaining of eLearning programmes is strongly dependent on the context of the organization. The Financial support is crucial, is required as to develop most of staff on site in turn reduce cost due to geographical barriers where the majorities gain knowledge and skills through E-learning course

# HATTA METHOD FOR ANALYSING COMPLETENESS AND USAGE OF ORTHOTICS PROSTHETICS HEALTH RECORD

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## BACKGROUND

Lack of orthotics prosthetics (OP) data to Indonesian government raised curiosity on the availability of OP data while two government's OP bachelor degree institutions still operate. This study analyze the quality of OP health record (HR): the itemized variables in OPHR, the implementation of ICF (WHO) - SOAP criterias and completeness-usage of OPHR. Analysing OPHR through Hatta Method, produce a new simpler, useful and informative OPHR.

## AIM

Systemized Hatta Method as a new analysing health record method for completeness-data usage, reducing itemized variables will produce a new informative OPHR.

METHOD

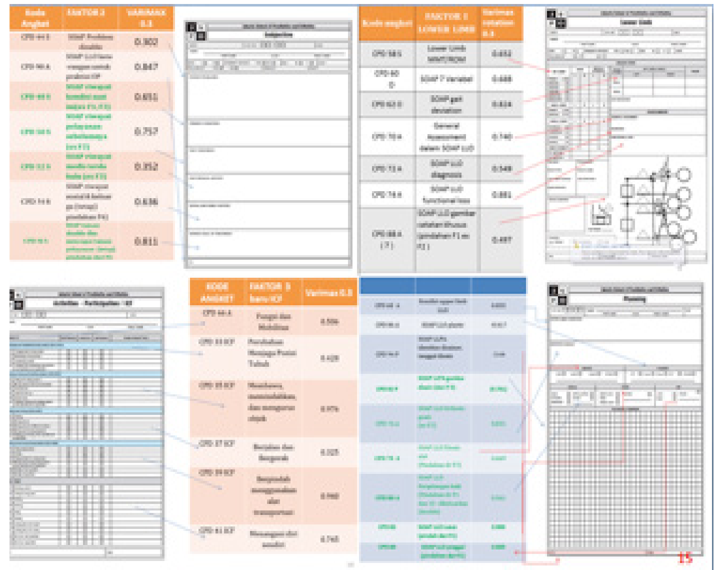
Sample retrospective innovative study: 30 lower limb (LL) OPHRs (JSPO Jakarta), 10 (Solo) due to homogenity. Hatta Method: Stage I: Questionnaires OPHR on LL i.e.Analyses: (a) Quantitative on completeness. (b) Qualitative (administrative & medical aspects). Two criterias in qualitative medical analysis with SOAP and WHO's ICF.
Stage II. Collecting data: Reviewing-analysing (RA) OPHR: quantitative, qualitative administrative and medical to find completeness-usefullnes 30 OPHRs with SOAP-ICF criterias.
Stage III. RA data of two OP schools in 2 cities Jakarta (2009-2014) and Solo.
Stage IV. Designing new OPHR forms (SPSS multivariate factor analysis). The second step of this research: design new OPHR

## RESULTS

Stage I a. Quantitative OPHR complete 44.26 % (12.78/30)
Stage Ib. Qualitative administrative complete 62.5% of 30. Medical (non scoring) complete 62.88 % of 30 OPHR. Medical qualitative: completeness of itemized variable - usefulnes of ICF's Activities Participation (ch. 4-5) only used 15.4 % ICF.
- Usage of ICF: only 13.34 % ICF databeing used.
- Usefulness of 30 OPHR: 37.08% SOAP data being used.

Update of ICF and SOAP record has to be re constructed.
- OPHR new form: Factor Analysis SPSS varimax rotation of Jakarta and Solo data in 3 series.

The result: from 7 factors of 58 variables on SOAP and ICF. The composition of new forms of OPHR:
G5.4 Patient Registration
G 5.3 Authorization
G 5.6 Subjective
G 5.7 Lower Limb
G5.8 Activities and Participation
G 5.9 Planning
G5.10 Progress Notes



## DISCUSSION & CONCLUSION

Hatta Method is a new analysing OPHR method with strengthening on completeness and data usage of chosen criteria. It ends with a new HR design and deleting the unused forms. Poor HR completion is corrected with better OPHR design. Presently objective (O), assessment (A) forms have been merged to Lower Limb form with simplification of certain O and A activites inside. Hatta method can be implemented globally to any HR.

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WHO,_ICF https://www.who.int/classifications/icf/en/

# CONSERVATIVE TREATMENT OF SCOLIOSIS – SYSTEMATIC REVIEW OF THE LITERATURE

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## BACKGROUND

Scoliosis is a three dimensional deformity of the spine and trunk including lateral deviation, rotation and a disturbance of the sagittal profile. As scoliosis may lead to consequences affecting health issues and quality of life1 treatment of the deformity is clearly indicated. Today physical rehabilitation and brace treatment are the modes as used within conservative scoliosis treatment of patients with scoliosis2. It has been shown in several papers that the amount of correction achieved determines the end result of conservative scoliosis treatment3.4.

## AIM

Purpose of this actual state of the art review is to gather the information available today and to search recent articles on scoliosis for the evidence they provide for the different modes of treatment.

## METHOD

A Pub Med search for review articles, prospective controlled trials (PCT) and randomized controlled trials (RCT) has been performed.

## RESULTS

When looking at current literature high quality evidence (Level I) has been found to support physical rehabilitation and brace treatment, while no evidence has been found to support spinal fusion surgery. The many unknowns patients might face in the long-term after operation and the lack of evidence there is for spinal fusion surgery have led to the conclusion that there is no medical indication for this kind of treatment.

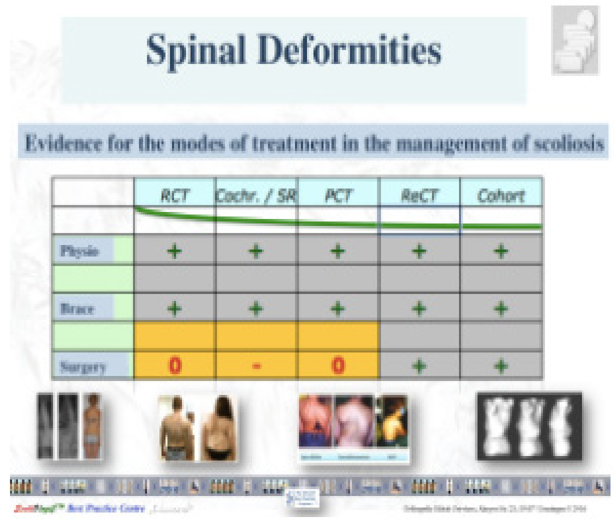


**Figure 1.** High quality evidence (RCT, Cochrane reviews, prospective controlled trials, PCT) has been found for physical rehabilitation (exercises) and brace treatment, no high quality evidence exists for spinal fusion surgery.

## DISCUSSION & CONCLUSION

There is high level evidence for conservative treatment of scoliosis, however, not all approaches will lead to the best possible results5. The better the correction the better the end result3,4. This is supported by evidence today. Therefore in physiotherapy and in bracing only high corrective procedures should be applied.

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# DESIGN AND FABRICATION OF AUTOMATION SYSTEM FOR TRANSRADIAL PROSTHESIS

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## BACKGROUND

Limb amputation, for example hand loss, can be extremely devastating as it renders a person impaired from performing day-to-day tasks.Prosthetic limbs are used to replace missing limbs and are of two types i.e. passive prostheses and active prostheses. Passive prostheses are mainly used for cosmetic purposes and provide very little functionality. However, active prostheses in addition to cosmetics provides functionality of actual limb, but they have high cost associated with them. The prohibitive cost of active prostheses prevents many patients in developing countries such as Pakistan with a limb difference. Therefore, there is a need to design and develop low cost fully functional battery powered (active) prostheses for increasing the accessibility and procurement of such devices.

## AIM

The aim of this project was to design and fabricate low cost upper prosthetic limb. Use of Force Sensitive Resistor (FSR) was aimed to control the muscle activities of amputees.Further the aim was to provide basic functionalities in a robust manner to the amputees, which includes wrist rotation and fingers opening and closing.

## METHOD

Developed prototype shown in Figure 1 consists of three fingers with one DOF in fingers and one DOF in wrist (Pronation/supination motion).

- Two servo motors are being used; onefor opening and closing of fingers andone for wrist rotation.
- Pressure sensor is placed on theforearm where it can detect thestimulus from the user to perform itsaction.

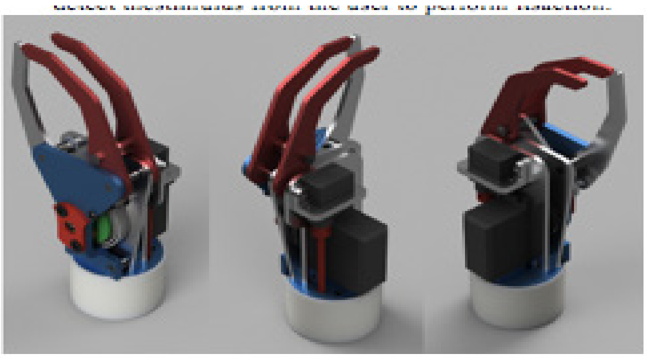


*Figure 1: Developed Prototype*

**Figure 1**: Developed Prototype

## RESULT

The results of following tests are summarised in Table (1).

- Maximum Hand Opening
- Pinch (Tip Prehension) Force Test
- Deadlifting with hook prehension
- Fingers speed

**Table 1:** Prosthetic Hand Parameters

| Parameter | Value/s | Units |
|---|---|---|
| Max Powered Pinch Force | 46 | N |
| Max Unpowered Pinch Force | 24 | N |
| Maximum tested deadlift with hook prehension | 18 | Kg |
| Tip prehension lock (toggle position for objects small than | 1 | mm |
| Finger close and open time | 1 | sec |
| Wrist rotation time | 1.5 | sec |
| Minimum operating voltage | 7 | V |
| Nominal operating voltage | 7.4 | V |
| Maximum operating voltage | 8 | V |
| Maximum current draw | 1 | A |

## DISCUSSION & CONCLUSION

The low cost prototype developed worked in a satisfactory manner providing the basic prehension types in an automated manner, while eliminating the stigmatisation that would otherwise come with body powered prosthesis. This was done at a much lower cost than thecommercially available myoelectric prosthesis. An embedded microcontroller, stimulus sensor (to sense the user's intentions) and a battery were used to control to required motion of prosthetic hand.

# ISSUES OF IMPORTANCE REPORTED BY TRANS-TIBIAL AMPUTEES IN PAKISTAN

Nizar Akhtar[1], Humza Faisal[2]

Pakistan Institute of Prosthetic & Orthotic Sciences

## BACKGROUND

In the field of prosthetics, there is an increasing acknowledgement by practitioners, clinicians and therapists of the need to measure the outcomes of their practice.1Without this information, it is difficult to make informed choices about a proper focus for patient-centered research in prosthetic rehabilitation.There is little published information about issues of interest to persons functioning with a lower limb prosthesis.2This study addresses the issues of importance that affects the daily life activities of the people with trans-tibial amputation using prosthesis.

## AIM

Aim of this research is to measure the percentage of trans-tibial amputees facing major issues with the prosthesis, the ability to move around, social and emotional aspects using a prosthesis.

## METHOD

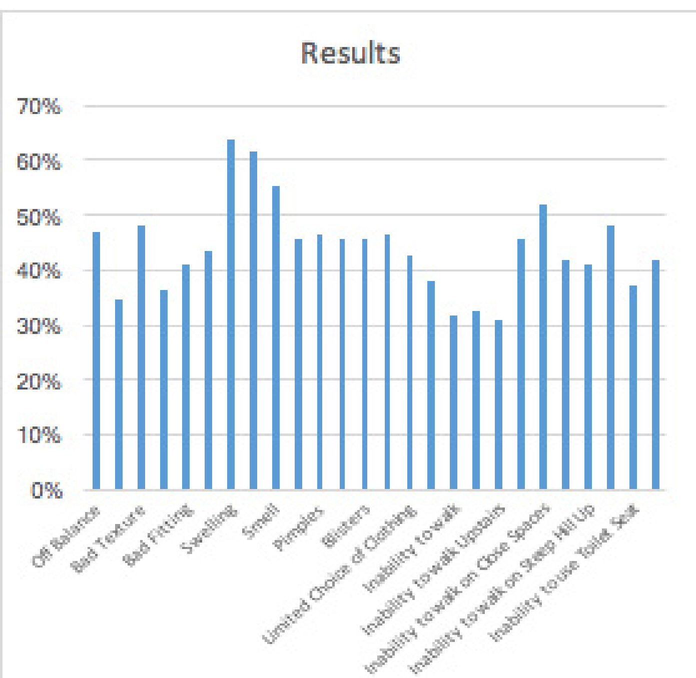
This outcome research study was conducted in major and tertiary artificial limb centers in nine major cities which covered all four provinces of Pakistan. The total duration of study was 8 months. The data was collected by using PEQ (Prosthesis Evaluation Questionnaire). 110 trans-tibial amputees who were using prosthesis for at-least 6 months were requested to visit at the centers. The questionnaires were provided one by one with a proper guideline by ISPO Certified Prosthetists & Orthotists working at the centers. Data was entered into SPSS V15 for statistical evaluation and MS Word 2016 was used for thesis writing.

## RESULTS

Issues related to prosthesis were Off Balance (46.7%), Difficult Donning (34.6%), Bad Texture (48.2%), Exhaustion (36.4%), Bad Fitting (40.9%), Heavy Weight (43.6%), Swelling (63.6%), Sweating (61.8%), Bad Smell (55.5%),Uncomfortable socket (45.5%), Pimples (46.4%), Rashes (45.5%), Blisters (45.5%), Noise (46.4%), Limited Choice of Clothing (42.7%) and Shoes (38.2%).

Issues related to the ability to move around were inability to walk (31.8%) on Sidewalks (32.7%), Upstairs (30.9%), Downstairs (45.5%), Close Spaces (51.8%), Slippery Surfaces (41.8%), Steep Hill Up (40.9%) and Down (48.2%). Inability to use toilet seat (37.3%) and Bathe (41.8%).

Very minor social and emotional issues were reported.




## DISCUSSION AND CONCLUSION

From the result of this study, it is concluded that a large percentage (More than half in some issues) of trans-tibial prostheses' users in Pakistan are suffering from problems either in their prostheses, social life or their ability to walk and carry out their ADL.This study is a gateway for prosthetists to develop universal and efficient solutions to these issues. Further research should be conducted on finding out the solutions to these issues and experimenting them on larger samples.

## REFERENCES

1. Billock, J. N. (1996) Journal of Prosthetics & Orthotics
2. Marcia W. Legro (1999) Journal of rehabilitation research and development

DISCUSSION AND CONCLUSION

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REFERENCES

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2.Marcia W. Legro (1999) Journal of rehabilitation research and development

# AMPUTEE'S INTERACTIONS AND EXPERIENCES WITH PROSTHETIST DURING PROSTHETIC FITTING PROCESS: A SURVEY

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## BACKGROUND

The prosthetist's effective communication with the patient and the duration of the visit are two important factors leading to patient satisfaction. Many amputees lacks source of prosthetic information and were dissatisfied with their prosthetic care. As a prosthetist, we felt that conducting this introspective survey addressing amputee's experiences before amputation, during prosthetic fitting and throughout the rehabilitation process will provide first-hand input from prosthetic users according to their personal experiences as both amputees and recipients of clinical services.

## AIM

This study was conducted to explore the professional gap between the patients and the prosthetist which results in less efficiency and satisfaction prevails among the patients during their pre and post- prosthetic fitment.

## METHOD

A 30 questions survey was created using YES or NO, MCQs and some questions having multiple parts. Most of the survey questions focused on variety of topics related to the participant's interactions with the prosthetist and their use of the prosthesis. The survey participants were asked to refer to their first prosthetist when answering questions. The responses to each of the 30 questions from 200 patients were compiled on excel spread sheet, and the resulting percentage figures for all questions were then graphed for analysis process. The survey participants were selected based on some specific criteria from across the country.

## RESULTS

The result of the survey is very interesting and somewhere it is unanticipated outcome. For instance, in the survey, 78% of respondents reported wearing their prosthesis for greater than 8 hours per day. The percentage of amputees choosing "comfort" and "function" as their biggest concerns for their prosthesis were 43% and 45% respectively. 61% of the survey participants classified their amputation surgeries as an 'emergency' and 39% 'planned'. 62% amputees indicated that their prosthetist was their main source of prosthetic information after amputation. 56% of amputees changed their prosthetists due to citing dissatisfaction with professional skills and comfort of prosthesis as their main reasons for changing prosthetists totalled 71% and 29% respectively. Several results of this survey that stood out as being noteworthy from either a positive or a negative perspective shall be highlighted in the presentation.

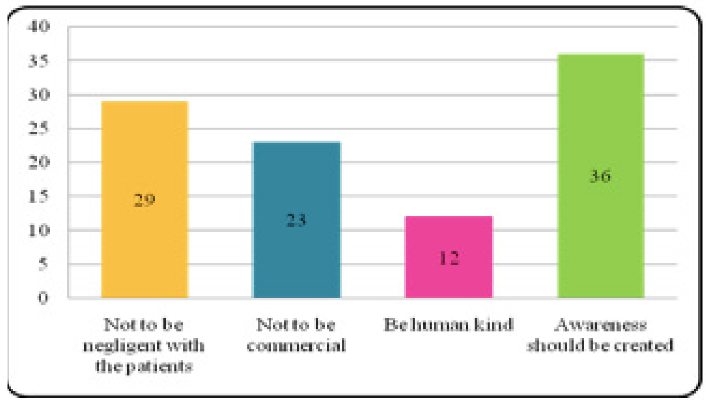


**Figure 1.** Suggestions from the Patients to P&O Professionals

## DISCUSSION & CONCLUSION

The main purpose of the survey is to implement a system which effectively meets the information needs of amputees, who are a growing segment of our population. The findings of this study could be shared with healthcare providers and prosthetic community with the intent to enhance the availability of information to amputees, both before and after surgery and to improve the overall satisfaction level with their prosthetic experience including comfort, fit and function.

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# THE EFFECT OF VARY VARUS MALALIGNMENT ON KNEE ADDUCTION MOMENT DURING WALKING OF HUMAN NORMAL GAIT

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## BACKGROUND

Measuring dynamic loading profile of knee joint directly is crucial; hence knee adduction moment (KAM) obtained from gait analysis can be applied as a substitute for dynamic loading [1]. Previous study found that peak KAM can be used to predict severity and rate of progression of knee OA, whereas peak KAM in OA patient is greater than normal [2] but no relationship between pain intensity and peak KAM was presented in severe OA patient [3]. Furthermore, varus malalignment that induced by KAM may effect to progress.

## AIM

The aims of this study are to design and analysis of walking aid device to reduce knee adduction moment and to create a prototype of a walking aid that can reduce knee adduction moment using passive compliant structure.

## METHOD

Subject: a healthy male with no history of knee pain or severe injury of lower limb was recruited to this study.
Gait analysis: eight Vicon cameras (MX-F40), Plug-in gait model and three AMTI force plates were utilized to produce kinetic data, movement and GRF. One successful barefoot trial by subject was used to create a walking model in Adams Life Module program. Furthermore, KAM was determined by body builder program.

**Experiment:** The selected value of K and C are the ones that resulted in the lowest error in the first and the second peak of vertical GRF. Then, tracking agent of 3D model was configured by varying the rotational stiffness (RoK) and rotational damping (RoC).The effect of the adduction angle of knee joint on the value of KAM was determined by increasing of the angle by increment of 1° at a time until the adduction angle reached 6°. Then, the changing of KAM that was calculated from simulation has been analyzed.

## RESULTS

The value of K= 140 N/mm and C = 20 N.s/mm were the proper value that yield the lowest error in left and right foot, the errors were 5.23% and 5.09% respectively(table1).

| Side | K (N/mm) | C (N.s/mm) | % Error at 1st Peak | % Error at 2nd Peak | % Absolute Mean Error |
|---|---|---|---|---|---|
| Left | 100 | 10 | 10.90 | 0.05 | 5.47 |
| | 100 | 20 | 8.55 | 0.39 | 4.47 |
| | 100 | 30 | 7.88 | 0.74 | 4.31 |
| | 120 | 20 | 9.03 | 0.95 | 4.99 |
| | 140 | 20 | 9.45 | 1.01 | 5.23 |
| | 160 | 20 | 9.80 | 1.10 | 5.45 |
| Right | 100 | 10 | -1.36 | -7.27 | 4.32 |
| | 100 | 20 | 5.61 | -8.10 | 6.86 |
| | 100 | 30 | 13.87 | -8.35 | 11.11 |
| | 120 | 20 | 3.64 | -8.07 | 5.86 |
| | 140 | 20 | 2.18 | -8.01 | 5.09 |
| | 160 | 20 | 2.73 | -7.97 | 5.35 |

**Table 1 :** Configuration error simulation result at peak vertical GRF

The RoK of 26,000 N/radian and RoC of 4,900 Ns/radian were the proper values that resulted in the lowest of error of 2.63% on the left side and 2.81%on the right side respectively. The KAM peak increased when the adduction knee angle increased. (Fig 1)The results show an increasing trend of KAM peak approximately in same in both left and right knees and the much higher impact as we varied the knee angle, the second KAM peak increased with higher percentage than the first peak of both side as shown in Fig.2. It is possible that the value of varus has higher impact on human gait at toe-off phase than heel-strike phase.

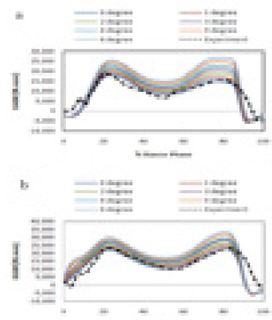

**Fig 1:** Changing of peak KAM in different adduction knee angle (a) left knee (b) right knee

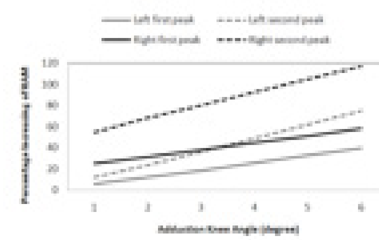


**Fig 2 :**Increasing of KAM in different adduction knee angle.

## DISCUSSION & CONCLUSION

The accuracy of result depends upon various parameters that we set on our model. In this study, variation of stiffness and damping values were used to find the minimum tolerance of KAM. The simulation result shows that the peak of KAM increased when adduction knee angle increased. It is expected because KAM is a product of frontal ground reaction force and frontal lever arm. This model simulation could be used to predict the value of KAM instead of directly measure from gait analysis laboratory and could be used to perform further analysis on KAM and OA disease progression.

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# RETROSPECTIVE STUDY OF POST AMPUTATION PAIN AND IT'S PHARMACOLOGICAL MANAGEMENT IN TRAUMATIC UPPER AND LOWER EXTREMITY AMPUTEES IN A METROPOLITAN SETTING

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## BACKGROUND

Post-amputation pain is challenging with most studies suggesting higher incidence in traumatic upper limb amputees .[1] Studies also suggest prolonged pre-amputation pain predisposition to persistent pain[2] and higher incidence of pain in compensation cases.[3] This study has focused on incidence of pain and its management in new traumatic amputees over 7 year period at a metropolitan tertiary level trauma hospital.

## AIMS

To study the demographics of traumatic amputees, the incidence and pharmacological management of post amputation pain. Investigate the relationships between cause of injury and the time elapsed between trauma to amputation on post amputation pain.

## METHOD

A retrospective chart review of a continuous cohort of traumatic amputees admitted to the hospital from January 2009 - April 2016. Data was collected on patient demographics, cause, time elapsed between trauma and amputation. Data was also collected on analgesics use pre amputation, at discharge and 6 months post amputation and analyzed using descriptive statistics.

## RESULTS

There were a total of 29 new traumatic amputees between Jan 2009-April 2016. Their demographics is shown in table 1 below.

Table1: Demographics of traumatic amputees:

| | | | |
|---|---|---|---|
| age | 47 yrs (18-75) | | |
| sex | 27 males (93%) | | |
| Amputation type and level | Lower limb | Transfemoral (TF) | 7 (1 bilateral+TR, 1 TF+TT) ) |
| | | Transtibial/partial foot (TT/PF) | 14 (1 bilateral, 3 PF) |
| | Upper limb | Transhumeral (TH) | 3 |
| | | Transradial/partial hand (TR/PH) | 5 (2 PH) |
| Prosthetic users | 25 (90%) prosthesis users | | |
| Cause of amputation | Workplace injury | | 13 |
| | Motor vehicle accident(MVA) | | 12 |
| | others | | 4 |

Most amputees had pre-amputation analgesics and mostly opioid-derived. The pain medications usage is shown in table 2.

**Table2:** Pain medications usage in amputees with varying causes of injury:

| | Workplace injury(n=13) | MVA(12)+ others(4) | P value |
|---|---|---|---|
| Mean pain medications pre-amputation | 1.8 | 1.9 | P= 0.9 (not sig) |
| Mean pain medications on D/C | 3.46 | 3.38 | P= 0.9 (not sig) |
| Mean pain medications 6 months post amputation | 2.5 | 2.25 | P= 0.9 (not sig) |
| Patients on Opioid medication on D/C | 11 (85%) | 14 (87%) | P= 1 (not sig) |
| Patients on opioid medications 6 months post amputation | 6 (50%; 1 unknown) | 7 (44%) | P=1 (not sig) |

Approximately 60% amputees had phantom limb pain at 6 months follow up with a higher incidence in upper limb amputees (67% vs 56%) and females (100%). Half had their amputations performed within 24 hours and ~35% were delayed over one week in a trial of limb salvage with incidence of pain 6 months post amputation as 80% and 62.5% respectively (p= 0.6; not sig).

## DISCUSSION & CONCLUSION

The incidence of persistent phantom limb pain in traumatic amputees was ~60% with higher incidence in females and in upper extremity amputees.[1] Most were treated with both neuropathic pain agents and opioids but there was a trend towards higher opioid use in workplace amputees at 6 months follow-up. Strict vigilance to monitor opioid weaning in long term is thus needed.

Post amputation pain was not significantly affected by timing of amputation surgery in our study. Further studies are needed to draw definite conclusions.

**Reference**:

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# MOUNTAIN CLIMBING AMONG ADULTS WITH UNILATERAL TRANSTIBIAL PROSTHESIS: A CASE SERIES

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[1] JBM Physical Medicine and Rehabilitation Centre Inc., [2] La Consolacion University Philippines, [3] Physicians for Peace Philippines

## BACKGROUND

In areas where lower limb prosthetic users are discouraged by their disability to have recreational activity, documenting five (5) adults with unilateral transtibial prosthesis who can climb the 2nd highest mountain in their country can be an eye-opening and inspiring. Mountain climbing as a form of recreational activity may still be considered by healthy adults with unilateral transtibial prosthesis because they can choose and set their own pace and goals.

## AIM

The purpose is to enlighten the health professionals and lay people that healthy adults with unilateral transtibial prosthesis can also climb mountains like their abled-body counterpart.

## METHOD

This is a descriptive study that showed the demographic profile and prosthetics specifications of the 5 healthy adults with unilateral transtibial prosthesis who climbed the 2nd highest mountain in their country. A survey on the occurrence of symptoms of altitude sickness and post-mountaineering musculoskeletal problems was also carried out. The status of the prosthesis was also checked and noted.

## RESULTS

The demographic profiles and prosthetic specifications of the five amputees are shown in figure 1. Four out of the five amputees with unilateral transtibial prosthesis succeeded in their quest to climb the mountain summit. The lone amputee, who was not able to reach the summit, voluntarily discontinued the climb due to residual limb pain and rested near the summit. Three amputees reported slight difficulty of breathing, difficulty of falling asleep while on top and mild feeling of hangover upon waking up. All of them complained of pain in the residual limb after the climb. Skin redness and blister in the residual limb and minor wound in any parts of the body were also reported by 3 amputees. All the transtibial prosthesis withstood the climb.

| | A | R | M | C | L |
|---|---|---|---|---|---|
| Age | 45 y/o | 35 y/o | 31 y/o | 32 y/o | 25 y/o |
| Sex | male | Male | male | female | female |
| Nationality | Filipino | Filipino | Filipino | Filipino | Filipino |
| Civil status | Married | Married | Single | Single | Single |
| Height in cm | 162.6 | 160.0 | 157.5 | 147.3 | 152.4 |
| Weight in Kg | 53.0 | 59.0 | 42.3 | 36.4 | 47.5 |
| Medical comorbidities | Hansen's disease, treated | None | None | None | None |
| Educational Attainment | Vocational | Vocational (TESDA) | Elementary | Vocational | Vocational |
| Occupation | Freelance artist | Automotive mechanic | Waste segragator | Clerk | Clerk |
| Smoker (current or previous) | Nonsmoker | 5 pack years | 1 pack year | Nonsmoker | Nonsmoker |
| Level of transtibial amputation / deficiency | Medium | Medium | Medium | Medium | Medium |
| Laterality of amputation / deficiency | Left | Right | Right | Left | Right |
| Presence of other limb deficiency / deformity | Clawhand deformity, left | Yes, both hands. | None | Yes, both hands. | Yes, both hands. |
| Duration of prosthetic use | 7 years | 31 years | 1 year | 3 years | 6 years |
| Types of transtibial prosthesis | Endoskeletal | Exoskeletal | Endoskeletal | Endoskeletal | Endoskeletal |
| Socket | PTB | PTB | PTB | PTB | PTB |
| Suspension | Suction | Supracondylar with strap | Suction | Supracondylar with strap | Suction |
| Ankle foot assembly | Single axis energy storing foot | SACH | Single axis energy storing foot | SACH | SACH |
| Weight of the prosthesis (including the silicon and socks) in Kg | 0.9 kg | 1.2 kg | 1 kg | 0.9 kg | 1.0 kg |

PTB – patellar tendon bearing
SACH – solid ankle cushion heel

**Figure 1.** Demographic profiles and prosthetic specifications of the five amputees

## DISCUSSION & CONCLUSION

Mountain climbing may be considered as a recreational activity for healthy adult with unilateral transtibial prosthesis. Orientation on the mountain regarding its geographical features, weather condition, safety, rules and regulations are essential prior to mountain climbing. Aside from these things, the potential medical issues should also be anticipated and addressed accordingly to have an enjoyable mountain climbing experience.

# IMPACT OF STRUCTURED WHEELCHAIR SERVICES ON SATISFACTION AND FUNCTION OF WHEELCHAIR USERS IN ZIMBABWE

Elsje Scheffler

## BACKGROUND

Providing wheelchairs without comprehensive support services might be detrimental to user satisfaction and function. World Health Organization (WHO) has developed guidelines on wheelchair provision. At the time of the study no evidence of the impact of these guidelines was available.

## AIM

This study compares wheelchair user satisfaction and function before and after implementation of comprehensive wheelchair services, based on the WHO guidelines on wheelchair service provision in less resourced settings, in Zimbabwe.

## METHOD

A pre-and post-test study with qualitative component was done. Quantitative data was collected with the Quebec User Evaluation of Satisfaction with Assistive Technology for adults and children and the Functioning Everyday with a Wheelchair Questionnaire. Data was collected from 55 consecutively sampled wheelchair users, who received a new wheelchair in the study period. A two-sample test of proportions was used to determine if a statistically significant difference in the percentage of satisfied participants between the pre- and post-test ratings occurred. Qualitative data was collected through two audio recorded focus groups and two case studies and is presented through narrative examples.

## RESULTS

The proportion of adult users who were satisfied significantly increased for all wheelchair and service delivery aspects ($p = 0{,}008$), except follow-up ($p = 0.128$). The same was true for children's post-test ratings on all variables assessed ($p = 0.04$), except training in the use of the device ($p = 0.052$). The biggest improvement in satisfaction figures were for comfort needs (44.3%), indoor mobility (43.2%), outdoor mobility (37.2%), safe and efficient, independent operation (33.5%) and transport (31.4%). Users reported improved independence, integration and participation, and many felt that they were now contributing to household activities rather than being a burden. The qualitative data further illustrated user satisfaction with wheelchair features and services and being included in the process.

## DISCUSSION & CONCLUSION

Significant positive changes in user satisfaction with the wheelchair, wheelchair services and function were recorded. Despite fewer resources and using more basic technology satisfaction levels were similar to that of wheelchair users from resourced settings. Since the programme was based on the WHO wheelchair guidelines one might conclude that service provision in accordance with these guidelines does result in satisfactory wheelchair services and improved user function in less resourced settings. It is recommended that the Zimbabwean government and partner organisations continue to support and develop wheelchair services along these guidelines.

# EVALUATING A NOVEL ENERGY-RETURNING ANKLE FOOT ORTHOSIS FOR FLACCID ANKLE MUSCLE PARESIS

Dymphy Van Der Wilk

## BACKGROUND

A patient-centered approach was used to develop a novel energy-returning ankle foot orthosis (AFO) called ADJUST. Existing AFOs generally limit normal ankle range of motion (ROM) and thereby hamper a patient during e.g. slope walking [1]. Especially walking down slope requires more ankle ROM when compared to level walking [2]. ADJUST was designed to provide independent support for flaccid plantarflexor and dorsiflexor muscles without limiting normal ankle ROM. ADJUSTs two (medial and lateral) hinged mechanisms, in which springs are inserted, enable independent dorsiflexor and plantarflexor support.

## AIM

To compare the ADJUST with patients own AFO on ankle kinematics when walking down slope, and AFO satisfaction.

## METHOD

Ten AFO users with flaccid plantarflexor and dorsiflexor paresis were recruited and walked with ADJUST and own AFO on the declined treadmill of our Gait Real-time Analysis Interactive Lab (GRAIL) while ankle kinematics were measured. A gait cycle was divided into four phases: controlled plantarflexion (heel contact (HC) – maximum (max) plantarflexion), controlled dorsiflexion (max plantarflexion – max dorsiflexion), powered plantarflexion (max dorsiflexion – toe off (TO)), and swing (TO – HC). Normal data were obtained from eight adults who walked in the same lab. The paired Wilcoxon signed-rank test was used to evaluate significant individual differences in ankle ROM per gait phase between AFOs. AFO satisfaction was evaluated using relevant questions from the D-QUEST [3].

## RESULTS

All participants own AFOs were non-hinged. Figure 1 displays a typical ankle kinematics graph (participant 1) when walking down slope. Only statistical significant differences ($p<0.05$) are reported. In six participants (1-4,6,8) controlled plantarflexion ROM increased between 2 and 6° towards normal range, and decreased between 3 and 7° below normal range in two participants (5,9) with ADJUST. In six participants (1-3,5,8,9) controlled dorsiflexion ROM increased between 2 and 11° towards and within normal range, and decreased 5° below normal range in one participant (6) with ADJUST. In three participants (1,3,8) maximum swing dorsiflexion decreased between 2 and 4° towards normal range, and increased between 5 and 11° within and above normal range in three participants (2,4,5) with ADJUST. Nine participants were satisfied with ADJUSTs' adjustment possibilities to slope walking that their own AFO lacked. Five patients were dissatisfied with ADJUSTs weight and size, especially of the medial hinge.

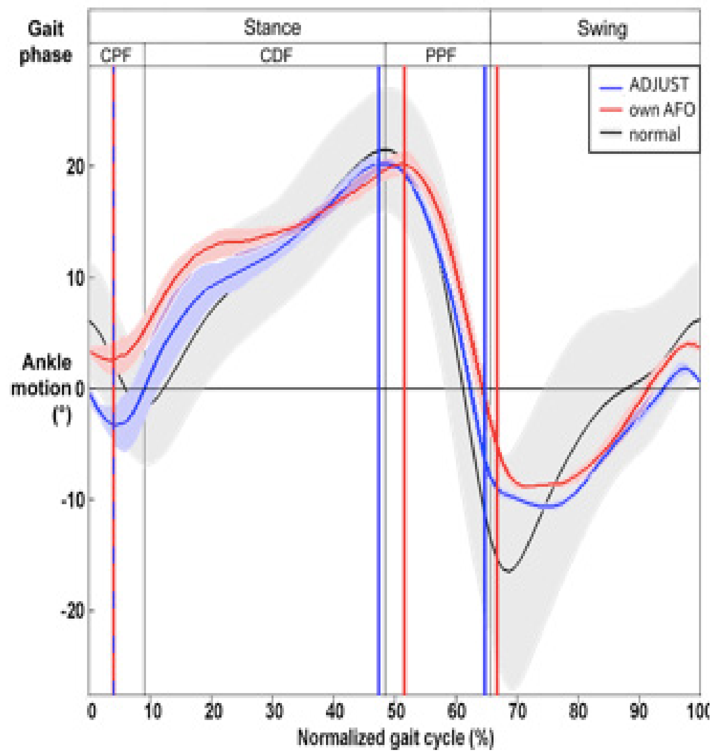


**Figure 1**. Typical ankle kinematics during walking down slope. CPF = controlled plantarflexion, CDF = controlled dorsiflexion, PPF = powered plantarflexion.

## DISCUSSION

ADJUST allowed more normal ankle ROM compared to patients own AFO especially during controlled plantarflexion. Allowing more normal plantarflexion ROM during controlled plantarflexion can decrease maximum knee flexion and consequently decrease energy consumption during down slope walking [4]. This beneficial effect of ADJUST on controlled plantarflexion ROM can also explain the beneficial effect on controlled dorsiflexion ROM. Maximum swing dorsiflexion was sufficient to provide clearance. Further improvements in ankle ROM are possible when optimizing ADJUSTs stiffness configuration per individual.

ADJUSTs weight and size could be reduced by implementing the function of its medial hinge into the lateral hinge. After improving ADJUST, future studies should compare ADJUST to existing hinged AFOs.

## CONCLUSION

Beneficial effects of ADJUST on ankle ROM were most prominent during controlled plantarflexion. Improving ADJUST should involve optimizing individual stiffness configuration, and weight & size reductions.

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# SUCCESS AND CHALLENGES IN TRAINING OF P/O PROFESSIONALS IN LOW INCOME COUNTRIES-TANZANIA EXPERIENCE

Author; Longini Mtalo

Affiliation; Tanzania Training Centre for Orthopaedic Technologists (TATCOT)

## BACKGROUND

The Tanzania Training Centre for Orthopaedic Technologists (TATCOT) was conceived in 1981 through joint collaboration between the Tanzania government and Germany government. The centre has existed for 35 years and it started with one academic programme (Diploma in Orthopaedic Technology) with enrolment capacity of fifteen (15) students. Among the first grandaunts included 9 first foreign trained P/O professionals and five (5) Tanzanians. In 2007 TATCOT had grown to five (5) academic programmes with approximately 105 students' population.

## AIM

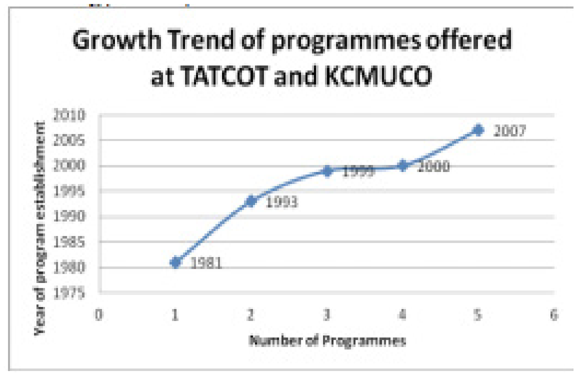
The aim of this paper was to explore the outcome and challenges of training activities at TATCOT since its inception and itsimpact in the professional carrier within Tanzania and beyond.

## METHOD

The information collected included data registry to all the programs that have existed at TATCOT since 1981 to 2015. In addition the graduates from the various programs and country of origin were evaluated with potential sponsors to the various students. Excel software was used to analyse data and results was presented in the form of tables and graphs.

## RESULTS

Since its inception (1981) to December 2015 TATCOT and KCMUCO had graduated a total number of 691. Of whom 116 were Cat I (BSc), 342 Cat II Diploma in Orthopaedic Technology (DOT),48 Lower Limb Orthotic Technology (LLOT),72 Lower Limb Prosthetic Technology LLPT, 68 Wheelchair Training Technology Course (WTTC) and 45 Spinal Orthotic Blended Learning( SOBL)




Growth trend of training programs at TATCOT

| | |
|---|---|
| Africa Continent | 658 (95.2%) |
| Outside Africa Continent | 33 (4.8%) |

Graduates statistics from Africa and beyond (1984-2015)

## DISCUSSION AND CONCLUSION

It is important to note that taking example of Diploma program since its inception was able to surpass its maximum enrolment capacity of 15 students in 1985/1988 and 1987/1990 respectively. In the other years Diploma program has not been able to reach this number that explains the school to enrol under capacity. The experience gathered over the years has been lack of potential sponsors to support students to attend programs at TATCOT. Over the years TATCOT has continued to recruit young teachers to take responsibilities to ensure continuous sustainability of training staff. However during the reporting period we have witnessed a total number of eight (8) teachers leaving TATCOT for greener pastures. Despite some of the huddles encountered over the 35 years we would like to mention that without the support from the government in ensuring that all staff salaries are coveredTATCOT would have not been able to survive if it were to depend on the tuition fees from students.

# ANALYSIS OF RESIDUAL LIMB'S HEALTH ISSUES RELATED TO DISCIPLINARY ACTION IN MAINTAINING RESIDUAL LIMB AND SILICONE LINER'S HYGIENE

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## BACKGROUND

For prosthetic users, the limitation of access to clean water source and use of correct soap to hygiene is an issue in Indonesia. The tropical climate deteriorates condition while snugly fitted socket excludes circulating air and traps the accumulated sweat against the skin. Perspiration can affect the skin to become dry and prone to damage. Maintaining residual limb and silicone liner's hygiene is crucial to prevent residual limb health issues.

## AIM

The objective of this study was to analyse the relation between residual limb's health issues and disciplinary action in maintaining residual limb and silicone liner's hygiene.

## METHOD

A cross-sectional survey was developed and distributed to prosthetic practitioners in Jakarta and Bali. Self-report with semi-structured interview method was used to collect the data. Fifteen transtibial amputees were chosen after several assessments including residual limb health issues with previous prostheses. Pilot test carried out to develop the instrument whereby the questionnaires were parted into three key themes; residual limb's health issues and disciplinary action in maintaining residual limb and silicone liner's hygiene. All three keys were coded and analysed to determine any statistically significant correlation among the group samples.

## RESULTS

The response codes defined all three key themes; residual limb health issues and disciplinary action in maintaining residual limb and silicone liner's hygiene including time used per day, frequency of washing residual limb and silicone, method used to wash residual limb and silicone. All these factors contributed development of residual limb issues; residual limb odor, dry skin, skin rash, ingrowth skin, blister, fungi (p_value=0.00 with 95% CI). Most of the participants wore prosthesis < 8 hours a day (53.3%), > 8 hours (13.3%), and (33.3%) ≥ 10 hours to do daily activity. According to data showing in Table 1, probability of developing blister and ingrowth skin associated with maintaining residual limb and silicone liner's hygiene.

**Correlation between residual limb health issues and disciplinary action in maintaining residual limb and silicone's hygiene**

| | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| Residual limb odor | Between Groups | 1.667 | 2 | .833 | 1.765 | .213 |
| | Within Groups | 5.667 | 12 | .472 | | |
| | Total | 7.333 | 14 | | | |
| Dry skin | Between Groups | 2.833 | 2 | 1.417 | 1.777 | .211 |
| | Within Groups | 9.567 | 12 | .797 | | |
| | Total | 12.400 | 14 | | | |
| Skin rash | Between Groups | 2.167 | 2 | 1.083 | 1.207 | .333 |
| | Within Groups | 10.767 | 12 | .897 | | |
| | Total | 12.933 | 14 | | | |
| Ingrowth skin | Between Groups | 2.967 | 2 | 1.483 | 3.734 | .055 |
| | Within Groups | 4.767 | 12 | .397 | | |
| | Total | 7.733 | 14 | | | |
| Blister | Between Groups | 4.967 | 2 | 2.483 | 4.404 | .037 |
| | Within Groups | 6.767 | 12 | .564 | | |
| | Total | 11.733 | 14 | | | |
| Fungi | Between Groups | 1.067 | 2 | .533 | 2.400 | .133 |
| | Within Groups | 2.667 | 12 | .222 | | |
| | Total | 3.733 | 14 | | | |

**Table 1.** Correlation between residual limb's health issues and disciplinary action in maintaining residual limb and silicone liner's hygiene

## DISCUSSION & CONCLUSION

Most of the participants were discipline in maintaining residual limb and silicone liner's hygiene (66.7%), very discipline (13.3%). Only about (33%) participants who wore prosthesis ± 8 hours every day were fairly maintaining residual limb and silicone's hygiene. Blister (6.7%) and ingrowth skin (13.3%) issues associated with hygiene of residual limb and silicone defined bothersome. Maintaining residual limb and silicone liner's hygiene is crucial to prevent residual limb health issues.

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# MAIN FACTORS AFFECTING BRACE COMPLIANCE IN ADOLESCENT IDIOPATHIC SCOLIOSIS: A LITERATURE REVIEW

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**Background**:

Brace treatment is the most popular non-surgical treatment for adolescent idiopathic scoliosis (AIS). Efficacy of brace treatment is related on compliance.

**AIM**:

The aim of this study is review the main factors affecting compliance in AIS subjects using corrective spinal orthoses.

**METHOD**:

The search was conducted in PubMed, Science direct, Medline and Scopus with the keywords: compliance, brace wear time, adolescent idiopathic scoliosis, brace treatment and efficacy of brace treatment. Inclusion criteria were English language, compliance and adolescent idiopathic scoliosis in title and keywords and use of spinal braces as AIS treatment.

**RESULTS**:

Based on the inclusion criteria, 17 identified articles were included that were published between 1988 and 2016. They have reported that there is positive correlation between compliance and correction of Cobb angle. 12 articles founded kind of brace was clearly affecting compliance. 2 articles were revealed the difference between of daily/night wearing and have contradictory results. There were 3 articles which have same results on negative relationship between age and compliance.

**DISCUSSION & CONCLUSION:**

Satisfaction of patients and their psychological profile, type of braces, daily treatment regimen and age are main factors affecting compliance. Wear-time report gives researchers information about deal of satisfaction of patients and provides opportunity to solve low wear-hours.

Finally it will be made perfect brace treatment plan which include proper brace based on patient`s condition, suitable instrument for report daily compliance and appropriate psychological scheme.

# OPTICAL 3D SCANNER ANALYSIS OF CHEST WALL FORM, VOLUME, AND MOBILITY IN LONG TERM FOLLOW-UP OF EARLY ONSET SPINE DEFORMITY

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## BACKGROUND

Severe spine deformities cause restrictive respiratory insufficiency due to asymmetry and stiffness of the chest wall. An important goal of the treatment is to guard the volume and mobility of the chest wall. A method to register the changes of the natural course over time and the treatment dependent changes should be able to give comparable values irrespective of age, body size, and length of the follow-up. For repeated monitoring a non-radiation method is preferred. A commercially available optical 3D scanner was earlier tested on scoliosis patients and found to be applicable, though more work was needed to improve the measurement accuracy (ref 1).

## AIM

The aim was to analyze if the optical 3D scanner method could capture restrictive respiratory changes and describe the abnormalities in congruity with more invasive examinations.

## METHOD

A set of four optical 3D scanners Artec3D® (Artec Group, San Diego, CA) were used to digitize 3D shape of thorax during inspiration and expiration. Captured data were used to quantify the breathing related volume differences in inspiration and expiration separately on the left and right body side and visualize their locations. The scanning was added on in a group of 24 patients as a part in a larger project including standard x-ray, computed tomography, pulmonary function tests, clinical examination, questionnaire of quality of life in a long term follow up of patients with early onset spine deformity. A control group, examined with the scanner, and standardized for age and body mass index, were included.

## RESULTS

The results of the control group were consistent: there was a significant difference in volumes between inspiration and expiration. There were no significant differences between right and left side in volumes nor in volume changes in inspiration respective in expiration. Thus, the controls did not show any asymmetry in volume nor in volume changes, as expected and which approves the potential of the method to be applied for the aimed purpose. The patient group showed significant difference in volumes between inspiration and expiration. They also showed a significant difference in volumes between right and left sides, thus documenting a quantifiable asymmetry between the right and left lung volumes in scoliotic patients. The volume difference within inspiration respective expiration was not significant. There was no obvious correlation between the asymmetry indices and the type or size of the deformity, which might have been confounded by the fact that many of the patients had been surgically treated

## DISCUSSION & CONCLUSION

Thorax asymmetry is an important parameter in evaluation of scoliosis deformity prevention and treatment. The current method has potential to quantify thorax respiratory volume changes, it is fast to carry out and includes no radiation. The measurement accuracy is expected to improve when used in pediatric population due to slender body contours, and when improving the pattern adjustments.

## REFERENCES

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# A MATHEMATIC SIMULATION OF HYDRAULIC FOOT SYSTEM: EFFECT OF DIFFERENT AXIS POSITIONS

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, Martin Pasurka [1]

[1] Streifeneder ortho.production GmbH; Germany

**BACKGROUND**

In recent years, the use of prosthetic feet with hydraulic joint increased. Different studies showed advantages compared to conventional feet [1,2]. In earlier studies, the complex deformations of prosthetic feet were shown by analyses of their rollover shapes (RoS) [3, 4, 5]. The complex interaction of the carbon spring and the hydraulic system is not able to measure sufficiently in the gait analysis or RoS-test bench. This new study evaluates whether a hydraulic foot with different axis positions can be simulated with a mathematic model. Therefore, different axis positions are simulated to compare their effects.

**AIM**

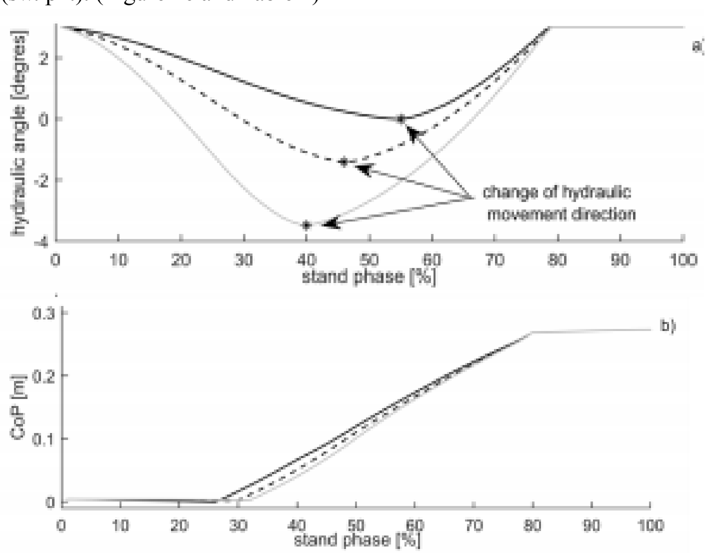
The aim of this study is to evaluate whether the hydraulic foot can be simulated mathematically and the effect of different axis positions.

**METHOD**

The foot is tested virtually; based on ISO22675(P5). Using the force reaction on the foot, the spring deformation and hydraulic movement can be calculated.
The position of the hydraulic rotation axis is defined 0.08m above the ground and successively moved to 25 %, 33% and 50% in front of the heel. By iteration of the hydraulic resistance is adjusted; so that the heel yields a defined value of 0.017m and the foot reaches the dorsal limit stop during the second power maxima. Based on the spring deformation and the hydraulic movement, the Center of Pressure (CoP), the RoS and the best-fit circle can be calculated.

**RESULTS**

An axis in the back causes more plantar flexion in the joint, and changes the direction of movement earlier (Figure 1a). A rear positioned axis causes the movement of the CoP to start earlier. The CoP moves slower, but is still ahead of the axis which is more in the front (Figure 1b) all the time. A rear axis position causes more dorsiflexion during swing phase (sw. ph.). (Figure 1c and Table 1)



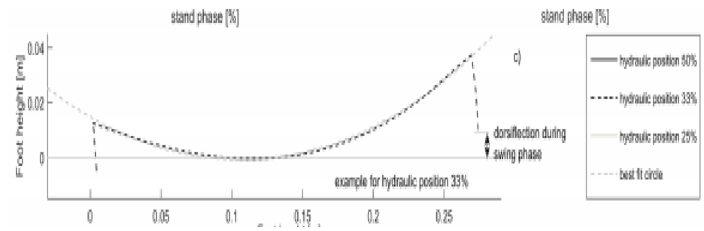




**Figure 1:** Difference between different axis positions by a) hydraulic angle and b) CoP. c) Exemplary calculated RoS with best-fit circle. A rear axis position causes a smaller radius by calculating the best-fit circle (Figure 1c and Table 1)

| Axis position [%] | 25 | 33 | 50 |
|---|---|---|---|
| Radius of best-fit circle [m] | 0.418 | 0.372 | 0.363 |
| Sw. ph. dorsiflexion [m] | 0.011 | 0.010 | 0.007 |
| Hydraulic axis movement change [% Stance phase] | 55 | 46 | 40 |
| hydraulic movement [deg.] | 3.007 | 4.441 | 7.485 |

**Table 1:** Numerical results from different axis positions.

**DISCUSSION & CONCLUSION**

Different axis positions could simply be simulated. The results show some significant differences between the simulated axis positions. The simulations have shown the positive effect of the toe lift during swing phase. A rear axis position enlarges this positive effect. This contrasts with the foot radius tending to decrease. This makes the foot rather unsafe or must be compensated by a harder base - which would cause less movement in Carbon and a decreased energy return. It is believed that patients with low activity benefit more from a rear positioned axis, because they endure less return of energy for having more ground clearance. A slower CoP movement is seen by smaller radius. This is confirmed
by a study which compares the CoP- Velocity and the roll over shape [6]. Further investigation is needed, to verify if the calculation conform to reality.

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# ADAPTATION RATE IN THE TREATMENT OF STIFF FINGERS AND HABITUAL TOE WALKERS

Bob Giesberts

## BACKGROUND

In the treatment of stiff fingers and habitual toe walkers (HTWs) stretching the tissues plays an essential role, and is accomplished by a splint or plaster casting. The longer a joint is held in its end range, the greater the improvement in range of motion [1]. However, over time the tissues adapt so the joint is no longer in its end range and effective correction ends. We hypothesize that correction stops long before the next weekly treatment session.

## AIM

The aim is to determine tissue adaptation rates in treatment of stiff fingers and HTWs, thus benefitting treatment of contractures through a better understanding of the biomechanics during correction.

## METHOD

This is a descriptive observational study for which a custom made force sensor is developed. The sensor is placed in the hand splint (stiff fingers) or within plaster casts (HTWs). Patients with an open wound are excluded. The skin-splint/cast interface force is measured (at 15 Hz) and stored locally for periods of 30 seconds every 15 minutes. The data is retrieved when the patient returns to the clinic. An exponential function is fitted over this data using Matlab to describe the decrease in force and to determine the adaptation rate of the specific tissues.

## RESULTS

The first stiff finger-patients are scheduled for measurements. The preliminary results of measurements with three HTWs (age 7 - 15) are presented in Figure 1. An initial force of 15 – 35 N was applied by the practitioner and after two weeks dorsiflexion increased with 10° – 15°. In these initial results the force seems to decrease rapidly over the first few hours before reaching an equilibrium. Mean half-life time was calculated to be 3 – 11 hours. Extrapolating this result suggests that 95% of the adaptation was realized within the first 12 – 48 hours. Results of further measurements during treatment of both stiff fingers and HTWs will be presented at ISPO2017.

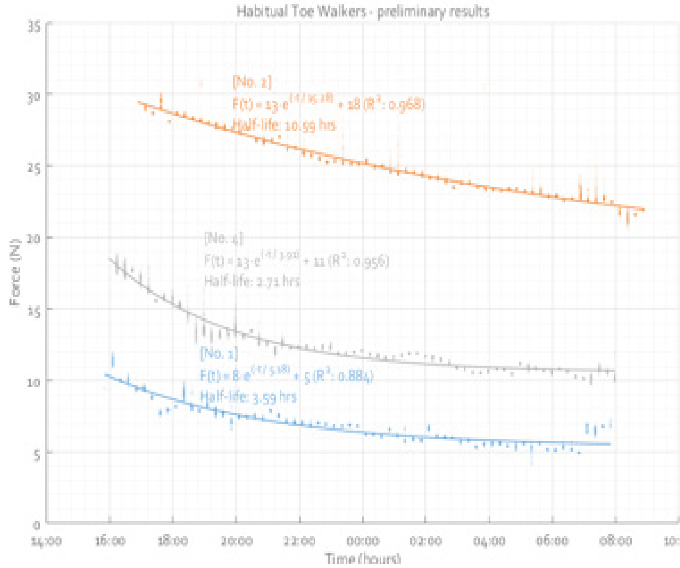


Figure 1. Measured force in the treatment of three habitual toe walkers.

## DISCUSSION & CONCLUSION

Reaching an equilibrium force within days suggests room for improvement in the treatment of HTWs. Instead of applying all correction in the first day, a more gradual correction using a dynamic brace might be more efficient and comfortable.

Further measurements with HTWs and Dupuytren patients will provide for a general model in the adaptation rate in the treatment of contractures.

## REFERENCES

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# PATIENT' SATISFACTION WITH LOWER-LIMB PPOSTHETIC AND ORHOTIC DEVICE AND SERVICE DELEVERY IN SIERRA LEONE AND MALAWI

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## BACKGROUND

People with disabilities have the right to personal mobility and available and affordable assistive technology, according to the Convention of Rights of Persons with Disabilities. Few studies have investigated overall satisfaction with prostheses fabricated using low-cost technology. Evidence-based recommendations for prosthetic and orthotic services in low-income countries are needed in order to more effectively provide services. Detailed analysis of variables which influence patient satisfaction with assistive devices are therefore of significance to investigate for improving of clinical rehabilitation practice.

## AIM

The aims were to investigate similarities and differences between Sierra Leone and Malawi concerning participants' mobility and satisfaction with their lower-limb prosthetic or orthotic device and related service delivery, and to identify variables associated with patients' satisfaction with assistive devices and associated services in the entire study group from these two low-income countries.

## METHOD

This is a cross-sectional survey study in two low-income countries with correlative and comparative design. Questionnaires, including QUEST, were answered by a total of 222 patients in Sierra Leone and Malawi.

## RESULTS

Eighty-six per cent of assistive devices were in use, but half needed repair. One third of participants reported pain when using their assistive device. A higher percentage (66%) of participants in Sierra Leone had difficulties or could not walk at all on uneven ground compared with 42% in Malawi. The majority in both countries had difficulties or could not walk at all up and down hills, or on stairs. Participants in both countries were quite satisfied (mean 3.7–3.9 of 5) with their assistive device. Participants were most dissatisfied with: comfort (46%), dimensions (39%), and safety (38%) of their assistive device. In Sierra Leone participants were less satisfied than in Malawi with service delivery (mean 3.7; 4.4, $p<.001$). Access to repairs and servicing of their assistive device was considered the most important item. In Sierra Leone patients were less satisfied with follow-up services (41%) than patients in Malawi were (22%). The significant association with satisfaction with assistive device was pain, general condition of the device, ability to walk on uneven ground/roads, ability to walk on stairs, and ability to get in and out of a car. The significant association with satisfaction with service was general condition of the device, ability to walk on uneven ground, ability to pay for costs associated with receiving the service appliances, accommodation, travel, and ability to walk on stairs.

## DISCUSSION

Implications of the results is that the design and manufacture of prostheses and orthoses using low-cost technology needs be improved, specifically towards appropriate dimensions, increased comfort, and increasing the ability of patients to ambulate on challenging surfaces with their assistive device, as well as increasing patients' ability to walk long distances with reduced pain. Increased or simulated ankle joint range of motion, careful dynamic alignment, more optimal dimensioning of assistive devices, and better training could facilitate the desired improvements. Access to repairs and follow-up services were important to participants, and should be addressed both by professionals operating within the rehabilitation field and policymakers, as it has the potential to improve mobility and satisfaction levels as well as reduce pain. The quality of assistive devices and service delivery could be enhanced by addressing the education level of staff.

## CONCLUSION

Participants reported high levels of use and mobility with their assistive device, in spite of pain and difficulties walking on uneven ground, which were also associated with the level of satisfaction with the assistive device. More than half of the assistive devices were in need of repair. Access to repairs and follow-up services were the most important to patients, and should be addressed. Country was associated with satisfaction with service, with participants in Sierra Leone significantly less satisfied.

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# PROFESSIONALS PERSPECTIVE OF PROSTHETIC AND ORTHOTIC SERVICE IN TANZANIA, MALAWI, SIERRA LEONE AND PAKISTAN

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## BACKGROUND

In order to implement the CRPD, the quality of prosthetic and orthotic services in low income countries is of concern. Little research related to prosthetics and orthotics in low-income countries was available, including outcomes related to the provision of orthotic devices and related service delivery. Therefore aspects related to quality of prosthetic and orthotic services have been investigated in this paper comparing findings from four low and middle income countries.

## AIM

To compare findings related to experiences of prosthetics and orthotic service delivery and education in Tanzania, Malawi, Sierra Leone and Pakistan, from the perspective of local professionals.

**Table 1:** Common and unique themes in Tanzania, Malawi, Sierra Leone and Pakistan

| Themes | Sub-themes from Tanzania and Malawi [1] | Sub-themes from Sierra Leone [2] | Sub-themes from Pakistan [3] |
|---|---|---|---|
| **Themes common to Tanzania, Malawi, Sierra Leone and Pakistan** | | | |
| Low awareness and prioritising of prosthetic and orthotic services. | • *Varied support from senior staff and other professionals.<br>• Low-status profession.<br>• Helping people with disabilities is the motivation. | • Low priority on the part of government.<br>• *Appraisals of work satisfaction and norms. | • Low awareness of prosthetic and orthotic services. |
| Difficulty managing specific pathological conditions and problems with materials. | • Lack of materials. | • Problems with materials and machines. | • Management of specific pathological conditions and administrative duties are most difficult for graduates. |
| Limited access to prosthetic and orthotic services available. | • Different demands when working in underserviced and less resourced setting. | • Limited access to the prosthetic and orthotic services available.<br>• *Appraisals of work satisfaction and norms. | |
| The need for further education and desire for professional development. | • Desire for continued training.<br>• *Varied support from senior staff and other professionals.<br>• Suggested ways of keeping updated. | • Desire for professional development. | • Currently varied opportunities for professional development<br>• Well-functioning support from senior staff.<br>• Prosthetists/Orthotists would like to specialise.<br>• A desire for networking within the country and interaction from outside. |
| **Themes unique to Sierra Leone** | | | |
| People with disabilities have low social status in Sierra Leone. | | • Low public awareness concerning disabilities.<br>• Patients neglected by family.<br>• Marginalisation in society. | |

**Subthemes divided into different themes*

## CONCLUSION

The perspective of local professionals was that they had a sense of inability to deliver high-quality prosthetic and orthotic services. Educating prosthetic and orthotic professionals to a higher level and providing opportunities for professional development was desired. Low awareness and low priority on behalf of the government when it comes to prosthetic and orthotic services was identified as a barrier to providing effective rehabilitation. In Sierra Leone, people with a disability needed to be included to a greater extent and supported at different levels within families, communities, government, international organisations, and society in general. Traditional beliefs about the causes of impairment and difficulties in accessing services were identified as barriers to providing effective rehabilitation services.

## METHOD

In total 49 prosthetists/orthotists and prosthetic/orthotic technicians participated from four countries. A comparative analysis of the results of the three studies [1, 2, 3] was conducted. The analytical approach used was a second ordered concept analysis where subthemes, categories and conceptions were aggregated into themes.

## RESULTS

Four common themes emerged and one theme was found to be unique to Sierra Leone see Table 1

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# PERCEIVED ORTHOTIC FUNCTION AND DIFFICULTY OF ACTIVITIES OF DAILY LIVING WITH THE C-BRACE AND CONVENTIONAL KAFOs.

Andreas Kannenberg

## BACKGROUND

Over many centuries, locked knee ankle foot orthoses (LKAFO) have been the standard of care to restore walking capability in patients with paretic lower limbs. They allow for walking with a stiff orthotic leg and require a multitude of compensatory movements. Stance control orthoses (SCO) rigidly lock for stance phase and unlock to allow for free swing, resulting in a more physiologic gait pattern (1,2). However, SCOs deliver their benefits mainly in level walking (3). The microprocessor controlled hydraulic C-Brace® enables patients to reciprocally descend slopes and stairs and walk on uneven terrain (4).

## AIM

This study aimed at investigating the perceived orthotic function and difficulty of activities of daily living (ADL) of previous LKAFO und SCO users.

## METHOD

For KAFO/SCO use no validated outcome measures exist. Therefore the Prosthesis Evaluation Questionnaire (PEQ) was modified for orthosis users, creating an Orthosis Evaluation Questionnaire (OEQ) administered at baseline for the existing orthosis and after 3 months of use of the C-Brace (Otto Bock HealthCare, Duderstadt/Germany) to assess perceived orthotic function. In addition, an ADL questionnaire previously used in a prosthetic study (5), surveying the perceived difficulty to perform 45 ADLs was used at baseline and follow-up. Statistical analysis was conducted using the Wilcoxon signed rank test with a power of 80%.

## RESULTS

Thirteen patients (9 male, 4 female, mean age 67.7±14.6 yrs) were enrolled in the study. Eight patients were polio survivors, 3 patients had an incomplete spinal cord injury, one had a femoral nerve lesion and one a stroke. Five patients used an LKAFO and 8 patients an SCO when entering the study. The total OEQ score for orthotic function was significantly higher for the C-Brace as compared to the conventional orthoses combined (p=.02) as were the scores for the subdomains of ambulation (p=.001), paretic limb health (p=.04), well-being (p=04), and sounds (p=.02). In previous SCO users, there was a significant benefit of the C-Brace in the subdomains of ambulation (p=.01) and paretic limb health (p=.04). In previous LKAFO users, a significant benefit of the C-Brace was seen in the subdomains of ambulation (p=.04). In the ADL questionnaire, the set of activities was rated to be important to very important to the patients´ lives. Compared to all previous orthoses combined, the categories family and social life (p=.01), mobility and transportation (p=.002), sports (p=.02), and other activities (p=.03) were rated significantly easier to perform with the C-Brace. Previous SCO users rated activities of mobility and transportation (p=02), previous LKAFO users activities of family and social life (p=.04), mobility and transportation (p=.04), and other activities (p=.04) easier to perform when using the C-Brace. Analyzing each of the 45 ADLs, a significantly easier rating (p<.05) was found in 22 activities when all conventional orthoses were combined. In the subgroup of SCO users, 4 ADLs requiring knee flexion during weight bearing and 1 ADL related to variable gait speed were significantly easier to perform with the C-Brace; another 13 ADLs showed a statistical trend with p≤.09. In the subgroup of LKAFO users, 12 ADLs were significantly easier to do when using the C-Brace; another 9 ADLs presented a trend (p≤.09) towards easier execution.

## DISCUSSION & CONCLUSION

Knee flexion during weight bearing as provided by the C-Brace (4) is necessary for reciprocal stair and slope descent as well as walking on uneven terrain. The present survey suggests that the novel orthotic functions of the C-Brace result in significantly improved perceived orthotic function and ease of execution of many ADLs. It confirmed that SCOs deliver their benefits mainly in level walking, resulting in the biggest improvements seen with the C-Brace on uneven terrain, stairs, and slopes. In contrast, previous LKAFO users benefit from the C-Brace in walking on all kinds of terrains. The study has shown that the C-Brace® may improve perceived orthotic function and ease of execution of many activities of daily living as compared to the use of SCOs or LKAFOs.

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# FACTORS THAT INFLUENCE ACCEPTANCE AND REJECTION OF AN UPPER LIMB PROSTHESIS: A REVIEW OF THE LITERATURE.

Andreas Kannenberg

## BACKGROUND

Clinicians and health insurances are well aware of the fact that many patients with upper limb (UL) amputations reject their prosthesis in the mid- to long run (1). Factors that influence acceptance and rejection of an UL prosthesis are much less understood. If such factors and their impact were known, they could be leveraged to improve the acceptance of UL prostheses and the function and quality of life of persons with UL amputations.

## AIM

The aim of this study was to identify factors that influence acceptance and rejection of a prosthesis by subjects with an UL amputation in the scientific literature. The results may help clinicians improve acceptance of UL prostheses.

## METHOD

A search of the scientific literature was performed in the Medline, Embase, CINAHL, OTseeker, and PEDro databases as well as in the online library of the Journal of Prosthetics & Orthotics. Search terms were related to UL amputations and prosthetics, acceptance, use, rejection and abandonment of UL prosthesis. Identified references were evaluated for pertinence to the subject and analyzed.

## RESULTS

Five pertinent publications were found. Malone et al. (3) suggested a “golden window” of 30 days after the amputation for the fitting of an (interim) UL prosthesis for occupational therapy. They found that all patients who received a prosthesis within this “golden window” were able to return to work, whereas only 15% of patients fitted after more than 30 days did so. In addition, patients fitted within the “golden window” did not present any striking preference for body-powered or myoelectric prostheses, irrespective of the first type of prosthesis fitted. They chose the prosthesis type objectively best suited for their everyday needs, whereas patients who were fitted later almost exclusively preferred myoelectric prostheses (3). Another study (2) found that definitive prosthesis fitting within 6 months of the amputation or 2 years after birth in congenital deformities increased the likelihood of prosthesis acceptance (odds ratio) by factor 16. The second biggest variable was the involvement of the patient in the selection of the type of prosthesis. Intense patient involvement in prosthesis selection increased the likelihood of acceptance by factor 8. Also, very young (<4 y), middle-aged (36-50 y), and older patients (>60 y) were 7 times more likely to accept an UL prosthesis than patients in different age groups. Patients with transradial amputations were more likely to accept a prosthesis than patients with more distal or proximal levels of limb absence (2).

## DISCUSSION & CONCLUSION

Patients should be fitted a functional prosthesis for occupational therapy as soon as medically possible, ideally within 30 days after the amputation to prevent them from learning to manage their everyday lives with their sound hand alone. Definitive prosthesis fitting should occur within 6 months of the amputation or 2 years of birth in case of congenital deformities for the same reason. Patient involvement in prosthesis selection is a very important factor that improves prosthesis acceptance. Patients involved in prosthesis selection are 8 times more likely to accept their UL prosthesis than those not involved in clinical decision making. These important factors may be considered and influenced by clinicians and health insurances to improve the outcomes of UL prosthesis fitting, prosthesis acceptance, and everyday prosthesis use.

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# EVALUATION OF THE REHABILITATION PROGRESS OF TRANSFEMORAL LIMITED COMMUNITY AMBULATORS USING A CUSTOM TAILORED MICROPROCESSOR CONTROLLED KNEE

Malte Bellmann

## BACKGROUND

When microprocessor controlled knee joints (MPK) were introduced in the nineties, the targeted user groups initially were active users that could profit from new knee functions like speed adaptation through swing control. Since then a continuously growing user group of less active users has established. On the one hand they profit from the high safety level MPKs provide, on the other hand they use a wide range of enhanced MPK functions to support their ADLs, such as intuitive standing or sitting down support.

## AIM

The aim of this case study is to get a better understanding of the individual gain that K2 transfemoral amputees may receive by fitting with a novel MPK that is tailored to their rehabilitation process.

## METHOD

2 transfemoral amputees (1 unilateral, 1 bilateral) were involved. Satisfaction and performance with their everyday prosthesis was documented (video, questionnaire, biomechanical measurements (unilateral only): level walking, 5° incline walking, sitting down). For the measurements a stationary gait analysis system with 12 Vicon Bonita cameras and 2 Kistler force plates was used. After this baseline study the subjects were fitted with a novel MPK. The MPK has 4 different modes locking or unlocking knee functions depending on the user's individual needs when progressing in rehabilitation. The fitting process comprised 6 training sessions with a dedicated physiotherapist over 4 weeks for a guided rehabilitation process. After 12 weeks the satisfaction and performance was documented again. There was a final follow up after 6 months.

## RESULTS

Both subjects reported high satisfaction from the first day of fitting with the novel MPK, profiting from high safety and functional gain. After 2 weeks the training success was clearly visible in their gait pattern and both reported an extended range of activities in their daily living. Biomechanical measurements after 12 weeks of use showed clear benefits, too. Such as higher self-selected walking speed, better step symmetry, relief of the contralateral side when sitting down and better knee and hip movements when walking 5° downslope since (using stance flexion function of the MPK vs. extended knee pattern when walking with mechanical brake knee of his every day prosthesis). By the time of the six months follow up the unilateral user evolved into a K3 ambulator.

## DISCUSSION & CONCLUSION

In patient care routine there is often a wide functional gap between very limited K1/K2 ambulators and high functioning MPKs at higher costs. On the one hand there is the risk the K1/K2 might not utilize most of the functions, on the other hand the rehabilitation of many low functional persons is limited by their components. This novel MPK concept of shiftable functions that support the individual demands can close the functional gap and shows an impressive rehabilitation progress for both subjects.

# PERFORMANCE AND SATISFACTION WITH INTUITIVE MULTIFUNCTIONAL HAND PROSTHESIS CONTROL

MartinWehrle

## BACKGROUND

Myoelectric control has been used for decades to control powered upper limb prostheses. It has been employed to control a single prosthesis degree of freedom such as closing and opening of the hand1. If wrist rotation is desired, amputees must co-contract their forearm muscles to switch into this mode; the same signals are then used to control the wrist rotator2. Users often rate switching to different modes as slow, cumbersome and not intuitive2. Technology pattern recognition has been identified as promising solution to solve this problem3, however commercial availability is still rare. Pattern recognition-based control functions in a fundamentally different way than conventional, myoelectric control. Instead of relying on two manually chosen electrode sites to control a single degree of freedom, pattern recognition uses many electrodes and intuitive movement mapping to control several movements seamlessly. This provides better prosthetic control with less cognitive burden.

## AIM

The aim of this exploratory feasibility study is to test the performance and satisfaction of transradial amputees as well as to obtain feedback from certified prosthetists and trainers when transitioning from prosthetic systems with conventional control to the equivalent system with pattern recognition control.

## METHODS

Transradial amputees currently wearing prosthetic systems with conventional control and fulfilling inclusion criteria (older than 18 years; a unilateral trans-radial amputee with stabilized residual limb; currently fitted with conventional prosthetic hand system with active wrist rotation; willing and able to independently provide informed consent, to comply with study procedures, to use the provided prosthesis, to wear interventional prosthesis exclusively at least 6 h/day for a period of one month) will be enrolled in the study. After recruiting and obtaining the informed consent, demographic, anthropometric, baseline and clinical information will be collected. Afterwards the participant will undergo a structured learning process guided by a trainer to assure optimal control of the pattern recognition prosthesis. The participant will be allowed to take and use the prosthesis at home when (1) the participant is capable to successfully control the prosthesis with distinguishable and repeatable patterns, (2) fulfills training tasks successfully and (3) acknowledges that he is comfortable with the prosthetic control. Each user will undergo functional assessment 4 times: 1) With his own prosthesis 2) With the pattern recognition endowed prostheses straight after fitting and 3) after 1 month of home use and 4) again with his traditionally controlled prosthesis (after a sufficient re-familiarization phase). The functional assessment is comprised of performance based (Modified Box and Blocks test, Clothespin Relocation and Proportional Control Test) and self-reported tests (Disabilities of the Arm, Shoulder and Hand, project specific questions, user´s preference of the prosthetic system). Additionally the certified prosthetists manufacturing the participants' prostheses will give their feedback about the entire fitting process. The concept and efficiency, as well as the ease of use of training method will be rated by the trainers involved in this study.

## RESULTS

The study is currently in recruitment phase. The fittings with pattern recognition devices are planned in November 2016, the first study results are expected by the beginning of 2017. The study should be finalized and data collected by May 1st 2017.

## DISCUSSION & CONCLUSION

The majority of previous pattern recognition studies have been performed on non-amputee subjects and only virtual arms had been controlled with pattern recognition systems and not the real prosthesis. Therefore, tests have only been conducted in controlled, laboratory environments. Home-use of such devices has not been studied yet with transradial amputees. In this study, extensive feedback from users, who have the possibility of testing the system at home for four weeks, will be gathered. Clinical outcome measures will provide quantitative data. Additionally, feedback from orthopedic technicians and trainers will help to direct product development in a customer oriented fashion.
The results and experiences obtained in this study will lead to an optimized product development and at the same time advance our scientific understanding of the challenges and benefits of advanced prosthetic control.

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# PATTERNS OF BONY DEFORMITY FOLLOWING TRANSTIBIAL AMPUTATION DUE TO SEPTICAEMIA.

M Geada, M McAlinden, Dr D Hoad, Dr I Sedki, Mr Peter Calder, Professor R Hanspal

Royal National Orthopaedic Hospital, London

## BACKGROUND

It is recognised that, following meningococcal septicaemia, there is epiphyseal growth plate disturbance. Bradish et al. (2011) have described the deformities and their management. However, in people who have had an amputation, these deformities are likely to affect prosthetic rehabilitation.
Aim: The purpose is to understand the pattern and assist in prosthetic fitting.

## METHOD

This study is a retrospective review of 8 transtibial amputees (10 transtibial amputations) before the age of skeletal maturity, who had an amputation following life threatening septicaemia. There were 5 boys and 3 girls with ages ranging from 4 to 14years. All children were under regular review and follow up for their prosthetic maintenance and required X-rays because of obvious physical deformities and associated symptoms. All X-rays were reviewed.

## RESULTS

Only one child with bilateral trans-tibial amputations showed no significant epiphyseal growth plate disturbance but had bony overgrowth requiring revision surgery in both his residual limbs. He also showed fusion of the distal end of the tibia with the fibula. All other children showed significant growth plate disturbance with premature closure of the tibial epiphyseal growth plate associated with overgrowth of the fibula. Notably 4 children showed that the premature closure of the physis was on the medial side leading to a varus deformity. One child had fused epiphysis in the antero-medial aspect leading to a valgus deformity associated with genu recurvatum. All had partial arrest of tibial growth on the medial side and associated overgrowth of the fibula.

## DISCUSSION & CONCLUSION

There seems to be a remarkable consistency in the pattern of the deformity that develops in these patients and this has not been recognised in previously published literature. We suggest two possible reasons for this:

- The anatomy of suggests that the fibula has a more secure arterial supply and thus the epiphysis is protected compared to the tibia.

- Another hypotheses would be the consequence of the 'Wolff's Law' that states that bone adapts to the load that it is subjected to and the 'Hueter-Volkmann Law' that proposes that growth is retarded by increased mechanical compression (Stokes I.A.F., 2002) and accelerated by reduced loading in comparison with normal values.

All X-rays showed a varus deformity to some degree and that would have subjected the medial side of the epiphyses to greater load leading to premature closure of the medial side of the physis. This may also explain why one patient did not show epiphyseal growth disturbance as he was largely dependant on his wheelchair for his mobility and did not load his knees. One would of course need to monitor his bony development as his mobility with prostheses progresses. The importance of recognising the growth plate disturbance and the subsequent pattern of deformity as described above is to assist in prosthetic socket fit and maintenance. This will help identify the need for regular assessments and for planning any surgical intervention, if and when required to assist prosthetic mobility.

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# EVALUATING THE POTENTIAL SYNERGISTIC BENEFIT OF A DYNAMIC REALIGNEMENT BRACE ON PATIENTS RECEIVING EXERCISE THERAPY FOR PATELLOFEMORAL PAIN SYNDROME - A RANDOMIZED TRIAL (DRKS-ID: DRKS00003291)

Ingo Volker Rembitzki

## BACKGROUND

Several studies suggest that patella maltracking probably plays a role in the pathogenesis of patellofemoral pain syndrome (PFPS). Exercises can be a causal therapeutic approach for PFPS because dynamic valgus probably plays a key role for the pathogenesis of PFPS. It has been previously shown that exercise programs PFPS can be supported by medially directed taping. Evidence supporting the use of patellar braces is limited because previous studies have been low quality.

## AIM

The aim of this study is to evaluate the effect of a new realignment brace on patients with PFPS who were treated with physiotherapy.

## METHOD

This study is a randomized multicenter clinical trial examining the effectiveness of a dynamic patellar brace in combination with exercise on short and long term PFPS outcomes compared with exercise alone. Inclusion criteria consisted of a patient age between 18 and 50 years and the presence of PFPS symptoms lasting longer than 2 months but not longer than 2 years. Outcome measures for this study were Kujala score, KOOS, and pain on VAS measured at 6, 12, and 54 weeks following the start of therapy.

## RESULTS

For the primary outcome measure (recovery) no significant group difference could be found at any time point. However, significant lower limb pain was assessed while climbing stairs or playing sports for the brace group compared to the non-brace group after 6 and 12 weeks. Significantly higher scores in the brace group could be detected for the KOOS pain, symptoms, activities of daily living (ADL) and quality of life (QoL) sub-scores at the 6- and 12-week time points. For the sports/recreational activities (Sport/Rec) sub-score, a significantly higher score could only be found after 12 weeks. After 54 weeks, significant group differences could only be found in the ADL sub-score. For the Kujala score between-group differences could be detected at 6 and 12 weeks.

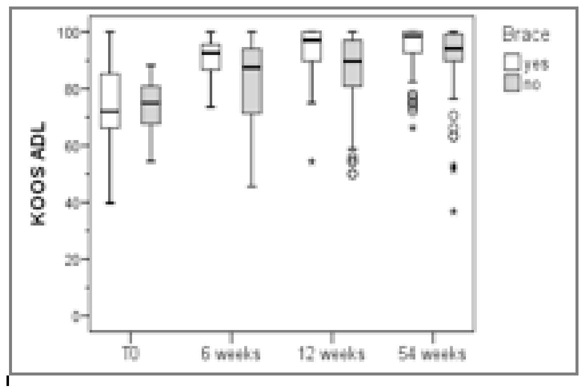


**Figure 1.** KOOS ADL at 6, 12, and 54 weeks after begin of treatment.

## DISCUSSION & CONCLUSION

The clinical results of this RCT are in accordance with a recent biomechanical study which has shown that the Patella Pro Brace improves lateral patella maltracking in patients with PFPS [1]. A limitation of the present RCT is that the study was not double-blinded. However, blinding to treatment was not possible. Despite this limitation, the results of this study allow us to make the conclusion that there is a synergistic effect of a patellar realignment brace and exercise for patients with PFPS.

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# FIRST RESULTS CONCERNING THE SAFETY, WALKING AND SATIFACTION WITH AN INOVATIVE MICROPROCESSOR-CONTROLLED 4-AXES PROSTHETIC FOOT

Andreas Hahn

## BACKGROUND

The innovative microprocessor controlled foot (Meridium, Ottobock) is a prosthetic component with adjustable stance phase characteristics. The hydraulic damping and the resulting range of motion are continuously controlled (real time) and adjusted by a microprocessor which receives sensor signals. The system adapts to variable walking speeds and cadences, adjusts to different heel heights and enables a neutral standing position on the ramps.

## AIM

The objective of this observational study was to investigate subjects´ and prosthetists´ perception of safety, walking and satisfaction with M during first routinely performed trial fittings.

## METHODS

Data from first routine trial fittings in a convenience sample of 86 subjects were retrieved in a prospective cohort design. Control was intra-individual to baseline assessment with the existing prosthetic foot of the participants. The first trial fittings began in November of 2014 and all trials were completed by May of 2015 in 44 prosthetic clinics across Europe, North America and Australia.. Data retrieved included information on baseline assessments, an interim follow-up (planned after 60 days of Meridium use) and at the end of the trial period (planned after 100 days of Meridium use). Questionnaires were provided to support data collection and to retrieve feedback from CPOs as well as the end users and referred to demography, fitting process, safety, ADLs, user satisfaction and preference. Descriptive analysis was performed on a pseudonomynized data set.

## RESULTS

Data on 70 users could be analyzed. Average M use was 106.3 (± 57.04) days. Users were mainly male (77%), mean age 45.6 years (± 13.7 years). Mean time since amputation was 13.9 years (± 13.6 years), amputation level was transtibial in 64% (TF/KD 36%) and mobility grade (MG) was MG3 in 63% and MG 4 in 37%. Amputation etiology included trauma (66%), tumor (13%) and vascular disease (13%). Prosthetic knees were C-Leg (44%), Genium (44%). Previous feet were mostly carbon fiber feet (93%). 89% of the subjects were satisfyingly fitted with Meridium within the first two visits. Acclimation period was reported as 1 day in 37%, 2 days in 15%, 3 to 7 days in 30% (> 8days in 15%) of subjects. Improvements were reported in level walking (by 54% of subjects), walking on uneven terrain (82%), ascending (97%), descending (91%) and standing on ramps (86%) (Figure 1). 53% of subjects preferred the toe clearance offered by Meridium. Ascending stairs with Meridium was favored by 37%, while descending stairs by 52% of users. Perceived safety during walking and standing was perceived as increased by more than 50% of users, respectively. No difference was observed in pain in residual and sound limb, as well as in concentration and exertion during walking between two prosthetic fittings. Amputation level, age, mobility grade and amputation level did not influence subject preference. Correlations could be detected in the TF group relating to the use of Genium ($\tau$= 0.617*) and to the length of the residual limb ($\tau$=0.453**).

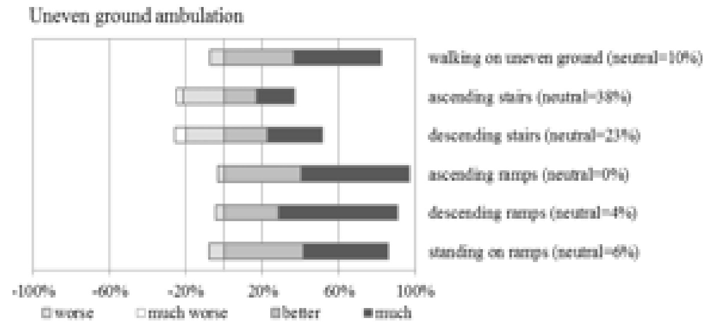


**Figure1:** Comparison of Merdium with previous fitting in terms of level ground ambulation, negotiation uneven trains and ramps.

## DISCUSSION & CONCLUSION

First fittings with Meridum showed the utilization of functional benefits in a distinct user population. Handling of the fitting by the prosthetist requires experience but has not been rated as being exceedingly challenging. Responders seem to be more recent amputees with a preference for natural walking and the requirements to safely and comfortably negotiate uneven terrain and slopes. While amputation level, age and general mobility grade seems to be of lesser distinguishing power, in TF amputees the use of Genium seems to significantly increase the potential of utilizing the functional benefits offered by the new component. The component seems to be less favored by users more sensitive to weight and those who prefer a high dynamic response of the component. Individual assessment and trial fitting seems to be essential to identify the most appropriate component.

Continued on next page

# FINAL REPORT OF AN OBSERVATIONAL STUDY WITH THE ANKLE FOOT ORTHOSIS AGILIUM FREESTEP

Ingo Volker Rembitzki

## BACKGROUND

Osteoarthritis (OA) is the most common form of joint disease. 6% of the U.S. population over the age of 30 years, or 9.7 million people, suffer fromsymptomatic OA of the knee. In patients with knee OA, the medial compartment is more affected than the lateral joint. New insights of biomechanics was the basis for the development of the Agilium Freestep1 AFO with a loadingshift mechanism of action.

Fig.1 Agilium Freestep

## AIM

The present observational study was initiated to gather survey data for a first evaluation of potential clinical benefits and risks of using this AFO for treating knee OA.The aim (or: purpose; or: objective; or: research question) is a concise statement of the goal, phrased in a precise way, that was targeted by this study.

## METHOD

Clinical Obervational Study to gather information on the potential medical benefits and risks of new AFO in 25 patients with unicompartimental knee OA grade 1-3 in a real-life out-patient clinical setting. Follow-up visits were scheduled after 3, 6, 9, and 12 months. The following parameters were captured in the visits: severity of knee OA using the Kellgren & Lawrence classification system,leg axis,affected side and compartment,previous treatment modalities, especially knee sleeves or braces, pain medication, WOMAC Score, ADL Questionnaire, VAS Scale,overall fit, handling and comfort,duration of the average daily use,adverse events of orthosis use.

## RESULTS

Out of the convenience sample of 25 patients enrolled, 15 patients were male and 14 patients female with a mean age of 60.5 ± 11.7 years. Fifteen patients had an OA of the left knee and 10 patients of the right knee. According to the classification of Kellgren scale 33% of Patients had grade 1 osteoarthritis, 55% had grade 2 and 12% grade 3. WOMAC total score demonstrated a statistically significant improvement when using the Agilium Freestep in all follow-up visits after 3,6,9 and 12 month compared to baseline, also significantly improved the WOMAC Pain, stiffness, functional, VAS subscores in all Follow ups visits.The analysis of patient responses clearly shows a reduction in perceived restrictions to the execution of ADLs over time when using the Brace.

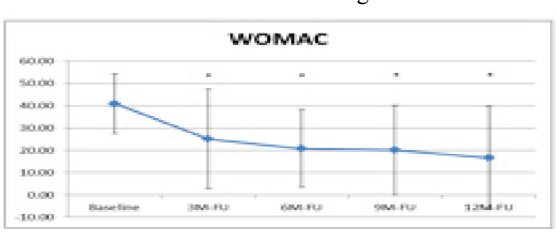


**Figure 2**, the WOMAC total score demonstrated a statistically significant improvement when using the Agilium Freestep in all follow-up visits after 3,6,9 and 12 month compared to baseline.

## DISCUSSION & CONCLUSION

This observational study suggests that the new AFO is effective in significantly reducing pain and stiffness and physical function of patients with mild to moderate unicompartimental osteoarthritis of the knee.The clinical benefits have the same magnitude as those known from clinical trials with knee unloader braces. To underline the good results of this study a larger collective is needed.

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# FIRST CLINICAL EXPERIENCES WITH MICROPROCESSOR CONTROLLED KNEE FOR MEDERATELY ACTIVE TRANSFEMORAL AMPUTEES

Milana Mileusnic

## BACKGROUND

Microprocessor controlled knees (MPKs) offer many benefits to moderately active amputees1-5. While improving safety and significantly reducing falls by 80%, MPKs also positively affect functional mobility and mobility grade1-5. Kenevo is a new MPK designed specifically for the needs of moderately active amputees. It adapts to individual mobility capabilities by offering a programmable stance and swing release control. It additionally offers various new functions (i.e. supported sitting down and standing up functions, standing function, safety functions, wheelchair function).

## AIM

The objective of this research was to collect first clinical experiences with Kenevo.

## METHOD

Data taken on first routine fittings with Kenevo between February and May 2015 were analysed. Subjects' data was collected with their old prosthesis and again on average 2 months after receiving the Kenevo. Questionnaires were provided to retrieve feedback from certified prosthetists and amputees. Data collected referred to demography, the fitting process, safety, activities of daily living and user satisfaction. Additionally, validated clinical tests such as Plus-M and Houghton scale were administered.

## RESULTS

29 mostly unilateral amputees were fitted with Kenevo (age 63.2+9.5 yrs; time since amputation 6.3+8.9 yrs; various amputation causes). 83% of them were MFCL-2 ambulators and used various knees before receiving Kenevo (polycentric 36%, brake 27%, locked 18%, mechatronic 18%). Most subjects choose Kenevo settings that allowed locked stance and free swing phase (67%) and needed on average 8 days toacclimate.

After 2 months of Kenevo use, a positive trend in Plus-M and Houghton scores were observed. Kenevo usage resulted in reduction of wheelchair dependency in many subjects. Majority of subjects reported of improvements in level walking during various speeds and on uneven ground. The percentage of subjects that report improvements in ascending, descending and standing on ramps was 53, 68 and 69%, respectively. Ascending stairs was better for 38% and descending for 56% subjects. More than 2/3 of subjects report of reduction in necessary concentration and perceived exertion when walking with Kenevo. Fear of falling was reduced in 50% of the subjects while the number of subjects that never fall increased from 45% to 72% (Figure 1) and those that never stumble from 8% to 50%. Finally, 89% of the fitted amputees prefer Kenevo over their previous fitting.

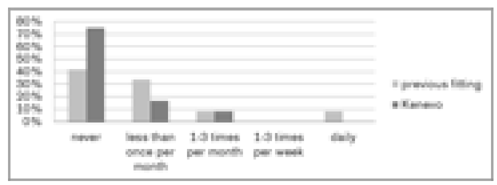


**Figure 1**. Perceived frequency of falling.

## DISCUSSION & CONCLUSION

High patient satisfaction with Kenevo was observed in lower activity amputees. New knee functionalities are very effective and beneficial for this population. In addition to improved safety, the amputees report of improvement when negotiating various terrains typically encountered during activities of daily living. These observations are in agreement with published evidence on effects of MPKs in limited community ambulators1-5.

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# FIRST USER EXPERIENCES WITH NEXT GENERATION OF C-LEG

Nadine Wismer

## BACKGROUND

C-Leg was introduced on the market in 1997 and is the most widely used microprocessor controlled knee and recognized as a standard in the fitting practice for transfemoral (TF) amputees in many countries. C-Leg is the most extensively studied prosthetic component with currently 64 publications reporting on clinical evidence. Research suggest that C-Leg significantly improves amputees' safety as well as their functional mobility, independence and quality of life1,2,3,4. The most recent generation (C-Leg 4) was launched on the market in 2015. In addition to reduced built height, the new C-Leg 4 offers several new functionalities such as a more sensitive initiation of the swing phase and improved stumble recovery.

## AIM

The objective of this research is to report first clinical results and experiences with C-Leg 4.

## METHODS

Data taken on first routine fittings were analysed. Subjects were followed on average for 16 weeks (± 7 weeks). Data collection comprised of assessments on perceived performance on a 5 point Likert Scale ('1' being much worse and '5' being much better) during level walking, slopes and stairs, walking at different velocities, standing, safety and well-being. The validated outcome measures such as timed gait tests and PLUS-M were used during routine assessment. Furthermore, preference and satisfaction was assessed.

## RESULTS

Data of 35 unilateral amputees was obtained and analyzed (average age: 51 years (± 11 years); time since amputation: 22 years (± 14 years)). Subjects belonged to various mobility grades (11% K2, 66% K3, 23% K4) and most of them were previous users of microprocessor controlled knees (94% C-Leg, 3% Compact, 3% NMPK). 61% of subjects reported acclimation to the new device within 1 day. PLUS-M as well as walking speed were better with C-Leg 4 but improvements did not reach minimal detectable change. Subjective feedback suggests improvements in walking at different speeds, traversing uneven surfaces, walking on ramps and stairs, standing on slopes, etc. Swing phase initiation was rated as 'much better' or 'better' by 72% of subjects, while stance phase by 60% subjects. Stumble recovery was rated by 39% of subjects to be better with C-Leg 4. Improvement in comfort was also reported during various activities as well as reduction in pain, especially back pain. Overall, 94% of subjects preferred C-Leg 4 over their previous prosthesis.

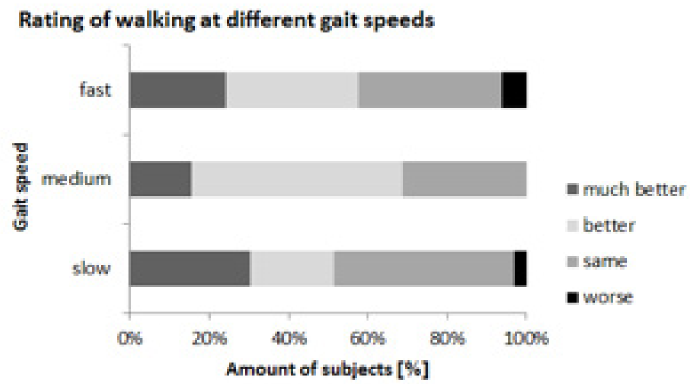


**Figure 1** Rating of perceived difficulty when walking with C-Leg 4 compared to previous prosthesis at different gait speeds (n=33).

## CONCLUSION

First routine fittings of C-Leg 4 have shown improvements compared to previous prostheses especially regarding ambulation and standing activities. C-Leg 4 was well received by subjects. In particular, subjects liked new standing function, smoother, easier and more natural walking, improved safety and stability, sitting function and adaptation to changing gait speed. Improvements can be explained by re-engineered functions containing technical improvements on one side and additional functionality on the other side leading to a higher user satisfaction with C-Leg 4.

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# RESULTS FROM A RETROSPECTIVE REGISTRY OF A MICROPROCESSOR-CONTROLLED KNEE ANKLE FOOT ORTHOSIS

Andreas Kannenberg

## BACKGROUND

Patients suffering from lower-limb paresis or paralysis are often prescribed a knee-ankle-foot orthosis (KAFO) to restore mobility. The C-Brace® is a microprocessor controlled Stance and Swing Controlled Orthosis (SSCO) developed to overcome the limitations of KAFOs that do not offer damped knee flexion during weight-bearing or dynamic swing control. A retrospective registry gathered safety and effectiveness data from patients that have been fitted with a C Brace.

## AIM

The purpose of the registry was to characterize safety through the collection of adverse events as recorded in the clinic notes and to characterize effectiveness based upon clinical outcomes data routinely collected at participating sites.

## METHODS

All clinics in the United States that had fit at least one C Brace patient were invited to participate in the registry. Case Report Forms were developed to collect results from clinical outcome tests and questionnaires based on interviews with prospective sites prior to data collection. Objective tests included Fast Walking Speed (FWS), and Berg Balance Scale (BBS). Patient reported outcomes included the Activities of Daily Living Questionnaire (ADLQ) and the Activities-specific Balance Confidence (ABC) Scale. IRB approvals and waivers of informed consent were obtained prior to data collection. Data used for baseline results were based on data recorded using either a previous orthosis or no orthosis. Cut-off values were established for each of the key outcome measures for improvements to be considered "clinically meaningful": FWS: 0.1 m/s; BBS: 8 points; ADLQ: 1 point (17% change on a 6-pt scale); ABC: 15%

## RESULTS

19 subjects (5 female) fitted with a C-Brace at 14 clinics had data available for collection in existing patient charts. The mean age was 49.7 years and the mean weight of 204 (125 272) lbs, 1 for bilateral fitting. The mean follow-up duration after C-Brace fitting was 6.4 (0-27.8) months. 7 were incomplete SCI, other indications included post-polio, neuropathy and TBI. The average number of falls at baseline was 9 per month ranging from 2 per year to 3 per day. No serious adverse events were reported related to the C Brace. Only 2 falls were reported, both without serious injury.
The baseline and change scores for each of four effectiveness outcome measures are summarized in Table 1.

| Outcome | FWS<br>m/s | BBS<br>score | ADLQ (Mobility)<br>score | ABC<br>% |
|---|---|---|---|---|
| n | 7 | 7 | 10 | 10 |
| Avg B/L | 1.1 ± 0.50 | 44.9 ± 7.5 | 1.2 ± 1.13 | 37 ± 24% |
| Avg Chg | 0.22 ± 0.26 | 1.57 ± 0.98 | 1.4 ± 1.38 | 15 ± 23% |
| Med F/U | 3 mos | 3 mos | 15 mos | 15 mos |

| Subject | FWS | BBS | ADLQ (Mob) | ABC | FU (mo) | ↓? |
|---|---|---|---|---|---|---|
| 0204 | GREEN | WHITE | WHITE | RED | 1 | ✓ |
| 0208 | WHITE | WHITE | GREEN | GREEN | 1/12* | ✓ |
| 0212 | GREY | GREY | GREEN | WHITE | 24 | ✓ |
| 0213 | GREY | GREY | GREEN | GREEN | 18 | ✓ |
| 0214 | GREY | GREY | WHITE | WHITE | 12 | |
| 0216 | GREEN | WHITE | GREEN | GREEN | 6 | ✓ |
| 0217 | GREY | GREY | GREEN | WHITE | 18 | ✓ |
| 0220 | GREY | GREY | WHITE | GREEN | 30 | ✓ |
| 0222 | GREEN | WHITE | WHITE | GREEN | 24 | ✓ |
| 0224 | GREEN | WHITE | WHITE | WHITE | 6 | ✓ |
| 0301 | RED | WHITE | GREY | GREY | 3 | |
| 0302 | GREEN | WHITE | GREY | GREY | 3 | ✓ |

Table 2. Changes in outcome measures by subject.
GREEN= clinically meaningful improvement, RED = clinically meaningful decline, WHITE= no change, GREY = no data
*FWS & BBS assessed at 1 mo; ADLQ &ABC at 12 mos.

## DISCUSSION & CONCLUSION

Clinically meaningful changes compared to baseline were observed in 10 of 12 subjects (83%) that had efficacy data at both baseline and follow-up as illustrated in Table 2. 5 of 7 (71%) of subjects had a clinically meaningful change in FWS. This study is limited in that it is a retrospective chart review with a small number of subjects with mixed follow-up duration and use of outcome measures. Results from this registry revealed that the majority of C Brace subjects demonstrated clinically meaningful improvements in outcome measures. FWS and ABC, in particular, appear to be sensitive outcome measures in the majority of subjects with implications for use in an on-going prospective registry.

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# MPC-KNEE AS FIRST CHOICE ON TRANS-FEMORAL AMPUTEES

Paul Forsling CPO
TeamOlmed Jönköping, Pjäsgatan [2], Länssjukhuset Ryhov
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## BACKGROUND

Hydraulic mechanical knee has over the last decades been the most common knee-solution when providing Trans-Femoral (TF)-amputees with a first prosthesis. The application process of having a Micro-Processor Controlled-knee (MPC-knee) will often take long time before approval. The patients (≤ 65 years) learn to walk with knees that they don´t really trust, their walking pattern in many cases become rather abnormal and in particular more or less permanent. At same time the
science tells us the importance of early mobilisation[1] and significant decrease in falls[2] with MPC-knee.

## AIM

What effects would we gain if we would have the possibility to fit the amputees with an MPC-knee from start? Will the amputees obtain a better walking pattern and get rehabilitated in a shorter period of time? And will this be possible in the current, rather time consuming, application process?

## METHOD

By selecting three new AK-amputees at our Rehabilitation Clinic a small pilot study was designed. The inclusion criteria was amputees 65 years or younger, fully mobile 3 months prior to the amputation without any walking aid, with standard or long stump and possible to be fitted with AK- prosthesis. The sockets were manufactured with direct laminationtechnique
(DS-socket™ Össur) to optimize the post-op process. The patients were fitted after at least 4 weeks of
compression treatment with silicone liner, maximum 10
weeks postoperative, with or without totally healed wounds. They were filmed in their first week of walking training, totally time of rehabilitation and TUG was measured. An Össur Rheo knee® trial-unit were used and initially set with higher Stance flexion (≥80) on even surface.

## RESULTS

The method of using the DS-socket technique in combination with early MPC-knee, the patients were able to ambulate with or without crutches/ walking sticks, from the first day of fitting. This also seemed to preserve more of the normal walking pattern. In comparison with earlier cases the amputees felt higher reliability to the prosthetic-knee from start. The time of Rehabilitation (measured in day of transcription) were significant shorter. By always having a trial knee in stock, the application-process did not affect the initial fitting as it used to do.

Pic 1. Patient using MPC-knee early in the rehab phase

## DISCUSSION & CONCLUSION

There are most likely a combination of actions that affected the rehabilitation outcome for the new amputee. In this study we found improved sensation and security of walking for the amputee, which also led to a shorter rehabilitation time when using a MPC-knee in our rehabilitation settings. A higher initial stance flexion-resistance and an early mobilisation made it easier for the amputees to keep more of their normal walking habits, findings that conforms the outcome of previous studies[1]. Our findings also support other studies outcome regarding the cost/benefit analysis with MPC-knees compared with increased quality of life[3]. Despite the limited number of users in this study, these results might be useful in the future local discussions with prescribers when applying for the rather costly MPC-units.

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# EFFECT OF LIGHT EMITTED DIODE IRRADIATION ON CHRONIC NON HEALED WOUND AFTER BELOW KNEE AMPUTATION

Haitham Elessawy[1], Wafaa Borhan[2], Nasser Ghozlan[3], Samah Nagib[2]

[1] Pharos University in Alexandria, [2] Cairo University, [3] Alexandria University (EGYPT)

## BACKGROUND

Chronic non healed wound after amputations is a serious problem that faces the healthcare team, therefore there is a need to find an adjacent therapy to address this problem. Photomodulation therapies used for wound healing supposed to introduce energy to the affected area and activate regeneration processes inside the cell to enhance the natural wound healing process. [1] Assessment of wound healing by measuring wound surface area using the computerized method by Adobe Photoshop aided by magnetic lasso tool. [2]

## AIM

The purpose to evaluate the therapeutic efficacy of the Light Emitted Diode (LED) irradiation on chronic non healed wound after below knee amputation (BKA) using a computerized method of evaluation by Adobe Photoshop aided by magnetic lasso tool.

## METHOD

Thirty patients of both sexes with chronic non healed wound after BKA (≥ 4 weeks). were equally divided into two groups: •Group (A) received the LED irradiation for 3 sessions per week for 8 weeks in addition to the standard medical treatment consisting of systematic antibiotic, irrigation with saline and wound dressing. •Group (B) received the standard medical treatment. The data related to the patients' age and sex had been collected at the beginning of the study, the data concerning the wound surface area, had been measured before the study (Pre) and after treatment sessions (Post), using a computerized method of evaluation by Adobe Photoshop aided by magnetic lasso tool by tracing the wound perimeter.

## RESULTS

•Pre and post treatment mean values of wound surface area of study group (A): The mean ± SD wound surface area pre treatment of study group was 161.14 ± 11.66 mm² and that post treatment was 79.54 ± 5.33 mm². The mean difference between pre and post treatment was 81.6 mm² and the percent of improvement was 50.63%. There was a significant decrease in the wound surface area in the study group post treatment compared with pre treatment ($p = 0.0001$). (Figure 1) •Post treatment mean values of wound surface area of both groups (study and control):

The mean ± SD wound surface area post treatment of study group was 79.54 ± 5.33 mm and that of control group was 90.06 ± 7.06. The mean difference between both groups was -10.52. There was a significant decrease in the wound surface area in the study group compared with control groups post treatment ($p = 0.0001$).

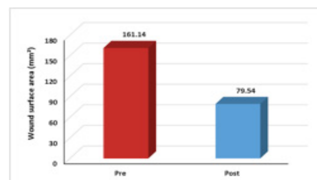


Figure 1. Pre and post treatment mean values of wound surface area of study group (A). Applying LED irradiation application is effective method to decrease the surface area of the chronic non healed wound after BKA. Although both Standard medical treatment and LED irradiation were of a significant effect in decreasing chronic non healed wound after BKA. Assessment of wound healing by measuring wound surface area using the computerized method by Photoshop aided by magnetic lasso tool is reliable, easy method that can be used in clinical practice.

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# FUNCTIONAL OUTCOME ASSESSMENT IN LOWER LIMB PROSTHETICS

Maja Mlakar

## BACKGROUND

Clinical guidelines in rehabilitation medicine recommend that rehabilitation teams define rehabilitation goals and detect causes that prevent achieving them [1, 2]. For most patients after lower limb amputation, one of the goals is fitting with appropriate prosthesis. The aim of lower limb prosthetic fitting is that persons after lower limb amputation get a prosthesis with which they can walk without problems. In 2001 Rheinstein published a checklist for evaluating transtibial prosthesis. Based on those, we prepared separate forms for evaluating transtibial and transfemoral prostheses [3]. Application of every lower-limb prosthesis to the patient should be done by the team and checked using the evaluation form.

## AIM

The first aim of the study was to find out if patients have problems with their new prosthesis, which kind of problems and how satisfied they are with new prosthesis. The second aim was suggest improvements of the prosthesis production process.

## METHOD

We reviewed medical documentation of all patients who received a new prosthesis during four months of 2014 at the University Rehabilitation Institute, Ljubljana, Slovenia.

## RESULTS

In total, 217 patients received a new prosthesis; in 45% of the cases, the evaluation form was not filled in. In addition, more than 50% of filled-in forms were incomplete in the parts regarding technical aspects of the prosthesis, examination of the patient during standing and siting with prosthesis, and examination of the stump and socket. The most frequently reported problems were irritation and abrasion of the skin on the stump (68%). In 28% of the patients with transtibial prosthesis, pistoning was noted; in 27% of the cases, the socket was not in full contact with the stump.

## DISCUSSION & CONCLUSION

The first problem that we recognized was that a large percentage of the produced prosthesis were not checked by the team and/or the evaluation forms were not filled in. Furthermore, over one half of the remaining forms were incomplete. We therefore decided to set up a training program for the members of rehabilitation teams on how to check the prosthesis using the evaluation forms. We also distributed organizational and technical instructions. The second problem was the large percentage of patients with poorly fitting socket. As a consequence, we decided to change the production protocol for lower limb prosthesis socket. We shortened the period between casting, check and definitive socket as much as possible, and we also introduced new types of sockets for the persons with frequent stump volume changes. To summarize, despite a very large proportion of missing or incomplete data, we identified some key problems and took several actions to improve lower-limb prosthetic fitting.

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# LOCALLY MANUFACTURED WHEELCHAIRS IN TANZANIA: DO THEY MEET THE NEEDS OF TANZANIAN WHEELCHAIR USERS?

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Tanzania Training Centre for Orthopaedic Technologists (TATCOT)1

University of Cape Town[2]

## BACKGROUND

Tanzania is estimated to have a population of over 49 million people in 2013. About 8% of the population experience some type of activity limitations1-3. WHO estimates that between 20 to 25 million people worldwide who need a wheelchair are unable to access one2. About 3.5 million disabled persons in Tanzania require or use a wheelchair. Wheelchair users in Tanzania experience various challenges relating to mobility and community participation.

## AIM

To determine the extent to which the needs of users of wheelchairs manufactured locally in Tanzanian are met in respect to activity and participation, features and service provision of the wheelchairs.

## METHOD

A descriptive, quantitative cross-sectional analytical design was utilized. The study was done in Tanzania whereby structured questionnaires mostly closed were administered. Convenient sampling was used to obtain 75 users. Inclusion criteria were adults aged 18 – 65 years who were active wheelchair users, should have possessed the wheelchair for at least three months at the time of the study, should have lived in the same area for at least six months at the time of recruitment. The exclusion criterion was people with cognitive impairment. Data were analyzed with the Statistical Package for the Social Sciences (SPSS®) software program version 20.0 (SPSS Inc. 2006).

## RESULTS

The median age of participants was 34 years, and the median period of using wheelchairs was 8.0 years (min: 1.0, max:30.0 years). Most participants (61%) had sustained spinal cord injuries, and used three-wheeler chairs (76%). More than 90% reported that their wheelchairs had positively influenced their activity and participation needs, and 85% were satisfied with their ability to carry out their daily activities. Relationship between the type of wheelchair and place of residence indicated that three-wheeler wheelchairs appeared to be mostly used in rural settings (33, 44.0%) compared to four wheeler wheelchairs (10, 13.3%). Participants expressed satisfaction with the durability of the wheelchair (89%), and the professional services received (71%), but not with follow-up services (77%).

| Variable | Median | Range |
|---|---|---|
| Duration of using wheelchair (years): | 8.0 | 1.0 -30.0 |
| Age of starting to use wheelchair (years): | 25.0 | 2.0 -56.0 |
| Number of wheelchairs used to date: | 2.0 | 1.0 - 7.0 |
| Characteristics of terrain | n | % |
| Flat | 24 | 32.0 |
| Hilly | 39 | 52.0 |
| Mountainous | 3 | 4.0 |
| Sandy | 9 | 12.0 |
| **Satisfaction with the wheelchair** | | |
| Yes | 63 | 84.0 |
| No | 12 | 16.0 |

Table 1: Usage of Locally manufactured wheelchairs (n=75) 1 Missing data for one participant who could not remember the duration of using the wheelchair

## DISCUSSION & CONCLUSION

The median age of starting using wheelchair, i.e. median (range) for 73 participants, was 25.0 (2.0-56.0) years. The majority of participants were more satisfied with wheelchair features than the services provided. The majority of participants (n=58, 77.4%) were dissatisfied with follow-up services. The wheelchairs had a positive impact on participants' activity and participation needs. People with disabilities expressed general satisfaction with the use of locally made wheelchairs but areas of dissatisfaction need attention.

## REFERENCES

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# EFFECT OF THE VARIATIONS OF TRANSFEMORAL SOCKET ALIGNMENT TO ATTAINED OPTIMUM GAIT

Aston Ndosi1, [2], Kamilo Oliha[2], Longini Mtalo[1,2]

Tanzania Training Centre for Orthopaedic Technologists (TATCOT)[1]

Kilimanjaro Christian Medical University College (KCMUCo)[2]

## BACKGROUND

Amputation is a surgical procedure that involves removal of an extremity/limb1. Successful rehabilitation of the amputee requires that the prosthesis be acceptable by user. One of the factors contributing to the acceptability of the prosthesis includes functions; this is facilitated by optimum alignment both bench, static and dynamic. The alignment of lower-limb prosthesis is critical to the successful prosthetic fitting and utilization by the user2. Patient could only be satisfied with an optimum alignment3.

## AIM

The aim of the study was to investigate effect of the variations of trans-femoral socket alignment on trans-femoral prostheses.

## METHOD

Experimental clinical case study design was implemented on two male trans-femoral amputees. Convenience and examination sampling procedure was utilized to obtain study participants. Inclusion criteria were adults unilateral amputees with medium stumps aged 18 – 45 years and have used prostheses for at least 12 months. Data was collected by vicon camera. Technical and quantitative analysis was done using computer aids. An Assisted Static Alignment Reference system (LASAR) was used to measure socket on static under different alignment conditions; including optimum aligned, angle malalignments of 6°, A/P and M/L translation malalignments of 10 mm of the socket relative to the foot.

## RESULTS

This study found that alignment variations might have consistent effects on the socket reaction moments in trans-femoral prostheses while extension or posterior translation of the socket resulted in increases in an extension moment, both angle and translation alignment changes revealed consistent changes in the socket reaction moments. An extension moment was dominant during stance in both participants under the optimum aligned condition, while the flexion moment was only found at late stance to early swing.

Effect of Sagittal Translation

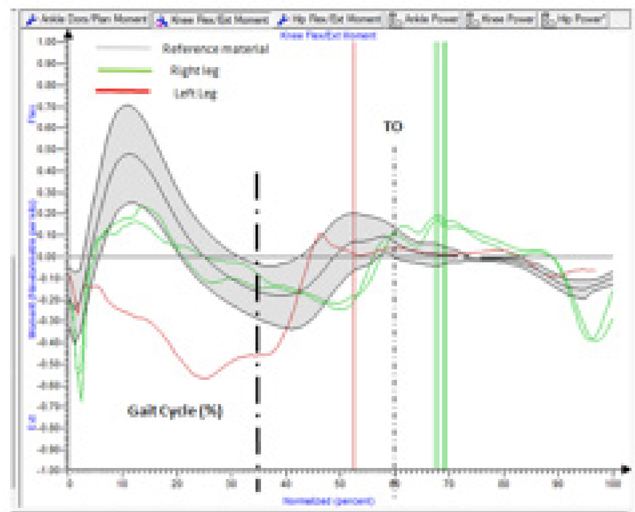


Figure 1: 1cm anterior displacement

## DISCUSSION & CONCLUSION

The effect of alignment changes revealed consistent changes in socket reaction moments. Limitation of the study was little number of participants. There is lack of published study in Africa and particularly in Tanzania on variations of socket align and mis-alignment effect analyzed in gait laboratory, which could be used for full comparative results. A larger scale study is important to confirm effects of variations of TF socket alignment..

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# SUITABILITY OF THE TOOL; GUIDELINES FOR SCREENING OF PROSTHETIC CANDIDATES: LOWER LIMB; FOR USE IN EASTERN CAPE PROVINCE

Luphiwo Mduzana

## BACKGROUND

The impact of lower limb amputation on an individual's functional mobility postoperative is life altering. In the study setting prostheses are prescribed based on clinical knowledge. This ad hoc practice might marginalize and discriminate. Currently the department has a backlog of over 700 dating back to 2008. In the Western Cape Province a prosthetic screening tool "Guidelines for Screening of Prosthetic Candidates: Lower Limb" (appendix 3) is used for prosthetic prescription.

## AIM

The aim of the study was to establish if the "Guidelines for Screening of Prosthetic Candidates: Lower Limb" is suitable for use in the rural Eastern Cape

## METHOD

A qualitative study was conducted in the Buffalo City Metro Municipality. Professional service providers to persons with above knee amputations from both hospitals and clinics in the study setting were invited to participate in the study. Ten occupational therapists, 12 physiotherapists and six medical orthotists and prosthetists participated. The participants were trained in the use of the tool and then asked to use the tool for six weeks after which their experiences of the tool was assessed. Data was collected through three focus group discussions; transcribed verbatim and emergent themes were identified during analysis.

## RESULTS

Nine themes emerged from the data. The themes were: A compass to patient management, comprehensiveness of content, practicality, multidisciplinary nature, barriers to use, application in the Eastern Cape, short test period and way forward. The comprehensiveness of the tool was such that it incorporates every therapist and it gives detail as to what role played by that therapist. Even though the focus groups participants` were in agreement that the tool was easy to use, self-explanatory, and had a logical flow some of the participants felt that the tool to some extent does need modification for better understanding. The nature in which the tool is crafted promotes those involved in prosthetic management to work hand in hand. The Eastern Cape province has a huge backlog on prosthetics and there is no current plan into screening for a prosthesis.

## DISCUSSION & CONCLUSION

The study findings support recommendations that use of the tool could assist with prosthetic prescription of persons who had lower limb amputations in the Eastern Cape Province. The findings showed the haphazard manner in which decisions re prosthesis are made currently, the uncertainty and the lack of teamwork. Professionals prescribe a prosthesis according to their discretion. The introduction of a prescription guideline might not only aid in ensuring proper prescription but also better the communication amongst the professionals.

# ASSISTIVE TECHNOLOGY SOURCES, SERVICES AND OUTCOMES OF USE IN DIVERSE AFRICAN SETTINGS

Surona Visagie

## BACKGROUND

Appropriate assistive technology products and services contribute to greater independence and improved quality of life for persons with disabilities. There is paucity of evidence on assistive technology provision and services in Africa. The little available evidence suggests that access to appropriate assistive technology and services is often poor.

## AIM

To explore assistive technology sources, services and outcomes of use in diverse African settings.

## METHOD

A survey was done in four purposively selected sites in each of South Africa, Sudan and Malawi, and five sites in Namibia. Sites were selected to include populations that highlight a particular characteristic of each country; displaced (Sudan) or dispersed (Namibia) populations, poor populations (Malawi) and those with inequitable access to health care (South Africa), rather than to be nationally representative. Within sites clusters were sampled and a household questionnaire completed with every household in the cluster. Household members were screened for disability, using the Washington Group on Disability Statistics 6 questions. An individual questionnaire that included questions on assistive technology was completed with 4 388 randomly sampled persons with a disability (1050 South Africans; 1118 Namibians; 1496 Malawians; 724 Sudanese). Descriptive analyses were done.

## RESULTS

Participants who used an assistive device varied from 29.6 % in the Namibian sample to 2.8 % in the Malawian sample. Walking mobility devices (46.3%) and visual aids (42.6 %) were most frequently used. Common sources included government health services (37.8 %), "other" (29.4 %), and private hospitals (22.9 %). Private hospitals were the most common source in urban settings while "other" was the most common source in rural settings. The majority of participants (59.2%) received training in the use of the device. Those who reported Private or Government Health Services as source most often received training, while those who reported "other sources" least often received training. Urban respondents received more training than rural respondents. Maintenance was mostly done by users and their families (37.3%). Devices improved the quality of life for 67.9% of participants, while 39.1% experienced functional difficulties despite the devices. Participants from rural areas experienced more functional difficulties and lower quality of life than urban users.

## DISCUSSION & CONCLUSION

There is wide variation between the study settings, but the main impression is that of fragmented assistive technology provision and services systems. Living in an urban area and receiving assistive devices from government or private health care sources had a favourable impact on services, function and quality of life.

# CHANGE IN MOBILITY POTENTIAL TO USE PROSTHESIS AND FACTORS INFLUENCING VARIABILITY IN CHANGE AMONG MAJOR LOWER LIMB AMPUTEES FOLLOWING INTENSIVE INPATIENT REHABILITATION, AND POST DISCHARGE FROM HOSPITAL

Ncedo Ludada

## BACKGROUND

Chronic vascular conditions and associated comorbidities among elderly population are debilitating prior amputation adding to the amputation surgery. Therefore, the goal of early multi-disciplinary rehabilitation post amputation is to improve physical capacity and mobility potential. Despite provision of multi-disciplinary rehab post amputation, trajectory of changes in mobility potential to use prosthesis in Hospital and post discharge remains unclear. In addition, factors influencing variability in mobility potential remain unclear as well.

## AIM

The study intended to evaluate trajectory of changes in mobility potential to use prosthesis and factors influencing variability in mobility potential to use prosthesis.

## METHOD

Retrospective clinical case-note audit and Prospective cohort case series. Setting: University Hospital Participants: In the retrospective cohort 49 consecutive participants rehabilitated in Repatriation General Hospital since 2008 were analyzed, whereas convenience sampling recruited 9 participants for the prospective cohort. Intervention: N/A Main outcome measures: Mobility potential to use prosthesis was measured by Amputee Mobility Predictor. Factors influencing variability in change of mobility potential were measured by various validated outcome measures. Demographics and comorbidities were measured by AMP comorbidity tool. Prospective cohort was also administered with Locomotor Capability Index-5, Falls Efficacy Scale- International, Activity Balance Scale, and Prosthetic Evaluation Questionnaire.

## RESULTS

Mobility potential to use prosthesis significantly improved following pre-prosthetic conditioning and interim prosthetic training P=0.001 CI (-.299 to .230). Whereas it was variable post discharge with 6/9 declined and 2/9 improved, the overall data showed trends of decline at border line of significance
p= 0,058 CI (-.213 to 10.2)

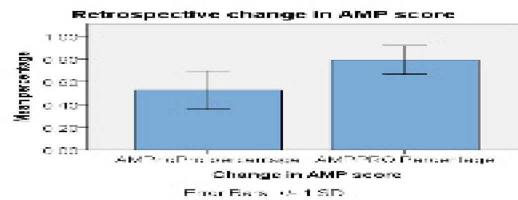
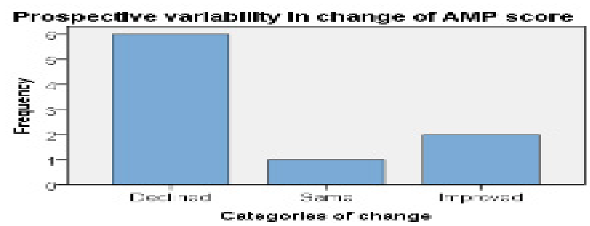



Figure1: Admission to discharge change in AMP score




The final multi-variate model indicates that age at amputation, level of amputation, and AMPnoPro score admission are all significantly (P=0,001) accountable for 72% of variability in mobility potential to use prosthesis during inpatient rehab.
Matrix correlation revealed that change in mobility potential post discharge strongly, and positively correlated with stump pain =.857; .014 patient satisfaction = .882; .002 QoL = .755; .019: LCI total score =.723; .028: LCI basic =.691; .039: LCI advanced= .707; .033 appearances = .866; .005, and utility = .772; .025.

## DISCUSSION AND CONCLUSION

The study findings support recommendations of early multi-disciplinary rehab post amputation, as it significantly improves mobility potential especially among young amputees with lower levels of amputation. Therefore, intensive inpatient rehabilitation improves mobility potential to use a Prosthesis especially among young patients with lower levels of amputation.

## REFERENCES

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2. Hordacre, et al; 2013 Physio Res Int

# BEAU AND HIS NEW AFO: A RESEARCH-BASED ILLUSTRATED STORY BOOK

Amelia Levick

## BACKGROUND

Also called "Introduction", this section describes the study's relation to past research, rationale, and prepares for the aim. The Background starts with a general context and then leads towards the actual (clinical/technical/educational/...) problem that the study addresses. Also cite relevant previous works [#] (from one's own or from others) to further direct the reasoning towards the aim. This section is used by reviewers to assess "relevance".

## AIM

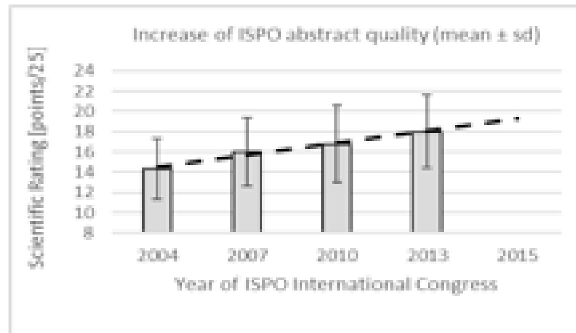
The aim (or: purpose; or: objective; or: research question) is a concise statement of the goal, phrased in a precise way, that was targeted by this study.

## METHOD

The method refers to how the study is designed and executed, by describing all the steps and selections that were made to fulfill the study's aim and to allow the reader to critically appraise the results. For most clinical studies, this includes participant selection criteria, agenda for each person who took part, measurements and interventions that were performed; how the data was processed into the concepts mentioned in the aim, and statistical evaluation. For non-clinical studies, the structure is less straightforward but relevant details must be provided, especially if the method is (technological) innovative.

## RESULTS

This section describes the actual results of your study. The main result should be presented in a manner that fits the way the aim of the study was phrased. It is encouraged to visualize the main results using a figure. Also, a table might be a concise way to present structured data. To ensure readability for figures and tables, please consider minimizing amount of information included, avoid small font sizes, and no colours. Preferably, describe your results in numbers and add statistical significance (p-values) if appropriate.




## DISCUSSION & CONCLUSION

While the result sections presents focussed outcomes, the discussion provides interpretation of the results. Discussion relevant questions can include: "are there important study limitations?", "do the results confirm or conflict with previous results?", "are the result generalizable?" After all relevant considerations, a final conclusion must be written. This conclusion should relate to the aim and not overstretch the importance of the results.

## REFERENCES

This is optional, but necessary if you build on previous work. Very short style is common in abstracts, meaning:

1. First author's name; year and abbreviated journal only

# PROSTHETICS AND ORTHOTICS EDUCATION IN GHANA: LOCAL STAFF PERSPECTIVES

Akouetevi Aduayom-Ahego[1, 2], Yoshihiro Ehara[1]

[1]Niigata University of Health and Welfare, Niigata Japan, [2]Ahelite Brace, Accra Ghana

## BACKGROUND

Few colleges offer courses related to the Prosthetics and Orthotics (P&O) rehabilitation in developing countries. The rate of people with disabilities in African countries is closely related to the poverty where there is little or virtually no access to education in the field of P&O. Due to lack of research and development in these countries, the assistive technology has less priority compared to other communicable diseases.

## AIM

The aim of this study is to acknowledge the challenges in P&O education from the perspective of the practitioners and students in Ghana. While all African countries are not the same in P&O rehabilitation services, the survey of the current situation in Ghana will provide necessary key elements that may be useful to other countries.

## METHOD

In this qualitative study, the focus group composed of technicians and students in Prosthetics and Orthotics was visited in April 2016 to answer a survey. Two types of questionnaire were designed: one for the practitioners and other one for the students in their final year. The questionnaires were distributed on hard copy to the technicians at National Prosthetics and Orthotics Centre (NPOC) which is the main centre in the capital city Accra and students of Br.Tarcisius Prosthetics and Orthotics Training College (BTPOTC) located in the eastern region.

## RESULTS

Out of sixteen questionnaires distributed to the NPOC technicians, thirteen participants (seven males and six females) responded to the survey. This represents an 81.2% response rate. In terms of credentials, nearly half (46.2%) of all respondents were physiotherapists and less than one third (23.1%) reported having the ISPO category II certificates. These P&O technicians were trained in Tanzania while some others had certificate courses from Iran. Only three respondents (23.1%) reported having further training either in rehabilitation course, physiotherapy assistant course and WHO wheelchair training programme. Moreover 77% of all respondents never participated in any P&O seminars or workshops. None of the respondents earned an ISPO category I certificate or Master degree and above. Participants reported that P&O face many challenges, mainly related to the lack of trained professionals, lack of infrastructure, lack of materials and machines including motions analysis devices for outcome measurements for the devices provided.

## DISCUSSION & CONCLUSION

The findings highlighted in this study were not exclusive to other related medical fields in Ghana. Previous researches in rehabilitation and nursing field have also reported a number of challenges concerning human resources, lack of financial support, lack of infrastructure and lack of materials. Thus in order to bring the healthcare service to a standard level, a new multidisciplinary team approach needs to be implemented with a constant support of government. An understanding of the current position and challenges in P&O in Ghana can contribute to the development of strategies for a sustainable rehabilitation service expansion in the African sub region.

# HOW APPROPRIATE IS THE INVERTED PENDULUM MODEL DURING GAIT FOR INDIVIDUALS WITH UNILATERAL TRANSFEMORAL AMPUTATION?

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## BACKGROUND

The inverted pendulum model can be used to mechanically represent healthy gait [e.g. 1,2]. This model dictates that the forwards velocity and vertical displacement of the whole-body centre of mass (CoM) both vary through the gait cycle, 180 degrees out of phase with each other. Thus peak CoM velocity is synchronous with minimum CoM height (during double support) whilst minimum CoM velocity is synchronous with peak height (during single support). Intuitively, such a mechanical model of gait appears to be appropriate for individuals with lower limb amputation, who are mechanically constrained by a prosthesis, however this synchronicity between CoM height and forward velocity is absent in the gait of individuals with unilateral transtibial amputation [3]. Individuals with a transfemoral amputation experience a lock of their prosthetic knee in an extended position during stance, which might make the application of this mechanical model more appropriate than for those with transtibial amputation.

## AIM

The aim of this study was to investigate the appropriateness of the inverted pendulum model in unilateral transfemoral amputees. It was hypothesized that the model would perform similarly between unilateral transfemoral (UTF) and able-bodied (AB) gait.

## METHOD

The gait of ten UTF (1.73±0.07m, 86.7±16.4kg) and 15 AB (1.81±0.05m, 75.1±9.1kg) participants were analyzed via a motion capture system (Vicon, Oxford, UK), force-plates (AMTI, Watertown, USA) and reflective markers. Vertical CoM position was determined kinematically using a 6 DoF Model [4]. CoM velocity was calculated as the first differential of CoM position. For each participant, data were analysed

from three gait cycles (C-Motion, Germantown, USA). A gait cycle was defined as being from initial contact of prosthetic (UTF) and right (AB) limb to subsequent initial contact of the ipsilateral limb. Timings, normalised to a gait cycle, of the minimum and maximum CoM vertical position and forward velocity were identified. The difference in timings of peak height and minimum velocity and of minimum height and peak velocity (relative time shift) was calculated in four phases: Initial prosthetic double support (DS) 1, prosthetic single support (SS) 1, intact initial double support, DS 2 and intact single support, SS 2. A Friedman's ANOVA was used to identify differences between the phases for each group, and a Mann-Whitney U-test for differences between the AB and UTF group in each phase ($p < 0.05$).

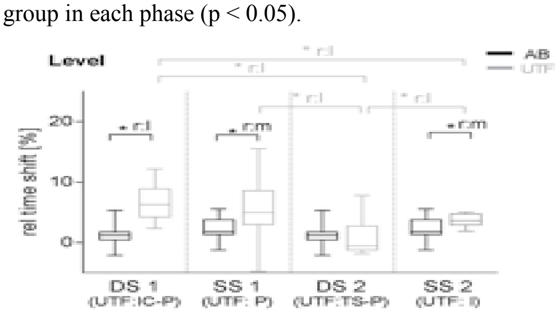


Figure 1. Relative time shift [%] for able-bodied (AB) and unilateral transfemoral (UTF) in the four stance phases double-support (DS) and single support (SS) 1 and 2.

## RESULTS

No significant difference was observed for the relative time shift in the AB group (Median between 1.2% and 1.8%). The relative time shift in the UTF group was significantly increased for the phases DS 1, SS 1 and SS 2 compared to the DS 2 and was highest in DS 1 (significantly increased compared to SS 2). Additionally, the relative time shift was significantly increased in these three phases compared to the AB group (Median between 3.7% to 6.3%) (Figure 1).

## DISCUSSION & CONCLUSION

Results from the current study suggested that whilst it may be appropriate to model able-bodied gait as an inverted pendulum, this was not the case for individuals with a unilateral transfemoral amputation. The increased relative time shift when compared to able-bodied individuals indicated a more in phase gait. This effect also varied across the gait cycle, suggesting a group specific gait adaptation. These differences mean that unilateral transfemoral gait cannot be assessed using a simple mechanical model of an inverted pendulum, even with the application of a consistent adjustment to the model to account for increased relative phase shift. In conclusion, an inverted pendulum model cannot be appropriately applied to unilateral transfemoral gait. Any simplistic methods of mechanically modelling unilateral transfemoral gait should be able to incorporate group specific adaptations.

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# PARENTAL SATISFACTION WITH THE USE OF AN ADM-DEVICE FOR CHILDREN WITH IDIOPATHIC CLUBFOOT

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## BACKGROUND

The ADM-device (Abduction-Dorsiflexion-Mechanism) has been prescribed at Astrid Lindgren Childrens´ Hospital in Sweden since 2014, for children with idiopathic clubfoot. The ADM-device has been applied when compliance problems has occurred with the earlier orhoses, as the Ponseti brace [1] or Knee-Ankle-Foot orthosis (KAFO), but also when children has experienced a relapse. To this date there are no studies published, concerning this type of orthosis.

## AIM

To evaluate the parental satisfaction with the ADM-device, and to study differences between the parents' of children who had a Ponseti brace before or KAFO before.

## METHOD

The present study is a non-randomized retrospective cross-sectional study, with a quantitative approach. A questionnaire QUEST (Quebec User Evaluation of Satisfaction with assistive Technology) 2.0 [2] was used, where the parents' of children with clubfoot have evaluated satisfaction with the use of an ADM-device and the service related to it, through twelve items and rating them from 1-5 (1 not satisfied at all - 5 very satisfied). The questionnaire also evaluates the three most important items. Sixty nine children met the inclusion criteria and their parents' were therefore invited through mail, to participate in the study.

## RESULTS

Fifty eight percent answered QUEST 2.0 (n=40). The median for all twelve items in QUEST were 3- 5 (more or less satisfied- very satisfied). The three most important items for parental satisfaction with the use of an ADM-device and the service related to it was comfort, effectiveness and easy to use. Other important items for parental satisfaction were professional service and follow-up. No significant difference was seen in satisfaction with the use of an ADM-device and service related to it between the parents' of children, who had used the Ponseti brace before or those who had used the KAFO before.

## DISCUSSION & CONCLUSION

This study showed that parental satisfaction with the ADM-device was good, and when parents were asked to choose the most important items they chose comfort, effectiveness and easy to use. When comparing satisfaction between the parents' of children, who had used Ponseti brace before or KAFO before, there was no significant difference. Since there are no previous results to discuss and the study is small the results cannot be generalizable.

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# BUILDING P&O IN SYRIA THE NATIONAL SYRIAN PROJECT FOR PROSTHETIC LIMBS

Luai Alhallaak

## BACKGROUND

P&O services are provided in developing world countries, zone torn regions through local and international organizations. The war in Syria has created significantly disproportionate numbers of amputations in a region where access to P&O services is very scarce .These challenges forced a group of Syrian doctors to find innovative solutions in these exceptional circumstances. The idea was to train, empower the local Syrians. Describe the stages, difficulties and achievements of NSPPL .Recruitment, launching, training, education, evolvement of P&O services and statistics.

## AIM

The aim of this article is to describe the unique experience of the NSSPL for the P & O since establishing.

METHOD

Retrospective collective review of all available information about all centres in NSPPL since establishment 2012 up to March 2016 including: Internal audit itself looking at numbers and types of causes, devices and patients. Interview of published reports. Interviews with the establishing members of NSPPL.

## RESULTS

NSPPL has provided P&O services3091 for patients

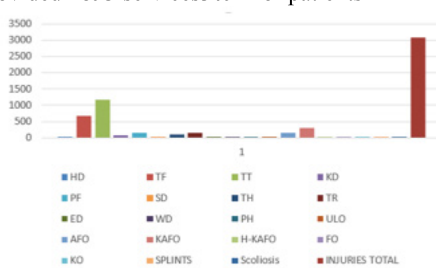


Figure 1. P&O services provided by NSPPL in (2014, 2015 and 2016)

Most common causes were war related injuries approximately (2473 of 3091) and others. NSPPL throughout its history had secured support from many bodies including Ankara University | (Turkey), Salford in UK, handicap international (France) and more recently H.S.NSPPL now has 43 employees distributed 3 clinics one in turkey and 2 inside Syria including one semi mobile clinic. Twelve of the NSPPL technicians are now enrolled in the H.S course to obtain ISPO cat2 certification.

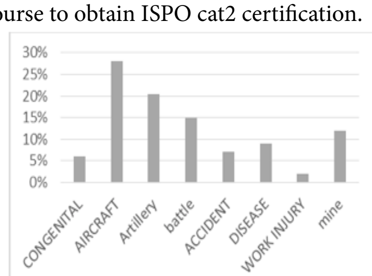


Figure 2. Patient's distribution related to cause of injury

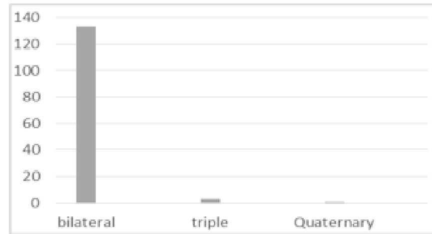


Figure 3. Multi-Amputations

## DISCUSSION & CONCLUSION

There are several excellent examples of similar P&O projects in deprived and war torn countries. In our opinion NSPPL present relatively a new approach of dealing with P&O needs in a very hostile and complex struggle. This situation forced a start in a neighbouring country (turkey), vast reliance on cyber communications, creation of semi mobile clinics and constant and rapid evolvement from low cost prosthetic limbs to more advanced modular techniques.

# GOAL SETTING: A CHALLENGE POST LOWER LIMB AMPUTATION

SANDEEP UPPAL

## BACKGROUND

In New Zealand there are more than 4300 amputees. Most common is lower limb amputees. Post-operative amputee management is always an issue because of no mandatory requirements for goal setting. Limb loss confronts individuals with challenges to activities of daily living, having serious impact on wellbeing. They often arrive with unrealistic goals leading to difficulties in adjusting to disability, therefore effecting goal achievement.

## AIM

The aim of this abstract is “In patients with Lower Limb Amputation (LLA) does goal setting (activity goals after fitting a prosthetic limb) lead to better quality of life (QoL) benefits compared to no goal setting?”

## METHOD

The CINAHL database search (1981 to October 2015) and Medline (1946 to October 2015) were searched for research studies about lower limb amputation, goal setting and quality of life. Because of lack of research data, I excluded ‘quality of life’ from my search strategy. For qualitative studies on ‘goal setting post lower limb amputations’, I searched both Medline and CINAHL. Selection criteria for two studies (quantitative) were study design, population (lower limb amputation) and intervention (goal setting). One qualitative study was selected on the basis of population (lower limb amputation) and intervention (goal-setting).

## RESULTS

What did you find? You may present this information in tables or graphs but need to also briefly describe these results within the te Coffey et al (2014), in a prospective cohort design study explored the impact of a self-regulatory programme fifteen months post discharge to examine goal pursuit and goal adjustment tendencies after LLA. The key finding showed that use of assimilative and accommodative strategies offered potential to increase understanding of post adjustment to LLA. Findings in this study provide strong support for the dual-process model.

The aim of a complementary study by Dunne et al (2014) about self-regulatory strategies following LLA was to use the dual process model as a theoretical framework from which to explore the types of assimilative (goal pursuit) and accommodative (goal adjustment) strategies employed by people with LLA in response to their acquired disability. They found four broad assimilative strategies and three broad accommodative strategies. The study findings point towards these strategies being useful to adopt for challenges faced by patients during rehabilitation after LLA.

Another cross-sectional, quantitative design study by Coffey et al (2014) examined the relationship between tenacious goal pursuit, flexible goal adjustment and effective well-being in a sample of individuals with LLA. The findings explained that goal pursuit and goal adjustment strategies with dual-process model is helpful for examining psychosocial adjustment to amputation. This might explain the mechanisms underlying this process and describe the diversity observed in people’s affective responses..

## DISCUSSION & CONCLUSION

In order to create better quality of life (QoL) and overall well-being for patients after LLA (Lower Limb Amputation); goal setting is required and forms an important part of the rehabilitation process. On the basis of these findings, I will offer in my practice, self-regulation goal setting programmes that improve the patients QoL and helps them achieve personal goals after prosthetic limb fitting. The findings of my research further supports New Zealand Artificial Limb Services strategy to evolve its wrap around patient care practices. Specifically, expanding its rehabilitation service offering to incorporate goal setting to improved outcomes for patients.

In the future, I will be looking to research goal setting benefits and their impact on patient outcomes in NZALS’ national database.

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# SECURE AND FULLY MECHANICAL MONOCENTRIC PROSTHETIC KNEE WITH GROUND SUPPORT ONE WAY BRAKE ACTIVATED AT VARIABLE KNEE FLEXION

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[1]ENSAM, [2]KEDGE BS

## BACKGROUND

According to recent surveys from D. Wyss, transfemoral amputees from emerging developing countries need a less expensive prosthetic knee with better stability and durability. Needs are similar in developed countries where 80% of transfemoral amputees have low equilibrium and need high stability in the standing phase and a lower cost than the current electronic knees.

## AIM

We aimed to design a prosthetic knee with a better suited compromise between cost, durability and stability by using the freewheel technology in an innovative way.

## METHOD

To keep costs down and to maximize durability the knee was designed to rely solely on simple mechanical principles. The chosen freewheel technology has proven its durability in bicycles. Our innovation is to use it as a ratchet to lock and stabilize the patient's knee in flexion only. It locks whenever weight is applied on the heel and unlocks otherwise. The leg is always free to extend.

## RESULTS

Hundreds of hours of testing on amputees have shown that stability and strength were the main benefits of using the freewheel technology on a prosthetic knee. Meanwhile, long term durability still has to be proven. Our production cost analysis for a hundred knees places the current design at a competitive price. The newer version 15 improved the previous one. Overall dimensions and freeplay were reduced and the swing phase is better controlled. A manual lock was added to walk straight legged if needed and to ease getting up from a chair by allowing the amputee to rest on the prosthetic leg before continuing to get up. The next prototype will concentrate on weight reduction.

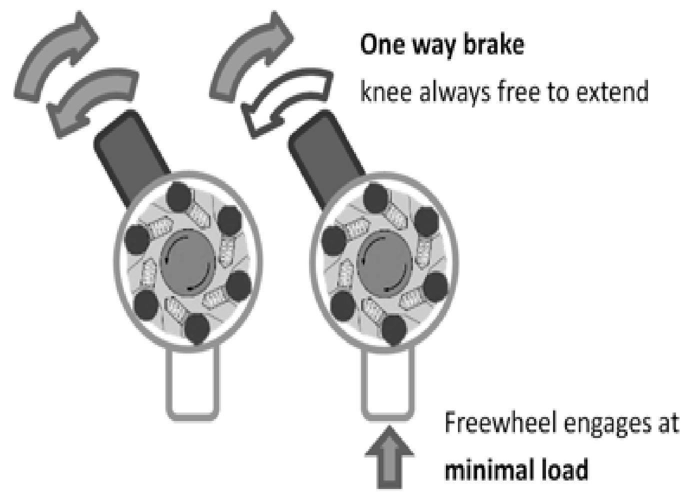


Figure 1. Freewheel mechanism

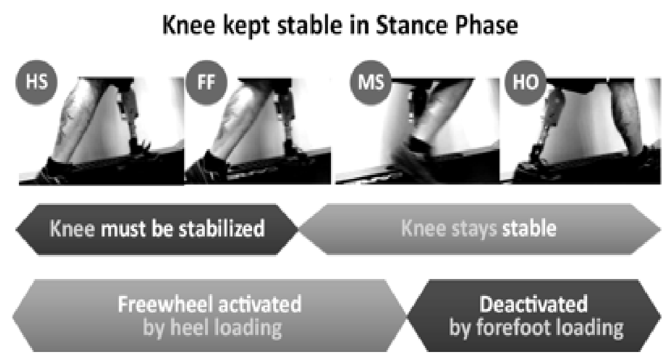


Figure 2. Freewheel action in stance phase to keep the knee stable

## DISCUSSION & CONCLUSION

The freewheel has proven to be a promising technology for prosthetic knees but improvements on the latest prototype still have to be made to reduce inconveniences and deliver its full potential in terms of stability, cost and durability.

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# LONG-TERM RESULTS AFTER INTERNAL PARTIAL FOREFOOT AMPUTATION (RESECTION)

Madlaina Schöni[1], Michèle Jundt-Ecker[2], David Bauer[1], Stephan Wirth[1], Thomas Boeni[1], Martin Berli[1]

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## BACKGROUND

Internal partial forefoot amputation of a phalanx or metatarsal head or a complete joint resection are treatment options, which can prevent minor or major amputation in the context with osteomyelitis of the forefoot, refractory to antibiotic therapy, and in the treatment of refractory and recurrent chronic ulcers of the forefoot. This technique can also be used as a prophylactic measure to prevent ulceration

## AIM

Verify if internal partial forefoot amputation is a valuable treatment option concerning the healing rate of osteomyelitis and/or chronic ulceration, risk of ulcer recurrence at the same area, or re-ulceration at a different area, and revision rate

## METHOD

All patients who underwent internal partial forefoot amputation (resection) of a phalanx or metatarsal head or a complete joint resection at our institution because of chronic ulceration of the forefoot and/or osteomyelitis from January 1st, 2004 to December 31st, 2014, were included. Information about patient characteristics, healing of ulceration, new ulcer occurrence, and revision surgery were collected. Kaplan-Meier survival curves were plotted for new ulcer occurrence and revision surgery.

## RESULTS

A total of 102 patients (108 feet) were included. Mean age at the time of surgery was 67.6 years. In 60 (55.6%) cases the patient had diabetes disease. In 56 cases a metatarsal head resection was performed, in 5 cases an isolated resection of sesamoids, and in 57 cases an internal partial amputation of a phalanx. The mean follow-up was 40 months. 98 (93.3%) ulcers healed after a mean period of 3.3 months, in 3 cases surgery was performed for osteomyelitis without ulceration. In 56 (52.3%) feet a new ulcer appeared: in the same area as the initial ulcer in 11 cases, in 45 cases elsewhere. Revision surgery was necessary in 39 (36.1%) feet. Only one major amputation and 6 complete transmetatarsal forefoot amputations were necessary during follow-up.

## DISCUSSION & CONCLUSION

Internal partial forefoot amputations are a successful treatment of osteomyelitis of the forefoot refractory to antibiotic treatment and of refractory and recurrent chronic ulcers of the forefoot. However, new ulceration is a frequent event following this type of surgery. Our results are consistent with the reported re-ulceration rate after conservative treatment of diabetic foot ulcers. The number of major amputations can be reduced with this procedure.

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# EFFECT OF SOFT BRACES ON PAIN AND PHYSICAL FUNCTION IN PATIENTS WITH KNEE OSTEOARTHRITIS: SYSTEMATIC REVIEW WITH META-ANALYSIS.

Tomasz Cudejko[1, 2], Martin van der Esch[2], Marike van der Leeden[1, 2], Leo D. Roorda[2], Jari Pallari[3], Kim L. Bennell[4], Hans Lund[5, 6], Joost Dekker1, [7].

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## BACKGROUND

Soft braces (knee sleeves) are elastic non-adhesive orthoses. They are commonly used because of their ease of use and low cost and are recommended as appropriate treatment for non-surgical management of knee osteoarthritis (OA). Nevertheless, to our knowledge a comprehensive overview of the effects of soft braces in patients with knee OA is not available.

## AIM

To systematically review and synthesize the effects of soft braces on self-reported pain and physical function in patients with knee OA.

## METHOD

Randomized controlled trials (RCT) and non-randomized controlled trials (non-RCTs), reporting on the effects of soft braces on self-reported pain and physical function in human adults (>18 years) with knee OA were included. The following electronic databases were searched from inception to April 20, 2016: The Cochrane Central Registry for Controlled Trials (CENTRAL), PubMed, EMBASE, CINAHL, SportDiscuss, Web of Science and PEDro. Cocharne Risk of Bias Tool for RCTs and the Downs and Black Scale for nonRCTs and for within design comparison of RCTs were used to assess the methodological quality. We synthesized data with meta-analyses.

## RESULTS

11 studies were identified, including six randomized controlled trials (RCTs) and five non-RCTs. The methodological quality of included RCTs was low.
There was a moderate improvement in pain ($P<0.05$) in favor of wearing a brace compared to not wearing a brace for the immediate, within-group comparison.
There was a moderate improvement in pain ($P<0.05$) and small to moderate improvement in physical function ($P<0.05$) in favor of patients receiving soft brace versus standard care or no treatment for the prolonged effect, between-group comparison.

## DISCUSSION & CONCLUSION

This review presents the first comprehensive synthesis of studies investigating the effects of soft braces in knee OA. Within the limitations of this systematic review, which mainly included a limited number of studies with low methodological quality, these findings highlight the importance of soft braces as a technique to improve pain and physical function in both, short and long-term. Further, high quality studies are warranted to improve confidence in the findings.

# INSTRUMENTED GAIT ANALYSIS OF MODERATELY ACTIVE TRANSFEMORAL AMPUTEES USING DIFFERENT PROSTHETIC KNEE JOINTS

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## BACKGROUND

Mobility is one of the most important aspects in human life. Therefore, the fundamental aim after a lower limb amputation is to recreate the physiological gait as good as possible. In particular, unilateral trans-femoral amputees have to learn how to adapt the lost muscles, while at the same time control the prosthetic joint. Prosthetic knees can be classified into two main groups: mechanical controlled (NMPK) and microprocessor controlled (MPK). In the past years, a number of biomechanical studies compared electronically controlled joints with mechanically controlled and showed that the use of a computerized prosthesis decreases the rate of falling,
increases mobility and improves security. [1] - [3]

## AIM

The purpose of this study was to compare ground reaction forces (GRF) and temporal parameters of mechanical controlled prosthetic knee joints (3R80 and 3R90; Otto Bock Health Care GmbH) with computerized knee joints (Kenevo and C-Leg; Otto Bock) in elderly and moderately active unilateral trans-femoral amputees with the use of two Kistler force plates.

## METHOD

15 individuals (age: 67.7 ± 7.8, weight: 71.6 ± 15.6kg, 11 male, 4 female), who suffered from unilateral trans-femoral amputation, were participated for that study. All subjects wore for the first measurement a mechanical knee joint (e.g. 3R80 or 3R90). Afterwards, an orthopaedic technician adjusted the prosthetic knee (Kenevo or C-Leg). After acclimtatization period of one week the same measurement was performed. All measurements were performed in a gait laboratory on a 8m walking track with two integrated Kistler force plates. Inclusion criteria were that the participants were able to walk without any aids and to have a minimum step length of 50cm to reach the force plates. GRF in all three dimensions and temporal parameters were analyzed. The entire data processing was performed in MATLAB (2014a, The MathWorks, Inc., Natick MA, USA). The Data are presented as means and standard deviation. P values below 5% were considered significant.

## RESULTS

Figure 1 shows the GRF of the intact leg versus the prosthetic leg of one representative subject. The right plot represents the intact leg and the left plot shows the prosthetic leg normal line: 3R80 and bold line: Kenevo. Graphs are plotted as gait cycle over time [s]. There are no significant differences between the MKP and NMKP with regard to the GRF. However, it has to be mentioned that the satisfaction was significant improved with the Kenevo according to each participant.

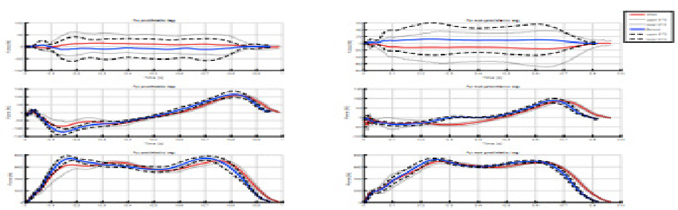

Figure 1. Ground reaction forces in all three dimensions (Fz, Fy and Fx) of one representative participant. The normal line represents the 3R80 and the bold line the Kenevo.

| | 3R80 | Kenevo |
|---|---|---|
| Walking Speed [km/h] | 3.343 ± 0.561 | 3.412 ± 0.605 |
| Step length prosthetic leg [m] | 0.582 ± 0.067 | 0.609 ± 0.028 |
| Step length non prosthetic leg [m] | 0.557 ± 0.047 | 0.539 ± 0.036 |
| Cadence [steps/min] | 86.800 ± 9.623 | 83.733 ± 8.276 |

Table 1. Temporal parameters of the NMKP and MKP.

In table 1 are selected temporal parameters of the 3R80 and Kenevo listed. There are no significant ($p > 0.05$) differences comparing the temporal parameters of the 3R80 with the Kenevo.

## DISCUSSION & CONCLUSION

Based on the results, it can be seen that the gait symmetry
with the Kenevo in elderly or geriatric patients is improved, compared with the NMKP. Furthermore, according to the amputee the satisfaction of each participant has improved while using the MKP. As mentioned above, many studies proved that in highly active amputees. Although, the GRF show no significant differences, mobility and security were increased. That leads to the fact that elderly amputees do profit from MKP technology in daily life.

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# THE USE OF OSSEOINTEGRATED TITANIUM IMPLANTS TO TREAT TRANS-TIBIAL AMPUTEES

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[1] The University of Notre Dame Australia, [2] Macquarie University, [3] The University of Sydney

## BACKGROUND

Osseointegration has been regarded as a new gold standard to overcome persistent socket prosthetic issues, by attaching the prosthetic limb directly onto the skeletal residuum. Until recently, this procedure has been performed mostly in trans-femoral amputee (TFA) patients. However, since August 2012, we have selectively performed osseointegration on eligible trans-tibial amputee (TTA) patients with below the knee amputation in our center. This paper represents the first pilot study to examine the results of performing osseointegration in the tibia.

## AIM

The primary objective of this study is to describe the reconstruction strategy and clinical management protocol used in the treatment of TTA patients with osseointegrated implants, as well as to report preliminary assessment of the safety and efficacy of the protocol in this particular group of patients.

## METHOD

This is a prospective pilot study of 15 patients, consisting of 8 males and 7 females, aged 37-77 (mean 55.1) years at surgery, with minimum two-year follow-up. Selection criteria included age over 18 years, unilateral TTA patients who had socket-related problems, as well as wheelchair bound patients with short stumps and non-reconstructable limb pathology. All patients received osseointegrated implants which were press-fit into the amputated limb. Principle outcome measures included the Questionnaire for persons with a Trans-Femoral Amputation (Q-TFA), Short Form Health Survey 36 (SF-36), Six Minute Walk Test (6MWT), Timed Up and Go (TUG) and K Levels Adverse events were recorded including infection, revision surgery, fractures, and implant failures.

## RESULTS

Comparisons were made using differences between the mean pre-operative and mean post-operative values for each outcome measure. Significant improvements for all five validated outcome measures were observed. The occurrence levels of adverse events including the infection rate and revision rate were similar to other established trans-femoral osseointegration studies.

## DISCUSSION & CONCLUSION

These preliminary results suggest that osseointegration surgery for trans-tibial amputees is a comparably safe and effective alternative treatment for amputees experiencing socket-related discomfort. This protocol has the potential to expand the application of osseointegration to help patients who have below the knee amputations where it was previously unavailable.

# TECHNICAL ANALYSIS AND MANIPULATION WATER HYACINTH FIBERS AS REINFORCEMENT MATERIALS IN FABRICATING PROSTHESIS SOCKET

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Polytechnic Health Science Ministry of Health Jakarta I in collaberation with

Department of Biomaterial Indonesian Institute of Science(LIPI)

**BACKGROUND**:

Water hyacinth fiber or water plants is widely used in the industries of furniture and household craft because easily available, cheap, does not endanger the health, it can reduce environmental pollution (biodegradability), so that in the future with the use of a fiber composite reinforcement is able to cope with environmental problems.

**THE OBJECTIVE:**

to get the technical analysis in the form of a tensile strength and elasticity of the composite fiber hyacinth with variations in treatment patterns of woven fiber direction angle towards the fibers of 45º and 90º with polyester resin matrix. The specific objective is to determine the strength and elasticity of water hyacinth fibers used as reinforcement material in prosthesis socket.

**METHODS**:

This experimental research is to analyze the tensile strength and modulus of elasticity of the water hyacinth fibers then compared with the value of tensile strength and modulus of elasticity of fiberglass fibers used as reinforcement material in prosthesis socket. The composite fiber is testing comparing hyacinth fiber pattern woven direction angle of 45º and 90º. Matrix volume fraction of 32% polyester and 68% water hyacinth fiber with hand lamination vaccum forming method.

**RESULTS**:

The test results obtained the highest tensile strength values possessed by the composite fine grain in fibers direction of 45º is 46.34 Mpa and 90º angle is 47.19Mpa. In which the same methods are using for fiberglass with result 42.90Mpa. The result of bending test with the

highest modulus of elasticity values possessed by the composite in direction of 45º is 766.119 N/mm2 and 90º angle is 684.958 N/mm2. and the same methods are using for fiberglass with result 688.945 N/mm2

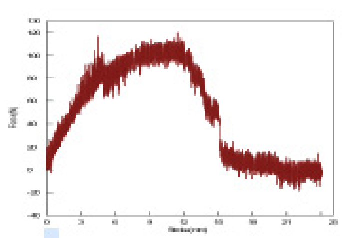
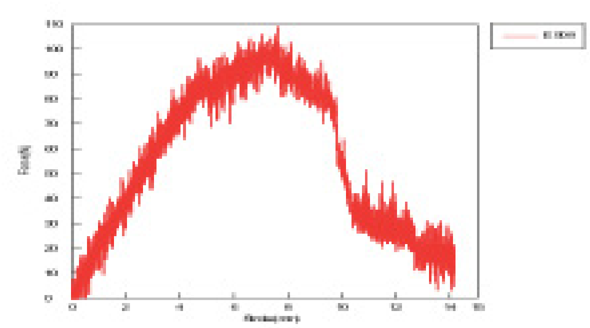


Figure 1. the graph of modulus elasticity and elongation of the fibers 45º

Figure 2. the graph of modulus elasticity and elongation of the fibers 90º



**CONCLUTION**:

The Water Hyacinth fibers are strong to and has potential become reinforcement material for fabricate the prostheses socket. Whereas the fibers direction of 90º is the highest tensile strength and has ability to stand with eksternal forces compare the fiberglass which is most common used in orthopaedic technology. But for the flexibility direction of 45º is the highest value of modulus elasticity.

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http://www.researchgate.net/publication/265478348 optimasi proses pembuatan serat eceng gondok untuk menghasilkan komposit serat dengan kualitas fisik dan mekanik yang tinggi
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# OCCUPATIONAL HEALTH AND SAFETY IN THE PROSTHETICS AND ORTHOTICS WORKSHOP

Sarah Anderson

## BACKGROUND

Prosthetists and Orthotists (P&O) are exposed to physical hazards within the workshop environment. Exposures to noise and volatile organic compounds (chemicals) can have adverse short and long term consequences on people's health such as pregnancy complications, stress, gastric ulcers, hypertension and heart disease1. Concern regarding these exposures has been expressed by P&Os; however, little research has been undertaken. At present we do not have an understanding of the noise levels in a P&O lab and what levels P&Os are exposed to. Nor do we have an understanding of how much exposure, through inhalation or absorption, people working in P&O labs have to common toxic substances such as acetone. Gaining an understanding of specific chemicals or noisy activities that P&Os are exposed to we will be able to target 'high risk' activities. The high risk factors can then be examined and risk mitigation activities such engineering controls or substitution methods to prevent exposure to these can be undertaken.

## AIM

The aim of this study is to identify and quantify hazardous noise and chemical exposures in a typical P&O workplace.

## METHOD

This pre-post study involved testing of noise and volatile organic compounds in 2011 and again in 2013. Between these two time points, modifications to the P&O workshop were undertaken to improve airflow, extraction and the physical requirements in the P&O facility. Noise testing was undertaken a qualified occupational hygienist using Integrating Sound Level Meter and Calibrator. The Noise Level Meter was set at a one-minute integration interval, a slow time constant and 3 dB exchange rate. Volatile organic compound testing, undertaken by the same occupational hygienist was taken in the breathing zone of P&O Department staff using organic vapour badges worn on the lapel over the course of a standard work day and while conducting

normal duties. The organic vapour badges were analysed by a regulated test laboratory using gas chromatography/mass spectrometry. The effectiveness of the local exhaust ventilation systems was assessed by smoke tests and average capture velocity (m/s) readings from air current tubes and anaemometers at 2 points within the workshop.

## RESULTS

The levels of volatile organic compounds were very low in all areas in 2011 and 2013. Noise levels were high and staff require the use of personal protective equipment to prevent unsafe exposure beyond levels prescribed in the Australian Standards. Noise. Modifications to the workshop environment to address reported noise and volatile chemical exposure concerns by staff resulted in reducing noise levels from a maximum peak noise of 96 dB(A) to 74 dB(A). However, changes to improve the extraction system resulted in an increase from 88 to 95 dB(A) during grinder use in the machine room. A reduction in noise levels in the lamination room from 96 dB(A) to 78 dB(A) was recorded following modifications to the ducting setup between 2011 and 2013.

| Area/Operation | LAeq 1 min dB(A) | period before eight hour standard exceeded* (hrs:min) | Points where/when measurements taken |
|---|---|---|---|
| Grinder | 95 | 0:47 | Fan speed 100% with all other outlets blocked off |
| Grinder | 89 | 3:11 | Fan speed 100% with all other outlet open |
| Chipping plaster with air chisel | 103 | 0:07 | At staff member's ear |

Table 1. 2013 Noise frequencies key results.

Volatile organic compounds. Exposures on the day of monitoring for both assessments were within the time weighted average exposures maximum acceptable levels (ppm) as specified by the legislative body for the following substance: Pentanes, Methyl Methacrylate, Isopropyl Alcohol, toluene, Xylenes, MEK and Acetone.

## DISCUSSION & **CONCLUSION**

Occupational environmental exposures in P&O are of concern to the profession. A pilot study of one facility demonstrated that Occupational Noise exposures are high and may result in hearing loss and other adverse health outcomes. Occupational chemical exposures through volatile organic compound exposures are relatively low. However, this facility has been proactive in substitution of key materials and substances such as toluene free based glues. As such there may be higher noise and chemical exposure at other facilities. A systematic investigation is required to develop a more comprehensive understanding of the P&O workshop hazards to enable evidence-based control strategies to be developed and implemented

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# THE USE OF OSSEOINTEGRATED TITANIUM IMPLANTS TO TREAT BILATERAL AMPUTEES

William Lu[1], Munjed Al Muderis[2,3]

[1] The University of Sydney, [2] The University of Notre Dame Australia, [3] Macquarie University

## BACKGROUND

Current socket prostheses remain problematic, resulting in more than 90% of patients with bilateral above-knee amputations being confined to a wheelchair due to the difficulty of mobilizing with prosthetics on both lower limbs. Osseointegration has been regarded as a novel approach to overcome persistent socket prosthetic issues, which uses a transcutaneous titanium implant that is directly attached to the residual bone. A number of bilateral amputees have been treated with osseointegration in our center since July 2012.

## AIM

The primary objective of this paper is to report the preliminary clinical outcomes in this particular group of patients, including the results of functional and quality of life assessments, and safety of the osseointegration procedure.

## METHOD

This is a prospective pilot study of 13 patients, consisting of 10 males and 3 females, aged 24-62 (mean 38.7) years at surgery, with minimum two-year follow-up. Selection criteria were age over 18 years, bilateral amputees who had socket-related problems or were wheelchair-bound with short stumps and non-reconstructable limb pathology. All patients received osseointegrated implants which were press-fit into the amputated limb. Principle outcome measures included the Questionnaire for persons with a Trans-Femoral Amputation (Q-TFA), Short Form Health Survey 36 (SF-36), Six Minute Walk Test (6MWT), Timed Up and Go (TUG), and K-levels. Adverse events were recorded including infection, revision surgery, fractures, and implant failures.

## RESULTS

Comparisons were made using differences between the mean pre-operative and mean post-operative values for each outcome measure. Significant improvements in all five validated outcome measures were observed. The occurrence levels of adverse events, including the infection rate and revision rate, were similar to other established trans-femoral osseointegration studies.

## DISCUSSION & CONCLUSION

These preliminary results indicate that osseointegration surgery is a safe and effective alternative treatment for bilateral amputees experiencing socket-related discomfort. Compared to the suboptimal outcomes of socket prostheses, osseointegration currently provides one of the best chances for any bilateral amputee to walk again and regain the ability to perform daily activities.

# OSSEOINTEGRATED RECONSTRUCTION OF WHEELCHAIR-BOUND TRANS-FEMORAL AMPUTEES: CLINICAL OUTCOMES

William Lu[1], Munjed Al Muderis[2,3]
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## BACKGROUND

Trans-femoral amputees often have significant problems obtaining a satisfactory fit with socket prostheses due to a short skeletal residuum, dense adherent scars, or heterotopic bone. Osseointegration provides a completely different strategy for managing these patients, using a transcutaneous titanium implant that is directly attached to the residual bone.

## AIM

The primary objective of this study is to describe our experience in using osseointegration as the definitive reconstruction strategy for severely handicapped trans-femoral amputees who are unable to use a socket-mounted prosthetic limb, and are therefore wheelchair-bound.

## METHOD

This is a case series of 15 patients who were originally wheelchair-bound. The patients included 8 males and 7 females, aged 24-66 (mean 44.6) years. All 15 patients were trans-femoral amputees (2 bilateral). Clinical outcomes were obtained pre- and post-operatively from 12 to 42 months, with a mean follow-up of 20 months. Principle outcome measures included the Questionnaire for persons with a Trans-Femoral Amputation (Q-TFA), Short Form Health Survey 36 (SF-36), Six Minute Walk Test (6MWT), Timed Up and Go (TUG), and K-levels. Adverse events were recorded including infection, revision surgery, fractures, and implant failures.

## RESULTS

All 15 patients were wheelchair-bound pre-operatively, with a K-level of 0. None of these patients were able to complete the 6MWT or TUG pre-operatively, yet all 15 were able to do so post-operatively. Compared to the pre-operative results, the mean post-operative values for all five validated outcome measures were significantly improved.

The post-operative Q-TFA global score ($39.13\pm5.6$ to $79.78\pm4.4$, $p<0.0001$) and the SF-36 physical component summary ($31.62\pm2.78$ to $42.21\pm2.74$, $p=0.0115$) were both significantly higher than the pre-operative values. The 6MWT (immobile, to $374\pm38$, $p<0.0001$) and the TUG (immobile, to $10.89\pm1.30$, $p<0.0001$) were also dramatically improved. K-levels improved in all 15 patients ($\chi2=28.667$, df=4, $p<0.0001$). In terms of adverse events, 4 patients experienced episodes of minor infection and responded to oral antibiotics, 3 patients required intravenous antibiotics, and 2 patients underwent debridement of the stoma. Refashioning of the soft tissue residuum was performed electively on 7 patients, as the soft tissue redundancy evolved over time. Two periprosthetic fractures occurred due to increased activity, and were successfully stabilized without the need to revise the implant. There was one implant fatigue failure that was revised successfully

## DISCUSSION & CONCLUSION

These findings have important implications for the reconstruction and rehabilitation of patients who have undergone a trans-femoral amputation and have a problematic residuum that cannot be successfully fitted with a socket-mounted prosthetic limb. Despite being completely unable to use a prosthetic limb pre-operatively, functional levels were dramatically improved in all reported patients after osseointegrated reconstruction.

# OSSEOINTEGRATION FOR THE RECONSTRUCTION OF DEVASTATING MILITARY AND TERRORIST BLAST INJURIES

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## BACKGROUND

Blast injuries from military and combat related explosions often result in devastating lower extremity injuries, which in many instances are not possible to reconstruct successfully. With soft tissues and bone obliterated by the explosion, the associated gross destruction of the extremities frequently results in lower limb amputations. These injuries are often bilateral, and can be notoriously difficult to fit with prostheses due to a short skeletal residuum, dense adherent scars, and heterotopic bone. Osseointegration provides an innovative solution, using a transcutaneous titanium implant that is directly attached to the residual bone.

## AIM

The primary objective of this study is to describe our experience in osseointegrated reconstruction following amputations resulting from blast injuries, including preliminary assessment of the safety and efficacy of the procedure in this challenging cohort of patients.

## METHOD

This is a case series of 10 patients who had military or terrorist blast injuries resulting in lower limb amputations. The patients were 10 males, aged 23-67 (mean 37) years. Clinical outcomes were obtained pre- and post-operatively from 10 to 30 months, with a mean follow-up of 16 months. Outcome measures included the Questionnaire for persons with a Trans-Femoral Amputation (Q-TFA), Short Form Health Survey 36 (SF-36), Six Minute Walk Test (6MWT), Timed Up and Go (TUG), and K-levels. Adverse events were recorded including infection, revision surgery, fractures, and implant failures.

## RESULTS

Compared to the mean pre-operative values with socket prostheses, the mean post-operative values for all five validated outcome measures were improved.

The post-operative Q-TFA global score (40.69±6.46 to 78.13±4.44, p=0.0003) and the SF-36 physical component summary (42.16±2.83 to 47.90±3.34, p=0.2) were both significantly higher than the pre-operative values. The 6MWT (102±56.17 to 437±60.61, p=0.0017) and the TUG (14.34±3.33 to 8.74±1.46, p=0.11) were also dramatically improved, with a 330% increase for the 6MWT and 39% reduction for the TUG. K-levels improved in 9 patients. There were episodes of minor infection in 3 patients, all of which responded to oral antibiotics. Refashioning of the soft tissue residuum was performed on 1 patient electively. One periprosthetic fracture occurred due to increased activity, and was successfully stabilized without the need to revise the implant.

## DISCUSSION & CONCLUSION

These findings have very important implications for the comprehensive reconstruction and rehabilitation of patients who have undergone amputation as a result of military combat blast injuries. Despite previously having tremendous difficulties in using a socket-mounted prosthetic limb, functional levels of the patients were greatly improved after osseointegrated reconstruction. Our experience in this small series suggests that osseointegration may be considered a highly effective strategy for the definitive reconstruction of amputees resulting from military-type blast injuries.

# HIGH MOBILITY AMPUTEES WITH OSSEOINTEGRATED IMPLANTS: A PROSPECTIVE STUDY OF 9 PATIENTS

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## BACKGROUND

The Amputee Mobility Predictor (AMP PRO) is a standardized instrument for assessing the ability of lower limb amputees to ambulate with their prostheses. It uses a 5-level functional classification system (K0-K4) to grade the ability of patients who had undergone lower limb amputation. When rated at the highest level of K4, the amputee is expected to have the ability or potential for prosthetic ambulation that exceeds basic ambulation skills, exhibiting high impact, stress, or energy levels. While K4 rated amputees are expected to mobilize with relative ease, socket interface drawbacks may still largely interfere with their overall quality of life due to cumbersome donning routines, skin friction, size fitting and diminished proprioception. Osseointegrated implants have been regarded as a new alternative for overcoming persistent socket prosthetic issues, by attaching the prosthetic limb directly onto the skeletal residuum. It is hypothesized that this technology can allow amputees to further improve their quality of life while maintaining the same ambulation abilities.

## AIM

The purpose of this study is to examine the efficacy of osseointegration in improving the quality of life for amputees who were originally highly mobile (K4).

## METHOD

This is a prospective pilot study of 9 patients, consisting of all males, aged 24-62 (mean 49.75) years at surgery, with minimum two-year follow-up. Selection criteria included age over 18 years, unilateral trans-femoral amputee patients who had a pre-surgery AMPPRO evaluation graded at the highest level of K4. All patients received osseointegrated implants that were press-fit into the amputated limb. Principle outcome measures included the Questionnaire for persons with a Trans-Femoral Amputation (Q-TFA), Short Form Health Survey 36 (SF-36), Six Minute Walk Test (6MWT), Timed Up and Go (TUG), and K Levels (AMPPRO). Adverse events were recorded including infection, revision surgery, fractures, and implant failures.

## RESULTS

At the time of follow-up, none of the patients suffered from a decrease in mobility after receiving the osseointegration implant. All patients maintained the same highest level of mobility rating at K4. Significant increases in the overall Q-TFA and SF-36 scores were observed, indicating substantial improvements in the patients' quality of life. In terms of adverse events, minor infections were relatively frequent but were easily managed using orally administered antibiotics. Implant failures that required surgical intervention were rare.

## DISCUSSION & CONCLUSION

In this study, we investigated the changes in quality of life for high mobility patients (K4) who underwent osseointegration surgery. The results confirm the hypothesis that osseointegration is able to provide highly mobile amputees with the opportunity to further improve their quality of life while still maintaining high levels of ambulation.

# A PILOT STUDY : THE EFFECT OF TIBIA INCLINATION ON GAIT PATTERN OF STROKE PATIENT WITH GENU RECURVATUM WHO WEAR ANKLE FOOT ORTHOSIS

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## BACKGROUND

Stroke is one of the main causes of adult disability in most countries including in Thailand. Fifty percent of stroke patients regain a limited level of mobility. Around 40-60% of post stroke patients suffered from genu recurvatum (GR) and treated with a rigid Ankle Foot Orthosis (AFO)1. Many researchers have been studied in tuned AFO aiming to improve rehabilitation on orthotic management of post-stroke patient. Tuned AFO can be achieved by adding heel wedges under the AFO, thus will affect the tibial inclination during stance phase. As the primary goal of orthotic treatment, tibial inclination is expected to change the knee flexion angle during mid stance. There is no information how much the optimum tibial inclination for post-stroke patient who have GR 100-300.

## AIM

The aims of this study is therefore twofold: 1) to investigate the optimum inclination in Rigid Tuned Ankle Foot Orthosis (RT-AFO) to normalize knee kinematics for stability in sagittal plane with 100-300 genu recurvatum of stroke patients in stance phase, and 2) to compare the effects of RT-AFO with different inclination in spatio-temporal parameters.

## METHOD

A total of four participants from Siriraj hospital with chronic stroke (>6 months) participated in three appointments. Participants walked 10 m without AFO (T1) and four conditions of tibial inclination ; 00, 50, 100, 150 (T2,T3,T4, and T5). Knee flexion-extension angle was measured and compared to see the effect of tibial inclination in reducing genu recurvatum angle during mid-stance. The Kolmogorov-Smirnov test was computed to evaluate differences in parameters of four participants. Paired t-test analysis was conducted to compare spatio-temporal parameters between T1 and

other four conditions. The significant level considered was $p < 0.05$.

## RESULTS

Kinematics : Application of tibial inclination on the AFO proven reduced the genu recurvatum in stroke patient. In condition T1 (walk without AFO) the mean±SD of genu recurvatum angle is -17.2±7.40. Genu recurvatum was significantly reduced in conditions T3, T4 ($p<0.001$) and in T5 ($p<0.05$). However the optimum inclination was found in 150 tibial inclination for patient who has 100-300 genu recurvatum and measure at mid stance with mean±SD of knee extension angle is -5.9±15.40 . As the optimum inclination, RT-AFO 150 had reduced the mean of genu recuvatum angle by 11.30 compare to T1 (walk without AFO). Spatio-temporal : This study reported the statistical significant of improvement in cadence was achieved in condition T4 (RT-AFO 100) ($p <0.01$). There was no significant result for improvement of walking speed and stride length.

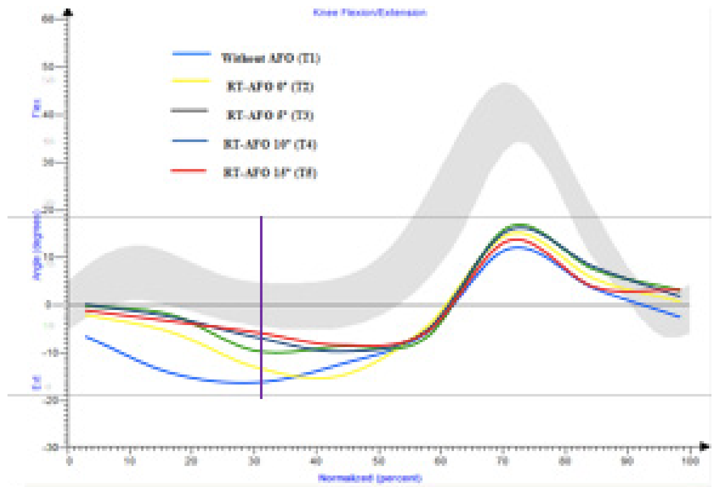


Figure 1. Comparison knee joint flexion-extension angle of five conditions: T1,T2,T3,T4, and T5 with normal (shaded area).

## DISCUSSION & CONCLUSION

Application of RT-AFO can reduce the overall recurvatum angle at the knee. Our study found the optimum inclination of the RT-AFO is 150 for the genu recurvatum angle 100-300. In this study, there is no significant difference in stride length and walking speed. Spatiotemporal results illustrated improvement in cadence with RT- AFO of 100 inclination was significant among participants. Limitations in this study including the limited sample size of subjects that reduces the power of the findings. Therefore, studies with greater sample sizes and longer study periods are recommended.To investigate the effect of tibial inclination for the spatio-temporal parameters, further study need to allow adaptation time for subject to use the new tibial inclination angle within three months interval. Combination of RT-AFO and gait training is necessary to improve the gait parameters.

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# EFFECTS OF ONE-DAY LOW-INTENSITY COMBINED ARM-LEG (CRUISER) ERGOMTER PRACTICE: GROSS MECHANICAL EFFICIENCY OF ONE VERSUS TWO LEGS OVER TIME

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## BACKGROUND

The combined arm-leg (Cruiser) ergometer seems a suitable instrument for testing and training the physical condition in patients with a lower limb amputation.1 The Cruiser ergometer can be used with two arms and one leg. It is not known whether there is a difference between one and two-legged exercising on the Cruiser ergometer and if there is a motor learning effect.


Figure 1. The Cruiser ergometer

## AIM

To determine if there is a difference in cardiorespiratory measures and Gross mechanical efficiency (GE) exercising on the Cruiser ergometer with one and two legs and if there is a motor learning effect when using this ergometer.

## METHOD

28 healthy male subjects between 18 and 30 years of age participated in this study. One group (n=14) used both legs and arms and one group (n =14) one leg and both arms. All participants performed a discontinuous low-intensity exercise protocol during a one-day intervention including a standardized pre- and posttest. The pre- and posttest consisted of three bouts of four

minutes submaximal exercise at 40W and at 50 rpm. Gross mechanical efficiency (GE (%)), oxygen uptake (VO2 (l/min)), carbon dioxide output (VCO2 (l/min)), breathing frequency (BF (breaths/min)), maximal ventilation (VE (l/min)), respiratory exchange rate (RER) and heart rate (HR (beats/min)) were measured.

## RESULTS

The one and two legged exercise differ significantly from each other concerning GE and HR for the pre and posttest (p=0.031 and p=0.034). The GE of one legged exercise has significantly (p= 0.001) increased from 9.2% at the pretest to 10.9% at the posttest while the two legged exercise showed a non-significant (p= 0.143) increase with pretest values of 10.8% and posttest values of 12.2%. Both groups did improve significantly over the 3 exercise bouts of the pretest. During the posttest however, no significant improvements were seen over the exercise bouts.

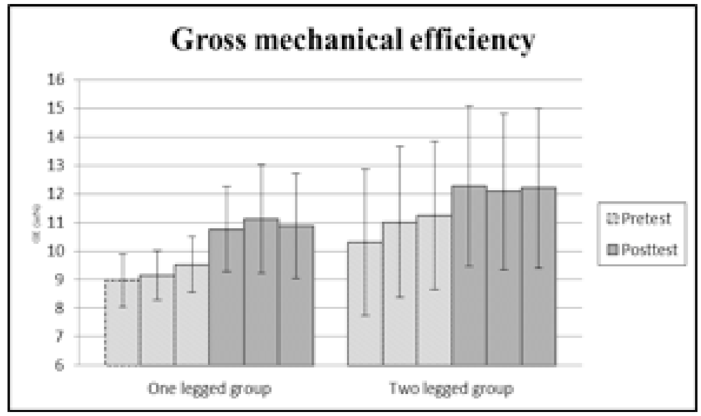


Figure 2. Mean scores and standard deviation of the gross mechanical efficiency during each of exercise bouts (1-3) pre- and posttest for both groups ( n = 14).

## DISCUSSION & CONCLUSION

This study shows that there is a difference in exercising on the Cruiser ergometer with one and two legs. Both groups showed an increase in GE after the intervention and thus motor learning and this effect was bigger for the one legged group. Further research concerning patients with a lower limb amputation using the Cruiser ergometer is suggested especially to the effects of motor learning.

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# A PILOT STUDY ON THE EFFECT OF RIGID POSTERIOR SHELL ANKLE-FOOT ORTHOSIS' SHANK INCLINATION IN THE WALKING SPEED OF SPASTIC HEMIPLEGIC STROKE PATIENTS

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## BACKGROUND

Stroke still remains a global burden in the Philippines which constitutes to 348 per 100,000 total number of disability-adjusted life-years lost in the population. Most stroke survivors would later on develop hemiplegia, and this could affect different parameters of gait, specifically walking speed. AFOs are fitted to aid in rehabilitation, and some studies claimed that fine-tuning the device with shank inclination could impact joint kinematics and affect walking speed.

## AIM

To determine if the AFO in various SVA inclinations had an effect in the walking speed of CVA patients, and observe if other factors such as device comfort affected speed.

## METHOD

Seven (7) established-hemiplegic-CVA AFO users were the number of subjects. The data gathered was grouped according to the four conditions: an AFO with the shank to vertical angle (SVA) in 0 degree, a fine-tuned AFO with the SVA in 10, in 12, and in 14 degrees inclination measured using a goniometer. Three outcome measures were used: the Orthotics and Prosthetics' User Survey (OPUS), the 10-meter walking test (10MWT), and the Numeric Rating Scale (NRS). The data, expressed in mean and standard deviation, were analyzed using the paired samples T-test and all statistical level of significance was set at p=<0.05.

## RESULTS

Seven (7) subjects who met the criteria participated in the study. Condition 1 (SVA in 0 degree) became the baseline for comparison to see if the other succeeding conditions had a significant increase in average walking speed. The results showed a trend that as it reached the succeeding condition, the walking speed would increase (Figure 1). Conditions 1 and 2 (p= 0.79), conditions 1 and 3 (p= 0.27), and conditions 1 and 4 (p= 0.11) failed to reach the level of significance (p= <0.05). In terms of device comfort, the AFO aligned in 12 degrees shank inclination made the subjects walk in a comfortable pace but comfort did not really show that it affected the walking speed of the subjects.

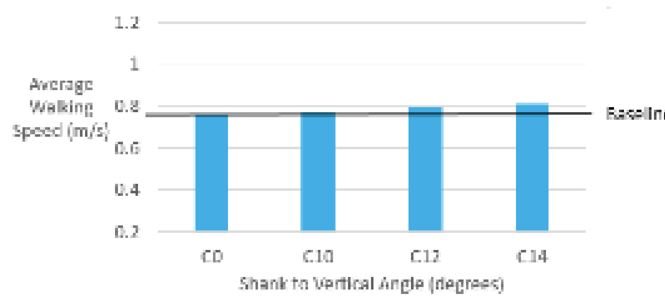


Figure 1. Average Walking Speed for Each Condition

## DISCUSSION & CONCLUSION

Changing the alignment of an AFO generated changes in walking speed of a spastic hemiplegic-CVA patient. Conditions 2, 3, and 4 wherein the SVA was aligned in 10, 12 and 14 degrees displayed changes in accordance to the first condition (SVA 0 degree). Greatest change or increase in speed was seen during the fourth condition (SVA 14 degrees) but garnered the lowest comfort score in relation to the other conditions.

# A NEW METHOD OF JOINT MOMENT EVALUATION AND ITS APPLICATION TO THE HIP JOINT CENTER ESTIMATION

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## BACKGROUND

The accuracy of joint moments is very important for gait analysis. If the joint moment is not accurate, it will mislead the clinical judgment. However there is no standard method to verify the reliability of joint moment. There are several methods for hip joint center (HJC) estimation. For example the Clinical Gait Analysis Forum of Japan; Data Interface File Format (DIFF) model, Plug in gait (PIG) model, the symmetrical centre of rotation estimation (SCoRE) model and three dimensional rotation estimation method developed by one of the authors. The HJC location depends on the methods used. If HJC changes, the joint moment also will be affected. It is unclear for which method to be used to calculate the joint moment accurately.

## AIM

The purpose of this study was to develop a new method to evaluate the accuracy of joint moment and its application on the HJC. As application of this new method we selected the most accurate of hip joint moment among the four methods to estimate the HJC.

## METHOD

Three healthy male participated in the study. Twenty three markers were set on the subject. Four HJC estimation methods were used to calculate each HJC. The HJC was calculated from the marker setting on the pelvis for DIFF and PIG methods. But for the SCoRE and 3D rotational methods, the HJC was calculated from the movements of markers set on the pelvis and the thigh. Then the subjects were instructed to bend the trunk forward at approximately 40 degrees which is the initial position of the motion. Next, the subject extended the trunk from 40 degrees forward to standing position. Later the data were processed using VICON motion analysis system. At first from Vicon data the centre of gravity was calculated and the potential energy increase during the motion was calculated. The joint moment was calculated from each of the HJC from the four methods. Then the joint moment power was calculated. And then the mechanical work was derived from the power. And finally the potential energy increase and work were compared and the method that has little difference was selected.

## RESULTS

The SCoRE method showed an average of 6.1 J of difference when comparing the potential energy increase and the mechanical work, while the DIFF and the PIG averaged 9.8J and 10.3J respectively. The maximum difference seen was 16.9 J for the 3D rotational method and the SCoRE method showed lest difference. (Table 1`

| | SCoRE | DIFF | PIG | 3D rotational |
|---|---|---|---|---|
| A | 15.4 | 0.9 | 1.6 | 36 |
| B | 2.5 | 13.3 | 21 | 8.5 |
| C | 0.5 | 15.4 | 8.5 | 6.4 |
| Average | 6.1 | 9.8 | 10.3 | 16.9 |

Table 1. Difference between potential energy and lower limb work of hip motion at 40 degrees bending forward (Joule)

## DISCUSSION & CONCLUSION

The present study highlights the evaluation of joint moment and its application on the HJC based on the potential energy increase and mechanical work comparison. The results observed showed that SCoRE has less difference (6.1J) compared to DIFF, PIG and 3D rotational method. The big discrepancy observed for the 3D rotational method might due to the limited movement performed in multiplanes directions.

# PROSTHETIC USE AND MOBILITY AMONGST PEOPLE WITH UNILATERAL TRANSFEMORAL AMPUTATION IN THE WESTERN CAPE, SOUTH AFRICA.

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## BACKGROUND

Studies have shown that a transfemoral amputation compared to transtibial requires more physical demands and shows less frequent prosthetic use [1]. Within the Western Cape's Public Health Sector, criteria for approval of a transfemoral prosthesis has been set according to predisposing factors for good post prosthetic mobility [2]. Prosthetic components available correspond with mobility needs of K1 (household) and K2 (limited community) ambulation level. Once the person has received their prosthesis, little is known about prosthetic use and mobility thereafter.

## AIM

To determine prosthetic use and prosthetic mobility of people with unilateral transfemoral amputation who received services from the Western Cape Government: Department of Health, South Africa.

## METHOD

The study follows a quantitative, descriptive study design. The study population included all adults who received their first prosthesis from the Orthotic and Prosthetic Centre between 1 June 2011 and 31 December 2014. Data were collected through telephone interviews. An adapted version of the Prosthetic Profile of the Amputee (PPA) was completed. The questionnaire included; frequency of prosthetic use, prosthetic mobility across different terrains, the need for additional mobility aids, prosthetic expectations and demographic characteristics. Descriptive statistics were calculated using range, medians, and relative frequencies. These are presented using tables, bar graphs and histograms.

## RESULTS

43 questionnaires were completed. The majority of study participants are older than 50 (77%), and are men (79%). Vascular conditions (47%) followed by diabetes (23%) are the primary causes of amputations. Thirty five participants (81%), reported that they use their prosthesis, of which twenty (mean age 53) use the prosthesis 5 days and more per week, and fifteen (mean age 57.5) use their prosthesis 3 days and less per week. The majority of prosthetic users, twenty six (74%), have the ability to walk indoors without assistive devices. Over outdoor uneven terrain, twenty six need either one (26%) or two elbow crutches (48%). Twenty four (69%) participants are limited to less than 500 steps at a time which challenges community ambulation. Nineteen of the participants (44%) feel that their initial expectations of the prosthesis are completely met and nine (21%) feel their expectations are only somewhat met.

## DISCUSSION & CONCLUSION

The high vascular cause of amputation is comparable to international studies [3]. The majority of the study participants used their prosthetic leg although limitations were experienced in frequency of prosthetic use, prosthetic mobility (walking distance, the need of assisted devices outdoors) and in prosthetic component choice. The results only describe the study population at the time of the study. It can however provide valuable insight to therapists and prosthetists that are involved in the prosthetic rehabilitation services within the Western Cape's Public Health Sector and assist them to better educate their patients on realistic expectations of prosthetic mobility and use.

## REFERENCES

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# DOES PROSTHETIC SPRING STIFFNESS ALTER THE TEMPORAL-SPATIAL PERFORMANCE IN A CHANGE OF DIRECTION MOVEMENT?

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## BACKGROUND

An ability to change direction quickly is important in sport. There is no research indicating how amputees perform a cutting movement from the prosthetic and intact limbs. In a prosthesis with a spring element, the spring deforms to store energy in loading and returns the energy in propulsion. The stiffness of prosthetic spring will influence the performance if all other measures are kept equal (Zelik et al 2011). No research has analysed how the spring stiffness influences performance in a controlled, complex change of direction movement.

## AIM

To establish if amputees could perform a change of direction (CoD) movement when wearing an energy storing foot (ESF) and determine if spring stiffness had an effect on performance characteristics.

## METHOD

Ten unilateral male transtibial (TT) amputees (age=34.6±8 years, height=1.81±0.08metres, mass=84.2±21.48kg) participated. Data were captured using 12 Vicon cameras and 2 Kistler force plates (FP) sampling at 120Hz and 960Hz respectively (filtered 4th order Butterworth filter, cut off frequency of 6Hz and 300Hz resp). Data was collected over two sessions with prescribed stiffness first and increased stiffness second. Participants jumped forward onto FP1, landing on the intact leg, then immediately side jumped to land on the prosthetic leg on the adjacent FP2. The movement was repeated with the prosthetic leg leading. Ten good trials (clean landing on FPs and a controlled landing on FP2) were collected and the middle five analysed. Paired samples t-test was used to analyse the effect of stiffness on both the prosthetic to intact limbs.

## RESULTS

Performance was defined by temporal-spatial measurements. The time to complete each phase of the movement and the distance covered in each part of the movement was determined and compared between limbs and between stiffnesses. Altering the stiffness had no significant effect on the performance. Significant differences were found between the intact and prosthetic limbs for four variables; forward jump flight time, stabilisation time, forward jump distance and the distance between the pelvis on foot at ground contact. The pelvic distance was longer on the prosthetic side and the side step was longer on the intact limb.

Table 1. Group mean data for prosthetic and intact limbs in the prescribed (P1) and stiffer (P2) conditions

| | P1 | I1 | P2 | I2 |
|---|---|---|---|---|
| F. jump flight time (s) | 0.59 ± 0.12 | 0.50 ± 0.07[a] | 0.58 ± 0.11 | 0.51 ± 0.08[d] |
| Stance time (s) | 0.60 ± 0.13 | 0.58 ± 0.14 | 0.60 ± 0.14 | 0.54 ± 0.16 |
| Side jump time (s) | 0.09 ± 0.02 | 0.08 ± 0.04 | 0.07 ± 0.04 | 0.09 ± 0.04 |
| Stabilisation time (s) | 0.51 ± 0.11 | 0.58 ± 0.04 | 0.50 ± 0.07 | 0.58 ± 0.07[d] |
| Total time (s) | 1.79 ± 0.24 | 1.74 ± 0.16 | 1.74 ± 0.30 | 1.72 ± 0.17 |
| F. jump distance (LL) | 1.11 ± 0.05 | 1.14 ± 0.03 | 1.10 ± 0.04 | 1.14 ± 0.02[d] |
| Side jump distance (m) | 1.08 ± 0.13 | 1.11 ± 0.2 | 1.12 ± 0.09 | 1.14 ± 0.16 |
| Attack distance (m) | 0.35 ± 0.06 | 0.29 ± 0.04[a] | 0.35 ± 0.06 | 0.29 ± 0.05[d] |

Table 1. Group mean data for prosthetic and intact limbs in the prescribed (P1) and stiffer (P2) conditions

## DISCUSSION & CONCLUSION

It was anticipated that a stiffer spring would result in a shorter stance time and longer side jump as less energy would be lost in the deformation. That this did not occur is likely due to altered mechanics at other joints. Significant differences between the intact and prosthetic sides were evident indicating the limitation of the prosthesis. Interestingly, these differences occurred in the first step onto FP1 rather than in the side-step onto FP2. In conclusion, it would appear that the amputees could perform the movement in a similar way from both the intact and prosthetic sides and that the stiffness of the prosthesis did not influence the performance.

## REFERENCES

1. Zelik et al; 2011 IEEE Part H.

# AUTOMATIC ASSEMBLY FRAME DEVICE

## An Integrated device for mass production of Orthotic Calipers

Sumit Bhowmik

**BASIC INFORMATION:**

AUTOMATIC ASSEMBLY FRAME DEVICE is basically and technology which outlines the concept of "Dynamic Alignment - Jig Fixture" (DAJF) Technology, a fully automatic electro-pneumatic device used to assemble high quality, correctly aligned, Correctly contoured, adequately shaped orthotic calipers (braces) for persons requiring caliper stabilization in a single stage process. Successful provision of well-fit caliper devices is currently limited by cost, time to manufacture and the requirement for multiple re-fits. The proposed process and technology is especially beneficial for those in underserved populations. People in these populations are often limited by lack of funding for the devices and
visits, and by lack of transportation to attend appointments. Those with none or ill-fitting devices develop additional health problems (pain, ulcers, infections and mal-alignment issues) which lead to further problems and costs, in personal, social and community realms. This process and technology
addresses issues to lower the cost of production, making these devices accessible to more people; reduce device alignment problems and therefore fit visits and improve the overall fit process which reduces dependence on operator skill. A caliper (Mechanical device fitted externally to victim's leg generally attached to
shoe for support or correct or to prevent further complication) is generally prescribed/given to the person who has lower limb impairment/weaknesses, may caused due to any disease or deformity like, Poliomyelitis, Para or Hemiplegic attack, other neurological disorders, congenital or caused by accidents.

**Problem we are trying to solve:**

a . Describe the problem and proposed solution Underserved populations face challenges in obtaining appropriate, high-quality orthopaedic calipers due to cost, access and time for production and re-fit. Therefore, these populations either go without or end up with mal-aligned devices which can put them at further risk for health care problems. These same issues
affect those populations which can afford well-made

calipers, but is most acutely felt in underserved populations. Manufacturing of these devices is expensive, takes a long time and requires multiple visits. DAJF will ensure following features like

1) Optimum alignment
2) Adequate Shaped caliper
3) Rightly contoured fittings
4) Right placement of joints and uprights in respect to any plane and axes

In a single step and lower overall costs for providing such devices, making them more accessible to underserved populations. This process will not only bring the cost down by may way but also help reducing the botheration of the user, enabling one to have better quality of life thus will help in societal harmony growth.

b . What are the existing alternate solutions that people are using & cost of those solutions? In our knowledge, at present there is no parallel technology, we are not aware of any technology which is being followed universally. Calipers are currently created one-by-one, it has to be made customized. Manufacturing and fit are subject to the skill and mood of the technician, which ultimately dictates the need for re-fit. Current solutions include the use of Plaster of Paris (POP) casting. Plaster casting is taken to have negative cast of the effected limb. It should be taken in weight bearing condition; however it is generally taken requesting patient to lying position, which itself is wrong beginning. POP molds are obtained
by filling this cast by the technician and further certain modification are being done on positive moulds, which again depends upon the skill of the technician. The calipers are made based on this plaster of Paris mould. The knee joints and side bars are being assembled on POP mould. This process is time consuming and costly and is heavily technician dependent for quality. The current cost of a high-quality calipers in India range between INR 35000.00 to Rs. 1,65,000.00. In the US and Western countries, the cost of these devices range between USD 636 to USD 3000.00. The figures/data furnished in the application are not from any particular authenticsource/s but accumulation of various feedbacks and based on experience of different professional in this segments thus does not attract any claim.

**Market Size and Customer Definition**

a . Describe your target customer * Target customers include any person requiring permanent orthopedic leg bracing for conditions including: Polio/Post-polio, congenital leg deformities, Para or Hemiplegic, other neurological disorders or deformities due to fracture. We will approach them by the agencies those who are providing Orthotic Caliper/braces to beneficiaries through welfare camps. Also private establishment will be added customers.

b . Describe market size * In the world today it is estimated that approx 9,50,000 persons are affected by
lower limb weakness, predominantly approx 400000 is because of Poliomyelitis. Geographically this will cover 80% of Africa, 60% of Asia, 40% of south and
Middle America and 10% of rest of the World. c . Describe competition and respective market shares *
Existing Companies with allied services in this space include:

Ottobock-Germany (# of employees, not known), market share: approx 45%(assumed) Proteor-France (# of employees, not known), market share: 10% (assumed) Blatchford –UK (# of employees, not known), market share: 20% (assumed) Hanger-USA (# of employees, not known), market share: 15% Others, market share approx 10% for such appliances, thus the business share area is 100%, as this is will be newly introduced technology.

**Description of innovative Product and Technology**

a . What is the current status of the product/technology? *This is currently in the conceptual stage. We are working with sketches. The part three that is the suction pulling (vacuum) chambers for plastic molding prototype is partially ready. The DAJF will require the following data like shape, and angles (contractures, structural changes, if any) of the leg: 1) A scanned (It is in form of X-ray and scanner to measure the girth of lower limbs in various linear distance (like to determine the compression stockings size.) which will be measured in weight bearing position of the patient's leg, in three
planes- Frontal, Sagital and transverse, These data will be obtained like an propriety machine such as Laser
Mapping scanner (LMS). Using these measures, the optimum alignment angles can be pre-determined using proprietary computer software. The alignment
parameters will be displayed digitally on a computer screen. The reference point will get aligned with the inputs data taken by LMS and the software will automatically try to minimize the zero error reading. The caliper parts/uprights will be placed in a moulds (made on CAD CAM machine) using PU foam or similar material. Based on these measures and the molding process can be completed using at proprietary, semi-automatic, vacuum based suction Technology.

b . What is new/innovative in the technology/service which is not offered by other companies, that would make societal impact? * This technology will provide greater accuracy (striving to become foolproof) of
the devices in a shorter period and less expensive process. * The acceptance rate for using Orthotic Calipers will increase from 32% to 94% by using "Dynamic Alignment Jig Fixture", DAJF Device. This figure has been assumed by having a report generated in PTO (Prosthetic and Orthotic Centre, situated in Nigdi, Pune. * By spending merely approx of 93% more than the prevailing expenditure of welfare camps, which is still lower by 60 % compare to Private establishments the output of usage goes to 100% thus make sense to call this worth. Making caliper (barring the capital item cost) using DAJF technology, the average moving price
will come-down to around INR 14000.00 approx USD 254.00 per Caliper, which is lowered by around USD 382 per Caliper. We, at PTO India, have been observing that post a welfare camps organized by GOs, under government funded camps, where huge crowds get assembled, approx 90% patients are getting repeated in a span of 1 to 2 years and around 95% of the beneficiary turns are of repeated kind and most of them claim due to improper fitting they are not comfortable wearing it.

**Analysis shows the benefit of this technology and process:**

1. Current cost of production of a single basic caliper (welfare based) is around USD 130.00 with an output result of 5%.

2. Estimated cost of production of a single caliper using DAJF technology is around USD 254.00 with and output result of 99%.

c . What is the proprietary nature of the technology/service? * The patent filing for this DAJF device is in pipeline as pre-requisites are getting prepared, hopefully will be done before February August 17. The concept will be shared with international crowd during World Congress ISPO 2017 at Cape Town in South Africa. The proprietary in this technology will be configuration and compatibility among electronic-electrical and pneumatic pre-owned items.

d . What are the key challenges and milestones for bringing the product to market? * As with any technology and process, adoption rates will vary largely based on:
present facilities (available Equipment and devices with existing centre), finances, cost of implementation and the "human factor" of technology acceptance, thus simulating average cost is difficult to determine at present. Current production uses the same raw materials as DAJF, however, implementation of this technology to any existing caliper production centre will require investment in approx USD 6500.00 to buy Device from us, however our cost will vary substantially depends upon the ongoing/and projects in hand.

**Describe Commercialization Strategy**

a . Describe Commercialization Strategy * The first step in commercialization is to obtain a patent for this device (technology/process). The projected timeline for filing the application is approx 2.0 Months. Once the appropriate patient is found who had been using the
conventionally made caliper, we will start making the caliper using DAJF device (we need to make prototype in advance). Based on the feedback from the user

about the caliper, we will incorporate added features, if come across and start producing some devices for agencies and FILM the process and results. Then
one can use this material to sell this process to organizations, individuals, manufacturing companies etc. Also another way of using DAJF device will be to become an agency to provide Orthotic calipers by being part of a charitable organization. The people who need
Calipers can be addressed in better way. The popularity among the users will get spread through word of mouth. We are sure that it will overcome and surpass the
prevailing technology whatever is in use. All the orthopaedic caliper centers which run under some schemes will be approached to sell the said Device by way of demonstrating (practical approach)
its features and application.

6. Past Experience & Accomplishments of the Team
a . US Team * Ms. Ellen Travis is a Principal Clinical Scientist. Her background is as a Mastersprepared
Family Nurse Practitioner and has over 29 years of experience in the US health care system. She is the owner of Ellen Travis, Consulting, providing consultation to companies for multiple health-cares related needs for the last 15 years. She has been to many countries across the globe to share her know-how and kept learning many new technologies and did research on innovative outcomes which ended up to enhance quality of life for the person especially who falls under health sectors. While doing this she had chance to learn many foreign
languages among which German, French, Spanish can be named prominently.

b . Indian Team *
Mr. Sumit Bhowmik is a certified Orthotist/Prosthetist. He had persuaded his advance studies from Germany in German language after completion of his highest level of study from New Delhi, India. He has been associated with Prosthetic and Orthotic fraternity and allied services for 22 years and has worked in the manufacturing of such devices for over 20 years. Sumit has vast experience of making prosthetic and orthotic appliances (such as Calipers, Artificial limbs, Rehabilitation devices/appliances by way of designing, prescribing and fabricating such things. During his this span he had.
opportunity to share his experiences in many countries of Europe, Asia and
African continents. Sumit is presently successfully copping-up with his
responsibility as Head R&D and NPD for M/s PROACTIVE TECHNICAL
ORTHOPAEICS, Pune, India.
He is well versed with many languages such as German, English, Hindi, Bangla
(Main), and other regional Indian languages like Punjabi, Marathi, Urdu, Punjabi
and Gujarati.
c . Other Partners (If any) *
Post sanction of the application, we will be exploring for many appropriate
agencies among this the research Institute/ Hospital in USA for application
design to paper publication will be done in most harnessed way. This will also
take involvement of mechanical engineers team with dedicated domain
professionals. Also an entity that will develop the logical set-up and develop the
software will be mutually done among Indian and US based team. Main device will
get completed in USA to produce the final product, Thus ultimate Engineering
capacity and work will get executed in USA, however the prototype design and
other prerequisites will be done in India.
So, Many specific tasks will be out-sourced the domain expertise agencies who
can be named as suppliers, partners and associates.

**Nature and Need of Collaboration**

a . Describe US role in the partnership * The US partner will explore US based Research Lab/Institutes/Private
establishment where research on Bio-mechanical analysis and engineering design of calipers will get executed leading to publication with scientific data.
Software design and development will also be part of US role. Further western country market and cost analyses will be conducted and further marketing
strategies will be developed by the US partner in concurrence with Indian partner. The same can be marketed well through US as most of the Welfare organization like Rotary International, Bill Clinton foundation etc are controlled and governed from US. Us partner is also in her way to involve a experienced well known personality who has vast experience of making and distributing the calipers on camp like approach and has served many with such expertise. For this she is
already in contact will company like Hanger in US.

b . Describe Indian role in the partnership *
The technology/process concept was developed by the Indian partner, thus patent filing along with required details will be done by Indian partner only. Once
the patent is obtained (at the same time the prototype will be made subject to fund availability) the first device along with minimum required features will be
manufactured here it in India. he final design and required features will be mutually decided among the
experts from India and US. This will be start of making final device where the expected output will be thoroughly studied. While final device is getting manufactured in US, Indian partner will explore
market in Africa, Asia, middle and South America. The cost analyses will be conducted and further global marketing strategies will be developed by the Indian
partner in co-ordination with US partner. The Indian partner will maintain a controlling interest in any company formed for the production, marketing and
sale of this technology/process.

# IMMEDIATELY ROTATIONAL EFFECT OF KNEE BRACE AND FULL LATERALLY WEDGED INSOLE ON PATIENT WITH MEDIAL KNEE OSTEOARTHRITIS; CASE REPORTS

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## BACKGROUND

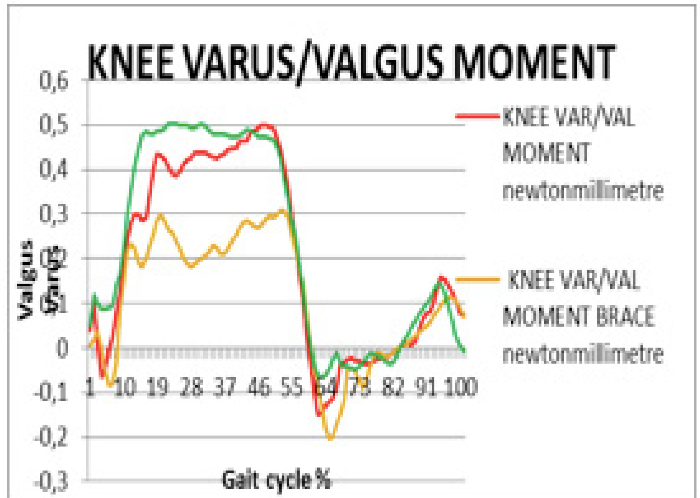
Osteoarthritis (OA) knee braces and lateral wedged insoles have been popular orthotic approaches to reducing the external knee adduction moment. OA knee braces apply a valgus force directly to the knee whereas laterally wedged insoles are designed to alter positon of the foot.(1,2) Lower limb alignment, foot progression angle and foot rotation have been suggested to affect the external knee adduction moment during walking thereby alterning medial tibiofemoral load. Foot motion has been potential to companse for proximal malalignments, such as knee varus or valgus. Symptomatic medial OA often tries to unload the diseased medial compartment by walking with an internally rotated foot. This foot rotation increases the adduction moment during late stance when the foot is in contact with the ground. Thus treatment effects of orthotics approaches are checked and considered.

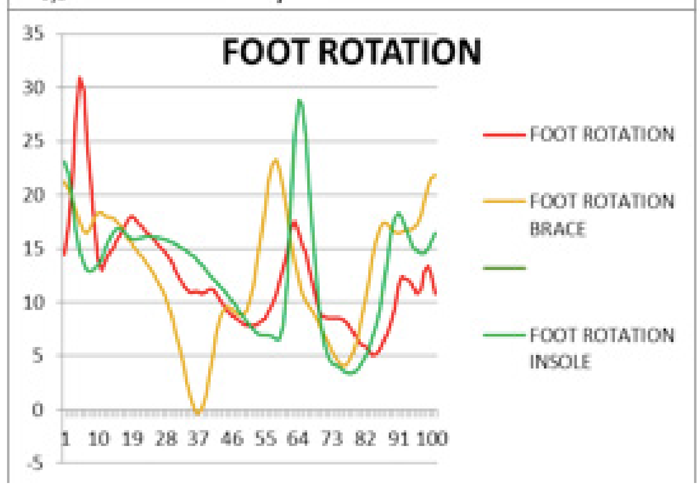
## AIM

The purpose of study was the examine knee and foot function during walking the patient with medial compartment OA.

## METHOD

A 67-year-old female, whose body weight was 70 kg and height 160 cm (BMI: 27.3 kg/m2 ), suffered from bilateral knee pain and gait disturbance for years .She had tenderness over bilateral medial knees with VAS at 50 mm in resting status. The painful sensation had aggravated when going down stairs and squatting down with VAS at 80 mm. She also showed poor walking endurance. We applied unilateral valgus brace (Unloader One/Össur) and 10 mm full- lenght lateral wedged insole (EVA material-) than underwent three-dimensional gait analysis. 3D motion system (Vicon Motion System Ltd.,Oxford,UK) with 6 cameras used to capture and analysed the motion of the lower leg.




## RESULTS

There was significant difference in the foot progression and foot rotation angle during late stance data between Unloader One and insole. Unloader One reduced external knee adduction moment, knee extension, knee rotation and foot internal rotation. Foot progression angle reduced in late stance thus foot motion changed toe-out. However insole not change external knee adduction moment, foot progression and foot rotation compared baseline data. There was no significant different cadence and walking speed between brace and insole.

## DISCUSSION & CONCLUSION

According to our results brace very effective treatment than laterally wedged insole in our patient. Complication of the knee brace such as suspension, discomfort and skin irritation were not observed.

## REFERENCES

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2. Lindenfeld TN, Hewett TE. Joint loading with valgus bracing in patient with varus gonarthrosis. Clinical Orthopedics and Related Research 1997;344:290-7.

# ASSESSING THE EFFECT OF WALKING SPEED ON THE RESIDUUM/SOCKET INTERFACE BIOMECHANICS

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## BACKGROUND

For lower limb amputees, the assessment of residuum/socket interface biomechanics is critical to ensure comfort and overall rehabilitation outcome. Although walking speed is considered as an important factor affecting joint loading asymmetry [1], its effects on interface biomechanics remains poorly understood. Despite a few relevant studies, there is lack of in depth understanding on the combined kinematic (residuum motion) and kinetic (stress experienced by residuum) evaluation at the residuum/socket interface. In the present case study, we employ a tri-axial interface stress sensor system and 3D motion capture method to provide synchronised pressure and shear data [2] coupled with kinematic motion [3] at the interface during amputee walking at different speeds.

## AIM

The aim of the preliminary study is to investigate the effect of walking speed on the residuum/socket interface by evaluating interfacial pressures and shear, and residuum motion in amputee walking tests.

## METHOD

Interface stress sensors [2] were placed at three critical load bearing locations on the residuum of a knee-disarticulation amputee. The participant was asked to walk, at approx. 80 Beats per Minute (BPM) (slow), 100BPM (self-selected) and 120BPM (fast) cadence, on the level walkway in a gait laboratory, equipped with CODA motion capture system and Kistler force plate. Interface pressure (P), longitudinal shear stress (SL) and circumferential shear stress (SC), as shown in Fig. 1b inset, were collected. Residuum motion including angular and axial coupling (L) were calculated based on simultaneous 3D marker data collection [3]. The trials were repeated at least 6 times.

## RESULTS

Fig. 1a shows vertical GRF with values of approx. 469N, 536N, 611N when walking at slow, self-selected and fast speed, respectively. Peak values of P (Fig. 1b) and SL (Fig. 1c), both at 15% gait cycle (GC), were approx. 58kPa and 14kPa at all speeds. However, at mid-stance 30% of GC, P values of 46kPa, 44kPa and 40kPa and SL values of 7kPa, 5kPa and 4kPa, were recorded at slow, self-selected and fast speed, respectively.

Axial coupling, L, tended to decrease (residuum is ‘pushed’ into socket) from 485mm at 0% of GC to 465mm at 50% of GC (Fig. 1d), after which L only began to restore to its initial value (residuum is ‘pulled’ out of socket). At approx. 30% of GC, L reached 461mm, 464mm and 466mm at slow, self-selected and fast speed, respectively

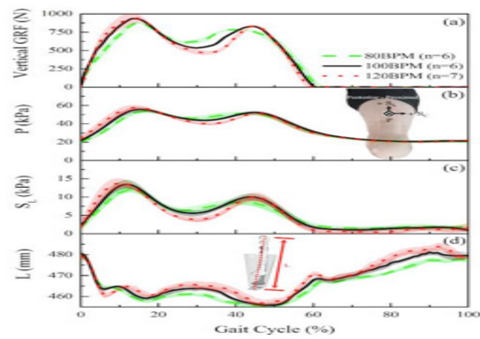


Figure 1: (a) Vertical GRF, (b) P, (c) SL and (d) L, over a gait cycle.

## DISCUSSION & CONCLUSION

In general, the ‘double-hump’ P (Fig. 1b) and SL (Fig. 1c) profiles align with the vertical GRF (Fig. 1a), due to the load transfer from the ground. At approx. 30% of GC, the increase in walking speed led to a reduction in vertical GRF (Fig. 1a), associated with a decrease in both P (Fig. 1b) and SL (Fig. 1c).
The decrease of L in Fig. 1d (residuum ‘push-in’ mechanism), from 0% to 15% of GC, appears to coincide with an increase in SL in Fig. 1c (longitudinal shear towards proximal direction). At approx. 30% of GC, an increase in the walking speed is associated with a decrease in SL and L values. This implies, at higher speed, the residuum presents less axial movement which is reflected by reduced longitudinal shear stresses. It is envisaged that the combined interface kinematic and kinetic assessment could be potentially used to aid the biomechanical understanding at the residuum/socket interface.

## REFERENCES

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## ACKNOWLEDGEMENTS

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# THE ABILITY OF THE ÖSSUR PROFLEX LP TO OFFER MORE RANGE OF MOTION WHILENOT SACRIFICING ENERGY RETURN COMPARED TO A SIMILAR LOW PROFILE PROSTHETIC FOOT

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## BACKGROUND

Ascending and descending ramps impose additional challenges for those with lower limb amputation in that the foot may not be able to appropriately dorsiflex or plantarflex enough to conform to the angle of the ramp. When the foot does not conform to the surface, the user must compensate using some other means (excessive knee joint torques, externally rotating their leg, etc.) that may increase the energetic cost of ambulation. These compensations are exacerbated with low profile prosthetic feet that have less material to allow for the foot to conform to a new terrain. A prosthetic foot can be design with a lower overall stiffness to enable it to better conform to different ramps but this comes at a cost of also reducing push-off during late stance.1

The Össur Proflex LP foot is an energy storage / energy return (ESER) type prosthetic foot that was designed to allow for more sagittal plane range of motion (ROM) that traditional low profile ESER feet while not sacrificing push-off performance. However, Össur Proflex LP foot performance has not been evaluated.

## AIM

The objective of this research was to compare push-off performance, and prosthetic foot range of motion during level ground, ramp ascent, and ramp descent of the Össur Proflex LP compared to the Össur Variflex LP.

## METHOD

Five people with a uni-lateral transtibial amputation not associated with vascular disease (80.5 ± 13.9 kg, 1.73 ± 0.08 m, 44 ± 13.9 y/o) provided informed consent for this IRB approved study. The participants walked at on an instrumented dual belt treadmill (GRAIL system, Motek Forcelink) for five different conditions (1.1 m/s at 0, +7.5°, -7.5° pitch angles) while wearing an Össur Proflex LP foot or an Össur Variflex LP foot. The order of conditions were randomized. The Human Body

Model markerset was modified to include three additional markers on the both shanks to allow simultaneous calculation of lower limb power using a uniform deformable model that does not assume fixed ankle joint center or the foot as a rigid body
1 Kinematic data (100 Hz) and ground reaction force data (1000 Hz) was collected in Vicon Nexus 2.2.
Data Analysis: Data was first processed in Visual3D to calculate ankle joint range of motion as the angular difference between the foot segment centerline and the shank segment centerline and lower limb power output via Uniform Deformabale model analysis.2 Data from ten strides per subject/foot/treadmill condition were then used for statistical analysis. A two factor RM ANOVA (foot x treadmill condition) evaluated statistical differences ($p < 0.05$) between prosthetic feet.

## RESULTS

The Proflex LP had significantly more ROM than the Variflex LP ($F = 7.30$, $p = 0.05$) (Figure 1) and delivered significantly more energy during push-off ($F = 9.327$, $p = 0.038$) (Figure 2) than the Variflex LP.

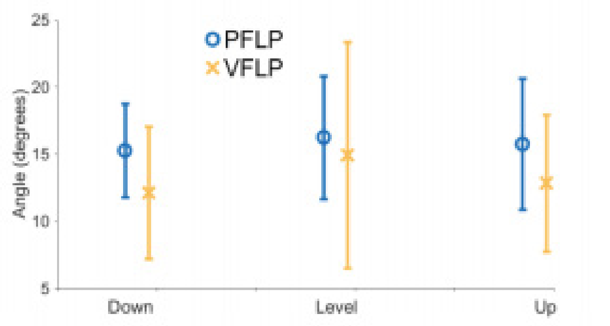


Figure 1. The Proflex LP demonstrated greater range of motion between foot and shank segments

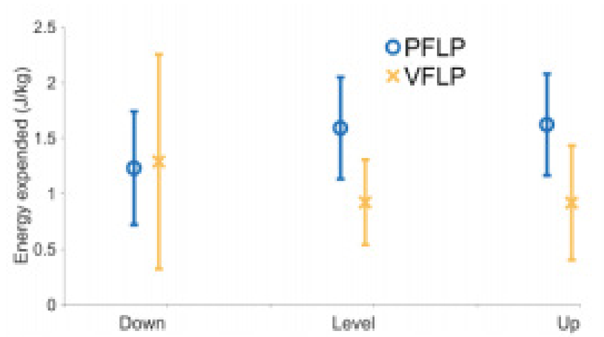


Figure 2. The Proflex LP delivered more push-off energy.

## DISCUSSION & CONCLUSION

The Össur Proflex LP foot allowed for greater ROM than the Össur Variflex LP foot regardless of terrain angle. This enabled the Proflex LP foot to achieve a more stable foot flat alignment with the ground faster than the Variflex LP. The conformability of the Proflex LP to terrain angle did not inhibit its ability to push-off during late stance. In conclusion, the Össur Proflex LP foot enabled more conformability to terrain while providing more push-off energy during level and uphill conditions. This will enable its users to better handle the changes in terrain they will experience in their daily activities while getting the benefit of enhanced push-off when the terrain requires it (level and uphill terrains).

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# PROSTHESIS FOR HEMIPELVECTOMY AMPUTATION WITH AXILLAR WEIGHT BEARING SYSTEM

1-Carlos Freddy Gutierrez, 2-Jose Daniel López

1-01336, 2-01339

## BACKGROUND

Male Patient, 23 years, mechanical electric escalators. While repairing a defective light, fell onto electric stairs at a shopping center. His lower body was crushed in stairs and was severing left leg up to level required for hemipelvectomy amputation with total loss of genitals and anal area destruction, several tissue damage, the skin has not healed well. He also presents a bladder catheter and colostomy.

## AIM

Due to the severe tissue damage of the residual limb, the poor healing the skin graft, bladder catheter with colostomy was really hard to find an appropriate weight bearing area.

## METHOD

Solutions to download weight: 1- support under the ribs 2-weight download the underarm by a kind of crutch built to prosthesis 3-hemipelvectomy socket not allow completely sealed movements that produce friction 4-hemipelvectomy socket anteriorly with plastic pushpins tight adjustable and time in the back with two hinge allowing open for the socket for the patient can get in and out of this.

## RESULTS

Fully built in thermoplastic: the residual limb was a duplicate thermoformed including crutch, the same lines side with plumb in front up and sagittal using the axillar weight bearing system. This System is a crutch fully incorporated socket structure and has a support and pylon axillary plastic modular high graduation.

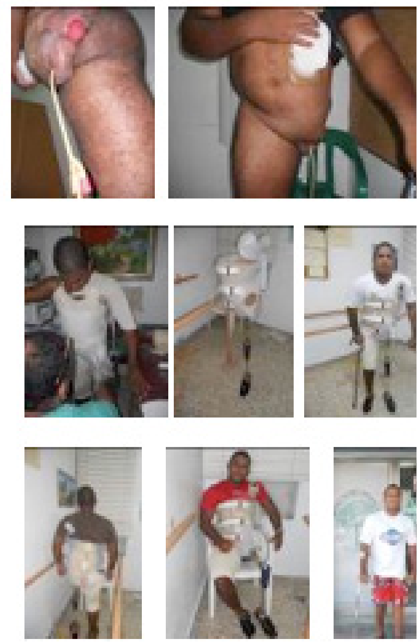

Figure 1. Pictures

## DISCUSSION & CONCLUSION

Finally we made the prosthesis and the patient get walked. We had consults with several professionals and they said it was impossible to do. We spent several months working with this project and the result was successful. We think a lot of patient around the world specialty in our countries with similar amputation could be walking with the axillar weight bearing system

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# A SYNTHESIS OF THE RANGE OF LOADS APPLIED ON THE RESIDUUM OF INDIVIDUALS WITH TRANSFEMORAL AMPUTATION FITTED WITH BONE-ANCHORED PROSTHESES

Shanthan Pather[1], Peter Sondergeld[1], Devakar Epari[1], Mark Pearcy[1], Laurent Frossard[1], [2]

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## BACKGROUND

Bone anchored prostheses have recently been implemented in the field of limb replacement, as it alleviates many of the issues surrounding the conventional socket interfaces [1]. However, due to the direct skeletal attachment, serious injury and damage can occur through excessive loading events such as a fall. For this reason, it is essential to understand the range of loads experienced within bone anchored prostheses to: optimize the design of componentry; provide safety solutions; and tailor rehabilitation programs accordingly.

## AIM

The aim of this study was to review the current literature targeting direct measurement of the forces and moments within bone anchored prostheses, to provide a synthesis of the range of loads observed.

## METHOD

A literature search was conducted to identify all articles related to the loading of bone anchored prostheses during: rehabilitation exercises; a variety of everyday activities; and adverse events (e.g., a fall). Studies were screened by examining whether direct measurement techniques (e.g., load transducers) were used to assess the three-dimensional forces and moments occurring within the bone anchored fixation of individuals with a transfemoral amputation. The three axes were defined as: Anterior Posterior (AP), Medial Lateral (ML), and Axial or Long (LG). The loading data were presented in raw units (Newtons) and a percentage of bodyweight (% BW) where possible. The data was mapped graphically to display the forces and moments for each activity analyzed across all studies.

## RESULTS

This study included 11 articles published between 1990 and 2016. Frossard et al. (2010) presented data `v from a subject falling, reporting the largest recorded loading values, where a maximum force of 1145 N, and moment of 153 Nm, occurred along the long axis and medial-lateral axis of the prostheses respectively, which corresponds to 126 % BW and 16.8 % BWm [2]. For everyday activities, the combined average of the maximum values and corresponding standard deviations for each axes are shown in Table 1, which displays a small portion of the results.

Table 1. Combined average value and standard deviation (in brackets) for the forces and moments applied on each axes of the bone anchored prostheses during everyday activities.

| Axis | Force (N) | Moment (Nm) |
|---|---|---|
| AP | 127 (41) | 17 (20) |
| ML | 100 (35) | 21 (16) |
| LG | 793 (102) | 5 (3) |

## DISCUSSION & CONCLUSION

The range of loads presented in this study has implications for a variety of areas in the utilisation of bone anchored prostheses. For example, the mean and maximum loading values for everyday activities can be used in the design and optimisation of system components, and limits can be established for safety devices. Additionally, rehabilitation programs can be tailored to accommodate these verified loads which regularly occur through daily living. This study highlighted the limited loading information available, and the requirement for further research into the loads experienced by bone anchored prostheses.
Overall, this study has demonstrated the large range of loads that occur within bone anchored prostheses, and provides a starting point for the optimisation of this technology.

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# HOW DOES AESTHETIC HAND PROSTHESIS IMPACT ON SOCIAL PARTICIPATION?

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## BACKGROUND

All health components must be considered after an amputation; function, activity and participation. In this study the focus is on social participation since maintaining friendship, and participation restrictions, has been reported to be common areas of difficulty after upper limb amputation. Which thoughts and emotions evokes when meeting known or unknown fellowmen? Which difficulties and obstacles faces the amputated person in the interaction with other people? Which role may an aesthetic prosthesis play in facilitating social participation?

## AIM

The aim is to explore patients own experiences of the impact an aesthetic prosthesis may have on social participation.

## METHOD

The study design is qualitative with an inductive approach to be able to capture the patients' own experiences of how the prosthesis have influenced their social participation.
The interviews were accomplished by following a semi structured guide and the questions considered different aspects on involvement in life situations. Each interview was audio-recorded and transcribed verbatim, noting non-verbal expressions, by the author. In conjunction with the interview the patient was asked to complete the SF-36 Health Survey where e.g. the physical and emotional roles and the social functioning are captured.

## RESULTS

The participants described a variation of emotional reactions of being truncated and how it affected their social participation. There was a feeling of exposure and awareness of reactions from others resulting for instance in isolation, hiding the hand or facing the fact with a direct approach. The role of the aesthetic prostheses for social participation, was described as normalizing, enabling to be one in the crowd, avoiding questions about the injury but also to feel fine and dressed up at a party. The prosthesis could be either crucial to social participation, optional depending on the context or transitory during the adaptation following amputation.

## DISCUSSION & CONCLUSION

Based on the World Health Organization´s biopsychosocial model (ICF), social participation is one of the three health components. The fields of function and activity are more obvious and concrete in the initial phase after an amputation, whilst the field of participation is more difficult to capture. It is of direct clinical use to achieve deeper knowledge about how an upper limb amputation may influence social participation, and the role an aesthetic prosthesis may play. Learning about the patients' experiences through their own words improves the ability to design and target efficient rehabilitation interventions and develop more effective interventions in the future for persons with upper limb amputation.

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# IMPACT OF BLENDED LEARNING IN HEALTH PROFESSIONAL EDUCATION AND SKILLS DEVELOPMENT - EVIDENCE BASED

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Tanzania Training Centre for Orthopaedic Technologists (TATCOT)[1]
Kilimanjaro Christian Medical University College (KCMUCo)[2]

## BACKGROUND

eLectronic learning could enable millions of students to train as professionals in different disciplines globally. The world is short of 7.2 million healthcare professionals, and the figure is growing1. Blended learning is a form of distance education which combines face – to – face instruction with on-line instructional resources2. Blended learning has shown to help bridge the gap between theory and practice. TATCOT is an example where blended learning has shown positive impact.

## AIM

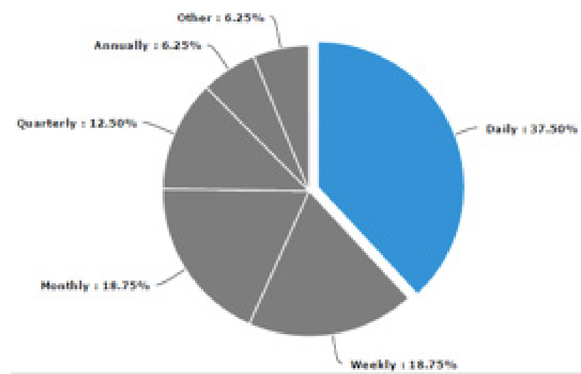
To determine impact of blended learning in the health professional education and skills development.

## METHOD

A descriptive Retrospective/Prospective method was utilized in this study. Literature review from various articles were done to confirm with other studies, A survey questionnaire which consisted of 10 questions were sent by email to 65 TATCOT eLearning alumni who completed their blended learning between 2007 and 2016. Survey questionnaire was adopted from InWENt and modified by the researcher. Data were collected and analysed by QuestionPro – Online research Made EasyTM. Alumni were asked to; provide their demographic profile, rate impact of the course in daily routine, learning effect, Tutor's competence, participants information exchange experiences, achieved objectives, organization, follow-up and overall approval.

## RESULTS

Blended learning is seen in the linkages between instructors, learners, and classrooms located in two or states, provinces, regions, countries, or continents3.
Evidence on Blended Learning: Blended learning has shown to help bridge the gap between theory and practice also improve a range of selected clinical competencies among students4 . ICTs for eLearning initiatives study, 82% of the (n=125 Member States) participating in the survey reported using this teaching tool for the health sciences, while 91% acknowledged using distance learning to train health professionals. About 76 rehabilitation professionals have been trained through blended learning at TATCOT between 2007-2016. TATCOT study results on blended learning shows that about 94% of the participants indicated are employed, Moreover, 94% reported very often to have applied acquired skills in their work.




## DISCUSSION & CONCLUSION

This study suggests that the blended form decreases the distance, also increase interaction between students and instructor. 94% reported very often to have applied acquired skills in their work, thus concluding the blended learning has positive impact to health professionals' education and skills development. This is in line with several other studies. There is limited research available on the impact of blended learning in Tanzania. Further research with bigger sample size into the impact of blended learning is needed.

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# RETURN TO WORK AFTER AMPUTATION IN TURKEY

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## BACKGROUND

After amputation, training of physical mobility and independence in the activities of daily living is not enough for younger patients. Besides, return to work or school is highly important. Employment and job satisfaction are not only important to the well-being of the people but also in enlarging their social environment (1, 2). There are many amputee adults in our country but there is no study regarding their work status or vocational reintegration after amputation.

## AIM

The aim of this study was to determine the rate of return to work after amputation and the factors affecting vocational reintegration in Turkey.

## METHOD

85 people with acquired unilaterally extremity amputation were included in this study. They were divided into two groups: Returned to work group and not returned to work after amputation. General descriptive amputee evaluation questionnaire formed by the authors was used to categorize the data concerning amputation, prosthetic use and information about job. Each subject was asked to complete of the TAPES which is the multidimensional assessment tool evaluating the level of compliance to the prosthesis and factors related to the use of prosthesis. Physical workload required by the work and the satisfaction of job was examined with 10 cm Visual Analogue Scale (VAS). The datas were analyzed using appropriate statistical methods.

## RESULTS

The rate of return to work was 68.2%. The average time of return to work was 33.7±35.8 months (3-204 months). The time of return to work in employed group in private sector before amputation was longer than the others. The main cause of knock off was amputation (88.8%). A statistically significant difference was found

in the level of psychosocial adjustment, time of daily prosthesis wearing, educational level, perception of general health status and general physical capacity between individuals that return and not return to work after amputation ($p<0.05$) (table 1). The difference in terms of physical workload and satisfaction with job before and after amputation values is shown in table 2. The difference between the physical workload values of employees before and after amputation was statistically significant ($p<0.05$).

| | Returned to work X±SD | Not returned to work X±SD | z | p |
|---|---|---|---|---|
| Age at amputation | 23.4±4.6 | 25.5±7.5 | -0.712 | 0.476 |
| The time through amputation | 11.2±5.8 | 13.1±6.3 | -1.429 | 0.153 |
| TAPES Psychosocial adjustment | 55.1±9.5 | 50.4±6.8 | -2.579 | **0.010** |
| TAPES Activity restriction | 7.5±4.6 | 9.7±5.6 | -1.514 | 0.130 |
| TAPES Satisfaction with prosthesis | 38.3±7.9 | 37.0±7.1 | -0.507 | 0.612 |
| Average duration of daily prosthetic use (hour) | 13.3±2.8 | 11.7±3.4 | -1.976 | **0.048** |
| General health status | 4±0.7 | 3.7±0.6 | -2.302 | **0.021** |
| General physical capabilities | 4±0.7 | 3.6±0.6 | -2.380 | **0.017** |

| | X±SD | z | p |
|---|---|---|---|
| Physical workload before amputation | 6.7±2.9 | -5.698 | **0.000** |
| Physical workload after amputation | 3.4±2.8 | | |
| Job Satisfaction before amputation | 7.2±3.0 | -0.012 | 0.990 |
| Job Satisfaction after amputation | 7.1±2.8 | | |

Table 1. Difference of some parameters between returned to work and not returned to work after amputation

Table 2. Comparison between job satisfaction and physical workload before and after amputation

# PERCEIVED EXPERIENCE OF ORTHOTIC TREATMENT IN CLIENTS WITH SCOLIOSIS ATTENDING KCMC, TANZANIA 2013

Ester Pasaribu, Egfrid Mkoba, Norman Jacob KCMCU, Tanzania, Exceed, Poltekkes Kemenkes Jakarta 1

**BACKGROUND**

Scoliosis is a chronic illness which can be managed by Orthotic management, using spinal orthosis. Many papers discuss the effects of different types of spinal orthoses, on psychological make-up, body image and quality of life. However, there has not been any study reported on the perceived experiences of the orthoses that has been used by clients. Knowing the experiences of client's orthoses may help in promoting improved orthotic fitting and better outcomes.

**AIM**

This study is to determine the perceived experience in the use of spinal Orthoses by clients with scoliosis, the perspective for treatment for scoliosis and its effect on clients' body image.

**METHOD**

This study took place at P&O program of the KCMC which used a qualitative design. Data from narrations and observations, of 8 participants who's experienced of using spinal orthoses ranges from 6 months and above with scoliosis, were collected through individual in-depth interviews. An interview guided with open-ended questions was tape recorded for 30 - 40 minutes per participant. The transcript of each interview was read through several times and notes were taken. Analysis proceeded with marking "meaning units." which were condensed and labelled with a "code." The codes in each interview were then compared and compiled according to similarities and differences.

**RESULTS**

The results are organized in two major sections namely socio-demographic information and the perceived experience in the use of spinal orthoses by clients with scoliosis.

| Socio-demographic Category | n (%) |
|---|---|
| **Sex** | |
| Female | 6 (75) |
| Male | 2 (25) |
| **Total** | **8 (100.0)** |
| **Age (yrs):** | |
| 14 | 1 (12.5) |
| 15 | 1 (12.5) |
| 18 | 2 (25) |
| 19 | 2 (25) |
| 22 | 2 (25) |
| **Total** | **8 (100.0)** |
| **Marital Status:** | |
| Married | 0 (0.0) |
| Single | 8 (100.0) |
| **Total** | **8 (100.0)** |
| **Occupation:** | |
| Not specific/not employed | **2 (25)** |
| Student | **2 (25)** |
| Business | **3 (37.5)** |
| Office | **1(12.5)** |
| **Total** | **8(100.0)** |

Table 1. Demographic Characteristics

1. Spinal Orthoses Information

The process during the fitting of the spinal orthoses, duration wearing of spinal orthoses, the effectiveness of improvement, and hygienic were expressed by most participants.

2. Orthoses works

Participants recognized the importance of spinal orthoses and the effectiveness to reduced restriction in activities.

3. Utility challenges

Most of the participants expressed challenge during wearing the spinal orthoses.

4. Body Image

Most of the participants reported problems of body image because of protrusion from the scoliosis and the spinal.

**DISCUSSION & CONCLUSION**

The findings reported orthotic treatment satisfaction although it affected the appearance and restricted some activities they still continued to wear the orthosis. A long period of treatment, psychological problems, and utility challenges can give negative effects to the patient to comply with the procedures of orthotic fitting and effectiveness of orthosis function. Language barrier even though during data collection and analysis, the researcher was helped by the translator and investigator.

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# SHARED DECISION MAKING IN STROKE REHABILITATION

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## BACKGROUND

A stroke can cause several types of disabilities and problems. Given the large number of rehabilitation treatment options, patients with stroke face multiple decisions. The treatment plan for a patient will depend on several factors, such as the type and severity of disabilities and problems, treatment history, age and health of the patient and on the patient's personal preferences and values.. Decisions on treatment should be made in partnership between the patient, the family and the caregiver(s). Decision aids facilitate the process of shared decision making, especially for preference sensitive decisions1.

## AIM

Our aim was to identify the preference sensitive decisions stroke survivors and health care professionals encounter during the treatment process in order to decide which decision aids to develop.

## METHOD

A systematic literature research and internet search was performed to identify relevant decision support tools, and we assessed their quality. Furthermore, a focus group interview with 12 patients/partners and online interviews with 11 healthcare professionals were carried out. In addition, relevant clinical practice guidelines were analyzed to identify preference sensitive decisions encountered by stroke survivors and healthcare professionals. Finally, all results were discussed with a mixed group of 10 experts, consisting of researchers, patients and healthcare professionals and a comprehensive advice was given to develop two decision aids for patients with stroke.

## RESULTS

Literature & internet search Decision aids (English language) found, addresses the following themes: prevention of stroke, long term care, depression, blood thinners, carotid artery stenosis, psychological management, thrombolysis, home based or hospital based therapy, botulinum toxin injection. Interviews with stroke patients and professionals All focus group participants confirmed a lack of partnership between health care professionals with patients/partners in the rehabilitation care process. Important decision points mentioned were 'transferring to another care setting', 'establishing individual treatment plan' and 'support for partners'. Health care professionals mentioned similar decision points. In addition, several decision points on specific treatments concerning physical therapy, occupational therapy and cognitive rehabilitation were expressed. Guidelines The Dutch guidelines on physical therapy and occupational therapy for patients with stroke stated the importance of shared decision making for treatment planning. Experts' advice The group of experts used the following criteria in the selection of decision points; (1) relevancy for patients and professionals; (2) size of decision problem addressed, (3) decision points about disease management and treatment and (4) availability of information on benefits and risks of treatments. The experts decided to develop two decision aids; one decision aid for treatment of ankle-foot impairment and another aid for treatment for upper limb impairment.


Decision Aid for treatment of arm & hand (in Dutch language)

## DISCUSSION & CONCLUSION

The International IPDAS criteria were used as a checklist for development of the decision aids2. Special attention was given to plain language, text, structure and visual support (pictures/films) to anticipate on cognitive and visual impairment of stroke survivors. Demo of the decision aids were tested in a rehabilitation center with both patients and health care professionals. The test revealed that the decision aids needed additional simplification. The final decision aids were adapted accordingly. Participating health care professionals turned out not to be familiar with approaching the indicated decision points as preference sensitive situations. In addition, integrating the decision aid in the clinical pathway turned out to be a challenge.
Given the tests results, training and support is needed to overcome the challenges for the implementation of decision aids and shared decision making in stroke rehabilitation.

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# AN OVERVIEW OF WHEELED MOBILITY DEVICE USE AND FUNDING IN CANADA

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[1]University of British Columbia, [2]GF Strong Rehabilitation Research Program

## BACKGROUND

Wheelchairs and scooters (wheeled mobility devices; WMD) provide individuals with mobility limitation the opportunity for participation in their daily lives in indoor and outdoor environments, contributing to health and well-being. Despite evidence supporting WMD provision, many individuals still do not have access to the devices they require. Factors including availability of equipment, access to clinical expertise, and funding all play a role in whether an individual has access to a WMD which meets the user's needs. Policies which impact WMD service provision may facilitate or obstruct access to these devices.

## AIM

The objectives of this study are to establish the prevalence of WMD use in Canada, and explore demographic and policy factors which impact WMD use and provision in Canada.

## METHOD

To establish the prevalence of, and demographic factors associated with WMD use in Canada, we conducted analyses of the 2012 Canadian Survey on Disability (CSD). The CSD included community-dwelling Canadians over the age of 15 who identified an activity limitation on the National Household Survey. Data were collected by Statistics Canada under the authority of the Statistics Canada Act. Prevalence of WMD use and demographic factors were calculated using bootstrapping analyses. To address related factors impacting WMD use, we completed a national evaluation of policies which regulate funding for WMDs. Data were collected through a review of policy documents online and by telephone, and verified by clinicians experienced in WMD provision in the relevant jurisdiction.

## RESULTS

Approximately 288 800 (1%) of the community dwelling Canadian population aged 15 or older uses a wheelchair or scooter for daily mobility; the majority (60%) are female. Manual wheelchair users are the largest group (0.7%), followed by scooter users (0.4%), and powered wheelchair users (0.2%). WMD use increase with age, with the highest prevalence among individuals over the age of 75 (approximately 4.2% of this cohort). Funding varies by jurisdiction, and may be limited for individuals over the age of 65, in residential care environments, or who are employed or in full time education. Five jurisdictions provide WMDs which meet the basic mobility needs at no cost, while four provide devices on a cost-share or means-tested model. The remaining jurisdictions (4) require eligibility for a specific program.

## DISCUSSION & CONCLUSION

WMD users are a heterogeneous group, including individuals across the age spectrum, and with a variety of predisposing conditions. Increases in WMD use with age are likely related to mobility related disability and diseases associated with aging. More female WMD users may be related to longer life expectancy, and the association between wheeled mobility use and aging. Variations in prevalence of WMD use by provincial and territorial jurisdictions, may be partially attributed to differences in funding available for these devices.

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# IMPLEMENTATION OF THE AMP AS A GOLD STANDARD IN THE CLINICAL REHABILITATION OF AMPUTEES IN ISRAEL

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BACKGROUND

In 2002 Professor Robert Gailey from the University of Miami developed and published the "Amputee Mobility Predictor" (AMP) [1]. This functional assessment was developed to predict the potential of using a prosthesis (AMPnoPRO), determine the functional level (K0-K4) and assist in assigning of the prosthetic prescription. In 2015 the AMP was translated to Hebrew by Mrs. Anat Kristal after studying its utility with Professor Gailey. The AMP translation was implemented in the working routine of the Orthopedic Rehabilitation Department at Sheba Medical Center, Israel.

AIM

Describing the translation process of the AMP to Hebrew and its validation. Additionally, we will show our 20 month experience of working with the AMP.

METHOD

First phase: "Forward translations" of the AMP to Hebrew by two Physical Therapist (PT).
Second phase: The final evaluation of the two translations was done by an experts' committee.
Third phase: "Back translation" of the AMP from Hebrew back to English by two other Physical Therapists whose mother tongue is English.
Forth phase: The experts' committee evaluated both the English translations in comparison to the Hebrew version and approved a final version in Hebrew.
Fifth phase: Beginning of working with the Hebrew version of the AMP at the Orthopedic Rehabilitation Department in Sheba Medical Center, Israel. We evaluate each patient in the gait training process and whenever there is doubt about the amputee's ability to complete the fitting of prosthesis.

RESULTS

100 subjects were evaluated during a period of 20 months. Their admission and release scores are presented in figure 1.
8 didn't finish their gait training due to medical problems. 49 improved their score (more than 3.4 points is considered an improvement beyond the Minimal Detectable Change [2]). 2 subjects with a score which indicated K0 mobility received a program to improve their skills, reassessed after 2 months and improved to K1. They received a prosthesis and finished successfully their gait training.

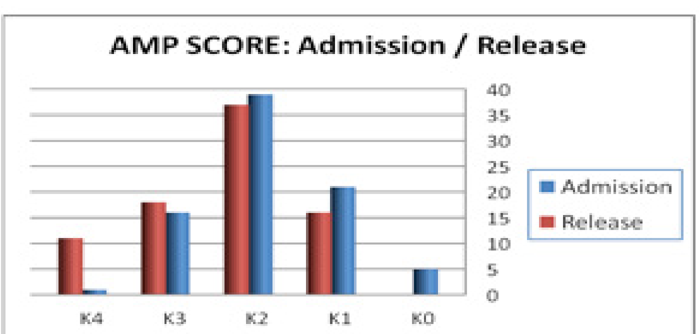


Figure 1.

Decision Aid for treatment of arm & hand (in Dutch language)

**DISCUSSION & CONCLUSION**

The International IPDAS criteria were used as a checklist for development of the decision aids2. Special attention was given to plain language, text, structure and visual support (pictures/films) to anticipate on cognitive and visual impairment of stroke survivors. Demo of the decision aids were tested in a rehabilitation center with both patients and health care professionals. The test revealed that the decision aids needed additional simplification. The final decision aids were adapted accordingly. Participating health care professionals turned out not to be familiar with approaching the indicated decision points as preference sensitive situations. In addition, integrating the decision aid in the clinical pathway turned out to be a challenge.
Given the tests results, training and support is needed to overcome the challenges for the implementation of decision aids and shared decision making in stroke rehabilitation.

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# INJURIES OF THE ACL - A NOVEL DYNAMIC BRACE CONCEPT

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**BACKGROUND**

Braces are used following ACL injury whether there is surgical intervention or not (1). Braces typically apply a barrier to motion with an adjustable range and can be termed static braces. Forces through the ACL are dynamic and vary with the degree of knee flexion (2). A brace has recently been designed to apply a variable dynamic anteriorly directed load, to the thigh to mimic the tension in the ACL.

**AIM**:

To demonstrate that this new design of brace imparts a dynamic anteriorly directed force to the thigh, similar to the varying tension in the ACL during flexion in biomechanical evaluation

**METHOD**

Five healthy subjects were fit with a custom sized brace. A force transducer was placed beneath the DTS to measure force exerted against the posterior thigh. Subjects were instructed to stand shoulder width apart with straight legs. The force data were then logged as the subjects performed six squats, one squat being 0° to 90° to 0° knee flexion. The brace angle was measured with an electrogoniometer fixed to the hinge of the brace. The force curves were normalised over 100% and averaged across individuals and users.
RESULTS Force on the posterior thigh increased from 53N to 66 N between 0 and 30 degrees then
decreased to 13N at 90 degrees knee flexion (figure 1). The force exerted against the posterior thigh was seen to increase and decrease during knee flexion in a manner similar in shape to that of the force in an intact ACL. The amplitude of the brace force was less than that of the native ACL

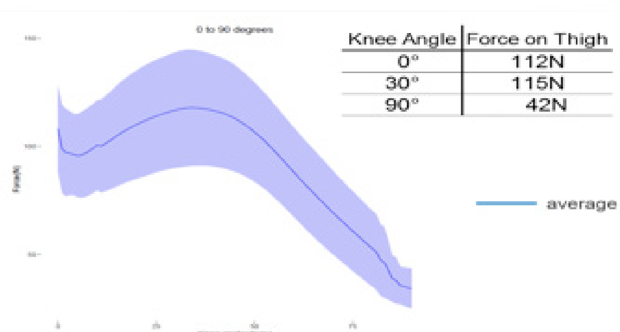


Figure 1. Posterior force [N[ applied by the DTS system during knee flexion

**DISCUSSION & CONCLUSION**

The data suggest that the brace would reduce tension in the ACL in proportion to the non-braced tension at any given angle. Complete elimination of tension is unlikely to be beneficial as tension in tissues is essential for nutrition, homeostasis and repair (3). Neither is it likely to be comfortable as excess stress would be placed on other tissues. In the post op knee this would reduce tension on the graft while still allowing for full knee extension. Intuitively this should reduce the chance of excess stretching of the graft. Conversely such a brace could expand the population of patients that can be successfully treated without surgery.

Clinical studies on post-surgical and non-surgically treated patients are needed.

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# LOWER-LIMB AMPUTATION DECISION MAKING FOR AN ADOLESCENT PRESENTING WITH THERAPY-RESISTANT COMPLEX REGIONAL PAIN SYNDROME –TYPE 1

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## BACKGROUND

Complex regional pain syndrome type 1 (CRPS-1) is a chronic neurologic condition that encompasses multiple clinical symptoms including, spontaneous pain, allodynia, vaso-motor dysfunction, motor impairment, swelling and autonomic instability1. A range of evidence exists to support multi-disciplinary therapeutic treatments for this condition, with varying results2,3. Limb amputation is discussed as a last resort option for patients resistant to these therapies, despite some cases reporting good outcomes for quality of life (QoL)4. However there is limited knowledge regarding amputation as a treatment for adolescent clients suffering long-term CRPS-1.

## AIM

The purpose of this case study is to describe the approach and methodology for the rehabilitation team to best guide lower limb amputation advice for an adolescent with CRPS-1.

## METHOD

A 17 year old school boy developed CRPS-1 at age 13 following traumatic injury to left ankle. Paediatric acute and rehabilitation services undertook multiple therapy modalities including: medication, desensitisation, epidural block, psycho-therapy, counselling and a range of physiotherapy interventions – all without significant effect at reducing his self-reported severe and debilitating pain. Loss of school and social interaction and consequent reduction in QoL led to the referral to adult rehabilitation and surgical services for possible lower limb amputation. Given the age of the patient and family support for undertaking a lower limb amputation, a novel approach was desired for simulating the weight-bearing requirement post trans-tibial amputation. The prosthetic/orthotic service conducted compression therapy with medical garment, and then silicone interface prior to manufacturing a

Plaster of Paris(POP) proximal tibial cast brim allowing the patient to bear weight for the first time in four years. A gradual increase in weight-bearing was achieved through use of a custom-made prehabilitation transtibial 'Sim Brim' (Fig 1). Utilising the SIT cast ring apparatus with the Sim Brim allowed static weight bearing to be achieved. The fixed plantar grade contracture of the affected ankle prevented the trial of a Patella Tendon Bearing Ankle Foot Orthosis (PTB AFO).

## RESULTS

Through the weight bearing apparatus, the patient was able to conceptualise the pressure a transtibial prosthesis would impart, undergo prehabilitation physiotherapy to increase weight bearing dosage, provide an indication of what the likely pain tolerance would be, if he proceeded with a lower limb amputation. This simulation therapy provided the patient, his family, rehabilitation and surgical teams with a significant level of confidence that amputation surgery and prosthesis use would be a positive outcome for regaining mobility and participation, and enhance his QoL.

Figure 1. Prehabilitation Transtibial Sim Brim

## DISCUSSION & CONCLUSION

The benefits of prehabilitation for an adolescent presenting with therapy resistant CRPS-type1with a multi-disciplinary approach– whereby the elements of post-surgical effect are simulated prior to surgery – are demonstrated through use of POP casting with weight-bearing, and a custom-made standing Sim Brim.
There is scope for this methodology to be applied to support pre-amputation decision making for a range of clients.

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# EFFECT OF WEARING THE ROBOT SUIT HAL® IN A PATIENT WITH MUSCULAR DYSTROPHY

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## BACKGROUND

Great expectations have been placed on robotic gait assistive technology to rehabilitate the loss of walking function1–3. Training with HAL®(Hybrid Assistive Limb for Non-medical Use) is monitored by surface electromyography from the wearer and assists in walking, standing, and sitting motions. Based on optimal assistive methods in accordance with the type and degree of disability, effects of using robot-assisted gait training need to be verified using various outcomes.

## AIM

The purpose of this study was to clarify the effect of wearing the robot suit HAL® in a patient with muscular dystrophy by performing three-dimensional motion analysis and examining energy consumption to evaluate changes in walking ability before and after wearing HAL®.

## METHOD

The subject was an 18-year-old boy with Becker's muscular dystrophy (BMD). The subject was 159 cm tall, weighed 60 kg, and had a body mass index of 23.7 kg/m2. He was capable of standing up from a chair independently, and he could walk a continuous distance of 200 m indoors unaided. Outdoors, he used a wheelchair to move around. A body-weight supported walker was used in gait training with HAL® to prevent falls (Figure 1). Gait training took place once a week, during which time the subject walked a 20-m indoor course back and forth 20 times (total distance of 800 m). Three-dimensional motion analysis and cardiopulmonary exercise testing were each performed after 1 month, 2 months, 3 months, and 1 year of training with HAL®. The MAC3D System (Motion Analysis Corporation, USA) were used to perform three-dimensional motion analysis before and after wearing HAL®.

## RESULTS

An improvement in walking speed was seen after wearing HAL®. The left–right displacement of the body center of gravity during walking was 9.8 cm before wearing HAL® compared with 7.7 cm (2.1 cm decrease) after wearing HAL®. The left–right displacement of the reflective marker attached to the spinous process of the seventh cervical vertebra was 13.1 cm before wearing HAL® and 11.9 cm (1.2 cm decrease) after wearing HAL®. A comparison of hip and knee torques before and after wearing HAL® revealed an increase from 7.4 Nm to 10.8 Nm in hip extension torque in the terminal stance phase of the gait cycle. Metabolic equivalents (Mets) at a walking speed of 1 km/h were 2.6 Mets both before and after wearing HAL®, indicating no difference.

## DISCUSSION & CONCLUSION

Gait training with HAL® was found to improve walking speed, reduce trunk sway, and have a good effect on the exertion of hip extension torque, probably because motion control and learning improved motor ability. HAL® only assists with flexion and extension of the hip and knee axes, which suggests that relatively simplified motor tasks and easing control by relieving burden contribute to the learning effect.
Note: HAL® has been included under medical insurance for intractable neuromuscular diseases in Japan as a robotic therapy for gait impairment since 2016.

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# ACCURACY OF THREE-DIMENSIONAL STERNAL POSTURE MEASUREMENT USING A RGB-D CAMERA SYSTEM FOR ASSESSMENT OF WHEELCHAIR SEATING: A PILOT STUDY

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## BACKGROUND

Wheelchair seating is important for disabled people who cannot maintain a sitting posture. Quantitative measurements are needed to make evidence-based changes for the individual patient. ISO16840-1 set the criteria for that purpose, although clinically it is difficult to evaluate seated posture quantitatively based on those criteria. However, a method that applies a RGB camera with a depth sensor (RGB-D camera system) has been marketed and seems to provide a solution.

## AIM

The aim of this study was to test the possibility of quantitating the three-dimensional posture of the sternum based on ISO criteria using this measurement equipment.

## METHOD

One healthy man participated in this study. We measured his seated postures in a wheelchair using three systems: Kinect v2 for windows based RGB-D camera system (Mobile Motion Visualizer AKIRA, System Friend Inc., Japan) (Figure 1); DL164V digital level meter (STS Corporation, Japan); QUALISYS Motion Capture Systems (three Oqus3+ cameras, Qualisys Inc., Sweden). For the RGB-D camera system, the subject's line angles of the frontal sternum and sagittal sternum lines were quantified using a reflective marker (bar type). Each measurement trial was 10 seconds (sampling rate: 30 Hz). Five seated postures□median position and forward, backward, rightward, and leftward inclinations of the upper trunk□were measured. Final values for each system measuring the seated postures selected were the differences from those of the median position. The results for the three systems were compared. The possibility of clinical applications was discussed based on the results.

## RESULTS

Values in the forward and backward conditions indicated sagittal angles. Those in the rightward and leftward conditions indicated frontal angles. For the frontal sternum line angle, the overall differences between the RGB-D camera and QUALISYS Motion Capture system were −0.3°, 3.0°, 0.1°, and −0.3° for the four postures, respectively (average 0.9°). The backward condition showed the greatest difference. A similar tendency was observed with the digital level meter system.

## DISCUSSION & CONCLUSION

RGB-D camera system measurements were simple and easy, which is important for clinical application. However, the results were different from those obtained with a three-dimensional motion analysis system (gold standard), particularly in the sagittal plane. Frontal plane errors were relatively small, and confirmation was easy using the RGB image. This error may be permitted clinically because the angle is often measured in units of 5°. For evidence-based decisions, however, more accurate posture measurements are necessary, requiring process re-evaluation. Possibly the environment, marker shape, or other factor influenced the measurement. Future verification in a large number of subjects, including those with disabilities, is necessary. Finally, this study measured only the upper trunk posture using the sternal line. When evaluating seating interventions, it is important to obtain pelvic posture measurements as well. Hence, future studies should include a method that measures both upper trunk and pelvic postures.

## REFERENCE

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# ACCESS TO PHYSICAL REHABILITATION: APPLIED RESEARCH BASED TOOLS, AND FIELD BASED-METHODOLOGY TO GUIDE POLITICS – AFGHANISTAN, KANDAHAR PROVINCE, A HANDICAP INTERNATIONAL CASE STUDY

Isabelle URSEAU

## BACKGROUND

The Afghan government takes today the lead in developing comprehensive health services including orthopaedic,mobility devices, and physio services. Thanks to collaboration with universitiesi and research laboratoryii, HI has developed tools and methods to guide countries developing their rehabilitation strategy.

## AIM

The presentation intends to demonstrate how tools and methods developed by Handicap International, support governments in developing their rehabilitation strategy. The specific case of Kandahar province, in Afghanistan is stressed here.

## METHOD

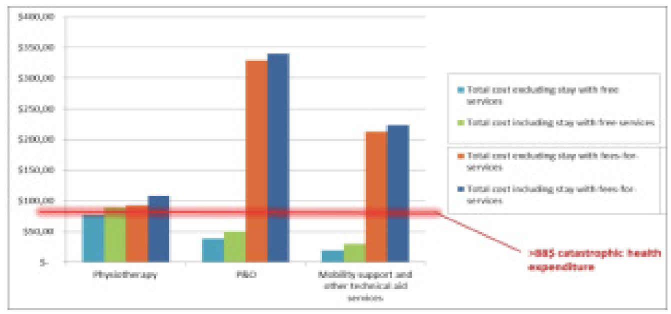
Over a period of 4 months, a combination of HI tools provided stakeholders with a clear understanding of the health-related rehabilitation situation and potential in Kandahar province. The IFARiii diagnostic tool, supported the analysis of the economic system of rehabilitation. The Sustainability Analysis Process (SAPiv) gathered governmental decision makers, provincial orthopedic and rehabilitation services leaders, users and DPOsv , donors. Participants analyzed facts and figures on health outcomes, services, ministry capacities, and civil society contribution.

## RESULTS

The IFAR provided the group with elements on technical level and cost of provided services, cost of services for clients  compared to catastrophic health expenditures threshold, existing social supportive mechanisms, and innovation potential of the rehabilitation system.

During the SAP workshop participants reached a consensus on sustainability priorities for Kandahar province. Main lines of a 5 years road map were identified, and related indicators chosen. A specific 5 years long financial handover strategy for the Kandahar rehabilitation center was agreed on, and related MoU signed between Handicap International and the Afghan Ministry of Health. A national integration steering committee was established. Its mission is to coordinate 3 sub-working groups finding out relevant orientations and processes supporting the handover. Sub-working groups themes: human resources homogenization, financial strategy development, and operations quality and efficiency.

Table 1: Rehabilitation costs in Kandahar Province, Afghanistan (USD), 2016




## DISCUSSION & CONCLUSION

The combined use of developed tools helped rehabilitation related stakeholders to commonly design a roadmap (SAP) taking into account financial requirement of province households and services (IFAR). SAP and IFAR tools, associated to other made in HI tools such as the RMSvi, could also provide any country with a baseline supporting rehabilitation strategy development. Trials are ongoing in Laos, Cambodia…

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# ICRC ACTIONS TOWARDS STRENGTHENING A SUSTAINABLE PHYSICAL REHABILITATION SECTOR IN MYANMAR

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[1] International Committee of the Red Cross

## BACKGROUND

Myanmar, a country in Southeast Asia, has suffered from decades of stagnation, isolation with economic sanctions and more, has started to have various reforms after 2012. This has resulted, among all the other development sectors, the physical rehabilitation sector in the country. ICRC through its contributions starting from 1986 has been one of the largest supporting organizations in the country strengthening the rehabilitation sector.

## AIM

This presentation gives an overview of ICRCs actions in the development of various key components of rehabilitation sector in Myanmar with the aim of sustaining those developments in the long run.

## METHOD

With the assessment of needs and demand perspective in the country, an overall cooperation and support system was framed by ICRC largely with Ministry of Health and partly with Ministry of Defence and implementation of various activities was carried out. The main and crucial components of the rehabilitation sector such as; services delivery, technology, human resource & skills development and financial contributions were addressed. These scope of collaborations have been strengthened and increased over the past few years notably with the Government of Myanmar and Myanmar Red Cross Society, amongst others.

## RESULTS

ICRC has set up two large Physical Rehabilitation Centers (3225 & 2808 sq mts) through Ministry of Health, supporting a total of 4 PRCs and 2 foot manufacturing units in the country. A network of repairmen and mobile repair workshops have also been supported through its partners to extend the rehabilitation services to the far-reaching communities. Almost all the existing qualified POs (12 Cat-IIs and 1 Cat-I) in Myanmar have been sent abroad for training with the support of ICRC ensuring the technical HR sustainability in the country. In terms of technology, ICRC is supporting the PRCs with polypropylene technology, which is one of the most cost-effective solutions for a less resourced country like Myanmar that the MoH can manage to sustain in the long run. ICRC is collaborating with other organisations working in the rehabilitation sector to develop a national standard in rehabilitation, which could lead towards a policy framework and possible financial allocation by the Government.


Figure 1. New Rehabilitation Centre

## DISCUSSION & CONCLUSION

Although it's a long way to go to ensure a full-fledged rehabilitation sector in the country corresponding to the need and sustaining it, the right steps taken at this time of an open and welcoming political scenario in the country could prove to be effective and beneficial towards building a more progressive and sustainable rehabilitation sector in Myanmar.

**t**

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# COMPARING THE QUALITY OF LIFE OF PATIENTS WITH SPINAL CORD INJURY WHO WEAR EITHER RGO OR HKAFO

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## BACKGROUND

The quality of life (QOL) in patients with Spinal Cord Injury (SCI) is lower in compare to the healthy people. Orthosis is prescribed to improve mobility and thus improving the QOL of SCI patients. Hip Knee Ankle Foot Orthosis (HKAFO) is a conventional choice for these patients, while Reciprocating Gait Orthosis (RGO) as a more contemporary option is now available. The impact of these two orthoses on walking biomechanics of SCI patients has been evaluated, but no study was found to compare their effect on the patients' QOL.

## AIM

This study aimed to compare the QOL of patients with SCI, Who wear either RGO or HKAFO.

## METHOD

This study had a cross-sectional method in which 22 patients with SCI (11 patients wear RGO and 11 wear HKAFO) recruited. Inclusion criteria included: a complete thoracic SCI, who wear orthosis at least 2 hours each day in the last 6 months. The exclusion criteria included: associated disability like upper limb amputation, brain trauma and participants who fail to achieve Grade A in the ASAI Impairment Scale. This study was done using Sickness Impact Profile (SIP68) questionnaire which has three areas and six dimensions (Table 1) [1]. The statistical analysis was performed using SPSS19 software.

## RESULTS

Significant differences among groups were found in Emotional stability and Communication and emotional independence dimensions, with better score for RGO users group (P<0.05). There were no significant differences between the groups for the questionnaires total score and Physical independence, Movement control, social behavior and mobility range dimensions (P>0.05).

Table 1- Comparison of QOL in HKAFO and RGO groups with SIP68 total score and its dimension's

| Areas | Dimensions | RGO | HKAFO | P-Value |
|---|---|---|---|---|
| | | Mean ± SD | Mean ± SD | |
| Physical | Physical independence | 10.64 ± 2.24 | 10.00 ± 3.06 | 0.585 |
| | Movement control | 8.00 ± 1.34 | 8.36 ± 1.62 | 0.574 |
| Psychological | Emotional independence | 1.00 ± 1.09 | 2.82 ± 1.83 | 0.011* |
| | Emotional stability | 1.36 ± 1.43 | 2.73 ± 1.42 | 0.037* |
| Social | Social behaviors | 3.09 ± 1.97 | 3.55 ± 1.86 | 0.585 |
| | Range of motion | 6.09 ± 1.70 | 4.45 ± 2.01 | 0.053 |
| Total | | 32.18 ± 4.35 | 33.91 ± 7.88 | 0.578 |

*significant differences ($p < 0.05$)

## DISCUSSION & CONCLUSION

The results shows that there is no difference in physical and social condition and general QOL between the RGO and HKAFO groups. Since several studies have shown that RGO improves the kinetic and kinematic aspects of walking more than HKAFO [2, 3], the finding of the present study may imply that the improvements in kinetics and kinematics are not significant enough to provide any functional difference and therefore are not able to impact on the QOL. To conclude, the results showed that individuals wearing RGO and HKAFO orthoses have equal QOL, although the psychological condition were better in RGO user group.

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# P&O: A TRAINING FOR PUBLIC HEALTH

Komivi Biessou Elom ELITSA

**Background**:

A quick look over trainings in P&0 world wide shows all the emphasis put on the production and delivering of orthopedic devices to the detriment of the environmental and medical aspects of the management and beyond ; This reduces pejoratively the role of the P&O, facing the major issues of health, such as deficits in health systems of our sub-Saharan countries, including some phase shifts of the P&O found in multidisciplinary teams.

**Aim**:

Re think the training of orthopedic professionals insisting on the teaching of medical disciplines for a real and full inclusion of P&O in the medical sphere, for better management of the whole population.

**Method**:

An objective analysis of different training curricula, medical social realities, the skill spheres and fields of action of P & O from the West African sub-Region, a meaningful analysis of some professional practices in Rehabilitation, expectations of our people, as well as interviews with some professionals helped us in the realization of this study.

**Results**:

Obviously, there is a need for qualified orthopedic technologists with proven skills in P&O sciences; professionals capable of building good orthoses and prostheses. This need is even greater than we are seeing an upsurge in non-communicable and debilitating diseases. When re-focusing training in P&O (at intermediate and higher levels) on medical fields, they will acquire a greater background and then, they would be much more efficient and well integrated into multidisciplinary teams and in the health system. P&O, through training and internships in hospitals, can prove real skills in multidisciplinary teams, where they would be valid interlocutors, and an essential actor in Public Health with proven expertise in "IEC" (Informing, Educating, and Counselling). Thus, they will be partners of choice in medical rehabilitation, good auxiliaries for doctors, surgeons, etc. in detecting, referring, counselling and follow up.

**Discussion & Conclusion**

The place of P&O in the medical landscape remains controversial, due to the character of trainings, which are mainly focused on P&O sciences. It results in a minimalist vision of the profession that is still perceived as a "craft", not a medical science, in the eyes of our people, our decisions makers and even by the medical professionals. Our main purpose would be to widen competences for a full integration and enhanced participation of P&O in the health systems of our countries.

# EARLY PROSTHETIC FITTING IN LOWER LIMB ELDERLY AMPUTEES - WHAT IS THE BENEFIT.

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## BACKGROUND

The division of orthopaedic of the Geneva University Hospitals offers early prosthetic fitting (EP) until stump healing following major lower limb amputations (MLEA).
Elderly patients who undergo MLEA for severe peripheral arterial disease (sPAD) start early rehabilitation as they benefit from EP. This likely promotes stump healing and increases the possibility of walking with a definitive prosthesis (DP). This also permits identification of those patients able to walk with a prosthesis.

## AIM

Assess the benefit to start early rehabilitation prior to stump healing, and its influence with regards to age, level of amputation and presence of diabetes as it affects receiving a DP.

## METHOD

This retrospective survey included all MLEA, defined as any level of amputation proximal to the foot, performed between 1990 and 2015 at Geneva University Hospitals. We included patients who underwent amputation for sPAD, with or without diabetes, older than 64 years of age. Patient data were prospectively collected. Time to DP (median [IQR]) was defined as the time between MLEA and DP. Time to DP between groups with or without EP was compared with U test of Mann-Whitney. Age, sex, level of MLEA, presence of diabetes, and EP were studied as univariate predictors of DP with a logistic regression method.

## RESULTS

528 MLEA were performed during the period. Age (mean±SD) was 77.3±6.9 years, 333 (63%) men, and 309 (58.5%) diabetic. 301 (57%) received a DP, 260 (49%) after EP, 44 (14.5%) with EP did not receive DP. Time to DP was 42 [44] days. Time to DP did not differ between EP and nonEP groups (64.5 [53] vs 88 [84], p=0.095), except in patients without diabetes (65.5 [45.5] vs 95.5 [86.5], p=0.045).
The probability to obtain a DP was significantly higher if patients received an EP OR 26.4 (CI95%16.6-42) and in cases of below knee amputation OR 4.37 (CI95% 2.84-6.7). Each year of aging decreases by 7% the probability to have a DP (OR 0.93 – CI95% 0.91-0.96).

## CONCLUSION

Elderly amputees for sPAD without diabetes benefit from EP as they decreased the time to obtain a definitive one, and likely influences the time of stump healing. Patients with MLEA more frequently benefit from receiving a definitive walking prosthesis if they had an EP for early rehabilitation, and in cases of below knee amputation. As patients age, they have less probability to benefit from a DP.

# CONDUCTING CLINICAL TRIAL RESEARCH IN THE FIELD OF ORTHOTICS AND PROSTHETICS: TRIALS AND TRIBULATIONS

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[1] Shirley Ryan AbilityLab/Rehabilitation Institute of Chicago, [2] Dept. of PM&R Northwestern University

## BACKGROUND

As health expenditures continue to rise, reimbursement is increasingly linked to pay-for-performance; prosthetic and orthotic technologies are constantly evaluated for clinical evidence to guide reimbursement. Evidence is primarily anchored by the ability to improve functional mobility that impacts quality of life, thus ideally decreasing overall health care costs. This assumes that the clinical evidence can be measured using standardized clinical trial research standards in the field of orthotics and prosthetics (O&P). However, O&P faces many unique challenges atypical to other clinical practices in establishing clinical trial evidence. There is still a lack of understanding between the O&P industry, the clinicians and the researchers on how to tackle this unique problem towards establishing evidence-based practice.

## AIM

This review thus discusses the challenges faced in designing, implementing and establishing clinical evidence for the field of O&P and some potential solutions towards launching the field's own evidence standards which are accepted within and outside the field.

## METHOD

The number of randomized clinical trials (RCTs) published in the field of O&P was investigated and analysed as to whether these trials changed practice. The design and implementation challenges of two RCTs conducted by us in both prosthetics and orthotics was reviewed and results interpreted. Key leaders in the field of O&P research were surveyed about the difficulties they faced in procuring funding and implementing their research. Furthermore, O&P industry leaders were surveyed regarding reimbursement challenges with the payers based on clinical evidence. All the above research probes were conducted to test of our primary aims.

## RESULTS

US FDA and the Centre for Medicare and Medicaid Services, require comparative clinical trials for ensuring the safety, effectiveness and economic value of medical devices. However, the quality of research in this area is often deemed poor by public and private oversite, leading to denial of new technologies. Challenges to quality O&P research include: small sample sizes, recruitment issues for long term studies, high number of variable components needed, high variability within device users, high costs and prolonged duration for fitting, fabrication and acclimation. Furthermore, many clinical outcome measures do not have the resolution to differentiate specific componentry value. Many advanced O&P technologies do not have established standardized clinical evaluation, training and progression strategies. In addition, the use of generic billing codes for these advanced technologies prior to establishing the clinical evidence for their use results in variable reimbursement while the clinical trials are on-going. The complexity of procuring oversite approvals leads the clinician to continue to recommend O&P technologies based on relationships built, prior use, and balancing profits for sustainability rather than based on clinical evidence.

## DISCUSSION & CONCLUSION

Quality O&P research guides appropriate clinical decision making and helps consumers in reimbursement claims. This can be achieved only if industry, clinicians, researchers and payers make a concerted effort to establish an independent accepted standard for the field of O&P, likely different from those in other clinical fields. This clinically important field, which impacts a large population of the world, should strive harder to establish quality evidence to help provide patients with the most appropriate mobility device rather than the most available device.

# LONG-TERM ASSESSMENT OF LIMB VOLUME AND SOCKET INTERFACE STIFFNESS

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The Ohio Willow Wood Company

## BACKGROUND

Existing re highlights that elevated vacuum suspension decreases pistoning, reduces internal socket pressures, stabilizes limb volume1 . Previous work by the authors found that in-socket movement can be controlled by changing the elevated vacuum suspension pressure setting2 . Since the socket geometry is fixed, it is reasonable to surmise that a chance in limb volume can affect the amount of limb motion inside the socket. This ch nge in motion is in turn a change of stiffness at the interface. In order to more efficiently transfer the movements of the limb to the socket, the socket interface should be stiff (i.e. little to no relative motion between the limb and socket). What is not well understood is long term changes in limb volume that may impact that stiffness and how this differs between different types of suspension.

## AIM

The purpose of this study is to understand the relationship between limb motion, limb volume, and socket comfort and how these outcomes are impacted by method of suspension.

## METHOD

Nine EVS prosthesis users and six suction suspension prosthesis users were recruited to participate in the study (8 transfemoral and 7 transtibial). Each subject completed three study visits: initial, one week, and eight week follow-up. Limb volume was collected using the Omega Scanner software before and after an intermittent walking activity and limb motion was collected using the LimbLogic Communicator3 during the intermittent walking activity at each visit. Volume measurements after the activity were collected at set time points during a 15-minute period. Subjects were instructed to stay in one of three positions; 1) seated, 2) lying supine, 3) lying supine with residual limb elevated. The order in which subjects completed the positions was randomized by study visit. A study specific questionnaire was used to collect information regarding subject demographics as well as socket comfort scores at each visit.

## RESULTS

Limb motion inside the socket was found to correlate to limb volume and socket comfort. The degree of volume change before to after the activity period was significantly greater compared to the change experienced for elevated vacuum suspension socket wearers. This change generally decreased while vacuum users gained or stayed the same as the before activity measurements. In addition, these users had a significant decrease in the amount of measured in-socket limb motion compared to suction suspension users. Volume change after the activity was highly dependent on the position for suction prosthesis users. Elevated vacuum suspension users on the other hand had a more consistent change in volume independent of position

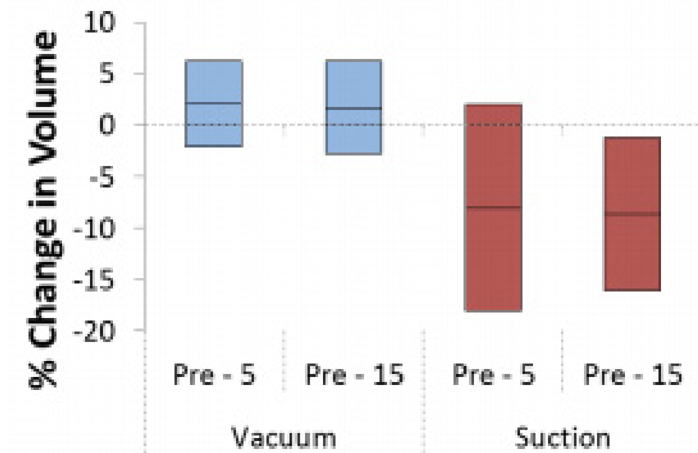


Figure 1. Percent change in limb volume before activity to 5 to 15 minutes after activity. Post-activity rest was completed with participants lying supine.

## DISCUSSION & CONCLUSION

Limb volume changes were dependent on both the method of suspension and the rest position. Limb volume tended to increase when in a seated position and decrease in a lying down position following activity. Prosthetists should consider how their patients are resting during a socket fitting as position was shown to change limb volume which could impact socket modification decisions. EVS suspension seemed to buffer differences in volume change among the various positions. Overall the results of this work support claims of previous work completed by the authors4 stating that beneficial changes in limb health resulted from a more stable environment for the soft tissues, allowing the limb to physiological adaptation to the socket environment. Future work should expand the number of test participants included and also investigate the acute impact of EVS on limb volume change for new users of EVS.

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# CLASSIFYING PHYSICAL ACTIVITY BY ACCELEROMETRY IN PERSONS WITH LOWER LIMB AMPUTATION. A PILOT STUDY

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## BACKGROUND

There are few studies using objective measurements of the activity levels among lower limb prosthetic users (1), and there is no Norwegian data on this topic. Information on how persons with a lower limb amputation use their prostheses on a daily basis and over time is important knowledge for improving rehabilitation practices and advance our understanding of prosthesis functionality.

## AIM

The main aim of this study is to measure the activity levels in three groups of adult lower-limb prosthetic users by 3-axis (3D) accelerometry and investigate if the level of amputation affect prosthetic use.

## METHOD

Two persons with a transfemoral amputation (TFA), two persons with a transtibial amputation (TTA) and two persons with a knee disarticulation (KDA) participated. They were all fitted with a 3D accelerometer (ActiGraph wGT3X-BT). The monitor was fastened to the right hip and the participants were instructed to wear the accelerometer at all times, except when showering and sleeping. Accelerometer counts from 0-99 was classified as Sedentary physical activity (PA), 100-2019 as Low PA, 2020-5998 as Moderate PA and counts above 5999 as Vigorous PA. Prosthetic mobility was investigated by the PLUS-M 12-item short form (version 1.2) (www.plus-m.org).

## RESULTS

The median (range) age, BMI and years as prosthetic users were: 59 (43) years, 23.5 (11) kg/m2 and 18(50) years. The PLUS M score (n =5) varied between 52.4 – 61.0, with a median score of 54.4. There was a linear relationship between steps/day and PLUS-M score (r2 = 0.92). There was a negative association between amputation level and sedentary PA (hours/week) (r2 = 0.42). MVPA is seemingly higher for TTA.

Table 1. Activity data on three groups of lower limb amputees.

| | Steps/day | Sedentary activity, h week$^{-1}$ | Low activity, h week$^{-1}$ | MVPA h week$^{-1}$ |
|---|---|---|---|---|
| **TFA** | 5008 | 56.5 | 22.5 | 7.0 |
| **n = 2** | (4030-5986) | (49-64) | (20-25) | (6-8) |
| **KDA** | 3862 | 55 | 33.5 | 7.5 |
| **n = 2** | (3327-4397) | (47-63) | (28-39) | (7-8) |
| **TTA** | 10 919 | 42 | 39.5 | 20 |
| **n = 2** | (6511-15327) | (41-43) | (36-43) | (17-23) |

TFA = Transfemoral amputees, KDA = Knee disarticulation, TTA Transtibial amputation. MVPA = moderate and high physical activity. Values are medians (min-max).

## DISCUSSION & CONCLUSION

The number of participants in this pilot study is low, thus generalization is not possible. However, there seems to be a trend that persons with a more distal amputation are more physically active and take more steps.
Physical inactivity is a serious threat to the health of LLA and it is important to implement accelerometer studies on a larger scale and over longer periods in order to improve rehabilitation practices and advance our understanding of prosthetic functionality.

## REFERENCES

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# ENHANCING WHEELCHAIR CAPABILITIES USING RADAR SENSORS

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## BACKGROUND

Wheelchairs are the most common devices used by disabled people to overcome daily problems. Studies indicate that about 1% of the world population (65 million) use wheelchairs [1]. However, in real-life situations obstacles such as steps and stairs can limit the mobility of wheelchair users. To overcome such obstacles many studies were done to allow either manual or powered wheelchairs to climb the stairs [2,3]. For automated obstacle handling, a robust and environment invariant detection of the surrounding is necessary. In order to initiate the right obstacle handling, the dimensions of the obstacle have to be acquired. Like in other safety systems radar sensors can be considered as an excellent option for this task, since they are capable to handle outdoor measurement conditions like sun light, dust, and other harsh circumstances [4].

## AIM

We propose a surrounding structure detection method based on radar sensor technology attached to a wheelchair, as a first step to automate the stair climbing process.

## METHOD

In this study a miniaturized low-cost millimeter wave radar sensor is used to measure the depth and the height of stairs in a staircase. The method is based on Synthetic Aperture Radar (SAR) scanning. The radar signals are mapped during a certain forced motion pattern of the sensor. Measuring in front of an object generates a two-dimensional scan in ether the vertical or horizontal plane. We compared a typical staircase in different harsh environmental conditions using two methods for radar scanning: (1) the radar is moved in a translational motion and (2) the radar is rotated in front of the stairs. The translational approach is expected to give better results than the rotational approach; however, the rotational approach allows a more compact design of the sensor system. All measured distances are mapped in a two-dimensional image and processed to extract object dimensions like the stair height and depth.

## RESULTS

The radar is fixed on a motor over the back of the wheelchair and placed at 2.7 meters from the staircase. The radar moves translationally at a height from 10 cm to 60 cm which corresponds to the maximal assembly space of the wheelchair. The motion of the radar is synchronized with the collected data. The same experiment is done on a rotational motion of 50o where data synchronization is applied to the collected data. Both methods allow the reconstructing of the stairs. The data measurements are combined to reconstruct the staircase as shown in Figure 1.

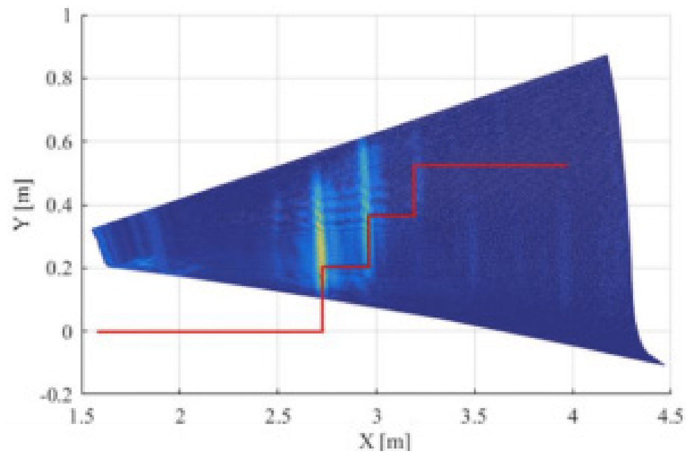


Figure 1. Stairs reconstruction from SAR radar

## DISCUSSION & CONCLUSION

Different techniques based on SAR radar scanning are used to demonstrate that radars are suitable for stairs dimensioning. This dimensioning enhances the wheelchair stair climbing process to work semi or even fully automated. For long staircases, the proposed method can rescan the remaining stairs after each climb. The main advantage of using radars is stability in harsh conditions that could be demonstrated, which enables the technology to be used in further wheelchair developments indoors and outdoors.

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# CURRENT ISSUES WITH MULTI-DOF MYOELECTRIC HAND PROSTHESES AND INDICATIONS FOR TESTING PATTERN RECOGNITION BASED CONTROL

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## BACKGROUND

Pattern Recognition (PR) might facilitate intuitive prosthesis control [1], which in return should ease the execution of activities of daily living (ADLs) with a prosthesis. Tests to evaluate PR based control and its implementation in daily use are currently not available but are required. These tests should ideally reflect realistic prostheses utilization, based on ADL tasks that users of modern multi degree-of-freedom (DOF) prosthetic hands perceive as relevant or difficult.

## AIM

The aim was to describe control issues with current multi DOF prostheses and to identify pertinent ADLs from the perspective of patients and therapists who are experienced with such prostheses.

## METHOD

This qualitative study was carried out in the form of semi-structured interviews with 16 adult patients and 7 therapists who were experienced with multi-DOF myoelectric prosthetic hands. Patient inclusion criteria were unilateral amputation at transradial or wrist level and at least six months of experience with the above mentioned prosthetic hands. Therapist inclusion criteria were at least six months of experience with the treatment of such patients. Moreover we included patients and therapists who already had experience with PR based myoelectric prostheses. The interviews were recorded and transcribed by an independent person. Data was analyzed according to a 5-step framework approach based on (1) Familiarization, (2) Creating a thematic framework, (3) Indexing, (4) Charting, and (5) Mapping & Interpretation.

## RESULTS

Myoelectric control was often described as too slow, fatiguing and requiring strong mental effort due to non-intuitive trigger signals, such as co-contraction. This also led to the selection of a small number of employed grip/movement modes. Relevant and difficult ADLs differed between individuals, but recurrent domains were mostly preparation of food, eating and dressing. Many patients perceived their multi-DOF prosthesis as a tool which should be able to support the sound hand in bimanual tasks, when these become very difficult or impossible to perform with one hand. Patients mainly choose a multi-DOF myoelectric hand because they expect additional functionality in comparison to conventional myoelectric prostheses, which is not always experienced in the end. Furthermore, persisting problems with current multi-DOF
prostheses were low technical robustness and poor manufacturer support (e.g. long waiting times for replacement of parts).

## DISCUSSION & CONCLUSION

This study revealed several aspects worth considering when testing future (PR based) myoelectric prostheses. The test should involve bimanual tasks related to preparing food, eating or dressing, where the prosthetic hand works to assist the sound hand. Next to completion time and quality of movement, variables such as ease of use, mental effort and grip type variety might indicate whether PR holds benefits for the patient in myoelectric prosthesis control.

## REFERENCES

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# DIFFERENCES IN SOUND HAND AND PROSTHETIC PREHENSION FROM A COORDINATION DYNAMICS PERSPECTIVE

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## BACKGROUND

Testing upper limb function after amputation and prosthesis fitting is an important step to evaluate the rehabilitation process and to gauge the functionality of prostheses. Characteristics of movement such as naturalness and coordination quality are relevant for the patient, but they are difficult to measure objectively. Principles and tools from the framework of coordination dynamics, however, might provide means to describe those aspects of motor behavior with a prosthesis.

## AIM

This study builds on findings in pilot experiments. The aim is to investigate whether coordination dynamic parameters of the upper limb can characterize differences between healthy participants and prosthesis users during rhythmic prehension movements.

## METHOD

During the pilot experiment three able-bodied participants picked up a wooden cylinder and returned to the starting position. They performed 50 repetitions with their sound hand and 50 repetitions with a prosthetic simulator (Otto Bock Variplus Hand). 3D Kinematics were measured with an optoelectric system and (relative) joint angles of elbow and shoulder were calculated. Discrete relative phase was calculated between prominent peaks in the time series of elbow and shoulder angles. Variability of discrete relative phase was assessed by its standard deviation. A larger follow-up experiment with more participants is planned, including patients wearing myoelectric prostheses.

## RESULTS

Visual inspection of relative angle plots of elbow flexion and the plane of shoulder elevation revealed a more variable pattern in the prosthetic simulator condition (Figure1). The standard deviation (SD) of discrete relative phase was moreover found to be higher in the prosthetic simulator condition (SD: 6.09) compared to reaching with the sound hand (SD: 3.44). In this poster, results of the follow-up study will be reported, including the comparison between able-bodied individuals and prosthesis users.

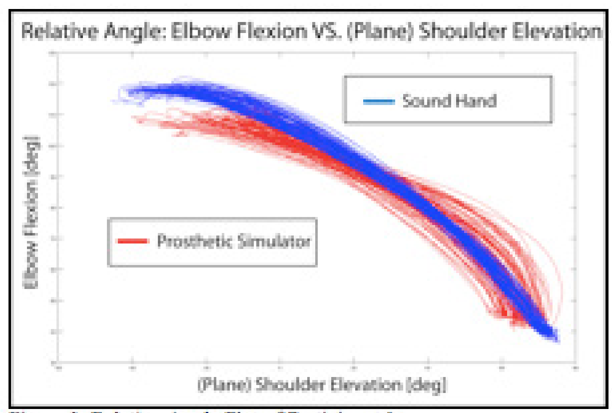


Figure 1. Relative Angle Plot of Participant 1

## DISCUSSION & CONCLUSION

Sound hand and prosthesis simulator conditions could indeed be distinguished by coordination dynamics parameters. Upper limb joint coordination patterns during a rhythmic prehension task appeared to be less stable when reaching with a prosthesis simulator, compared to reaching with the sound hand. Establishing ranges of natural performance and criterion values of these coordination dynamics parameters will be used in the future to develop a new tool to assess prosthesis user skill or to evaluate functionality of prostheses.

# 5 STEPS GAIT TRAINING PROGRAM USING THE EXOSKELETON ROBOT HAL (HYBRID ASSISTIVE LIMB) FOR ACUTE STROKE PATIENTS

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## BACKGROUND

For acute stroke patients, task-specific mobility training early after stroke may enhance beneficial neuroplasticity and recovery from paralysis. Recently, a new wearable robot suit with a hybrid system that allows both an automatic and a voluntary mode of action to support training of gait, Hybrid Assistive Limb (HAL) has developed (fig.1). HAL synchronizes with slight voluntary muscle contraction and supports and amplifies knee- and hip-joint movements. HAL also enables patients to start walking training at early stage

## AIM

In this study, we developed novel gait retraining program using HAL for acute stroke patients in addition to regular rehabilitation method and examined its feasibility and efficacy.

## METHOD

were 21 acute stroke patients. A new gait retraining using HAL program consists of five steps (fig. 2), were determined according to the function of the paralyzed limb, step I: exercise on the bed, step II: standing-up, step III: walking training bringing up knees (marching style), step IV: add knee extension (kicking motion), step V: increase hip work (long strides walk style). We set control for HAL depending on each step and provided an integral HAL and regular rehabilitation program. HAL training was administered about 3 days in a week, The study protocol covered safety ad feasibility issues and aspects on motor function, gait performance according to the 10meter walking test and Functional Ambulation Categories (FAC).

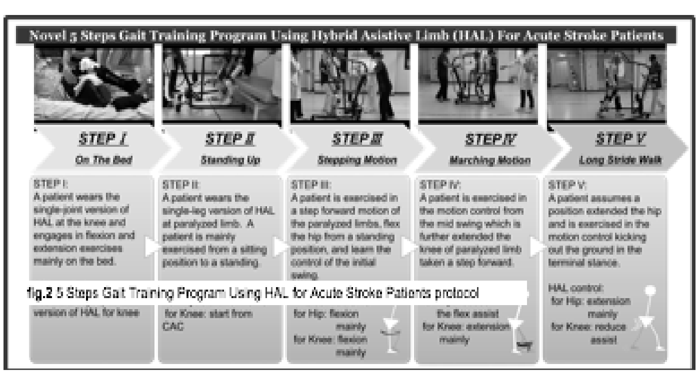



fig.2 5 Steps Gait Training Program Using HAL for Acute Stroke Patients protocol

## RESULTS

Average duration from onset was 10.3 days ± 4.2 days. All 21 patients completed the study with no adverse events. The average number of sessions was 6.3 and the average duration of HAL trainings was 18.2 days. All clinical measures were improved significantly (table 1). Gait speed, cadence, and step length during the 10meter walking test increased significantly (table 2). 19 patients improved the FAC (from 0 to 2 in median) (fig. 3).

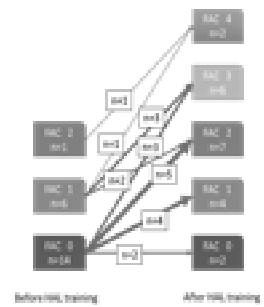


fig.3 Comparison of FAC

## DISCUSSION & CONCLUSION

We formulated and implemented novel 5steps gait training using HAL program for patients with acute stroke hemiplegic patients. There were no serious adverse incidences, and the program was deployed safely. The formulated exercise program consisted of HAL settings unique to patients' conditions and every step target settings, and the link between the traditional rehabilitation was clearly defined. Moreover, the program was designed in such a way that the operation was safely, efficiently, and effectively conducted. Together, it is expected that the use of HAL can be an effective measure for early intervention.

table.1 Comparison of clinical measures before and after HAL

| Clinical measures | Before HAL Training | After HAL Training | p-value | n |
|---|---|---|---|---|
| Duration Assessment Day from Onset | 10.2 | 28.3 | | |
| NIHSS | 11.5 ±4.7 | 7.6 ±4.4 | <0.01 | 21 |
| 12Grade Hemiplegia Scale | 4.7 ±3.5 | 7.5 ±3.2 | <0.01 | 21 |
| Brunnstrom Stage | 3.1 ±1.4 | 4.4 ±2.0 | <0.05 | 21 |
| Fugl-Mayer Assessment | 52.1 ±10.1 | 66.1 ±12.6 | <0.001 | 14 |
| FIM | 41.8 ±13.7 | 72.3 ±24.1 | <0.001 | 12 |
| FIM-locomotor | 2.25 ±0.45 | 5.25 ±3.14 | <0.001 | 12 |
| Barthel Index | 19.4 ±19.1 | 53.1 ±22.3 | <0.001 | 18 |

table.2 Comparison of 10MWT before and after HAL Program

DISCUSSION & CONCLUSION

| | Before HAL Training | After HAL Training | P value | n |
|---|---|---|---|---|
| Gait Speed (m/min) | 14.8 ±9.3 | 34.1 ±19.7 | <0.01 | 15 |
| Cadence (steps/min) | 62.8 ±16.6 | 84.8 ±30.0 | <0.05 | 12 |
| Step Length (m) | 0.27 ±0.089 | 0.38 ±0.12 | <0.05 | 12 |

We formulated and implemented novel 5steps gait training using HAL program for patients with acute stroke hemiplegic patients. There were no serious adverse incidences, and the program was deployed safely. The formulated exercise program consisted of HAL settings unique to patients' conditions and every step target settings, and the link between the traditional rehabilitation was clearly defined. Moreover, the program was designed in such a way that the operation was safely, efficiently, and effectively conducted. Together, it is expected that the use of HAL can be an effective measure for early intervention.

# EPIDEMIOLOGY OF LOWER EXTREMITY AMPUTEES IN INDIA

Pooja Mukul

## BACKGROUND

Demographics of LICs create a patient profile vastly different from that in the HICs. Patterns of disability are influenced by trends in health, environment and other factors such as traffic conditions, conflicts and natural disasters. Amputees seem like a homogenous group in terms of their impairment and it may be presumed that there would be little difference in the prosthetic solutions needed for amputees around the world. However, no such generalization can be made. The user profiles are unique, the socio-cultural, environmental and occupational needs are distinct and so should be the solutions. Meaningful country specific data is the cornerstone of evidence-based practice and the available data on epidemiology of amputees in India is scant.

## AIM

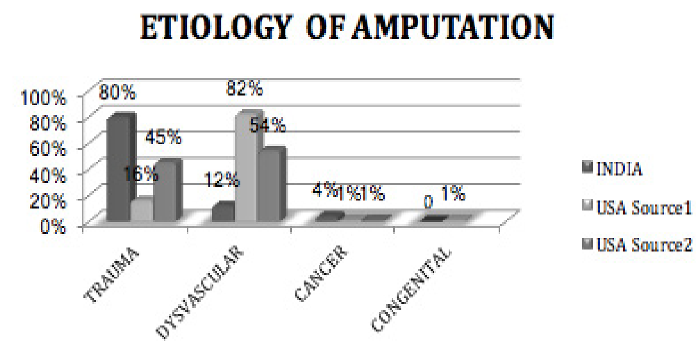
Rehabilitation of amputees calls for orientation of the service providers to the profile of the end users. The study was undertaken to capture reliable data on the profile of amputees in India.

## METHOD

Epidemiological data of 6750 lower extremity amputees across North India was collected in person at the BMVSS- Jaipur Foot Organization, Jaipur, India. Information regarding Gender, Age at amputation, Level of amputation, Etiology of amputation, Interval between amputation and prosthetic fitting, Background-Rural/ Urban, Occupation- pre and post amputation and pre and post prosthetic fitting were recorded.
The data was analyzed using SPSS.

## RESULTS

The compiled data was in conflict with published estimates. 75% amputees were less than 40 years of age and 52% were under 30 years. 80% of the amputees were post traumatic and only 12% were dysvascular which is in variance with the World Diabetic Foundation claims that 40,000 lower limb amputations are performed as a consequence of diabetes each year in India, 4% were post malignancy. Only 8% of the amputees were women, although the Census claims that 37% of all patients with locomotor disabilities in India are women.




## DISCUSSION & CONCLUSION

Data on amputees in India is insubstantial and unreliable making it extremely difficult to carry out research necessary to fully understand the needs of amputees, develop appropriate prosthetic technologies, effective policies and strategies. Country specific data is available only for the developed world and using this to extrapolate data for the developing world may be highly inaccurate and meaningless.. Estimates of even authoritative sources are disconsonant with country specific census figures, the WHO states that there are 7.4 million amputees in India whereas the latest Census puts the figure close to just 3 million.
For meaningful intervention there is an urgent need to demonstrate the scale of demand and provision of prosthetic services by dependable country specific data rather than irrelevant extrapolation.

# THE PHANTOM HAND MAP – A POSSIBLE TARGET FOR NON-INVASIVE SENSORY FEEDBACK IN HAND PROSTHESES

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## BACKGROUND

Many amputees experience referred sensations described as sensations from the phantom fingers elicited by stimulation of specific skin areas on e.g. the residual limb – a phantom hand map (PHM) [1]. Some amputees have a very detailed PHM with a mapping of all fingers, while others have a more "simple" map containing one or two fingers and others do not have a map at all. The anatomical and physiological substrate behind the PHM is not completely understood [1, 2].

## AIM

To evaluated the sensory qualities of the PHM.

## METHODS

A consecutive sample was made and individuals with acquired transradial amputation that experienced a PHM at two national prostheses centers were asked for participation, which resulted in ten participants. Touch thresholds (Semmes Weinstein monofilaments) [3] and discriminative touch (Two point discrimination) [4] of the PHM were assessed. They were assessed for ability to localize touch in the PHM areas. They were also asked to grade how distinct and similar to normal touch the referred feeling was on a Visual Analogue Scale. Corresponding areas on the contralateral, intact forearm, was used as controls.

## RESULTS

Similar touch thresholds were seen in the PHM and the control site at the contralateral forearm. Tactile discrimination, requiring both detection of stimulus and interpretation, was significantly better in the PHM. The quality of touch in PHM areas compared to normal touch experience was rated as mean 7.4 (range 3-10) on a Visual Analogue Scale (0-10).

| | PHM | Contralat. arm |
|---|---|---|
| SWM (g) *a | 0.008 | 0.008 |
| 2PD (mm) **a | 25 (10-40) | 45 (12-60) |
| Localization (%) | 95 (Median) | |

Table 1. Results from assessment of touch thresholds, discriminative touch and capacity to localise touch.

* Normal touch threshold forearm: 0.010 – 0.18 / Normal touch threshold index finger: 0.02 – 0.13 (20)
** Normal discriminative touch forearm: 40mm (20) / Normal discriminative touch index finger: ≤ 5mm
a) Tested in the site with the strongest phantom feeling

## DISCUSSION & CONCLUSION

The superior ability to detect and localize sensory stimuli in the PHM, the subjective experience of the "fingers" in the PHM, together with the fact that cutaneous stimulation of the PHM results in activation in the finger areas in the primary somatosensory cortex, suggest that the PHM is an optimal target for transferring sensory information from a hand prosthesis to the prosthesis user

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# PROMOTION OF ACADEMIC EXCELLENCE IN P&O IN AFRICA

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## BACKGROUND

In many P&O schools in Africa, best students and the average students have the same fate at the end of their studies and during their careers in P&O in Africa and after some years, those outstanding students are forgotten.

## AIM

This paper aims to point out the lack of academic excellence promotion in P&O schools in Africa compared to medical studies and raise a question.

## METHOD

This is a comparative study of upgrading system in P&O and the one in Medical Studies in Africa. We took the case of Medical Studies in Africa and studied the way medical students and doctors upgrade in their profession and carrier and compared it to the way P&O students and professionals evolve in their field. In this study, regarding P&O, we only considered the way P&O Cat.2 can move to P&O Cat.1 and how medical doctors become Professors, with an end focus on P&O field.

## RESULTS

In medical studies, the pathway is well designed and is as follows: a highly selective competitive examination is organized for all students from the sixth year of studies and the two or three who succeed at such an exam can automatically go for specialization after the seventh year without waiting to defend a thesis. Researches allow medical doctors to upgrade progressively until they become Professors. As long as they continue to conduct researches and publish them, they will be progressing. When it comes to the field of P&O in Africa, there is nothing like that for the best students. No upgrading pathway is designed. A lot of good and outstanding students are let to themselves.

There's no way to upgrade unless they have money to continue. Many good Cat.2 are still cat. 2 for years and years without any way to go. Many of those who got a possibility to upgrade owe it to a partnership between an NGO and their government or the center in which they work. Even in cases like that, nothing guarantees that it is those who got outstanding results that will be taken.

## DISCUSSION & CONCLUSION

This situation raises a big question in P&O in Africa: what is the use of working hard and getting good results if nothing comes out of it? Academic excellence should be encouraged by setting a strong and sustainable mechanism of upgrading system for outstanding students in order to promote hard work, research which will a great impact on the P&O field in Africa.

# HOW MUCH TIME? A PILOT STUDY QUANTIFYING ACCOMMODATION TIME IN UNILATERAL TRANSTIBIAL AMPUTEES

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## BACKGROUND

In lower limb amputees, fitting and evaluation of prosthetic components involves an accommodation period to familiarize subjects to these components.
1 In unilateral transtibial amputees (TTAs), the published accommodation times for prosthetic feet range from a few minutes to a few weeks, 2,3 as the minimum amount of time necessary to accommodate to a foot is not available. Also, a standardized method for quantifying accommodation to a prosthetic foot has not been published.

## AIM

This study proposes a method for quantifying gait-related accommodation to prosthetic feet, and aims to determine if 15 minutes is enough accommodation time for dynamic response (DR) prosthetic feet in unilateral TTAs.

## METHOD

Four high-functioning unilateral TTAs (mean age 38±9 years) tested three commonly used DR prosthetic foot designs: Jshaped; multiaxial and low profile – in random order. They received standardized prosthetic gait training4 for each foot and accommodated to the foot by walking on a treadmill for 15 minutes. At the end of the accommodation time, vertical ground reaction force (GRF) data were collected using wireless insole sensors as subjects completed a 2-minute walk
test on the treadmill. Subjects were tested on five occasions: Baseline session in their original DR foot; test feet 1, 2 and 3; and final session again in their original foot.

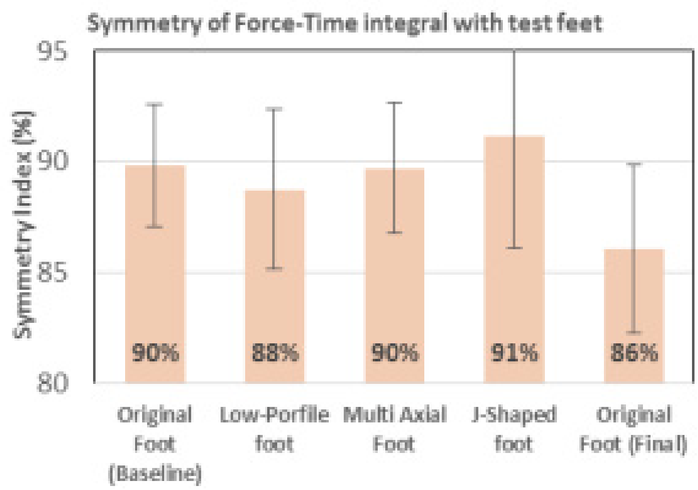
## RESULTS

Table 1 shows the demographic characteristics of test
subjects. Force-time integral (calculated using GRF and
stance time) was averaged over 30 steps of the intact and prosthetic limbs, and a symmetry index was calculated
between the limbs. Figure 1 shows the average symmetry index for the five testing sessions. There was no significant difference in the symmetry index of the force-time integral or the 2 minute walk distance between the five testing sessions.

Table 1: Demographic characteristics of test subjects

| ID | Age (years) | Cause of amputation | Time since amputation (years) | Existing prosthetic foot |
|---|---|---|---|---|
| 1 | 25.3 | Trauma | 5 | Renegade |
| 2 | 45.2 | Trauma | 4.9 | Renegade |
| 3 | 35.6 | Trauma | 1.8 | Triton |
| 4 | 45.1 | Trauma | 6.1 | RUSH |

Figure 1: Symmetry index of force-time integral at the five testing sessions




## DISCUSSION & CONCLUSION

As the force-time integral was similar between sessions,
subjects accommodated to the prosthetic feet by maintaining similar GRFs and stance times between feet. Therefore, forcetime integral could be used as a measure for quantifying gaitrelated accommodation to a prosthetic foot. Accommodation
time of 15 minutes appears to be sufficient for those unilateral TTAs, who are current users DR feet and have been trained to appropriately utilize the properties of the new foot.

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# COMPARISON OF POSTURAL CONTROL PARAMETERS IN AMPUTEES WITH AN OSTEOINTEGRATED VERSUS TRADITIONAL SOCKET PROSTHESES

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## BACKGROUND

Osseointegration (OI) for bone-anchorage of an external lower limb prosthesis has become an alternative for traditional socket suspension. People with an osseointegrated prostheses (OI) have reported a phenomenon called osseoperception, which is an improved ability to identify various sensations through their artificial limb.1 Research has quantified that amputees with OI have improved ability to detect vibrations through the prosthesis2 with potential applications for improved ability to balance.

## AIM

The purpose of this study is to compare balance confidence and balance performance in people with lower limb amputation who use an OI to a traditional socket prosthesis (TSP).

## METHOD

Subjects: A convenience sample of 15 community ambulators with unilateral OI participated at the 2016 Amputee Coalition National Conference. All OI subjects had surgical procedure performed in Sydney, Australia by Dr. Munjed Al Muderis. Another 15 participants with TSP were identified as case-control matches for the OI cohort based on age (range 25-67), gender (7 male, 8 female), amputation level (4 TTA, 11 TFA), and K-Level of the OI cohort. Subjects completed the Activities Specific Balance Confidence Scale (ABC), single limb stance, and conditions 1-3 of the Modified Test for Sensory Integration and Balance (mCTSIB). An inertial measurement unit (IMU), was attached to the sacrum with an elastic belt to measure postural sway during the mCTSIB activities. SPSS Statistical Software was used to describe the study sample, paired t-tests were used to compare differences in the two groups.

## RESULTS

There was no significant difference in single limb balance duration between groups, but there was a trend of the OI group to have better sound limb balance (p=.09)(Table 1). The OI group had significantly higher ABC scores, with an average increase of 7% balance confidence over the TSP group. All subjects (n=30) were able to maintain bipedal balance for 30 seconds in the mCTSIB conditions. There was no difference in the postural sway in the AP or ML directions between the groups for mCTSIB conditions 1-3.

| | OI (n=15) | TSP (n=15) | p |
|---|---|---|---|
| **1.Floor, Eyes Open** | | | |
| AP (cm) | 1.29 ± 0.55 | 1.26 ± 0.45 | 0.86 |
| ML (cm) | 0.88 ± 0.46 | 0.87 ± 0.42 | 0.84 |
| **2.Floor, Eyes Closed** | | | |
| AP (cm) | 1.94 ± 0.99 | 1.63 ± 0.51 | 0.29 |
| ML (cm) | 0.89 ± 0.46 | 0.90 ± 0.36 | 0.26 |
| **3.Foam, Eyes Open** | | | |
| AP (cm) | 1.37 ± 0.46 | 1.39 ± 0.39 | 0.88 |
| ML (cm) | 1.63 ± 0.79 | 1.57 ± 0.83 | 0.84 |
| **Single Leg** | | | |
| Prosthetic (sec) | 0.98 ± 0.47 | 1.14 ± 0.58 | .44 |
| Sound (sec) | 23.1 ± 11.0 | 17.9 ± 13.9 | .09 |
| **Balance Confidence** | | | |
| ABC (%) | 94.7 ± 5.7 | 86.9 ± 12.2 | .04* |

Table 1. Comparison of Balance Outcomes for OI and TSP; results show the average maximal sacral excursion in AP and ML planes for bipedal positions (1. Eyes open, 2, eyes closed, 3. Standing on foam), average single leg balance durations, and average percentage of balance confidence. *Significant at p<.05 level.

## DISCUSSION & CONCLUSION

Balance performance measures selected did not show any differences between subjects with OI and TSP who were age, gender, amputation level, and k-level matched. Both groups demonstrated minimal sway excursion during bipedal mCTSIB conditions 1-3, whereas single limb balance performance was more variable and challenging. Subjects with OI had higher balance confidence. The osseointegration surgical procedure allows an alternative to traditional socket suspension with similar balance outcomes in bipedal and single limb stance. Moreover, there is a self-reported increased confidence by the OIP group that may be related to osseoperception or other factors related to balance not yet determined. Because of the small sample in this study future work should determine where differences in posture during single-limb and bipedal balance activities might exist.

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# THE EFFECTS OF TRANSHUMERAL AMPUTATION AND PROSTHETIC USAGE ON GAIT PARAMETERS: A CASE REPORT

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## BACKGROUND

Arm swings during gait facilitates lower limb movements and enhance gait quality. The restriction of arm swing like folding of the arms, holding the arm in a sling or pocket and strapping the arms has negative impact on walking. Although several studies have been done by restricting upper limb movements for aimed at examining how walking parameters change, there is still not enough information about the gait parameters after upper limb amputation.

## AIM

The aim of this case report is to define the consequences of the absence of upper extremity and arm oscillation on spatio-temporal gait parameters and kinematics of the gait.

## METHODS

The 53 years old woman case has transhumeral amputation due to the traffic accident occurred in 2006. She is a professional dancer. She has been using a mechanical functional transhumeral prosthesis, weighing 3,30ibs, since 2010. First of all, demographic informations were recorded. Second, spatio-temporal parameters of gait were assessed by GAITRite computerized gait pathway, the system with 18,432 sensors, the data will be obtained at 60-120Hz, and third, the angular values of lower and upper extremities were evaluated on both sides by Dartfish Prosuite 7 Analysis Software. Gait assessments were going to be applied twice with and without prosthesis.

## RESULTS

When we examined the gait parameters of case with and without mechanical functional transhumeral prosthesis without shoulder joint, highly symmetrical values were obtained in the right and left limbs in terms of the spatio-temporal parameters of the gait, but it was determined that there are differences between with and without prosthesis values in terms of step length, stride length, arm oscillation, velocity and cadance (Table 1). When the patient was assessed with prosthesis, walking speed, cadence and intact side arm oscillation were increase. Arm oscillation with prosthesis 29,7° on intact side, 0° on affected side, without prosthesis 20.7° intact side and18.8° on affected side were measured.

| Parameters | WithProsthesis | | WithoutProsthesis | |
|---|---|---|---|---|
| Velocity (cm/sec) | 100,9 | | 82,7 | |
| Cadence (Step/Min) | 105,5 | | 93,6 | |
| Step width(cm) | 19.21 | | 17,58 | |
| | Left | Right | Left | Right |
| Step Time (sec) | .56 | .57 | .64 | .64 |
| Cycle Time (sec) | 1.14 | 1.12 | 1.28 | 1.25 |
| Step Length (cm) | 56.75 | 57.87 | 53.11 | 53.00 |
| Stride Length (cm) | 114.80 | 115.67 | 106.13 | 107.59 |
| Single Support (%GC) | 38.1 | 38.9 | 36.5 | 37.2 |
| Double Support (%GC) | 21.3 | 22.5 | 24.3 | 25.8 |
| Swing (%GC) | 38.4 | 38.6 | 36.4 | 37.3 |
| Stance (%GC) | 61.6 | 61.4 | 63.6 | 62.7 |
| Toe In/Out (deg) | 5 | 5 | 5 | 2 |
| Arm swing range degree) | 29,7 | 0 | 20,7 | 18,8 |

Table-1 Gait Parameters of Transhumeral Amputee With and Without Prosthesis

## DISCUSSION & CONCLUSION

Walking parameters of the left and right extremities are symmetric to each other due to the fact that the patient is a professional dancer so this reason symmetrical body movements are frequently used. Gait parameters such as step length, stride length, gait velocity and cadence increase with prosthesis because of increase the arm swing intact side. There is a need for further studies on more cases.

# SIMULATION OF THE ELDERLY DROP-FOOT IN THE YOUTH TO ASSESS THEIR RISK OF TRIPPING

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## BACKGROUND

The major causes of fall in the elderly are tripping and slipping, which are potentially caused by a common walking deficiency known as drop-foot. The assistance in the minimum toe clearance (MTC) from the ground has been reported to be an effective tripping prevention method, that can be achieved by certain walking adding devices; however, the development and tests of such devices using the elderly might jeopardize their safety. Hence, specific characteristics of the elderly could be simulated in the youth to progress in the understanding of the elderly needs and provide effective assistance.

## AIM

We aim to devise a technique to simulate the reduced MTC in the youth by restricting the activity of specific muscles, that could aid the study of the risk to fall in the elderly and the development of effective walking assistance devices.

## METHOD

Ten male subjects with average ages of 22 years participated in this study. Using a motion capture system, we recorded the toe clearances as the vertical distance from the ground to a marker placed right next to the hallux, centered at the tip of the distal phalanx.
A technique called as Muscle Activity Restriction Taping Technique (MARTT) [1] was devised to simulate a reduced MTC in the youth by restricting the activity of the muscles at the shank and at the thigh, as shown in Figure 1. Force sensors where embedded to measure the restriction force. Two different walking speeds were tested: the natural speed of young adults (4 km/h) and the average of the speeds reported for the elderly (3.5 km/h). The statistical significance of the reduction in the MTC was examined by the Mann-Whitney-Wilcoxon test.

## RESULTS

As shown in Table 1, the restriction of the muscles at the shank and at both shank and thigh achieved reduction in the MTC regardless of the walking speed, and a lower MTC resulted in a significant increment of toe-ground contacts, where the highest incidents occurred when both shack and thigh were restricted.
The MTC values after the restriction were validated to be in the range of the ones reported for the elderly (e.g. 7.1 mm [2] and 12.9 mm [3]). The variability of the MTC in restricted walking appeared to be lower than in normal walking; however, a higher variability in the elderly than in the youth has been reported. Moreover, the MTC during restricted and normal walking at both walking speeds were not Gaussian distributed but positively skewed and leptokurtic, similar to what was previously reported.

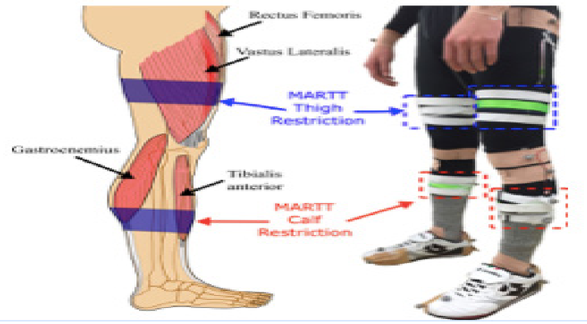


Figure 1. MARTT belts were used to restrict the gastrocnemius and tibialis anterior muscles at the calf and the rectus femoris and vastus lateralis at the thigh.

| Speed | Leg | Natural | Shank | Shank/Thigh |
|---|---|---|---|---|
| 3.5 | L | 0.64±0.26 | 0.40±0.31*** | 0.40±0.31*** |
| | R | 0.71±0.25 | 0.59±0.18*** | 0.59±0.18*** |
| 4 | L | 0.60±0.30 | 0.44±0.30** | 0.44±0.30** |
| | R | 0.65±0.18 | 0.56±0.16** | 0.56±0.16** |

Table 1. Average MTC under each condition in percentage of the body height. *** p<= 0.01, ** p<= 0.05, * p<= 0.1 indicate the significant differences compared with normal walking.

## DISCUSSION & CONCLUSION

The reduction in the MTC could be described by the changes in the joint angles. The principal restriction effect of the shank restriction was the reduction in the ankle flexion, and that of the shank and thigh restriction was the reduction in the hip flexion at the instant of the MTC. The lower variability of the MTC in restricted walking was due to the limitation of the full range of flexion of the hip and ankle joints. Consequently, the sporadic occurrences of high MTC values commonly seen in the elderly walking due to their loss of control of their muscle contraction were not simulated. However, MARTT could simulate a higher number of MTC values near zero clearance observed in the elderly, which are the ones of main concern in falling prevention. This suggests that MARTT can simulate elderly drop-foot characteristics, which can help assess their risk of tripping or falling.

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# REFINEMENT OF A SMARTPHONE-DELIVERED PEER PHYSICAL ACTIVITY COUNSELLING PROGRAM FOR MANUAL WHEELCHAIR USERS.

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## BACKGROUND

The importance of physical activity (PA) is amplified for manual wheelchair (MWC) users, yet participation is rarely sufficient to elicit health benefits.1 Even slight increases in PA can have considerable effects. Existing community-based PA programs for MWC users appear to work, but adherence is low.2,3 Most existing programs are atheoretical and thus miss the opportunity to foster a set of complex psychosocial variables that are linked with PA (autonomy, motivation, selfefficacy).4
These programs are also void of the use of the power of peers to enhance motivation and PA. The proposed
Smartphone Peer Physical Activity Counselling (SPPAC) program answers these gaps as it (a) is theory-based; (b) involves peers; and (c) is aimed to enhance psychosocial constructs as a precursor to PA.

## AIM

To gain expert consensus on the content and delivery of the SPPAC program.

## METHOD

A two-phased mixed methods design (1. Focus groups; 2. Delphi surveys) was performed with experts in MWC use and PA (occupational therapists, knowledge users, MWC users). In phase 1 experts discussed content, delivery method (peerled, Smartphone), frequency and duration, important components, and perceived barriers of the SPPAC program. Thematic content analysis was used to create the Delphi surveys for Phase 2, then experts were asked to rate their level of agreement with statements and practices regarding the SPPAC program. Statements and practices were summarized and further elaborated until 70% consensus was attained.

## RESULTS

Twelve experts participated in two focus groups (5
occupational therapists, 3 knowledge users, 4 MWC users). All 12 completed the first survey, while 10 completed the second and final round. Results from the focus group suggested that participants liked the inclusivity of SPPAC (i.e. available to all ages and diagnoses); delivery by a peer, and its potential to reach MWC users who otherwise may not have access to community-based PA services. Experts noted how SPACC content should include initial assessments and consider MWC skills, and delivery should consider various mediums (i.e., video chat, voice calls and text messages) depending on participant preference. Compelling statements from focus groups are summarized in Figure 1.

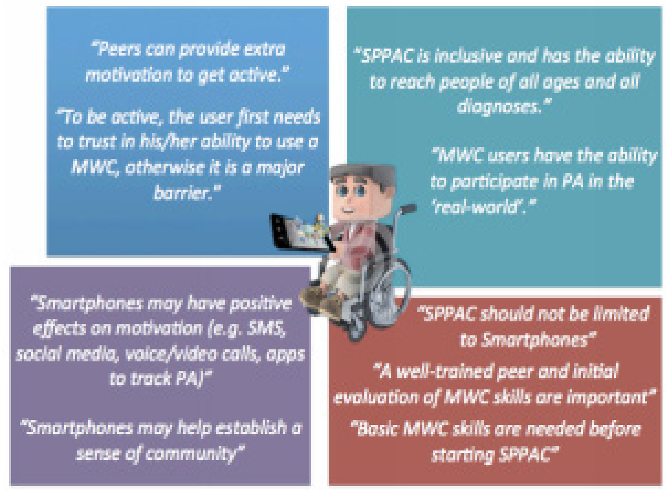


Figure 1. Expert statements regarding the SPPAC program.

At least 70% consensus was obtained on all items related to SPPAC program content (e.g., initial evaluation of wheelchair skills and PA levels, be individualized to participant preferences and goals, include motivational strategies). Suggested motivational strategies included: use of existing Smartphone applications (i.e., social media, video calls, text messages), goal setting, and organizing community events. It was agreed that the SPPAC program would: provide a sense of autonomy to participants; improve confidence; prevent weight gain and injuries; motivate MWC user to be more physically active; help to overcome issues with transportation, cost, scheduling, accessibility, seasonal barriers; and create a sense of belonging among participants. Concerns regarding the SPPAC program were the burden of sustaining a peertrainer and ensuring involvement from a healthcare professional.

## DISCUSSION & CONCLUSION

The SPPAC was developed using a client-centred approach that was favourable among the experts. Knowledge users and stakeholders support the SPACC intervention, and believe the program has potential to improve PA in MWC users. There are substantial benefits for the SPPAC program including limited burden on healthcare professionals, decreased barriers associated with inaccessible physical environments and
transportation, development of peer social supports, and costsavings (particularly when considering the expenses of physical inactivity on health). The SPPAC may extend to a large number of MWC users.

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# FEASIBILITY STUDY OF MICROCONTROLLER KNEE JOINT FOR ACTIVE TRANSFEMORAL PROSTHETIC LEG BASED-IN SOCKET SENSOR (PIEZOELECTRIC)

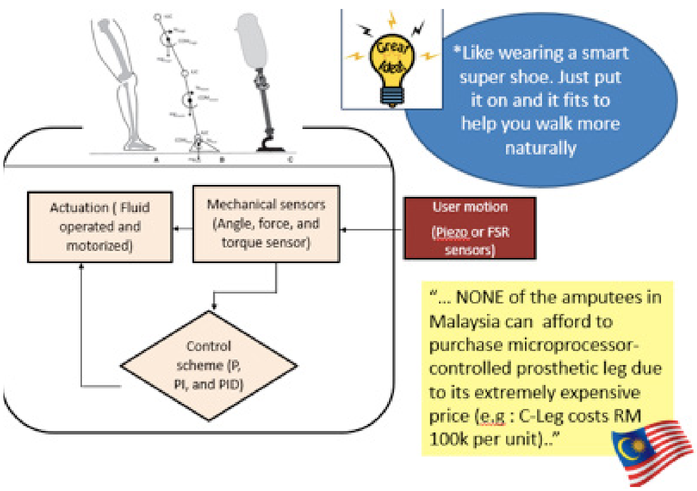
(Nur Hidayah Mohd Yusof, Farahiyah Jasni, Nur Azah Hamzaid, Lai Khin Wee)

## BACKGROUND

Amputation of an extremity is considered as a life-altering phenomena which causes deprivation the amputee of the independent living. About 300,000 Malaysians needed prosthetic limbs. Approximately 1.9 million people suffer from limb loss all over the world. The common way of rehabilitation for the affected people is applying the prosthetic limbs. The more the functions provided by the prosthesis the more restoration of the lost functions.

## AIM

To develop a cost effective microprocessor controlled prosthetic leg with user intention recognition for transfemoral amputees which is able to mimic a manner of ambulation close to that of normal healthy individuals.

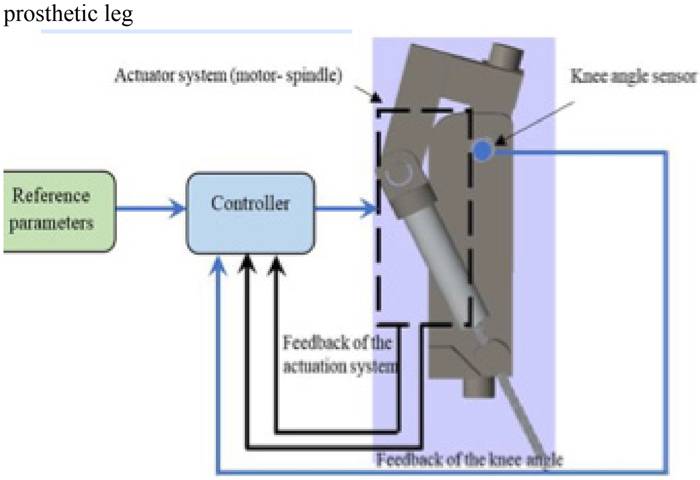



## METHODOLOGY

Stage 1: Development of novel sensing method using piezoelectric sensors embedded to the transfemoral socket of prosthetic leg

Stage 2: Classification of feedback signals to identify the intention and gait transition of the user

Stage 3: Development of the ANFIS based control algorithm for the prosthetic leg



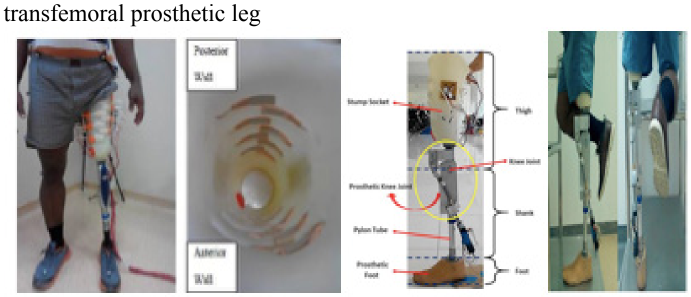

## RESULTS AND DISCUSSION

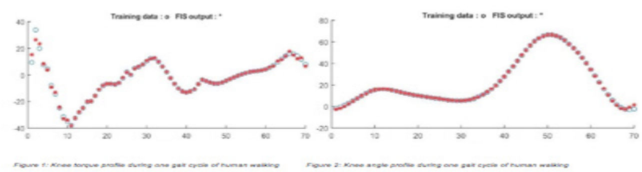
Simulation of the ANFIS controller proved that the system can evaluated the efficacy of the sensing method that was added on the smart prosthetic leg system and also the accuracy of the mechanical movement based on the controller requirement.

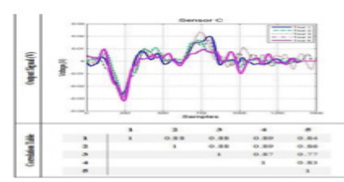
Figure 1: ANFIS output knee torque versus training data

Figure 2: ANFIS output knee angle versus training data

Figure 3: Piezoelectric output signal from in-socket transfemoral prosthetic leg




## CONCLUSION

The mechanical structure was successfully developed and angle of the mechanism was measured at all gait phases during walking. The overall physical dimension of the prosthetic leg allows fitment and user comfort. ANFIS control system, allows high precision and accuracy for the prosthetic legs to replicate human motion ambulation based on simulation the various phases of gait cycle. Further analysis will be carry out later with more patient participation.

# EFFECT OF ORTHOTIC TREATMENT ON CURVE CORRECTION & CARDIO RESPIRATORY FUNCTIONS IN CONGENITAL SCOLIOSIS WITH SINGLE-LEVEL HEMI VERTEBRAE

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## BACKGROUND

Congenital scoliosis is lateral curvature of the spine caused by deficiencies in formation or segmentation of the vertebrae or a mixture of both 1.
The natural world of congenital scoliosis with hemivertebrae is changeable, especially when it is combined with a unilateral unsegmental bar 2.
Orthotic treatments primary goal is to stop further curve progression.

## AIM

The aim of this study is to find the effect in treating congenital scoliosis with single-level hemi vertebrae using orthotic interventions on curve correction and its cardio respiratory functions.

## METHOD

14 years old with single-level hemi-vertebrae related congenital scoliosis undertook non-operative at our body with an average supplement period of 2 years.
Without orthotic intervention physiotherapy was continued for 1 year. Spinal orthosis (moulded-TLSO) fitted on the patient in according to a sub classification of the SRS definition of curve type. Breathe cardio-respiratory data analysis and the metabolic data analysis done through the COSMED-Srl-Italy, K4B2.We measure the O2 consumption level (ml/min/kg), Tidal volume(VT),Heart rate, Energy cost EE/min(Kcal/min), VO2,VCO2,O2 expenditure. Adaptability period was five minute. Data were taken at normal room-temperature while in the sitting position & 30 meter walking test.

## RESULTS

The cardio-respiratory table and graph established a significant better result in congenital scoliosis with spinal orthosis. Orthotic treatment gives good result over only physiotherapy treatment in term of curve progression & correction. Energy expenditure EE/min with brace was significantly in normal range 2.5359±0.4289 (P=0.0000). VCO2 was in significantly normal range with brace 135.561±22.1332 (P=0.9936). Heart rate was significantly decreased with brace 88.0000±8.7178 (P=0.8046).

| Parameters | Mean | St. dev | P-value | T-value | F-value |
|---|---|---|---|---|---|
| Normal,EE/min | 1.9842 | 0.5124 | 0.0000 | 4.7951 | 22.9931 |
| WithBrace,EE/min | 2.5359 | 0.4289 | | | |
| Normal,$VCO_2$ | 134.753 | 46.8989 | 0.9336 | 0.0836 | 0.0070 |
| WithBrace,$VCO_2$ | 135.561 | 22.1332 | | | |
| Normal $O_2$ exp | 39.2490 | 6.1173 | 0.6127 | 0.5081 | 0.2582 |
| Withbrace $O_2$ exp | 39.9179 | 4.1241 | | | |
| Normal HR | 90.6667 | 15.1438 | 0.8046 | 0.2643 | 0.0699 |
| Withbrace HR | 88.0000 | 8.7178 | | | |

## DISCUSSION & CONCLUSION

Rideau and colleagues (1984) concluded that in the progressive clinical situation the development of severe spinal deformation could not be avoided by an orthotic treatment in improvement of Pelvic tilt, Cobb angle & comfort in sitting, trunk balance 3.This is accordance with this study. Cardiorespiratory results suggest that the patient was comfortable with Brace.
Moulded TLSO can significantly increase patient's acceptance to stop curve progression without cardio-respiratory discomfort in hemivertebrae patients.

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# GOVERNMENTAL PERSPECTIVE ON FAIR AND EQUITABLE PROVISION OF BONE-ANCHORED PROSTHESES: BARRIERS AND FACILITATORS

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**BACKGROUND**

Individuals with lower limb amputation fitted with conventional artificial limbs often experience continuous socket-related discomfort leading to a dramatic decrease in quality of life. Most of these functional issues can be overcome by replacing the socket with a surgically implanted bone-anchored prosthesis attached directly to the residual bone using an osseointegrated fixation. (1-3) Government organizations are facing challenges in adjusting procedures to accommodate the emergence of bone-anchored prostheses. This study shares the knowledge gained by the Queensland Artificial Limb Service (QALS) an Australian State government organization, while implementing a procedure for fair and equitable provision of bone-anchored prostheses care. (4)

**AIM**

The aim of this study was to share some insights drawn from QALS' experience with strong emphasis on barriers and facilitators encountered when implementing procedure for provision of bone-anchored prostheses care in Queensland, Australia.

**METHOD**

Barriers and facilitators were identified over nearly 3 years following typical phases of action research led by QALS management team and researchers who consulted key stakeholders (e.g., 18 Queensland-based consumers, 3 prosthetists, 2 multidisciplinary clinical teams).

**RESULTS**

One outcome of this study was the identification of barriers to overcome during the implementation of such a procedure including, but not limited to:

1-Initial lack of a definitive rehabilitation program, particularly for the treatment with press-fit fixation. This issue is resolving as rehabilitation programs are becoming more established nationally and worldwide. (2)

2- Initial uncertainty in the relevance and timing of prosthetist involvement for pre- and post-operative prosthetic care.

3-Need to fit bone-anchored prostheses' consumers with advanced micro-processing knees, providing critical biomechanical advantages but expensive.

4-Consistent updating of complex procedure to accommodate bone-anchored prostheses clinical improvements (e.g., surgical procedures, long terms outcomes) and development of prosthetic components (e.g., biomechanical performance, cost).

Equally important were the facilitators to implementation also identified during the development of the procedure including, but not limited to:

1- Early and consistent consultations of stakeholders to warrant relevance and adhesion,

2-Adapting existing processes rather than creating new ones,

3-Use a passport of service to facilitate continuum of care particularly for multidisciplinary services performed interstate,

DISCUSSION & CONCLUSION

To date, the proposed QALS' procedure has only been implemented over one year for 18 consumers. All consumers had unilateral transfemoral amputation. They were mainly located in metropolitan areas in reasonable proximity of prosthetists. Only a small number of dedicated prosthetists and clinicians were involved. Consequently, revisiting regularly the presented barriers and facilitators will be required following consideration for more complex case mixes (e.g., transtibial, multi-level amputations), the geographical spread of consumers extending to rural areas with limited access to a prosthetists, the increasing number of treatment sites in Australia and abroad as the surgery becomes more routinely performed. For the first time, an overview of barriers and facilitators for implementation of procedure from one government organization for fair and equitable bone-anchored prostheses are presented. The QALS' experience reported here is a stepping-stone providing a working template for both development and implementation of procedure to stakeholders responsible for policies around prosthetic care.

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# SENSITIVITY ANALYSIS OF SOCKET INTERACTION FORCES IN UNILATERAL TRANSTIBIAL AMPUTEE WALKING: A NEUROMUSCULAR SIMULATION STUDY

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## BACKGROUND

The prosthetic socket is a key element in the prosthetic setup as it defines the interface to the human and plays a crucial role for socket comfort and the feeling of maneuverability and security. Although different and very detailed modelling approaches of the residual limb-socket-interface (RSI) exist [1], the mechanical and neuromuscular interaction has not been considered so far. Knowledge about this interdependency can lead to a better understanding of corresponding gait adaptations.

## AIM

This study aims at using a neuromuscular gait model to identify interaction forces at the RSI as well its influence on specific gait measures, e.g., step length and contact times.

## METHOD

A neuromuscular gait model [2] is used and adapted by replacing the distal part (shank, ankle, foot) of one leg by the model of a mechanical prosthesis [3] and a spring-damperRSI model with two degrees of freedom: anterior-posterior (ap) and proximal-distal (pd). A pattern search optimization algorithm is used to identify model parameters to fit measured ground-reaction-forces. The kinematic and kinetic data of one female unilateral transtibial walking amputee (age: 17 years, height: 1.68 m, mass: 55 kg) serves as reference data.
Segment lengths and inertial properties of the model are scaled to the dimensions of the subject. To analyze the sensitivity of the RSI-model, the parameters of the forwarddynamics simulations are set to different stiffness values (50%, 100%, 150%) in pd-direction.

## RESULTS

The normalized interaction forces for the varying stiffness values are shown in Fig. 1. In pd-direction the typical 'Mshape' is observed. Tab. 1 shows the simulated step lengths and contact times in comparison to the calculated values from the reference data. Step lengths are almost similar, while the contact times of the intact leg differs by 130 ms. A less stiff RSI parameter setting resulted in higher walking speeds due to slightly longer steps of the prosthetic leg.

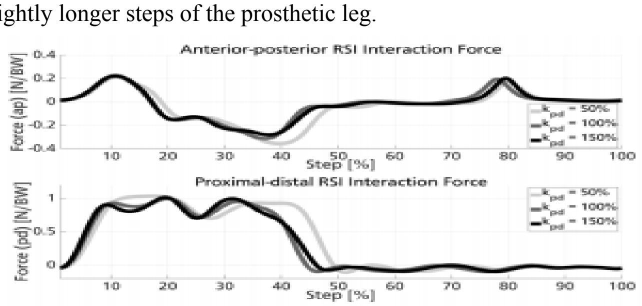


Figure 1. Simulation results of the RSI interaction forces ap- (top) and pd-direction (bottom) for different stiffness values kpd

Table 1. Measured and simulated step length and contact time for prosthetic (Pro.) and intact (Int.) side for different stiffness values kpd

| | Side | Experiment | Simulation ($k_{pd}$=50%) | Simulation ($k_{pd}$=100%) | Simulation ($k_{pd}$=150%) |
|---|---|---|---|---|---|
| Step length | Int. | 0.56 m | 0.58 m | 0.59 m | 0.58 m |
| | Pro. | 0.49 m | 0.46 m | 0.45 m | 0.44 m |
| Contact time | Int. | 0.66 s | 0.79 s | 0.78 s | 0.79 s |
| | Pro. | 0.61 s | 0.57 s | 0.58 s | 0.58 s |
| Walking speed | | 1.10 m/s | 1.01 m/s | 0.98 m/s | 0.96 m/s |

## DISCUSSION & CONCLUSION

The neuromuscular gait model could replicate the asymmetric amputee-like walking patterns. The predicted interaction forces show good agreement with forces measured directly distal to the RSI. [4,5] Since it considers physiological muscle properties and reactive responses of its neuromuscular model, it was able to cope with modified properties of the RSI. Although it neglected subject-specific responses due to human factors, e.g., pain, insecurity etc., it provides access to key prosthesis design parameters and thus permits studying interaction mechanisms between the prosthesis and the user. More elaborated RSI models are needed to increase the practical relevance (e.g., transferability to current socket designs).

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# DEVELOPMENT OF SOFT ARTIFICIAL LIMB FOR INFANTS WITH TRANSVERSE UPPER LIMB REDUCTION DEFICIENCY TO INDUCE EXTENDED PHYSIOLOGICAL PROPRIOCEPTION BY SELF-TOUCH

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## BACKGROUND

Previous research on pediatric upper limb prosthesis indicates the importance of use of affected side limb for the development of the sensorimotor system without a prosthesis1. It is also known that “double touch” and “self-touch” in their infancy is also important for the sensorimotor development2. With appropriate design of a terminal device to induce the self-touching to the lips and face with the artificial limb, the development of the affected limb’s extended physiological proprioception should become intense. That way, the affected side limb in bilateral limb motion as well as prosthetic hand use may become more close to innate.

## AIM

The aim of this research is to develop a soft artificial upper limb for transverse upper limb reduction deficiency infants. The design targets to induce touching their face and body with the deficient limb side.

## METHOD

The distal end is modeled to a form a thumb and four-fingers flexed and coupled into a smooth curved surface. The proximal part is formed as a forearm sleeve. In the first prototype, the tip of the thumb was shaped to stick out, and the second to lie parallel in lateral to the fingers. The wrist was lightly tilted in palmer and ulnar flexion. No mechanical joints are formed or installed.

## RESULTS

The artificial limb was produced with a silicone rubber to have softness and damping effect at contact to the human body. A medical use silicone rubber with high durability and strength to tension and tear was used and colored in beige. The distal end was created solid. The 2nd prototype’s length was 170mm with circumference of the forearm 135mm, hand width 50mm, and hand length 40mm. The weight of the artificial limb was 215g and the center of mass was 60 mm from the distal end. The buckling load is 13.72N applied in the longitudinal direction.

Figure 1. Silicone upper limb prototype 1 for infant with congenital transverse upper limb reduction deficiency to induce self-touch

## DISCUSSION & CONCLUSION

A soft and high stretch-compression tolerant artificial upper limb for transverse upper limb reduction deficiency infant was designed and produced. The weight of the solid distal end is large and needs to be modified, whereas, an easy and safe method for donning and doffing the artificial limb handled by the parent need to be designed with userfriendly manner. The risk of heat damage and discomfort of thermal difference are the remaining problem to be improved.

## ACKNOWLEGEMENT

This work was supported by JSPS KAKENHI Grant Numbers JP25350662 and JP16K01533

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# FINITE ELEMENT ANALYSIS OF RESIDUAL LIMB OF TRANSFEMORAL PATIENT WITH SOCKET PROSTHESIS IN STANCE PHASE

Tuan tLe Van

## BACKGROUND

An amputation that occurs through the femur is known as transfemoral prosthesis amputation. The transfemoral prosthesis is attached in contact with part of the above-knee residual limb. The prosthesis socket surrounds the residual limb and acts as a medium to transfer the load from the residual limb to the prosthesis. The soft tissue of the residual limb experiences severe stress and excessive distortion during gait positioning such as sitting, standing, taking steps, and walking. The stress and strain in the residual limb described the compliance and quality of socket prosthesis. In the previous studies, researchers attempted to develop a method to observe stress and strain in a residual limb with the finite element method. Almost of them consider in the static state and inadequacy all parts of the prosthesis.

## AIM

This study was to develop a method to observe the stress and strain of the residual limb in the stance phase of the gait cycle. The model of the prosthesis includes all parts of the prosthesis and the model of residual limb includes soft tissues and bone.

## METHOD

Three-dimensional (3D) models of the residual limb and socket were created using magnetic resonance imaging data; the models were composed of 18 layers, each separated by 10 mm. The residual limb includes soft tissues and bone. The 3D model of prosthesis includes knee joint, shank and ankle foot were created from real size. After that, they were imported to Hypermesh software to meshing with appropriate element type and size (Fig 1). The total model has two joints in hip and knee. The residual limb rotation around the hip joint and wore by the socket. The shank and ankle foot rotation around the knee joint. The dynamic parameters include the position and angle of hip and knee joint were taken from experiments with the support of the Mac 3D system.

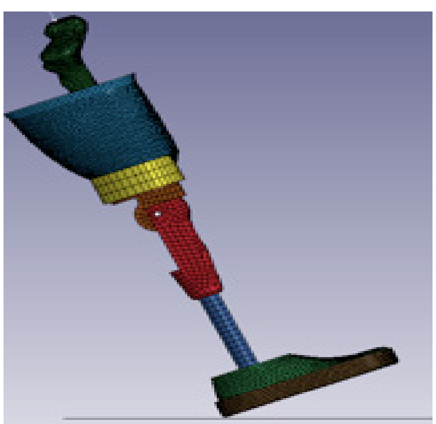

Fig 1. The finite element model

## RESULTS

The effective stress of residual limb at three phases: heel strike, mid-stance and toe-off were shown in Fig 2. In the heel strike and mid-stance phase, the stress appears on the bottom of the residual limb. The maximum of stress on residual limb is in toe-off phase with 0.84 Mpa. The area on the anterior distal of residual limb was observed at the highest tress area.

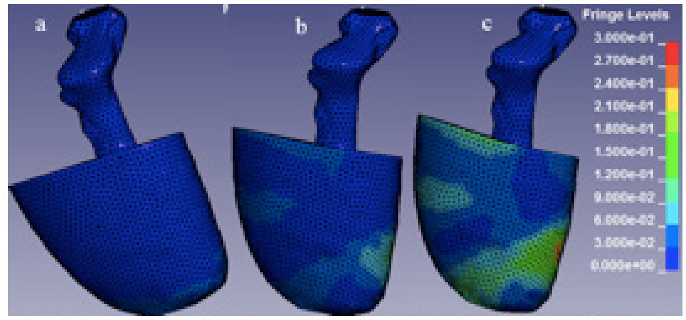


Fig 2. The effective stress on residual limb at heel strike (a), mid-stance (b) and toe off (c).

Figure 3 shows the effective stress inside the residual limb at the cross section through middle of the bone. The maximum stress at the toe-off phase on the cross section is 0.65 Mpa at the distal end of bone area.

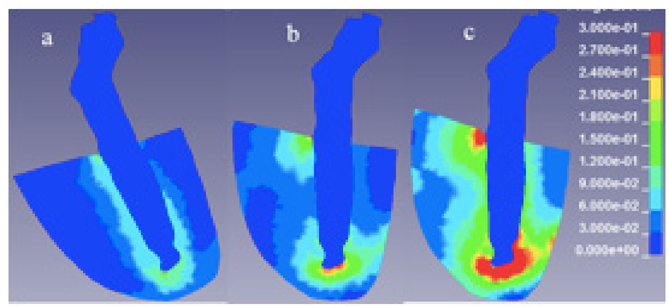


Fig 3. The effective stress at the cross section of residual limb at heel strike (a), mid-stance (b) and toe off (c).

## DISCUSSION & CONCLUSION

The primary objective of this work was to develop a process that allows health care providers and engineers to simulate the stress of residual limb with transfemoral prosthetics socket in stance phase. The simulation can do with various models of socket and help the prosthetist decide to the suitable socket for the patient. Furthermore, this method can use to optimize the shape of the socket in manufacture the socket, reduce the time to modify positive models of socket by reducing the number of refits needed.

In the future work, the model of the residual limb and prosthesis were established with more detail to enhance the precision of computation.

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# EVALUATION OF THE STRENGTH OF PROSTHETIC SOCKETS USING DIC-MEASUREMENTS: PRELIMINARY RESULTS.

Creylman V [1], Saey T [1], Balcaen R [2], De Raeve E [1], Cuppens K [1], Knippels I [1], Broeckx M [1], Muraru L [1]

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## BACKGROUND

Additive manufacturing techniques are more and more considered as a production process to fabricate patient-specific sockets. With this, the question rises if the so-called printed sockets can resist loading in a similar way as traditional sockets and if they are as strong as the traditional sockets.

## AIM

In this study we evaluated the strain concentration of a printed socket during gait using DIC-measurements in a robotic gait simulator mimicking prosthetic gait.

## METHOD

A prosthetic socket was designed based on the scan of an artificial prosthetic stump [1] and produced using the laser sintering technique in polyamide 12. The artificial prosthetic stump was attached to a robotic gait simulator that is able to mimic prosthetic gait [1]. During a step of the robot, strains on the prosthetic socket were evaluated using DIC-measurements.

## RESULTS

Figure 1 shows Von Misses strain during heel contact. Based on these results it can be concluded that stresses remain of an acceptable magnitude whilst walking with the prosthetic

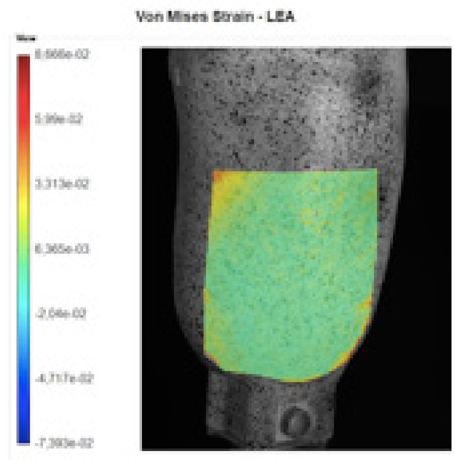


Fig 1. Von Misses strain during heel contact

## DISCUSSION & CONCLUSION

Our results show that acceptable stresses occur in a prosthetic socket produced with laser sintering technique at heel contact. Moreover, the feasibility of evaluating prosthetic sockets using a combination of a robotic gait simulator and DIC-measurements is demonstrated. The results of this study are only preliminary. To fully evaluate the feasibility of using such sockets in daily practice, more calculations are necessary: stress concentrations should be evaluated during different phases of gait and measurements should be repeated after cyclic loading using the robotic gait simulator.

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# TRUNK DRIVE: A NOVEL TRUNK ASSISTIVE DEVICE FOR PEOPLE WITH DUSCHENNE MUSCULAR DYSTROPHY

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## BACKGROUND

The most common form of muscular dystrophy in children is Duchenne muscular dystrophy (DMD), affecting 1 in every 3,500 boys[1]. DMD causes progressive degeneration of muscles which leads to progressive loss of muscle strength[1]. The loss of muscle function causes among others instability of the trunk. A trunk assistive device may be useful to stabilize and support the trunk during arm movements. Enabling stable trunk functions leads to a bigger range of motion and makes specific movements easier[2].

## AIM

We developed a 1DoF active trunk assistive device (Trunk Drive) for people DMD that actively assists and supports trunk flexion and extension from 0 to 33 degrees. It consists of a rigid harness that encloses the trunk of the user. The harness can rotate around a transverse axis which is aligned with the hip joints, and is supported by 2 identical motors that support the user. For control, we included electromyography (EMG) and force-based control interfaces. On this paper we present the preliminary controllability results from a healthy subject.

## METHOD

The participant was asked to control the Trunk Drive with different control interfaces by means of joystick (for comparison), EMG (abdominal muscle for flexion and iliocostalis for extension) and force (with a force sensor between sternum and harness). The signal of each control interface was an input to a second order admittance model with virtual mass and damping that was generating the reference position. Also, a one dimensional position tracking task was presented by means of Fitts's law with 3 different distances and constant target size resulting in 3 different indexes of difficulties (ID). The participant was asked to steer a yellow dot cursor that represents the trunk's flexion/extension, into a red dot target that appeared in one of 3 distances randomly presented on a screen. The subject had to perform a sequential series of flexion and extension for 9 times each to fully accomplish one trial. In total, 8 blocks of trials were performed. The first 2 were used for familiarization so they were excluded from the analysis. The time for trial accomplishment was measured and used as a comparison method.

## RESULTS

Fig. 1 shows the movement time for different IDs of flexion. For all IDs, force contrrl was fastest. The movement time was significantly different between all three control interfaces ($p<0.001$).

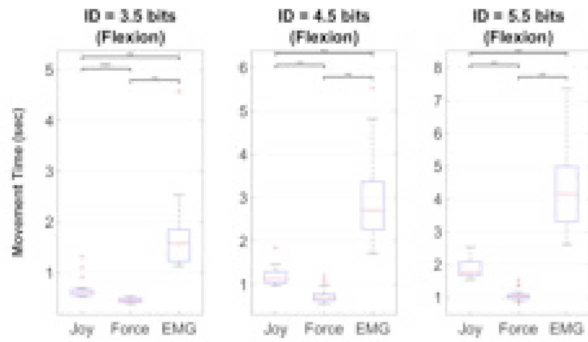


Fig.2 shows the movement time for different IDs to control trunk extension. In ID = 3.5 bits, the joystick showed the smallest movement time (0.7982 sec ±0.1552) and it was not significantly different with force ($p = 0.1249$) followed by the EMG ($p<0.001$). In all other cases, force based control interface recorded the smallest time. As in flexion, there was a significant difference between the time comparisons of all three control interfaces ($p<0.001$).

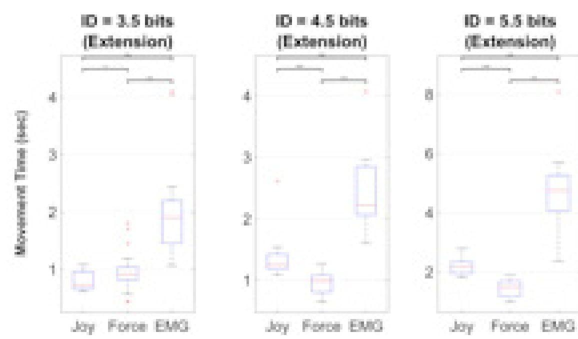


Figure 2 Extension comparison per ID

## DISCUSSION & CONCLUSION

The results show that the Trunk Drive system is capable of supporting trunk flexion and extension using EMG and Force signals. We have shown that the trunk drive can be controlled to produce a desired trunk position when worn by a healthy person. According to the results, the force based control interface showed the smallest movement time except from the lowest ID of flexion where joystick had the smallest movement time. The second faster control interface was the joystick followed by the EMG.

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# ROLE OF DE-ROTATIONAL STRAPS ON ALIGNMENT, BALANCE AND GAIT IN CHILDREN WITH CEREBRAL PALSY

Deepak Sharan

## BACKGROUND

Children with cerebral palsy (CWCP) often walk with in-toeing gait after single event multilevel surgery(SEMLS). At present de-rotation straps (DrS) are gaining popularity in improving in-toeing gait in CWCP. DrS are a new and innovative option to correct the in-toed gait. These straps are wearable garments with straps attached to control the in-toeing. DrS provides stability for the children with mild femoral and tibial rotation to play as they want.

## AIM

To evaluate the effectiveness of DrS in improving alignment, balance and gait in CWCP after a type of SEMLS called Single Event Multilevel Lever Arm Restoration Anti Spasticity Surgery (SEMLARASS).

## METHOD

Prospective experimental study conducted among 60 CWCP post SEMLARASS who were in-toeing due to dynamic factors(not due to bony torsion). They were randomly assigned to Group A(n=30), received balance training with DrS and Group B(n=30), received only balance training. Study duration was 5 weeks with 1hour of intervention per day for 6 days per week. Paediatric balance scale (PBS), Dynamic Gait Index (DGI) and Physicians rating scale (PRS) are the primary outcomes. Kinovea software was used to evaluate the lower extremity alignment. These were performed at baseline, 5 weeks after the treatment and follow-up 1 month and 3 months later.

## RESULTS

Participants in Group A had mean age of 8.54±3 years and Group B with mean age of 7.8±3.45 years. Group A showed significant differences in the scores of PBS ($p<0.05$), DGI ($p<0.05$) and PRS ($p<0.05$) scores when compared to Group B. The lower extremity alignment were also better in Group A joint angle measurements ($p<0.05$) compared to Group B. The obtained outcomes were maintained at 1 month and 3 months follow up also.

Figure 1. Gender distribution among Group A and Group B

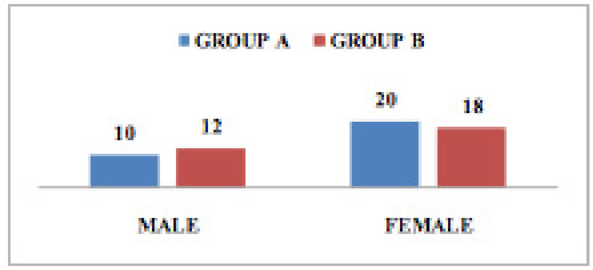
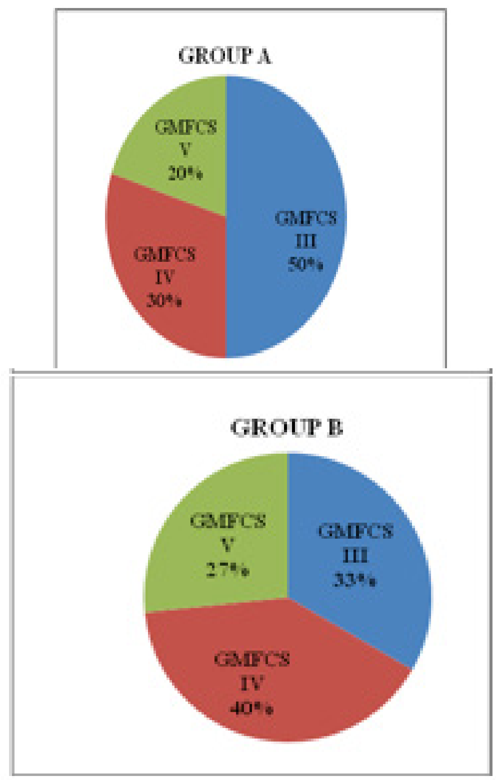



Figure 2.GMFCS Distribution among Group A and Group B




## DISCUSSION & CONCLUSION

Balance training with de-rotational straps in Group A showed a better improvement in all the scores parameters compared to Group B who didi not use de-rotational straps. Hence, DrS can be incorporated in the post SEMLARASS rehabilitation program of children with CP who are in-toeing to improve alignment, balance and gait. The study is under progress and final results involving a larger sample group would be presented at the conference.

# FACTORS CONTRIBUTING TO LEG LENGTH DISCREPANCY AFTER SINGLE EVENT MULTI LEVEL SURGERY IN CHILDREN WITH CEREBRAL PALSY: A RETROSPECTIVE ANALYSIS

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## BACKGROUND

Differences between the lengths of the lower limbs are leg length discrepancies (LLD). The limbs can be of different lengths or appear to be different lengths because of misalignment. LLD is common among children with cerebral palsy (CWCP) after single event multilevel surgery and often requires orthotic correction.

## AIM

The aim of this study was to identify the factors contributing to LLD in CWCP after a type of single event multilevel surgery called single event multilevel lever arm restoration and anti spasticity surgery (SEMLARASS).

## METHOD

Eighty children with CP between 5 to 20 years of age who underwent SEMLARASS in a tertiary level hospital by a single orthopaedic surgeon from 2013 to 2015 were analysed retrospectively. Fifty-eight CWCP (30 boys and 28 girls) were selected who had LLD.
Each child was measured for leg lengths (true length: anterior superior iliac spine of pelvis to medial malleolus of ipsilateral leg, apparent length: umbilicus to medial malleolus of ipsilateral leg) using inch tape during the third month of their post operative intensive rehabilitation phase to check for LLD and possible predisposing factors contributing to LLD were evaluated.

## RESULTS

Thirty of the 58 patients had a lower limb that was more than 15 mm shorter. Factors contributing to LLD in CWCP was analysed by clinical testing. Participants who underwent proximal femoral varus de-rotation osteotomy (80%) and distal femoral de-rotational osteotomy (20%) had the LLD. The majority factors contributing to LLD post SEMLARASS at hip level may be due to pelvic obliquity (33%) or decreased neck shaft angle (55%) and at knee level may be due to extension correction at femur or tibia (12%) which changed the biomechanics of knee joint.

Figure 1. Gender Distribution among Participants

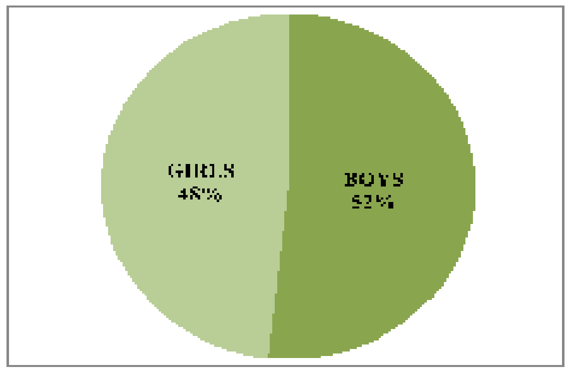
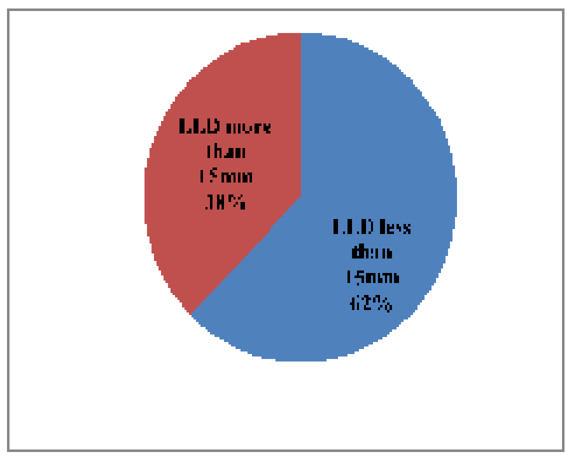



Figure 2. LLD shorter than 15mm among Participants




## DISCUSSION & CONCLUSION

The LLD in children with CP post SEMLARASS can be due to soft tissue or muscular involvement and be due to bony corrections made by the surgeon to improve the biomechanics of lower limbs for better functional use in children with CP.

# TWO MODES OF VIRTUAL REALITY BASED THERAPY MODALITY FOR IMPROVING STANDING BALANCE IN CHILDREN WITH CEREBRAL PALSY: A COMPARATIVE STUDY

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## BACKGROUND

Virtual reality based therapy(VRBT) is the use of interactive simulations to present users with opportunities to perform rehabilitation in virtual environments that appear, sound, and less frequently, feel like real-world objects and events. It uses an accelerometer technology to allow the user to make movements in real time and is plug and play. It is promising intervention for rehabilitation of individuals with a wide range of physical and cognitive impairment.

## AIM

To compare the useof NintendoWii vs Xbox360 in improving standing balance and weight shifting for children with CP(CWCP) following single event multilevel lever arm restoration and anti spasticity surgery (SEMLARASS).

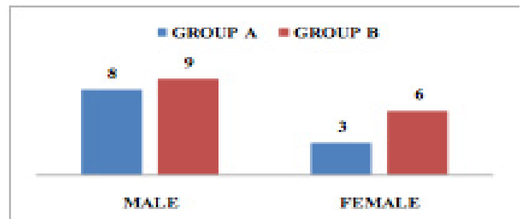
## METHOD

A Prospective experimental study was conducted among 25 CWCP post SEMLARASS, who were randomly assigned into Group A(n=11) which received the VRBT-Xbox360 with Kinect(XwK) and Group B(n=14) which received the VRBT-Nintendo Wii with Balance Board(WwB). The study duration was 5 weeks with 30 minute of intervention per day for 6 days per week in both groups. Paediatric Balance Scale(PBS) and Dynamic Gait Index(DGI) were the outcome measures, which were performed at baseline, 5 weeks after the treatment and follow ups at 1 month and 3 months later. Other data collected includes game statistics and the balance board stabilometry tests.

## RESULTS

A total of 3 games were played per session supervised by a physiotherapist. The participants age group was between 5 to 15 years. Although the improvement was significant in the pre and post intervention of both the groups, group A which underwent XwK, showed significant difference in the scores of PBS ($P<0.01$) and DGI ($P<0.05$) when compared to group B. The obtained outcomes were maintained at 1 month and 3 months follow up.

Figure 1. Gender distribution among Group A and Group B



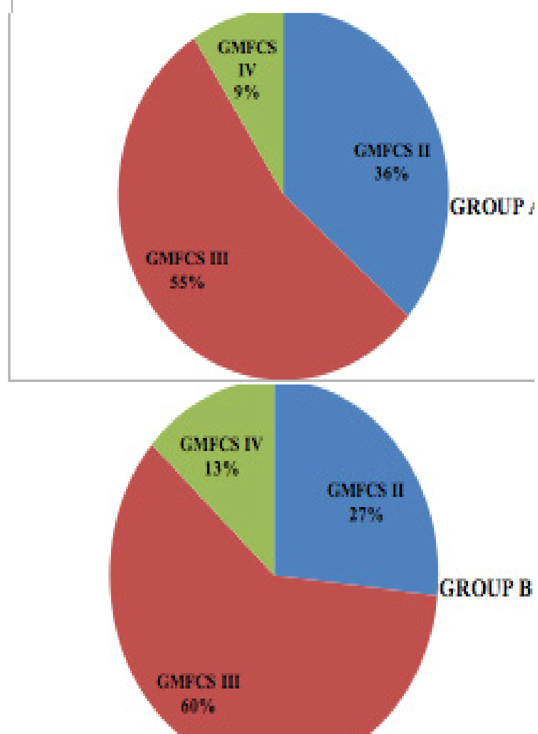




Figure 2. GMFCS Distribution among Group A and Group B

## DISCUSSION & CONCLUSION

The results of this study showed that improvement in postural stability of children with Cerebral Palsy, aged 5 to 15 years, was possible using VR-based therapy in the form of XwK and WwB. Hence, both the devices can be incorporated in the post SEMLARASS rehabilitation program of children with CP for improving standing balance and weight shifting.

# AN ANALYSIS OF DYNAMIC FORWARD MOVEMENT PERFORMANCE IN TRANS-TIBIAL AMPUTEES USING A RUNNING-SPECIFIC PROSTHESIS

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[a] University of Roehampton [b], Blatchford & Sons Ltd.

## BACKGROUND

Substantial improvement has occurred over the years in prosthetic foot technology, especially with the addition of elastic mechanisms. However, prosthetic movement remains inferior to able-bodied movement, as indicated by increased energy expenditure and decreased efficiency of prosthetic gait1. Houdijk et al. (2009)2 associated increased energy cost of prosthetic locomotion with reduced propulsion work of the prosthetic leg and increased mechanical energy loss during the step-to-step transition. This supports the continued development of prosthetic feet with elastic properties to optimise energy storage and return, plus enhance progression and efficiency in movement biomechanics. The application of greater GRFs during sprinting results in faster running speeds and thus better performance3. However, running-specific prostheses (RSP) diminish force generation and limit performance4. Intact limb biomechanics is also affected by the prosthesis, especially since lower limb asymmetry is pronounced in the amputee population5. Intact limb exhibit higher GRFs when compared to biological limbs of able-bodied control group6 which underlines a higher risk of injury.

## AIM

The aim of this study is to analyse movement performance of a forward dynamic start-stop movement in trans-tibial amputees with a RSP, in comparison to able-bodied individuals.

## METHOD

Eleven male unilateral trans-tibial amputees (Mean [SD]: 36 [8] years, 83 [21] kg, 1.80 [0.09] m) performed a forward start-stop movement (Fig. 1B) with a RSP. Eleven control participants (35 [10] years; 77 [12] kg; 1.81 [0.06] m) performed the movement with the dominant limb. Kinematics and kinetics was collected by a twelve-camera motion capture system (Vicon, Oxford, UK) synchronised with a Kistler force platform. Stance time, flight time, touchdown (TD) and take off (TO) angles and velocities, ground reaction forces, impulses, and lower body stiffness were compared between intact, prosthetic and control limbs, using a three-way ANOVA and effect size (Hedges' g).

## RESULTS

Amputees showed shorter initiation and flight times and longer ground contact time when bounding with either the prosthetic or intact limb, compared to controls. Amputees showed a more horizontal approach to the bound at TD and TO, compared to controls. TD and TO angles were lower on the prosthesis side, compared to the intact limb (g=0.60-0.67).

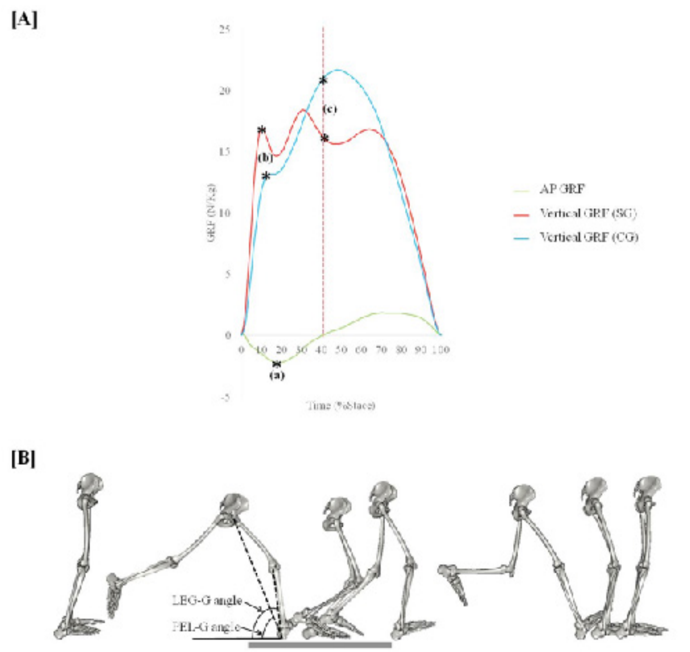


Figure 1. [A] A representation of the typical GRF time profiles seen in this study. Typical vertical GRF curves for the study group (SG) and control group (CG) are illustrated in red and blue respectively. Noteworthy results: (a) AP GRF braking peak was higher in the intact limb when compared to the prosthetic (g=0.60) and control limbs (g=0.88, p<0.05). (b) Control limbs showed lower impact peaks compared to the intact (g=0.75) and prosthetic (g=0.97) limbs. (c) Control limbs showed a significantly higher vertical GRF at Fy0 (dotted line) when compared to both the intact (g=1.17, p<0.05) and prosthetic (g=1.27, p<0.001) limbs. [B] An illustration of the forward dynamic start-stop movement performed by participants in this study.

No significant or noteworthy results were found for lower body stiffness.

## DISCUSSION & CONCLUSION

Amputees' more horizontal movement may reflect difficulty in movement initiation with a running-specific prosthesis, compared to the more dynamic vertical movement of control participants. Higher impact forces and loading rates of the intact limb suggest increased chronic injury risk7. The consistent lower body stiffness implies compensation strategies through other joints.

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# THE ROLE OF GENDER MAINSTREAMING IN PROSTHETICS AND ORTHOTICS PROGRAM AT TRAINING INSTITUTIONS/UNIVERSITIES IN TANZANIA

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## BACKGROUND

Gender inequality is a major obstacle to socio-economic and political development of people in any nation; gender inequality as one of the underlying causes of low productivity, hamper the participation of at least half of the country's population.

The Prosthetics and Orthotics course is offered by Tumaini University Makumira through its constituent Kilimanjaro Christian Medical University College, and only offering Cat I Prosthetics and Orthotics professionals in the country.

## AIM

The study explores gender inequality through graduate in rehabilitation medicine at Tumaini University – KCMU-College. With anticipation to restoration function of people with neuromuscular and muscular skeletal deficiencies in Tanzania

## METHOD

The Descriptive Retrospective study was applied. Retrospectively the case series and trend of student's admission to the Rehabilitation training program at Tumaini University KCMMU-College was identified. Graduate from the program were analysed. The Tanzania Commission of Universities set policy for student admission also reviewed. 12 years records were review to identifying the students admitted to the program and how many of them graduated and whether gender mainstreaming was addressed.

## RESULTS

Analysis of the records of twelve years (12) was reviewed and who was the main funding of the students. Out of 78 graduates, 17 (22%) were female. However, Tanzania with the leading number of graduates, 27 (26%), 10 (22%) or 11% of the total graduates are female. The study also indicates ISPO to be leading in sponsoring students by having provided 20 (19%) of all the sponsorship with 1 (5%) female sponsorship.

On Tanzania Commission of universities policy document, there was no area excluded gender mainstreaming rather supported for both equally in admission, however due to the criterion for mark that are required for one to be admitted to the rehabilitation program, male were more advantaged as they meet the criterion than female students applied to join the program.

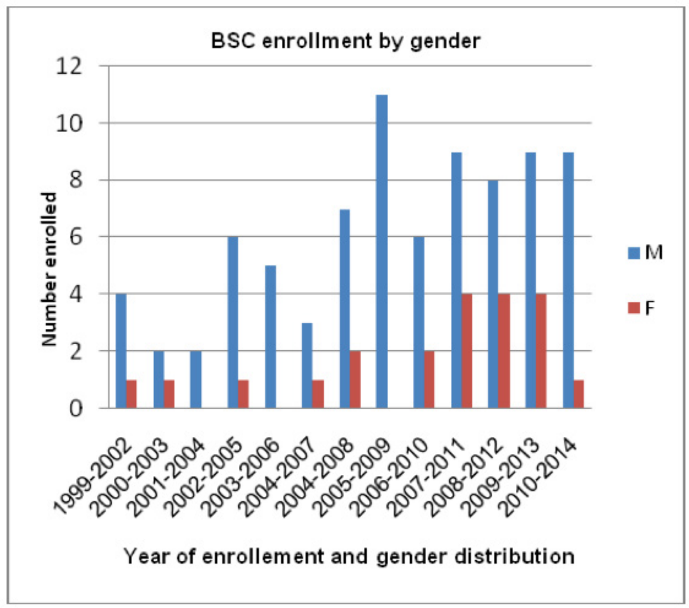


Figure 1: Number of students enrolled with their gender distribution per year.

## DISCUSSION & CONCLUSION

Deliberations on the Gender issue focuses on the continuing prevalence of inequality between boys and girls, and in the opportunity to act as agents in the development and control of services. The Inclusion of female students to higher education shall enable change to the field of Prosthetics and Orthotics program. Promote enrolment and development of women by providing priorities and sponsorship to interested women may equalize the gender situation.

# FRACTURES IN LOWER LIMB AMPUTEES: CASE SERIES

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## BACKGROUND

Fractures are commonly encountered in amputees. Although they share common pathologies and mechanism in able bodied individuals but their consequences are far more disabling. Management principles are similar to able bodied individuals. Rehabilitation following fractures in amputees is more challenging to patient and clinicians equally. It is therefore recommended to undergo rehabilitation of amputees following lower limb fractures in a specialised amputees' rehabilitation centre.

## AIM

To understand the effect of fractures in lower limb amputees and the consequences on their mobility along with the challenges in rehabilitation

## METHOD

This is a case series of selected cases. A total number of 400 patients' notes seen in clinic over a six months' period were reviewed. Only 5 patients were identified who had sustained a fracture in their lower limb during a stage in their rehabilitation (preprosthetic or post prosthetic period). Only patients who sustained fractures were included in this study. Notes were reviewed retrospectively. Only patients with lower limb fractures were included

## RESULTS

Trauma was not always the direct cause for the fractures. Three patients (60%) were transfemoral amputees and 2 (40%) were transtibial. Only one out of five (20%) patient became a non-limb wearer.Only 2 patients (40%) have progressed and were able to resume their prosthesis use, however their rehabilitation following the fractures was prolonged. There was no deterioration in their outcome measures SIGAM scores following the appropriate intensive rehabilitation.One patient (20%) had not started mobilisation following the amputation (preprosthetic fracture).The fifth patient sustained a second fracture and was recovering. Age range was 41-74 years with average 57.5 years.Three patients (60%) were surgically managed and 2 patients (40%) were managed conservatively.Interestingly those managed conservatively were the ones who progressed and resumed their prosthesis use. Female to male ratio was 4/1

## DISCUSSION & CONCLUSION

• Long bone fractures can happen at any stage during the rehabilitation process
• The risk factors for secondary osteoporosis do play the same role in increasing the risks of fractures in amputees

## LIMITATIONS

We appreciate that this is a case series of only five patients which could have limited the information and subsequently the results, however the data from these studies did reflect the general consensus for fracture management in amputees

# PILOT TESTING A 3D PRINTING TECHNOLOGY FOR TRANSTIBIAL PROSTHESIS IN COMPLEX SETTINGS

Case study in Handicap International programs of Togo, Madagascar and Syria

## BACKGROUND

The lack of physical rehabilitation services, qualified human resources and adapted technologies are the major barriers for the access of persons requiring assistive devices.
For some years the development of emerging technologies as 3D printing technology in biomechanics open new pathways to the classical channels and methods for providing technical devices; and both approaches are not working really together.
To generate evidence Handicap International partnered with the industrial companies (ProsFit Technologies and Proteor SAS) and the academic (Strathclyde University) to test a 3D printing technology for transtibial prosthesis.

## AIM

To test a 3D printing technology for trans tibial prosthesis in low income countries and war situations as well as with reference and remote P&O rehabilitation services.

## METHOD

An evaluation protocol was implemented for technology, clinic and implementation and cost domains. The tools developed were proposed to the rehabilitation professionals from partner's services in the targeted countries: Togo, Madagascar and Syria. Voluntaries persons were selected (complying with ethical and confidentiality considerations), and divided in two groups:
• Test group receiving a 3D printed prosthesis
• Control group receiving a conventional prosthesis.
Data were collected from:
• The patients (standard evaluation of performance, comfort, satisfaction),
• The environment of the services (means, human resources, accessibility, costs)
• The technology (ISO tests for resistance, endurance of the socket).
It allowed objectively assessment, understanding and measurement of the innovative approach.

## RESULTS

The test was completed in Togo and Madagascar and Syria with the same protocol and methodology. A total of 19 patients were tested in the three countries.

The results by domain:
1. Technology: the 3D printed sockets match with the trans tibial prosthesis requirements in term of durability, resistance and endurance according to the ISO tests completed.
2. Clinic: the comparison between the two groups shows that there is no detrimental effect and no major improvement of performance between the two groups.
3. Implementation and costs: using a 3D printing process significantly reduces the means in term of infrastructures, equipment and human resources. Regarding the direct costs of the prosthesis is high for Togo and Madagascar. For Syria, the direct costs are almost the same as the prices proposed currently in the country.

## DISCUSSION & CONCLUSION

The results show the benefits of the new process to be a great application for improving quality and access to treatment of rehabilitation services. It is important to enlarge the group of voluntaries to validate the study and to propose technological research to reduce the direct costs of the prosthesis (cheaper soft socket, using basic printer, cheaper and local components).
The 3D printing technology is clearly one of the solutions to enhance the service provision in physical rehabilitation for persons living in low income countries and for war contexts.

# EDUCATION BY EXPERIENCE: COUPLED ROTATIONS IN THE LOWER EXTREMITY

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## BACKGROUND

A good understanding of the lower extremity's kinematic chain 1,2 is of critical importance to those who assess the functional characteristics of the loaded leg3. Supporting devices such as insoles, orthoses and prostheses limit the chain's range of motion (ROM). However, such alterations are often overlooked in clinical practice, hard to quantify on an individual level and may even result in counterproductive treatment strategies3,4.

## AIM

To let students and professionals experience and measure the coupled mechanisms in the kinematic chain of the leg and to provide insight in the effects of alterations to this chain.

## METHOD

A sitting or standing user places the foot on a platform that measures axial rotations of the foot relative to the floor. A potentiometer in the platforms' vertical axis is aligned with the longitudinal tibia axis and can be manually reset. All measurements can thus be made relative to a neutral position. The platform can be tilted to simulate biomechanical interventions. This offsets the tibia's axial rotation (Fig.1) and alters the maximal internal and external rotation of the foot relative to the floor. Users can examine and experience the direct effects of a biomechanical intervention on their kinematic chain.

## RESULTS

Students and professionals interested in orthopaedics, podiatry and physiotherapy without an extensive biomechanical background experience the effect of coupled rotations in the loaded leg. The method provides insight in the extent to which the kinematic chain is affected by insoles, braces, orthoses and prosthetics, and invokes students' interest in the biomechanics of the coupled mechanism.

In clinical practise, the tool quantifies axial rotations of ankle, knee and hip and aids the evaluation of interventions that alter the biomechanics of the lower extremity. Potentially, the device could help predict adverse effects of interventions to other joints in the chain.

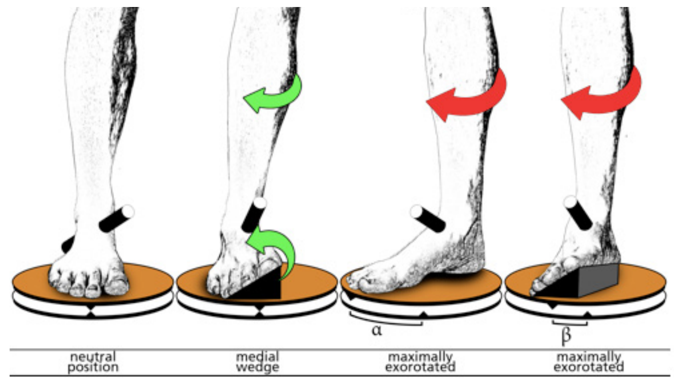


Figure 1. A medial wedge offsets the tibia towards exorotation and thereby limits the maximal exorotation of the foot relative to the floor by α-β. Notice by the knee marker that the tibia rotates to equal extent.

## DISCUSSION & CONCLUSION

The platform provides immediate feedback concerning changes in the kinematic chain and lets users experience and quantify how joints in the lower extremity are inextricably linked. The device convinces students and professionals that coupled rotations are of critical importance during physical examination and in designing gait aids.
A protocol should be devised that aids the used during evidence-based practise in evaluating biomechanical interventions and in predicting adverse effects to surrounding joints.

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# PROSTHETIC AND ORTHOTIC REHABILITATION SERVICE IN MADAGASCAR - THE STAFF´S EXPERIENCES AT TWO REHABILITATION CENTERS

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## BACKGROUND

Madagascar is the fourth biggest island and one of the poorest countries in the world, with more than 75 % of the 24 million inhabitants living under poverty line. The health care system in the country is under development, as well as the field of rehabilitation services and the area of prosthetic and orthotic services in specific. There is very limited published research concerning rehabilitation services for people with physical disability in Madagascar.

## AIM

The aim of this study was to describe and explore the rehabilitation services in Madagascar, with a focus on prosthetic and orthotic services, from the perspective of local rehabilitation staff.

## METHOD

Eight staff members from two rehabilitation centres in Madagascar were interviewed, including one medical doctor, two prosthetic and orthotic technicians, two physiotherapists, one nurse, one social worker, and, one shoemaker. One centre was public and the other centre was run by a nongovernmental organization. Interviews were conducted in English with interpreter to Malagasy. A semi-structured interview guide was used. The data were analysed by using manifest content analysis.

## RESULTS

Three main categories emerged from the analysis: i) Financial situation, distance, attitudes and lack of knowledge stops people from getting rehabilitation service. Dissemination of information about physical disabilities and rehabilitation services were needed to increase the awareness of people in general. There was also a need of more rehabilitation centres with staff to increase the access to rehabilitation services. Many persons with disability could not afford rehabilitation service, and the available financial assistance was not enough to support all who needed the services. However, all people with disability that were coming to the rehabilitation centres were treated equally; ii) Materials, equipment and level of knowledge among staff affect the rehabilitation services. The available materials and equipment differed a lot between the two rehabilitation centres. Further education for the staff was required to improve the quality of rehabilitation service. Appearance and information given by the staff affected acceptance of the assistive devices. Mobility skills were depending on the assistive device, type of disability, and the attitude of the individual patient; iii) Collaboration and communication need to be improved to give a more efficient rehabilitation service. Multidisciplinary approach contributed to good outcome for the patients. Collaboration with, and sponsorship from, nongovernment organizations could increase the quality of rehabilitation service. Furthermore, communication between different professions needed to be improved. An increased collaboration between rehabilitation centres and the Ministry of Health was needed. Finally, community based rehabilitation programs and mobility teams facilitated follow-up services.

## DISCUSSION & CONCLUSION

In order to improve rehabilitation services in Madagascar a combination of measures including increased availability to rehabilitation services and increased financial assistance to people with disability is required. Sustainable economic and material supply chains for rehabilitation centres, and, opportunities for the rehabilitation staff to receive professional relevant basic and continuous training is also required. It was highlighted that awareness and knowledge concerning the needs of persons with disability and the existing rehabilitation service should be increased both among politicians and among the general public in Madagascar.

# CHARACTERISATION OF LOWER LIMB AMPUTEE PATIENT IN BANGLADESH

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## BACKGROUND

The incidence and etiology of amputation vary significantly both between and within country because of socio-economic status, environmental factors and decision making of the clinicians.1 On the other hand, the occurrence of lower limb amputation (LLA) is greater than the upper limb.2 In Bangladesh, the main indication of LLA were peripheral vascular diseases and road accidents.3 However, there is meager information regarding the clinical types, socio-demographic characteristics and management of LLA patients in Bangladesh.

## AIM

To determine the socio-demographic status, etiology and amputation level of patients with LLA of Bangladesh.

## METHOD

Descriptive cross sectional survey design was chosen to meet the study objective. LLA patients attended at Savar and Chittagong branches of Centre for the Rehabilitation of the Paralysed (CRP) within the period of January-2014 to August-2016 were selected conveniently considering patients having LLA and complete information. From the initial pool of 494 potential LLA candidates 332 patients were successfully approached and 162 patients were not reached (e.g. not answering the phone or wrong contact information). Telephonic interviews were done with an adapted structured questionnaire.4 Data were analysed using descriptive statistics with the SPSS version 22. Verbal informed consent was taken.

## RESULTS

Of 332 patients with LLA, the age ranged 5-76 years (mean 37.5±13.8). Majority of them were male (88%), not formally educated or primary level completed (62%), married (78%) and from rural area (65%). Around 20% of the patients had lost their job and 67% had to change their occupation because of amputation. As a result, patient's mean monthly income drastically reduced from US $ 121.4 (±434.3) to US $ 48.4 (±66.7); before and after amputation respectively. Road traffic accident (59%) was the main cause of amputation followed by peripheral vascular diseases (08%) and then infection (06%).

The mean duration of amputation was 08 (±10.0) years and majority of them had below knee (52%) (Fig-1) and unilateral (96%) type of amputation. Although, 75% of the LLA patients sought treatment from doctor, 73% of the patient attended for a prosthetic rehabilitation after 2 years and 46% of them said they did not know about prosthetic rehabilitation.

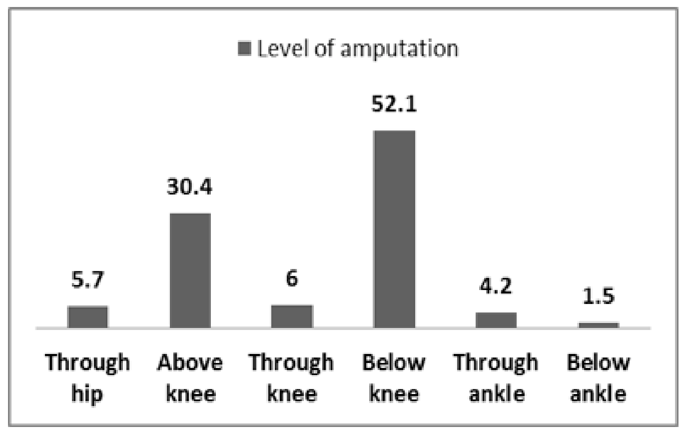


Fig-1: Distribution of level of amputation

## DISCUSSION & CONCLUSION

Majority of the LLA occurred because of traumatic reasons, which were preventable. LLA mostly prevailed among young male with less education and low socio-economic status. Thus, it created severe impacts on patient's social, economic and family life. Effort should be given to raise awareness among the medical professionals as well as general people about the importance and availability of prosthetic rehabilitation in Bangladesh.

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# USE, SATISFACTION AND FUNCTIONAL OUTCOME WITH PROSTHETIC DEVICES AMONG THE LOWER LIMB AMPUTEE PATIENT

Mahmudul Al-Imam[1], Zahid Hossain[1], Rangila Islam[2]

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## BACKGROUND

An amputation in lower limb not only impacts on mobility, but also affects social participation and quality of life.1 However, a proper prosthetic rehabilitation can help the patient to regain functional independence and social life.2 Despite the advantages of prosthesis, a large number of amputee patients do not use those devices.3 No study has evaluated the use of prosthesis and functional outcome among the lower limb amputees in Bangladesh, till date.

## AIM

To investigate the use, satisfaction and functional outcome with prosthetic devices among the lower limb amputee patient of Bangladesh.

## METHOD

Cross sectional survey was conducted on lower limb amputee patients attended at Savar and Chittagong branches of Centre for the Rehabilitation of the Paralysed (CRP) within January-2014 to February-2016. Patients having major lower limb amputation (amputation above ankle joint), aged 18-70 year, and had been discharged 6 month before the initiation of the study were selected conveniently. Out of 262 primarily selected patients, 183 patients were successfully approached and rest of them were not reached (e.g., phone off or wrong contact information). Telephonic interviews were done with a structured questionnaire including a four point Likart Satisfaction Scale4 and the Locomotor Capabilities Index (LCI).5 Data were analysed using descriptive statistics, Fisher exact and independent sample t test. Verbal consent was taken.

## RESULTS

The sample consisted of 164 (90%) male and 19 (10%) female. Majority of them had below knee amputation (61%).
Most of the patients (96%) wore the prosthesis on a daily basis (Table-1). Prosthesis use was greatly afflicted by stump pain (24%), followed by heat (21%) and then weight (14%).

| Gender | Duration of prosthesis use/day | | | | p value |
|---|---|---|---|---|---|
| | No use | 1-5 hour | 6-10 hour | >10 hour | 0.04 |
| Male | 2.7 | 27.9 | 39.3 | 19.7 | |
| Female | 1.6 | 3.8 | 2.2 | 2.7 | |

Table-1: Distribution of daily prosthesis use by gender

The mean LCI score was 45.9 (±12.1). The LCI score also revealed that male patient had a significant higher functional outcome ($p<0.04$).
Duration of use per day was significantly associated with gender ($p<0.05$), level of amputation ($p<0.00$), presence of associated health problems ($p<0.05$), had a mobility aids ($p<0.03$), overall satisfaction on prosthesis ($p<0.00$). Patient who used more than 6 hours /day had higher basic LCI score ($p<0.02$), advanced LCI score ($p<0.00$) and total LCI score ($p<0.00$).

## DISCUSSION & CONCLUSION

Majority of the lower limb amputee patients were using prosthesis daily and were satisfied with the devices. Additionally, patient who used prosthesis most of the time of a day had a higher functional outcome. Factors such as gender, level of amputation, associated health problems, having an assistive device should be taken under consideration during prescription, design and trial phase so that the goal of prosthetic rehabilitation can be achieved precisely.

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# FIRST ASSESSMENT OF A MULTI-SCALE PROSTHESIS SATISFACTION QUESTIONNAIRE IN TRANSFEMORAL AMPUTEES

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## BACKGROUND

Although there is a constant improvement in lower limb prosthetic technologies, amputees are often unsatisfied with their prostheses and have to deal with restrictions in their quality of life. Perceived satisfaction with the prosthesis is a complex construct which is open to influence by different qualities [1]. Existing Questionnaires like PEQ, TAPES or EQ-5D do not work well in identifying and explaining inconsistencies in user responses [2]. Not only technical and functional aspects leading to satisfaction, also the acceptance of dissatisfaction has to be considered in further development of questionnaires for the assessment of satisfaction [3].

## AIM

The aim of this study is to collect and analyze first data with a psychometric questionnaire to identify relations between psychological and technical factors in transfemoral amputees.

## METHOD

A questionnaire developed by Christ, Schürmann and Beckerle [4] included 70 items representing both technical and psychological factors concerning Satisfaction (SAT), Feeling Of Security (FOS), Body Schema Integration (BSI), Support (SUaP), Socket (SOC), Mobility (MOB) and Outer Appearance (OUT). An online-survey was conducted from January to November 2015. Eleven transfemoral amputees (5 males, 6 females) completed the questionnaire. Ages ranged from 21 to 68 years with an average of M = 40.82, SD = 27.58 years. Time span since amputation ranged from 1 to 35 years with an average of M = 13.73, SD = 3.54 years. Items were measured on a 5-point Likert scale ranging from 1 = "No Agreement" to 5 = "Complete Agreement". Means and standard deviations over all 7 factors were calculated and correlated.

## RESULTS

Figure 1 shows means and standard deviation of ratings divided into the 7 factors of the questionnaire for subjects with transfemoral amputation in gender specification. No significant differences were found between the two groups.

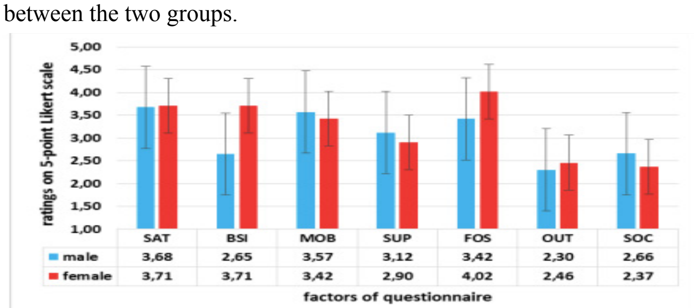


Figure 1: Means and standard deviation of questionnaire factors (SATisfaction, Body Schema Integration, MOBility, SUPport, Feeling Of Security, OUTer Appearance, SOCket)

Pearson correlation was conducted for the 7 factors (Table 1) and showed significant coherences between both technical and psychological factors. High ratings in Body Schema Integration (p = .036), Feeling of Security (p < .01) and low ratings in Support (p = .006) (indicating subjects do not feel a lack of support with their prosthesis) correlate significantly with subjects overall Satisfaction with their prosthesis.

Table 1: Pearson Correlations between SATisfaction and other factors

| | | BSI | MOB | SUP | FoS | OUT | SOC |
|---|---|---|---|---|---|---|---|
| SAT | Pearson correlation | ,560* | .243 | -.727** | .901** | -.483 | -.107 |
| | significance | .036 | .236 | .006 | .000 | .066 | .377 |

* = p < .05; ** = p < .01

## DISCUSSION & CONCLUSION

Body Schema Integration, Support, and Feeling Of Security appear to be important for the level of overall Satisfaction in transfemoral amputees. Due to the small sample size, the results can only be understood as indications of possible directions. Comparisons to transtibial and/or other amputees are necessary to work out specific characteristics. Quality of life measures and outcomes of questionnaires like PEQ or TAPES should be matched with the presented results to differentiate. Satisfaction with the prosthesis is a central factor for its usability and thus for quality of life and health of amputees.

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# INVESTIGATING THE EFFECTS OF QUADRATUS LUMBORUM AND PRIFORMIS MUSCLE PRESSURE PAIN THRESHOLD ON FUNCTIONAL STATUS AND AMBULATION IN INDIVIDUALS WITH LUMBAR HERNIATION NUCLEUS PULPOSUS: A PILOT STUDY

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## BACKROUND

Previous studies showed that there were various factors effecting the functional status in individuals with lumbar herniation nucleus pulposus (LHNP). However, there is little known about how the pain severity effects the ambulation and functional status in individuals with LHNP.

## AIM

To investigate whether the lower extremity pressure pain thresholds (PPT) have impact on functional status and ambulation in individuals with lumbar herniation nucleus pulposus or not, was the aim of the study.

## METHOD

Thirteen individuals with LHNP were the participants of the study. Quadratus lumborum and priformis muscles PPT were evaluated with digital algometer. Functional status were assessed with Oswestry Disability Index (ODI). Ambulation index, is a composite score based on foot to foot time distribution ratio and average step length, was evaluated with gait trainer at participants self-selected speed. Data from 2nd minutes to 4th minutes were selected for statistical analyses.

## RESULTS

There were correlation between ODI score and muscle pressure PPTs ($p<.05$) except from PPT in right priformis ($p=.06$). There were correlation between all muscle's PPTs ($p<.05$). There was correlation between ambulation index results and ODI score ($p<.05$).

## DISCUSSION & CONCLUSION

The pilot study showed that functional status in individuals with LHNP strongly correlated with muscle pressure pain thresholds and ambulation. Even there were no directly correlation between the PPT and ambulation, PPT may be related with the ambulation indirectly as a part of the functional status in individuals with LHNP. Quadratus Lumborum and Priformis muscle pressure pain threshold have negative impact on functional status in individuals with LHNP and related with ambulation indirectly. It is recommended to increase the participants to make precise comments.

# PSYCHOLOGIST´S PRACTICE WITH PATIENTS WITH CONGENITAL MALFORMATION IN ORTHOPEDIC WORKSHOP

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Sarah Network of Rehabilitation Hospitals, Brasília, Brazil.

## BACKGROUND

Children with congenital malformation of the lower limbs may face functional limitations and require prostheses to carry out their day-to-day activities, to favor the acquisition of walking, functionality and social development (Boonstra, Rijnders, Groothoff & Eisma, 2000). Amputation surgery may be an indication along its growth. Decision-making involves the patient and family, as well as team accompanying (Hamdy, Makhdom, Saran & Birch, 2014).

## AIM

The study aims to evaluate the perception of self-concept, self-image and functionality of children and adolescents with congenital deformities.

## METHOD

Developed a cross-sectional study with children and adolescents until 16 years, accompanied at SARAH Network of Rehabilitation Hospitals, with congenital malformation of the lower limb, in use orthoprosthesis or prosthesis. The assessment was performed using the instruments Functional Measure for Amputees Questionnaire (FMA) and Self Concept Scale for Children and Youth (EAC-IJ), self-portrait drawing and data collected with family about schooling and social life. The evaluation took place during the sessions previously scheduled for adjustments to the prosthesis.

## RESULTS

We evaluated 15 patients from eight to 15 years. 73.33% of patients were fitted with orthoprosthesis until 2 years old. The FMA shows that 87% were using orthoprosthesis in the external environment and 60% in the home context. The average of prosthesis use was 9.67 hours. The main reasons for non-use was pain (22%), need for adjustment of the orthoprosthesis (22%) and fatigue. The Self Concept Scale shows 40% were above 75 percentile and 40% between 25 to 50 (highest percentile indicates better self-concept). The social (80%) and personal (73.33%) areas were better evaluated (percentile above 50). The worst performance was shown in the school area. Of the sample, 60% received financial assistance from the government. There were no reports of difficulty in relationship with peers or academic learning.

## DISCUSSION & CONCLUSION

Studies to understand the impact on the patient's life with limb congenital deformity are especially low in our country. The Self Concept Scale showed satisfactory perception, particularly in personal and social area in most cases, but poor school self-concept, which was observed in the evaluation of children without disabilities (Bolsi et al, 2005). The study reveals the importance of broadening the team's work to other areas of life of the patient, beyond the functional physical aspects.

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# INVESTIGATING THE EFFECTS OF PAIN ON GAIT VARIABILITY IN PATIENT WITH LUMBAR HERNIATION NUCLEUS PULPOSUS

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## BACKGROUND

Pain is major disabling symptom effecting daily living activities in patients with lumbar herniation nucleus pulposus (LHNP). However, how the pain in LHNP effects the quality of gait and effects of the quadriceps femoris muscle pain threshold is not described adequately.

## AIM

To investigate the effects of pain on gait variability in patient with LHDP was the aim of the study.

## METHOD

Ten individuals with LHNP were the participants of the study. Participants general resting pain level were evaluated with visual analog scale. The quadriceps femoris muscle pain threshold (PPT) evaluated with digital algometer. Gait variability of participants were evaluated with treadmill. Participants were walked at their preferred speed for six minutes. Data from 2nd minutes to 4th minutes were selected for statistical analyses.

## RESULTS

The gender of participants was 5 male, 5 female; mean age was 52,88 ± 12,78 years; height was 168,22±12,78 cm; weight was 75,77±7,94 kilograms. All participants have right hand preference. Resting pain was change from 0 to 6,3. Quadiceps femoris PPT were 5,06±1,07 kgf for right leg and 5,15±2,46 kgf for left leg. Left step length variability was 11,0±6,05, right step length variability was 12,1±6,52. There was correlation between left step length variability and resting pain (p=.032). There was differences between right and left quadriceps femoris PPT (p=.015).

## DISCUSSION& CONCLUSION

The pilot study showed that resting pain level has negative impact on gait variability and left step length variability may be resulted from the difference between right and left quadriceps femoris PPT. Quadriceps femoris PPT and resting pain level are important for gait stability. For further studies increasing the number of participants and determining the other factor associated with gait variability was recommended to make precise comments.

# EXPLORING CHANGE IN COMFORT PERCEPTION AFTER PROTHESIS REPAIR THROUGH A QUESTIONNAIRE DEVELOPED FOR TRANSFEMORAL AMPUTEES

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## BACKGROUND

There are generic Quality of Life (QOL) assessment questionnaires that have shown high quality results. And although, the Prosthetics Evaluation Questionnaire (PEQ) has shown reliability and validity for assessing QOL and comfort on lower-limb amputees; it is recommended to be used for research purposes only due to its length and scoring scale [1].

## AIM

The purpose of this study is to explore the use of a comfort questionnaire developed specifically for transfemoral amputees in the assessment of comfort perception in order to evaluate prosthesis repair.

## METHOD

Fifteen healthy amputees that consulted the prosthetic workshop because of any kind of damage in their prosthesis were interviewed. Any amputee that was going to start the use of a prosthetic system for the first time was disregarded. And an informed consent was signed by each participant according to the guidelines of the Ethics Committee of Universidad Nacional de Colombia. The comfort questionnaire used was developed by Ramirez et al., [2]. The responses frequency was registered according the six factors in which the questions are classified (i.e. appearance, well-being, pain, function, and psychological and social factors). Each amputee was interviewed at the prosthetic workshop and one month later.

## RESULTS

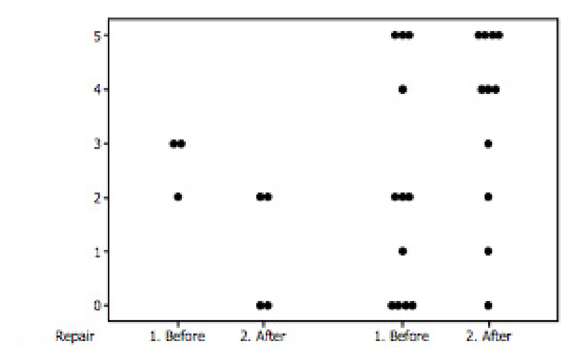


Figure 1. Change in the first question of the pain factor according to the comfort state after repair (decrease/improve)

Figure 1 shows an example of the frequency in the different type of responses for people whom their comfort perception decrease and increase after repair. The answers of people who had lower perception of comfort displace to the lower values after repair while the answers of the people who had a higher perception of comfort displace to the higher values. The lower values are related to discomfort sensations and vice versa.However, not all the answers detected the change in perception or even have opposite behaviour, as can be observed in Table 1.

Table 1. Relation between the change in comfort perception and the frequency of the different type of questions.

| Question | | Direct change | No change/ undefined | Indirect change |
|---|---|---|---|---|
| Appearance factor | 1 | ■ | | |
| | 2 | ■ | | |
| | 3 | | ■ | |
| | 4 | | | ■ |
| | 5 | | | ■ |
| Well-being factor | 6 | | ■ | |
| | 7 | | ■ | |
| | 8 | ■ | | |
| | 9 | ■ | | |
| | 10 | ■ | | |
| Pain factor | 11 | ■ | | |
| | 12 | | ■ | |
| | 13 | ■ | | |
| | 14 | ■ | | |
| | 15 | | ■ | |
| Functional factor | 16 | | | ■ |
| | 17 | | ■ | |
| | 18 | | ■ | |
| | 19 | ■ | | |
| | 20 | | ■ | |
| | 21 | | ■ | |
| Psychological factor | 22 | ■ | | |
| | 23 | | ■ | |
| | 24 | ■ | | |
| | 25 | ■ | | |
| | 26 | | ■ | |
| Social Factor | 27 | ■ | | |
| | 28 | | ■ | |
| | 29 | | | ■ |
| | 30 | ■ | | |

## DISCUSSION & CONCLUSION

Almost half of the questions change according to the change in the amputees' comfort perception. However, four questions had an opposite behaviour. This behaviour could be the result of negatively influencing the interrogated amputees on these topics after the first interview. Then, these questions should be analysed in future works, specially the one related to socket fit (from the functional factor), in order to improve the questionnaire feedback.

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# FUNCTIONAL OUTCOMES AFTER PROSTHETIC REHABILITATION IN ABOVE AND THROUGH KNEE AMPUTATION IN CANCER PATIENTS.

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## BACKGROUND

Amputation for cancer treatment is generally performed for advanced diseases. Primary cancers of the extremities are more frequent in the lower limbs. In an effort to achieve the cure above knee amputations are generally indicated. Hip disarticulation is generally associated worst functional outcomes compared to through knee disarticulation and transfemoral amputation. Little is known about the impact of the prosthetic rehabilitation on functional outcomes in amputees survivors for cancer treatment.1,2,3,4

## AIM

To investigate functional outcomes after prosthetic rehabilitation in above and through knee amputation for cancer patients.

## METHOD

Descriptive study of patients diagnosed with cancer at the lower limbs, at age of 18 years or older, after at least one year of prosthetic rehabilitation between January 2010 and December 2014, treated in the National Institute of Cancer José Alencar Gomes da Silva, Rio de Janeiro, Brazil. The Functional Measure for Amputees questionnaire5 was applied to access self related functionality. Demographic, clinical and rehabilitation data were reviewed from the reports. Statistical analysis was performed by descriptive measures (StataCorp 2011, Stata Statistical Software: Release 12. College Station, TX: StataCorp). Approval from the Institute`s Ethic Committee was taken under the number 730.513.

## RESULTS

From 126 selections, thirty patients answered the questionnaire. Thirty deaths, 29 non-answers and 37 not found people were considered as lost. The results of the demographic, clinical and rehabilitation data are shown in table 1. Twenty seven patients (90%) answered that use the prosthesis. Three patients (10%) answered not to use the prosthesis for the following reasons: one transfemoral patient due to weight gain and two hip disarticulations in which one of them due to fitting problems associated with social difficulties in accessing the institute and the other because the physician told her she was not a candidate to use it.

## DISCUSSION & CONCLUSION

To date, the results confirm that prosthetic users had osteosarcoma as the principal cancer diagnosis1. In general patients are able to put the prosthesis on independently but still depend on crunches especially for outdoors walkings3. Few patients of hip disarticulation had high functional outcomes.4 Two important limitations were the selection bias, as patients that don't use the prosthesis could not be interested in participate, and small population that are relatively common in lower limb cancer, due especially to poor survival. Although it is an aggressive disease it could be expected good functional outcomes in prosthetic rehabilitation for longer survivors.

Tabela 1- Demographic, clinical and rehabilitation data by amputation level.

| | Transfemoral | Knee disarticulation | Hip disarticulation |
|---|---|---|---|
| N (%) | 16 (53.3%) | 4 (13.3%) | 10 (33.3%) |
| **Patients** | | | |
| Male | 12 (75%) | 2 (50%) | 6 (60%) |
| Female | 4 (25%) | 2 (50%) | 4 (40%) |
| **Age** | | | |
| Mean, range, sd, years | 42 (18-92) 5.7sd | 66 (60-73) 6.95sd | 41 (20-85) 7.1sd |
| **Pathohistological diagnosis** | | | |
| Squamous cell carcinoma | 4 (25%) | 4 (100%) | 1 (10%) |
| Osteosarcoma | 9 (56.2%) | - | 8 (80%) |
| Chondrosarcoma | 2 (12.5%) | - | - |
| Soft tissue sarcoma | 1 (6.2%) | - | 1 (10%) |
| **Metastasis at diagnosis** | | | |
| Yes | 4 (25%) | - | 1 (10%) |
| No | 12 (75%) | 4 (100%) | 9 (90%) |
| **Phantom limb** | | | |
| Yes | 11 (68.7%) | 3 (75%) | 5 (50%) |
| No | 5 (31.3%) | - | 4 (40%) |
| Missing information | - | 1 (25%) | 1 (10%) |
| **Admission at rehabilitation** | | | |
| Mean,range, sd; months | 1,93 (1-2) 0,25 sd | 2 (2-2) 0 sd | 12 (3-32) 11,3 sd |
| **Prosthetic rehabilitation follow-up** | | | |
| Mean, range, sd; months | 5.1 (3-8) 0.5 sd | 3.73 (3-6) 0.7 sd | 11.3 (3-32) 3.5 sd |
| **Prosthetic users, n (%)** | 15 (94%) | 4 (100%) | 8 (80%) |
| **Ability to put on** | | | |
| Independently | 16 (100%) | 4 (100%) | 7 (87,5%) |
| With help | | - | 1 (12,5%) |
| **Walking aids - indoors** | | | |
| Independently | 12 (75%) | 2 (50%) | 2 (20%) |
| With one or two crutches | 4 (25%) | 2 (50%) | 8 (80%) |
| **Walking aids - outdoors** | | | |
| Independently | 8 (50%) | - | 1 (10%) |
| With one or two crutches | 8 (50%) | 4 (100%) | 6 (90%) |
| **Walking distance** | | | |
| As far as desired | 9 (56.2%) | 2 (50%) | 4 (40%) |
| Nearly 100 steps non stop | 5 (31.2%) | 1 (25%) | 2 (20%) |
| 30-100 steps non stop | 1 (6.2%) | - | - |
| 10 - 30 steps non stop | - | 1 (25%) | 2 (20%) |
| Cannot walk with it | 1 (6.2%) | - | 2 (20%) |
| **Use - hours per day** | | | |
| Mean, range, sd | 13 (6-24) 1.5 sd | 9.25(4-14) 2.0 sd | 8.3 (0-24) 8.1 sd |
| **Use - days per week** | | | |
| Mean, range, sd | 6 (0-7) 1.8 sd | 7 (7-7) ,000sd | 4 (0-7) 2.6 sd |

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# SUBTALAR STRAP WITH LATERAL WEDGE INSOLE IN KNEE OSTEOARTHRITIS: WHAT ARE THEIR IMMEDIATE BIOMECHANICAL EFFECTS?

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## BACKGROUND

The most objective of the conservative treatment in knee osteoarthritis is reducing of the dynamic loading at the knee. One of the most common prescribed noninvasive treatments is lateral wedge insole.

## AIM

The immediate effects of lateral wedge insoles with subtalar strap on external knee adduction moment in knee osteoarthritis were compared.

## METHOD

Seventeen patients aged over 40 years with medial compartment knee osteoarthritis were tested in 3-conditions, including without insole, lateral wedge insole and lateral wedge insole with a subtalar strap, to compare the effect on external knee adduction moment and knee adduction angular impulse. A longitudinal arch support embedded in all insoles.

## RESULTS

There was no significant effect of lateral wedge insole with and without a subtalar strap on first and second peak, mid-stance, and impulse of the external knee adduction moment during stance phase of gait.

## DISCUSSION & CONCLUSION

It seems that efficacy of a lateral wedge insole having an arch support in treatment of patients with medial knee osteoarthritis is still under question and also there is a need for adaptation time to record changes in gait patterns.

## REFERENCES

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# LOWER EXTREMITY LOADING SYMMETRY IN ADOLESCENT IDIOPATHIC SCOLIOSIS WHILE WALKING WITH AND WITHOUT BRACE

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## BACKGROUND

Some gait abnormalities were defined like decreased torsional movements of spine1, increased muscular work and energy expenditure2 in adolescent idiopathic scoliosis (AIS). Additionally wearing a brace limits pelvic motions and affects pendulum-like mechanism of gait.3 Studies have shown no distinct asymmetry in vertical forces with or without brace in comparison to healthy subjects but loading pattern is still not clear in AIS.

## AIM

To investigate lower extremity loading symmetry in AIS while walking with and without brace.

## METHOD

Twelve (11 female, 1 male) subjects with primer structural thoracolumbar/lumbar curve, between 20-400 Cobb angle according to Lenke classification, participated in the study. All participants were using a custom made rigid thoracolumbar brace. Subjects with leg length discrepancy more than 10 mm or any additional orthopedic or neurologic problem were excluded. Plantar loading symmetry was assessed with a pedobarograph (Medilogic, Basic Platform, Germany) located in the middle of a six meters walking way. Measurements were taken in braced and non-braced conditions with three repetitions, 2 months after having worn the brace. Loading symmetry was calculated and compared as percentage of total pressure. The research procedures were approved by Ethical Committee of University and written informed consent was obtained from all participants.

## RESULTS

Twelve subjects aged 13.3 ± 1.2 years and with 17.4 ± 2.5 kg/cm2 body mass index were assessed. Their mean Cobb angle for major curve was 27.0 ± 6.50 initially and 19.1 ± 7.30 in brace. There were no differences between left and right sides for braced or non-braced measurement results ($p>0.05$) (Table 1).

Table 1. Loading percentages (%) of right and left limbs in braced and non-braced conditions

| | Right | Left | p |
|---|---|---|---|
| | %, X ± SD | | |
| **Braced** | 49.3 ± 4.9 | 50.7 ± 4.9 | 0.721 |
| **Non-Braced** | 51.2 ± 2.8 | 48.8 ± 2.8 | 0.206 |
| **p** | 0.440 | 0.440 | |

## DISCUSSION & CONCLUSION

We have found no loading asymmetry between two limbs while walking with or without brace in AIS. This finding is in accordance with previous studies which showed symmetrical vertical forces in AIS. However Quervain et al.1 showed no vertical but rotational moment asymmetry in AIS with and without brace. We just measured the total force on plantar surface not the direction of forces that it is hard to say there is a whole symmetry between two limbs according to our results. To conclude there is a symmetrical total loading between two limbs while walking in AIS with or without brace.

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# IS HIGH-TECH P&O ASSISTIVE TECHNOLOGY BENEFICAL IN THE DEVELOPING COUNTRIES ?

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## BACKGROUND

Whilst working in United Kingdom for the past several years, the author had experience of conducting free medical camps for amputees in the rural areas of South East India, in providing prostheses to individuals below the poverty line using Jaipur foot concept. Having learnt several lessons in providing this service to adult amputees through a local *Non-Governmental organization (*NGO) over the past 10 years, the author also had an opportunity to supervise/ conduct a new project in November 2016 taken up by another NGO, in which it was planned to provide Endolite prostheses (to children under 18 years) that are provided in England.

## AIM

The aim of this study is to analyse the medical / prosthetic data related to this small sample of child amputees in which Endolite limbs were provided along with other prostheses obtained from Mobility India and from Jaipur. This data has been compared with an adult amputee camp conducted at a different village using the basic prosthesis made with HDPE tube / Jaipur foot.

## METHOD

Children under the age of 18 years were traced by advertising in the local newspapers, contacting the local district hospitals & Assistant Director for disabled and senior citizens welfare, and also through the other local NGOs who normally provide Jaipur foot. Suitable children were admitted as a resident for a period of 3 days to the school hostel based at this NGO. Different types of artificial limbs were provided as per the availability of prosthetic components at that time, by an experienced Ortho-Prosthetist within a period of 2-3 days. Within a week, at a different village another camp for adult amputees was conducted using Jaipur foot only (by doing a walk-in type of clinic, following an advertisement in the local newspapers).

## RESULTS

26 child amputees: age group 4-18 (M:17, F: 9). Causes of amputation: RTA-11, Farming accidents-4, congenital-5, Polio-3 and misc-3. Level of amputations: BK-9, AK-7, KD -2, Congenital Bilateral BK-2, AD -3, Polio -3. Types of prostheses provided: Endolite -5, Mobility India Kit -8, Jaipur foot kit- 6, Calipers- 4, Custom made foot -3. Amongst the 30 adult amputees: Age group 20-85 (M-24/ F-6). Causes: RTA-15, Diabetes-6, snake bite-2, work injury -2, misc -5. Level of amputations: AK-6, Bilateral LL-1, BK -23. All were provided with Jaipur foot at this camp. Several new observations were made and new lessons were learnt during these Child /Adult camps, which were conducted with in a span of one week apart. *(AK- Above Knee, BK- Below Knee, KD-Knee Disarticulation, AD - Ankle Disarticulation).

## DISCUSSION

In India, Jaipur foot is commonly available to the amputees who cannot afford to buy high-tech prosthesis, through many NGOs / Charitable organisations and via ALIMCO (http://www.alimco.in) –an Indian Government project. Many a times the quality of these limbs is not satisfactory, if the free camps were conducted in a large scale. There are very few limb centers attached to district hospitals or to a teaching hospital. New generation of cheaper ankle-foot units & knee joints are available through Mobility India organization (http://mobility-india.org) at an affordable price. However, the main practical problem is poor follow up of these amputees, either for repairs or for replacement limbs. People living in the rural areas do not have easy access to these mobility aids because of distances they need to travel together with financial restrictions and family support.

## CONCLUSION

From our observation/experience based on issuing various types of prostheses, we feel that provision of expensive Hi-Tech prostheses is not an ideal option for the growing children and even to the adult amputees living in rural/ remote areas where there is no scope for regular follow-up together with financial restrictions and transport problems. Bringing awareness about these services, establishment of amputee centres in Govt Hospitals to facilitate easy access together with regular follow-up pattern to repair / replace prostheses are the key factors in delivering effective service to the needy in the rural areas. An open-ended socket could still be a good method using HDPE pipe, where the patient cannot get quick access for a re-fit of the socket. In addition, introduction of prosthetic rehabilitation in to the medical curriculum, training of more prosthetists and introducing mobile units to reach the unreachable may improve the services to the amputees significantly in the developing world. The Government & Health authorities too should increase funding and make further efforts to provide better quality / comfortable basic prosthesis to the needy individuals who cannot afford to use high-tech prosthesis.

# DEVELOPING A MOBILE FEEDBACK SYSTEM FOR GAIT RETRAINING IN PEOPLE WITH LOWER LIMB LOSS

Krista Kutina[1], Goeran Fiedler[1]
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## BACKGROUND

Gait dysfunction is an impairment that can effect multiple patient populations [1, 2], both neurologic and orthopedic, including those with limb loss, and become chronic and linger for years. It has been frequently reported that gait retraining with augmented sensory feedback improves dysfunctional lower extremity impairments and related gait patterns including those of amputees [3]. However, a primary criticism of these previous studies is due to the expense and tightly controlled laboratory conditions, conducted with instrumented treadmills and optical systems, many of the findings have had difficulty being applied to realistic clinical environments.

## AIM

Progressing from this previous limitation, the overall goal is to design a system based on an integrated load cell sensor to provide real time mobile visual feedback (RTMVF) to transtibial amputees for gait training. We describe here our first prototype.

## METHOD

Translating current positive findings of real time visual feedback into a clinical application was attempted by providing the visual real time feedback directly from the patient's limb displayed on smart glasses. Objective here is to create a mobile more realistic environment in which the training can occur.

Our work took advantage of existing and validated technology in the form of a prosthesis-integrated load cell (ipecs, RCT Electronics, Dexter, MI) and a variety of commercially available wearable head-up displays. After testing several models, including the Google glass system (Google, Mountain View, CA) and the Recon jet (recon instruments, Vancouver, BC), we implemented Vuzix M100 smart glasses (Vuzix, West Henrietta, NY) in our prototype. Establishing connectivity between the different components posed continuing challenges. The current prototype uses cable connections between the load cell, a laptop computer, and the smart glasses. Given that all those components have Bluetooth capabilities; an updated wireless prototype is anticipated for future iterations of the development project.

## RESULTS

Our initial protoype (Figure 1) allows the capturing, processing and displaying of load cell gait data in close to real time. Initial feasibility tests suggest that a patient can be fitted with the system in about 30 minutes, most of which time is required for the installation of the load cell into the prosthesis structure. Battery life of the head-up display is currently the limiting factor in use time, though without affecting the commonly allocated one-hour time frame for gait therapy sessions.

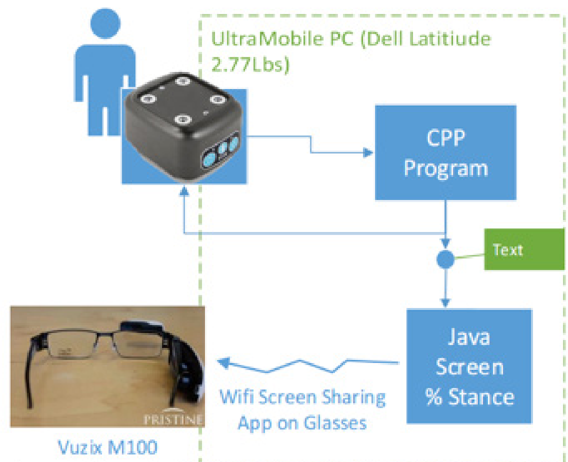


Figure 1. Schematic of the integrated wearable feedback system

## DISCUSSION & CONCLUSION

The presented effort is anticipated to provide the groundwork for subsequent research to determine how to best convert the raw data to the visual warning signal resulting in a (RTMVF) gait training system for transtibial amputees.

Long term goals are the effective supplementation of traditional therapist-based gait retraining with a wearable "assistant" that can provide comparable feedback on a patient's gait deviations. This should help improve outcomes for patients who have limited access to specialized health care, and who are therefore at risk of adapting habitual gait deviations following limb loss and prosthesis provision.

In order to achieve this, our group is working to develop and test algorithms for the detection of individual gait deviations and feedback modalities next.

In conclusion, a mobile gait analysis and feedback system as described provides the technical prerequisites for enhanced gait retraining approaches in people with lower limb loss.

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## ACKNOWLEDGEMENTS

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# THE USE OF AN INTEGRATED LOAD CELL AS A MOBILE GAIT ANALYSIS SYSTEM TO DETECT GAIT EVENTS IN PEOPLE WITH LOWER LIMB LOSS

Krista Kutina[1], Goeran Fiedler[1]
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## BACKGROUND

Gait impairments can effect patients with various health conditions [1, 2], including neurologic pathologies and musculoskeletal disabilities such as lower limb loss. Uncorrected, gait deviations can become chronic and cause additional comorbidities. Gait retraining with augmented sensory feedback was shown to improve gait patterns in people with lower limb prostheses [3]. A noted limitation of the respective studies is the lacking transferability of findings from tightly controlled laboratory conditions into real-life conditions, as the required equipment (instrumented split-belt treadmills), gait analysis personnel, and time are often unavailable in clinical settings. Mobile gait data collection equipment offers the opportunity of addressing this shortcoming, which requires the development of adapted data post-processing and analysis methods.

## AIM

The purpose of this work was to investigate the utility of a validated prosthesis-integrated load cell (IPECs, RCT Electronics, Dexter, MI) to detect deviations from healthy gait based on kinetic data in transtibial amputees. In this work, we investigated the effect of verbal cueing and time on kinetic output from the IPECs to inform future choice of variables for feedback.

## METHOD

Initially raw data (6 values, Fx,Fy,Fz,Mx,My,and Mz) from a single transtibial amputee test subject, weighing 188lbs and 54yo, with an apparent clinical gait deviation of dynamic Valgus (KAbM) and Varus (KAdM) in the frontal plane was used to design a step detection algorithm (Matlab 2015b, Mathworks). The patient was asked to ambulate with the IPECs sensor under several conditions, including a trial with and without guided feedback. The sensor data was examined graphically then quantitatively to develop algorithms to accurately detect steps and gait parameters to be used as feedback to the patient. Four variables were calculated including; #steps, Stance Duration, Peak Fz, and My. Transition steps, and turns were not removed from the analysis at this time as the IPECs sensor is to be used as a "mobile gait lab".

## RESULTS

162 (158 correct) total steps during the feedback trial were derived from specialized Matlab algorithms placing the accuracy > 95%. The cueing by the Therapist regarding KAbM and KAdM with verbal and tactile cues in the sagittal plane and frontal plane, did not result in changes kinetically in the variable My ($p=.66$). Clinical judgement was used to determine improvements. However, the clinically judged improved steps were found to have significantly ($p<.05$) less %stance (M=50.9±25.6) than those not deemed improved (M=59.6±14.29). The Peak Fz was significantly different between ideal stance (58-63%) and over ideal ( > 63%) during Baseline and Video Taped trials ($p<.05$).

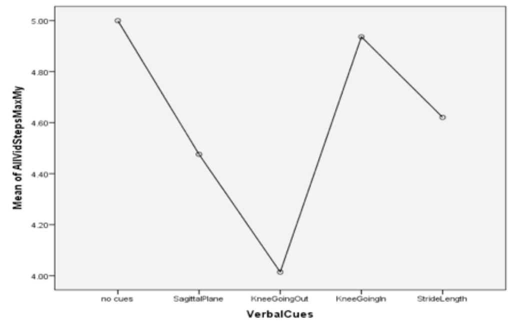


Figure 1. MaxMy Means as Distributed across Verbal Cues

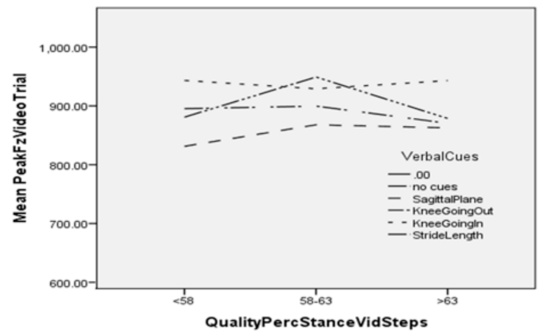


Figure 2. Peak Fz Means as Distributed across Percent Stance Quality, organized by Clinical "goods"

## DISCUSSION & CONCLUSION

This case subject presented with apparent significant valgus moment during stance, however this variable from the IPECs does not seem appropriate for feedback as his MaxMy apparently stabilized the most from stride length feedback (Fig 1.). Therefore, other variables/modifications to the algorithm may be needed. From initial baseline testing, the subject's average peak Fz decreased by almost 150 N overall. Therefore, the variable chosen for feedback may not be individualized per patient deviation, but rather based on previous findings [3] that providing Peak Fz feedback can improve stance symmetry. In order to determine variables that are correlated to typical gait deviations and thus suitable as feedback to improve gait, further testing is required. This should include investigating how the parameters calculated would respond to a different gait deviation and improving the accuracy of the step detection algorithm for a mobile system.

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# A GAIT EMULATOR BASED ON SIX-BAR MECHANISM FOR TESTING TRANSTIBIAL PROSTHESIS

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## BACKGROUND

The increase in lower limb losses highlights the importance of providing amputees with highly functional and comfortable prostheses and emphasizes the need for test setups which evaluates the prostheses performance and durability prior to human testing. By using prosthetic testing setup, designers and manufacturers can ensure that the prostheses perform as intended, detect problems in functionality and fine-tune the design for optimum performance. Thus providing amputees with more functional, durable, comfortable limbs, and minimize rejection or injury.

## AIM

The design of transtibial prosthetic testing setup that emulates human gait utilizing six-bar mechanism, movable ground and can measure knee and ankle angles, ground reaction forces, and center of pressure.

## METHOD

The design was done by selecting a proper mechanism (Stephenson III 6-bar linkage) which gives designer flexibility due the larger number of design variables. Mathematical optimizations were used to design the apparatus that models the kinematics of a sound human leg in the stance and swing phase. The anthropometric measurements of an average male were taken into account. A gear box was used to adjust the speed and a movable ground, allowing testing of adaptive limbs. The various electrical components (AC motor for driving the assembly, Gyroscope for angles measurement, four load cells for reaction force measurement, and a microcontroller) are added.

## RESULTS

The final test setup is a functional system that imitates a human leg from which various informative variables can be acquired, such as the torque and moments generated on the foot, along with the center of pressure about the longitudinal axis. Furthermore, the testing system was used to assess fatigue and the number of cycles it takes to lead to failure. The changes in angle along the trajectory generated by the system were also capable of being determined, which if compared to normal human gait angles, can detect abnormalities in the design of the prostheses tested. Lastly, the system showed immense potential in being a test setup for advanced computerized artificial limbs. Figure 1 shows the first prototype with a SACH foot attached to its end.

Figure 1. The test set up

## DISCUSSION & CONCLUSION

A new system for testing transtibial artificial limbs has been developed. The system allows the feet to be tested in dynamic field simulating the real life conditions of walking while avoiding the use of treadmill and allowing test on inclined surfaces (lateral and frontal) at different walking speeds where the six-bar mechanism plays a key role in matching the normal gait kinematic during the stance phase while the foot is the moving part instead of the ground.

# DEVELOPMENT OF A PASSIVE MECHANISM THAT REALIZES A SEMI-CROUCHING POSTURE FOR TRANSFEMORAL PROSTHETIC KNEE

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## BACKGROUND

For transfemoral prosthesis, the function of the prosthetic knee joint is critical to regain motor capacity. Stair ascending is a difficult task for transfemoral prosthetic users. To solve this issue, we developed a passive mechanism that enables amputees to ascend stairs [1, 2]. Another difficult task is to maintain a semi-crouching posture, which is often required in daily life. This motion is demanding, even for microprocessor-controlled prosthetic knees that have the advantage of multifunctionality. However, mechanically controlled prosthetic knees have advantages in terms of cost, maintenance, and the usage environment. Therefore, it is worthwhile to improve their functionality.

## AIM

The purpose of this study was to develop a passive mechanism that realizes a maintained semi-crouching posture at any given prosthetic knee angle.

## METHOD

The original passive mechanism has two modes, which are for level walking and stair ascending [2]. The stair-ascending mode functions when the prosthetic knee contacts the ground while in the flexed position. We added a ratchet gear to the mechanism to prevent prosthetic knee flexion during the stair-ascending mode. An intact subject with a simulated thigh socket and the proposed knee on the right leg participated in this experiment. The subject was asked to crouch from a standing posture and to maintain a semi-crouching posture at three different self-selected knee angles (high, middle, and low). The motion and the ground reaction forces were recorded using a motion capture system and force plates, respectively.

## RESULTS

The subject succeeded in maintaining a semi-crouching posture at three different self-selected knee angles (Figure 1). The prosthetic leg was able to support more than half of the body weight while maintaining the semi-crouching posture. The ground reaction force of the prosthetic side decreased negligibly in the knee flexion phase, but was nearly half of the body weight during the knee extension phase to assume a standing posture.

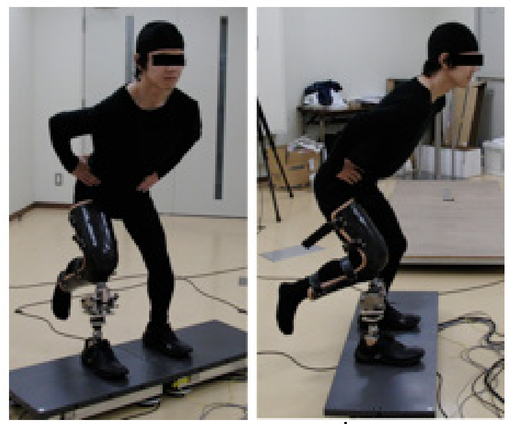

Figure 1. Semi-crouching posture with a self-selected knee angle using the proposed mechanism for transfemoral prosthetic knee.

## DISCUSSION & CONCLUSION

The ratchet gear that we added to the original mechanism functioned as designed. The decrease in the ground reaction force of the prosthetic side in the knee flexion phase was due to the lack of a yielding function in the mechanism. It was assumed that the ground reaction force on the prosthetic side during the knee extension phase was derived from the knee extension function of the original mechanism. In conclusion, the proposed passive mechanism for a transfemoral prosthetic knee realized a maintained semi-crouching posture.

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# EFFECT OF ADAPTOR LOCATION AND KEEL SHAPE ON PREDICTED DISPLACEMENT PROFILES OF THE NIAGARA FOOT™

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## BACKGROUND

The Niagara Foot™ is a prosthetic device uniquely targeted for low-income demographics and post-conflict regions to restore functional gait. The injection molded keel is comprised of modifiable heel, forefoot and C-spring regions that control the timing of energy storage and release (Figure 1a). Previous work has identified the effect of standard modifications on deflection properties of the device [1], but these studies have not addressed timing aspects related to loading during stance.

## AIM

The objective of this study was to estimate the relative timing of peak displacements with respect to peak forces in the heel and forefoot during stance for modified Niagara Foot™ keels compared to reference SACH and dynamic components.

## METHOD

There are currently seven standard modifications of the Niagara Foot™ [2], with two recently introduced. The first of these, the Mod 9 (Figure 1b), has a 5mm flattened heel and 20mm flattened forefoot, designed to increase deflection. The second, Mod 10, has a 15mm posteriorly placed adapter connection, to improve integration with some lower-limb systems. Samples were obtained from the manufacturer (Niagara Prosthetics & Orthotics International, St. Catharines) for comparison to commercially obtained SACH and Axtion™ feet.

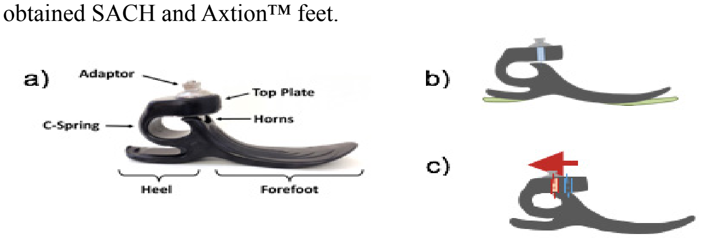


Figure 1. a) Baseline Niagara Foot™ b) Mod 9 with a flattened heel and forefoot c) Mod 10 with a posteriorly placed adaptor.

Mechanical properties were measured from a series of force deflection curves obtained at specific loads and shank angles (critical points) extracted from a standard dataset used in ISO22675, based on the protocol described by Zhao et al [3]. This method produces a predicted displacement profile during stance. Interestingly, the peak heel and forefoot displacements do not coincide with the corresponding peak forces, as shown in Figure 2. The measures of heel displacement lead and forefoot displacement lag were used to determine relative timing of peak displacements and forces [3]. These were expressed in terms of both percent stance and shank angle with respect to vertical.

## RESULTS

Heel displacement lead and forefoot displacement lag were calculated for the Baseline, Mod 9 and Mod 10, and referenced to previously collected data for the SACH and Axtion™ (Table 1). Of note, are the larger heel displacement leads and the smaller forefoot displacement lags of the Axtion™ and Niagara Feet compared to the SACH. Compared to Baseline, heel displacement lead was increased with Mod 9 and Mod 10 by 0.6 % stance and 1.7% stance respectively. Interestingly, forefoot displacement lag was increased with Mod 9 by 1.5% stance and decreased in Mod 10 by 0.1% stance.

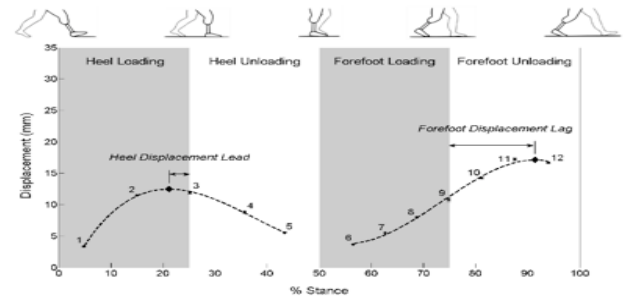


Figure 2. Typical displacement profile with 12 critical points, five for the heel and seven for the forefoot. Peak loading occurs at critical point 3 for the heel and 9 for the forefoot. The heel displacement profile typically shows a peak displacement that proceeds the peak force (heel displacement lead). In contrast the forefoot peak displacement lags the peak force (forefoot displacement lag).

| | Heel Displacement Lead | | Forefoot Displacement Lag | |
|---|---|---|---|---|
| | Angle deg. | Time % Stance | Angle deg. | Time % Stance |
| SACH | 1.4 | 4.0 | 13.1 | 16.9 |
| Axtion™ | 2.0 | 6.0 | 4.3 | 5.5 |
| Baseline | 2.6 | 8.5 | 6.4 | 8.2 |
| Mod 9 | 2.5 | 7.9 | 7.7 | 9.7 |
| Mod 10 | 2.2 | 6.8 | 6.6 | 8.3 |

Table 1. Heel displacement lead and forefoot displacement lag between peak loading and peak displacement as measured by shank angle and percent stance.

## DISCUSSION & CONCLUSION

Results indicate that it is possible to vary the timing of the peak displacements at the heel and forefoot by altering the shape and the pylon attachment point for the keel. However, the effect of these changes in the timing aspects in both modifications of the Niagara Foot™ on prosthetic users' performance or preference is unknown; future studies are required to investigate this directly.

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