ISPO UK MS ANNUAL SCIENTIFIC MEETING

8 & 9 September 2017
Gillespie Centre, Clare College, Cambridge

"Advances in Neuromuscular Rehabilitation and Quality of Care"

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Welcome

We are delighted to welcome you to the 2017 ISPO UKMS Annual Scientific Meeting in Cambridge.

Since our last joint meeting TIPS/ISPO2016 in Glasgow, the ISPO UK MS committee has established a three-year strategy plan aimed at education and training required for sharing the knowledge and experiences of best practices for the development of care pathways with users' unmet needs at its core.

The theme of ISPO 2017 is **Advances in Neuromuscular Rehabilitation and Quality of Care**. The program aims to disseminate the latest medical sciences' research in prosthetics and orthotics, sharing the latest NHS and NIHR strategic plans in P&O and will provide an update on the direction of work in the coming years. Following the very successful one-day workshop on P&O research methodology in July, the importance of the collection of data for the future is now being accepted by many national ISPO member societies in Northern Europe & America and also at an International level. Open access to the data will enable researchers to target their scarce resources by providing scientific evidence much needed to back up best practice. This is the key for our future success and we will continue to create a forum to allow colleagues to present their findings to you.

We plan to continue this theme during future scientific meetings. On 12th of October 2018 ISPO UKNMS will meet at Southampton focusing on body interfaces in P&O and the use of sensor technology for diagnosis and prognosis. The focus remains on users' comfort, stability and security leading to increased confidence, and prolonging independent living. Our next Joint TIPS and ISPO meeting at the locality of P&O schools, will brings us to Salford on 18th of March 2019. By providing the same ISPO membership delegate discount rates to BAPO and BACPAR members we hope to pull together this unique family of ours to share the best clinical experiences alongside latest scientific knowledge in light of the rapidly growing technological nature of our work. We can meet these obligations through facilitating nationally and internationally renowned guest speakers, from technical, clinical and scientific backgrounds, who are encouraged to freely share their knowledge and experiences as well their visions.

ISPO is unique in providing a multidisciplinary approach to disability rehabilitation. Updates on children's prosthetics provision and R&D, NIHR Sandpits, latest developments in osseointegration outcomes, CRG update on MPK policy, vision of 2020 integrated smart orthotic solution of MovAid and topics covered by Bio-medical Engineers, Physicians, Surgeons, Occupational Therapists, Physiotherapists, Prosthetists, Orthotists, Clinical Scientists and many other professions, are all reflected in this year's programme.

International Keynote speakers and lecturers from both Cambridge and UK-wide universities, will aim to challenge our current practice. Free paper sessions and a poster exhibition will disseminate best methodology in functional assessment and outcome measures, and report on development of new measurement tools as well as their use in providing evidence for our future work.

The ISPO UK meeting could not take place without the strong support of the membership, the committee's tireless effort and sponsorship of the commercial companies. Special thanks are extended to Platinum Sponsor, ***Steeper Group*** and Gold Sponsor, ***Orthomobility,*** to ***Opcare*** and ***North Sea Plastics Ltd, Blatchfords, OETT*** and ***others*** for their generous contributions. In tandem, and with the support of all our commercial exhibitors, this enables the organising committee to host a MDT-led scientific meeting and commercial exhibition, along with an entertaining social programme.

Sir Saeed Zahedi
Chairman
ISPO UK MS

Dr Stephen Kirker
Chairman Scientific Committee
ISPO UK ASM 2017


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Programme

Friday 8th September 2017

0830 hrs **Registration**

0930 hrs **Welcome** – Dr S Kirker, ISPO UK MS Scientific Chair & Prof Sir S Zahedi, ISPO UK MS Chair

Theme: Sports Prostheses

0940 hrs ***Experience of trying all Paralympic sports, when four limbs are partially missing***
Guest Speaker: Mr John Willis, Founder & CEO Power2inspire

1020 hrs ***Research & Development plans and report following Government announcement of extra funding for children's prostheses***
Guest Speaker: Dr Nicola Heron, Programme Director, NIHR D4D Healthcare Technology Co-operative, The University of Sheffield, UK

1100 hrs **Refreshments, Commercial Exhibition and Poster Exhibition**

Free Paper Presentations:

1130 hrs ***The influence of socket fit on the socket interface stresses – a case study on a trans-tibial amputee***
Mr J Tang, PhD Student, University of Southampton, Southampton, UK

1145 hrs ***Activity Limb provision for Upper Limb and Lower Limb Paediatric Amputees: Birmingham's Story – Our Race***
Ms C Spencer, Physiotherapist, West Midlands Rehabilitation Centre, Birmingham, UK

1200 hrs ***The effects of a 12-week exercise programme on stair walking performance and falls prevention in lower limb amputees***
Ms Z A Schafer, PhD Researcher, University of Hull, Hull, UK

1215 hrs ***How does attempting to walk symmetrically affect dynamic balance in unilateral transtibial amputees?***
Ms M Bisele, Postgraduate Researcher, Nottingham Trent University, Nottingham, UK

1230 hrs ***An Analysis of Agreement between Medicare Functional Classification Levels and The Amputee Mobility Predictor Assessment Tool: A Retrospective Study***
Ms R McBride, P&O Graduate, University of Strathclyde, Glasgow, UK

1245 hrs ***Early Amputation vs Limb Salvation – Comparing the impact on Quality of Life (QOL) in short and long term***
Dr R Munjal, Consultant, M&SRC, Northern General Hospital, Sheffield, UK

1300 hrs **ISPO UK MS Annual General Meeting**

1315 hrs **Lunch, Commercial Exhibition and Poster Exhibition**

1400 hrs ***A Heavy Reckoning: War, Medicine and Survival in Afghanistan and Beyond***
Guest Speaker: Dr Emily Mayhew, Historian in Residence, Imperial College London, London, UK

1415 hrs ***Update on NHS England commissioning of microprocessor knees and service reviews***
Guest Speaker: Carolyn Young, Lead Commissioner – Rehabilitation & Disability, CRG, NHS England (Midlands & East), UK

1430 hrs ***The impact of Microprocessor Knees on amputees: personal experiences***

Theme: Effort Using Prosthesis

1510 hrs ***Osseointegration: the Australian system; MoD/NHS evaluation and future plans***
Guest Speaker: Group Captain Jonathan Kendrew, RAF, Consultant Trauma & Orthopaedic Surgeon, Queen Elizabeth Hospital, Birmingham, UK

1555hrs **Refreshments, Commercial Exhibition, Poster Exhibition**

1620 hrs **The Blatchford Lecture:**
Rehabilitation after Osseointegration
Guest Speaker: Dr Kerstin Hagberg, Associate Professor, Sahlgrenska University Hospital, Gothenburg, Sweden

1710 hrs *Pattern recognition software to control a multi-articulating upper limb*
Guest Speaker: Mr Geoffrey Andrews

1750 hrs **Company Presentations**

1800 hrs **Conference close**

1830 hrs **Exhibition close**

1930 hrs **Drinks Reception. Conference Dinner and Entertainment**
Clare College Dining Hall, University of Cambridge

Saturday 9th September 2017

0830 hrs **Registration**

0900 hrs **The OETT Lecture:**
Instrumented gait analysis: is it clinically useful in prosthetics and orthotics?
Guest Speaker: Mr Roy Bowers, Principal Teaching Fellow,University of Strathclyde, Glasgow, UK

0940 hrs ***Developing services and training in gait analysis: Cambridge experience***
Guest Speaker: Dr Thomas Stone, Clinical Scientist, Addenbrooke's Hospital, Cambridge, UK

1030 hrs **Refreshments, Commercial Exhibition and Poster Exhibition**

Free Paper Presentations:

1100 hrs ***The longitudinal changes in functional and psychosocial outcomes after wearing a passive dynamic ankle-foot orthosis (PD-AFO) in UK military***
Mr P Ladlow, Higher Scientific Officer & Mrs N Bennett,Lead Orthotist,DMRC Headley Court, UK

1115 hrs ***Optimising plantar-pressure sensor distribution for centre-of-pressure estimation***
Ms L A Raymond, Research Engineer, Chas A Blatchford & Sons Ltd, Basingstoke, UK

1130 hrs ***Prosthesis use outside the clinic – an objective approach***
Ms Alix Chadwell, Medical Engineer/PhD Student, University of Salford, Salford, UK

1145 hrs ***The effect of a lower-limb prosthesis on skin temperature***
Mrs L Diment, PhD Student in Engineering Science, University of Oxford, Oxford, UK

1200 hrs ***Use of a hydraulically articulating versus rigidly attached prosthetic ankle-foot device improves gait and walking performance in unilateral transtibial amputees with lower activity levels***
Dr C T Barnett, Senior Lecturer, Nottingham Trent University, Nottingham, UK

1215 hrs ***Articulating, hydraulic prosthetic ankles compared to rigid attachments: a literature review***
Dr M McGrath, Research Scientist, Chas A Blatchford & Sons Ltd, Basingstoke, UK

1230 hrs ***Advanced prosthetic components improve standing balance and limb load symmetry for transfemoral amputees***
Dr M McGrath, Research Scientist, Chas A Blatchford & Sons Ltd, Basingstoke, UK

1245 hrs ***Amputee activity-monitoring through non-invasive prosthetic foot spring deflection measurements***
Dr P Laszczak, Mechatronic Research Engineer, Chas A Blatchford & Sons Ltd, Basingstoke, UK

1300 hrs **Presentation of Prizes**

1310 hrs **Lunch & Conference Close**

Guest Speakers

John Willis

John Willis (born without forearms or lower legs) is Founder and CEO of the Cambridge-based charity Power2Inspire. John formed the charity as a means of promoting a more inclusive society through the power of sport. Whilst John's role is primarily a strategic one, guiding and directing the charity to achieve its objectives, he has also been instrumental in setting personal challenges to inspire and promote the ethos of the charity. Most recently his ***Road2Rio*** challenge involved John participating in 34 Olympic and Paralympic events in the run up to the 2016 Rio Games.

Dr Nicola Heron

Nicola is the Programme Director for the NIHR Devices for Dignity Healthcare Technology Cooperative (D4D). Prior to joining D4D, Nicola gained her PhD in Organic Chemistry in Boston, US in 1998 and joined AstraZeneca Pharmaceuticals as a medicinal chemist and drug discovery leader with an outstanding track record of delivery from the exploratory phase to the clinic.

Nicola joined D4D in 2009. In her role as Programme Director she is responsible for the overall operational management of the consortium and the delivery of over 80 R&D projects in that period. The focus of projects ranges from validation of un-met clinical needs to health technology development and evaluation, with special emphasis on patient involvement and realising the commercial and health impact of the resulting technologies. Nicola completed an executive MBA in 2015, with a special interest in new product development and adoption within the medical technology field. She has published over 50 research papers and patents and sits on a number of Research and Innovation Boards within NHS organisations.

Emily Mayhew

Dr Mayhew is a military medical historian specialising in the study of severe casualty, its infliction, treatment and long-term outcomes in 20th and 21st century warfare. She is historian in residence in the Department of Bioengineering, Imperial College, London working primarily with the researchers and staff of The Royal British Legion Centre for Blast Injury Studies, and a Research Fellow in the Division of Surgery within the Department of Surgery and Cancer. Her latest book, "A Heavy Reckoning" was published in May 2017.

Carolyn Young

Carolyn joined the NHS in 1985 working for East Hertfordshire Health Authority. She has worked in a number of roles across the East of England leading to her appointment as Associate Director for Specialised Commissioning with the East of England Specialised Commissioning Group. Following the establishment of NHS England in 2013 Carolyn was appointed to the role of Programme of Care Lead for Trauma Services for the Midlands & East. Carolyn is also the NHS England Lead Commissioner for Rehabilitation & Disability which includes complex rehabilitation, prosthetics, augmentative and alternative communication (AAC) and Environmental Controls (EC). Carolyn has been instrumental in leading the work on microprocessor controlled knees which culminated in NHS England approving a routine commissioning policy for microprocessor knee in December 2016.

Group Captain Jonathan Kendrew

Jon Kendrew qualified from University College London Medical School in 1996. He undertook Orthopaedic Specialist training in Nottingham and Derby and was appointed as a Consultant Orthopaedic Surgeon at the Royal Centre of Defence Medicine in 2009. He is experienced in the acute and long-term surgical management and rehabilitation of military blast, gunshot wounds and other penetrating injuries.

Dr Kerstin Hagberg

Kerstin is a physiotherapist and a researcher at the Sahlgrenska University Hospital, Gothenburg, Sweden focusing on lower limb amputee rehabilitation for more than 30 years. She has been responsible for the rehabilitation of patients treated with bone-anchored prostheses for more than 25 years. For this group of patients Kerstin founded the OPRA rehabilitation protocol as well as the patient-reported outcome assessment routines. She has authored more than 25 scientific publications and supervised several PhD students. Kerstin has also been serving as the President of ISPO-Sweden for 8 years and today she is currently a member of the ISPO world conference scientific committee. Kerstin is also part of the board for the National Registry for lower limb amputations and prostheses in Sweden.

Roy Bowers

Roy Bowers is Principal Teaching Fellow and Course Director for the BSc (Hons) Prosthetics and Orthotics degree course at the University of Strathclyde. His main clinical and research interests are in the lower limb orthotic management of neurological conditions. He was an expert reviewer for the ISPO consensus conferences on the management of stroke (2003) and cerebral palsy (2008), and has been a regular member of the teaching faculty on ISPO instructional courses on the management of both cerebral palsy and stroke for many years. He has lectured extensively in Europe, Asia and the United States.

Roy is co-author of chapters on “Biomechanics of the hip, knee and ankle” and “Lower limb orthoses for stroke” (Atlas of Orthoses and Assistive Devices, 2008), and acted as project lead and specialist clinical advisor for the NHS Scotland Best Practice Statement on the use of AFOs following stroke (2009).

Thomas Stone

Thomas is a graduate in Electronic Engineering from the University of Sussex. Following graduation, Thomas worked at the National Clinical FES Centre at Salisbury District Hospital for four years where he received his PhD in Biomedical Engineering. He then transferred to Bath University and the Royal National Hospital for Rheumatic Diseases where he developed home based motion and rehabilitation tools. He subsequently spent four years at the clinical gait laboratory in the Oak Tree Lane Rehabilitation Centre, Birmingham Community NHS Trust until four years ago when he moved to Cambridge University Hospital. Here he supports the development of the new Clinical Movement Laboratory and the development of Clinical Engineering Innovation - a hospital based design and development service. Thomas is a state registered Clinical Scientist with the Health Care Professionals Council.

Abstracts (in order of presentation)

Title:	**Experience of trying all Paralympic sports, when four limbs are partially missing**
Guest Speaker:	**John Willis, Founder & CEO Power2inspire**
E-mail:	john@power2inspire.org.uk

In this opening, keynote presentation, John will explore the possibilities of participating in sport with an interactive demonstration of the prostheses and adapted equipment used in his *Road2Rio Challenge* – taking part in all 34 Olympic and Paralympic sports in the run up to the 2016 Olympic and Paralympic Games.

Title:	**Research & Development plans and report following Government announcement of extra funding for children's prostheses**
Guest Speaker:	**Dr Nicola Heron, Programme Director, NIHR D4D Healthcare Technology Cooperative, University of Sheffield, UK**
E-mail:	nicola.heron@sth.nhs.uk

Following the announcement of investment into research in Child Prosthetics, the National Institute for Health Research (NIHR) appointed D4D to develop and lead a national Child Prosthetics Research Collaboration to bring together clinicians, families, academics and industry partners so that innovations inchild prosthetics can be brought to the NHS more quickly and to greater scale.

An extensive needs assessment has been completed working across these stakeholder groups. The outcomes and plans for next steps will be discussed.

Title: **The influence of socket fit on the socket interface stresses – a case study on a trans-tibial amputee**

Presenter: **Jinghua Tang, PhD Student, Mr**

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Piotr Laszczak PhD, Mechatronic Research Engineer, Blatchford
Joe McCarthy, Principle Prosthetist, Blatchford
Saeed Zahedi PhD, Technical Director, Blatchford

Introduction

For lower limb amputees, ill-fitting sockets could potentially lead to discomfort and poor outcome of the prosthesis. Different types of stress sensing systems have been reported as means to evaluate socket fit[1]. However, they are either not able to measure pressure and shear simultaneously or require socket alteration and thus are not clinically applicable. Therefore, the assessment of socket fit as a function of interface stress is still not well understood. The aim of this study is to investigate the effect of socket fit on the interface stress at key load bearing locations of a trans-tibial residuum during ambulation, using a multi-directional interface stress sensing system[2].

Method

Interface stress sensors were placed at the distal end, the sub-popliteal fossa (SPF) and the patella tendon bar feature of the inner socket wall of a trans-tibial amputee (male, body mass of 48kg and height of 165cm). The participant was asked to walk, at a self-selected speed, on a level walkway for one minute wearing two thick socks. Subsequently, the participant was asked to remove one sock in order to alter the socket fit. A repeated level walking session was performed by the participant. Interface pressure and two orthogonal shear stresses at these locations were collected (Fig. 1).

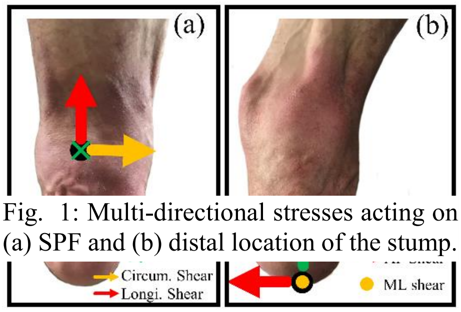

Fig. 1: Multi-directional stresses acting on (a) SPF and (b) distal location of the stump.

Results and Discussion

Fig. 2 shows the typical interface stresses measured at the SPF and distal location. Up to 126±5kPa and 149±6kPa of peak pressure were obtained (Fig. 2a and Fig. 3a), when wearing one and two socks, respectively. It is evident that lower pressure was obtained, upon the removal of one sock. Up to 50±2kPa and 55±3kPa of peak longitudinal shear was obtained in early stance phase (Fig. 2b and Fig. 3b), when wearing one and two socks, respectively. The increase in the longitudinal shear stress with more sock plys may be associated with weight bearing at proximal location, as the residuum was held higher in the socket.
Up to 12±1kPa (Fig. 2c and Fig. 3c) and 7±2kPa of peak pressure was obtained, when wearing one and two socks, respectively. Peak to peak AP shear stress of approximately 4±1kPa and 2±1kPa were measured when wearing one and two socks (Fig. 2d and Fig. 3d). Upon removal of one sock, higher stress were obtained at distal location. This may be explained by the sinking of the residuum due to the removal of one sock, allowing increased distal contact with the socket.

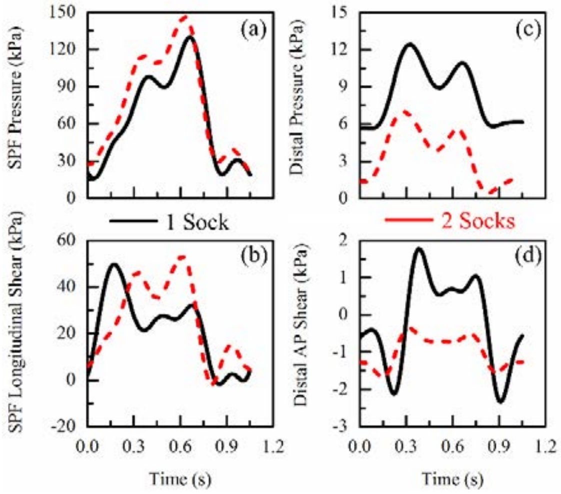

Fig. 2: Interface stresses obtained at SPF and distal location of the residuum, as a function of time.

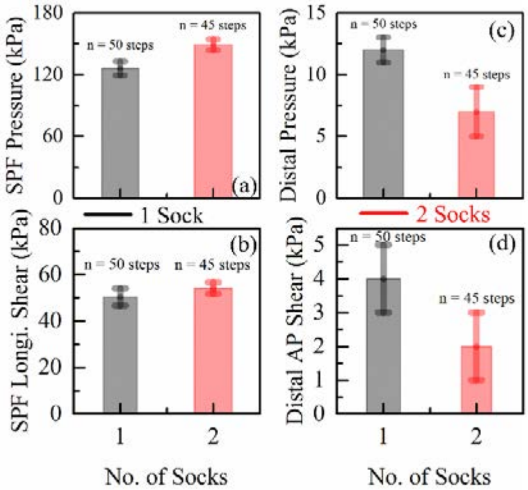

Fig. 3: Mean and standard deviation of peak stresses measured at SPF and distal location of the residuum.

Conclusion

This preliminary study showed the variation of the interface stress when socket fit is altered. The removal of a sock may potentially lead to the reduction of interface load at proximal regions and an increase in interface load at the distal region. Further work is required to quantify the interface stress at different residuum locations to understand the load re-distribution under different socket fitting conditions. This outcome of this study, combined with stump tissue viability, could be potentially used as a guidance for both clinician and amputee when altering socket fit.

Acknowledgements

The authors would like to thank the UK MRC, the EPSRC and the China CSC for support.

References

1. Sanders JE, Daly CH and Burgess EM. Interface shear stresses during ambulation with a below-knee prosthetic limb. *Journal of rehabilitation research and development*. 1992; 29: 1-8.
2. Laszczak P, McGrath M, Tang J, et al. A pressure and shear sensor system for stress measurement at lower limb residuum/socket interface. *Med Eng Phys*. 2016; 38: 695-700.

Title:	**Activity Limb provision for Upper Limb and Lower Limb Paediatric Amputees Birmingham's Story – Our Race**			
Presenter:	**Catherine Spencer, Physiotherapist in Amputee Rehabilitation, West Midlands Rehabilitation Centre**			
Contact Address	West Midlands Rehabilitation Centre, Oak Tree Lane, Selly Oak, Birmingham B29 6JA	Tel: Fax: E-mail:	0121 466 3161 N/A catherine.spencer2@nhs.net	
Other Authors	Susan Barlow, Occupational Therapist in Amputee Rehabilitation, West Midlands Rehabilitation Centre. Andrew Sharpe, Principal Prosthetist, West Midlands Rehabilitation Centre. Dr Poorna Ramamurthy, Consultant in Rehabilitation Medicine, West Midlands Rehabilitation Centre.			

Introduction/Background:

The Department of Health announced time limited funds for provision of activity limbs for children with limb loss to enable them to engage in physical activity and sports.
West Midlands Rehabilitation Centre is a tertiary centre catering to paediatric amputees across the whole of the West Midlands and is one of the largest centres in the country.
In response to this, we developed an effective process of prioritising our patients and delivering this service effectively within the limited time frame and resources.

Aims:

- Outline the process to implement the project effectively.
- Obtain relevant data and information to enable us to begin to assess the impact of activity limb provision within our paediatric population.

Method:

Following the announcement for the sports prosthesis funding, we agreed an initial process as a team, and this began with identifying those eligible.

From a full patient list we used a 'traffic light' system to identify who met the eligibility criteria and who did not. Those eligible were identified as green, those not eligible, red and those for who there was a query over suitability, amber.

Number of Children Identified to the service	Level of Amputation		Suitability for activity limb provision		
			Green	Amber	Red
182	Upper limb	111	45	0	66
	Lower limb	48	23	4	21
	Multi limb loss	21	11	3	7
Total		180	79	7	94

(Nb: 2 children were pre – amp at the time the list was generated)

The process then began of providing those who were deemed eligible with the most appropriate prosthesis to suit their choice of activity. This, for most included a general consultation appointment where information was gathered relating to current activity levels and participation in activity and play and the process was outlined to the child and family. This was then followed by the standard prosthetic process of cast and measure, limb build and fit/delivery of limb.
The children were supported by the team to adapt to the activity limb and the new componentry of this prosthesis versus their standard limb and to introduce activity limb wear into school play/sporting activities as was felt necessary.
An important part of the process for us to develop within the early stages was regarding outcome measures and data collection. As a team we were keen to assess the impact of activity limb provision for our children and this is being done in a variety of ways, including both subjective and objective methods.

Results:

From 182 children, 79 were deemed eligible for activity limb provision. Of those deemed eligible, 23 were lower limb amputees, 45 were upper limb, and 11 had multiple limb involvement. To date, we have provided a total of 26 activity limbs (8 Upper limb and 18 lower limb(s)). There was found to be limited uptake from the upper limb patients and delays in provision for a number of lower limb patients due to pending surgery.

Conclusion/Interpretation:

Early findings show an overall increase in speed of running for the lower limb patients when using their activity limb versus their standard prosthesis, but perhaps the most noticeable finding across the whole population has been the positive psychological impact activity limb provision has had on the child.

Future plans:

It is believed that over the next few months we will complete provision of activity limbs for the majority of the lower limb group and around a quarter of the upper limb group. Data collection and information gathering will continue, further looking at the benefits, limitations and areas for development within the provision of activity limbs for the paediatric amputee population.

We are also supporting some research into activity limb provision externally through Limb power and the University of Bolton who are conducting a Service Evaluation to provide supporting evidence and to enhance the case for on-going funding.

Title:	**The effects of a 12-week exercise programme on stair walking performance and falls prevention in lower limb amputees**		
Presenter:	**Zoe A Schafer, PhD Researcher**		
Contact Address	Sport, Health and Exercise Science, University of Hull, Hull, HU6 7RX	Tel: Fax: E-mail:	01482 466080 N/A z.schafer@hull.ac.uk
Other Authors	Dr Natalie Vanicek, Reader in Clinical Biomechanics, University of Hull		

Background

Stair walking requires a greater range of movement (ROM) at lower limb joints, compared to level gait and primarily requires muscle action of the ankle plantarflexors and knee extensors. Given these constraints, stair walking is known to particularly challenge lower limb amputees (LLAs). This study assessed whether a 12-week exercise intervention improved stair walking performance and reduced falls in community-dwelling LLAs.

Methods

This study forms part of a larger project exploring the effects of a supported exercise programme on falls prevention and activities of daily living performance. Fifteen LLAs were recruited and matched into two groups, exercise [n=7, mean(SD) age: 59.7(12.7) years; transtibial: n=2; transfemoral: n=5), and control [n=8, mean(SD) age: 64.9(16.4) years; transtibial: n=3; transfemoral: n=5], based on age and level of amputation. Participants were asked to ascend and descend a custom-built 5-step staircase ten times. Three-dimensional kinematic data were collected using a 10-camera motion capture system with a full body 6 degrees-of-freedom marker set. Stair walking data were collected at baseline and post-intervention. The exercise group engaged in twice-weekly, 12-week supervised group sessions and an individualised home-based programme, consisting of strength, balance, flexibility and walking endurance. The control group were asked not to change their physical activity levels during the intervention period. Self-reported falls history was collected for the two years prior to baseline testing and at one year follow-up. A repeated measures general linear model indicated significant differences (P<0.05). Effect sizes are reported as Cohen's *d,* values greater than 0.8 indicate a large effect size.

Results

Ten participants utilised a step-to strategy for stair ascent, and 12 participants for stair descent. Reciprocal gait pattern users were excluded from analysis to allow comparison. Following the exercise intervention, mean(SD) gait speed for the exercise group increase by 0.15m/s to 0.35 (0.21) m/s during stair ascent, although this was not statistically significant (P=0.051; *d*=1.21). During stair descent, the exercise group significantly (Intact: *P*=0.019, *d*=1.03; Prosthetic: *P*=0.005, *d*=1.11) increased bilateral cadence, and peak hip extension significantly (Intact: *P*=0.022, *d*=2.10; Prosthetic: *P*=0.018, *d*=1.58) increased for both limbs. During stair ascent, the exercise group intact limb peak hip extension increased significantly (*P*=0.017; *d*=1.91). There were no significant changes in the control group. In the exercise group, there was a significant (*P*=0.011; *d*=1.56) reduction in falls over the one-year follow-up period, whilst falls incidence did not change in the control group (*P*=0.308; *d*=1.08).

Discussion

Increased gait speed observed during stair ascent may have contributed to the greater hip ROM performed, these changes likely demonstrate more confidence whilst performing higher falls-risk activities, although this was not measured. The change in hip ROM in the exercise group may be due to reduced forward trunk lean, possibly indicative of less reliance on the handrails, increased prosthetic confidence or strength. A significant reduction in falls, in the exercise group, has important implications for patient wellbeing and healthcare provision. Our 12-week exercise programme demonstrated benefits for stair walking performance and falls reduction. Supported exercise programmes should be offered within the community for continued health and wellbeing of LLAs.

Title:	**How does attempting to walk symmetrically affect dynamic balance in unilateral transtibial amputees?**		
Presenter:	**Maria Bisele M.Eng, Postgraduate Researcher, Nottingham Trent University**		

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Other Authors	Dr. Martin Bencsik, Reader in Physics and Mathematics Dr. Martin G.C. Lewis, Senior Lecturer in Biomechanics Dr. Cleveland T. Barnett, Senior Lecturer in Biomechanics		

Aims and Objectives:

Underlying biomechanical factors that lead to falls in lower-limb amputees (LLAs) are not fully understood, necessitating further investigation. Often LLAs aim and are encouraged to walk in a more symmetrical manner. However, increased gait symmetry has been linked to a decrease in dynamic balance[1], which may consequently increase the likelihood of falling. Therefore, the aim of the current study was to investigate the effect of imposing temporal-spatial symmetry on the dynamic balance of unilateral, transtibial amputee (UTA) gait during overground level walking.

Methods:

Individuals with a unilateral, transtibial amputation (age 53±10years; height 1.71.5±0.6m; mass 79.1±12.5kg) provided informed consent to participate. Participants performed walking tasks under two conditions: during visit 1, they were required to walk at self-selected speed across a 15m walkway without restriction (NORM), whilst during visit 2, participants were required to walk across a 15m walkway while step length and step frequency were controlled to be symmetrical using floor markings (step length) and a metronome (step frequency) (SYM). For all trials, 70 reflective markers were attached to participant's upper and lower extremities and trunk, measuring full body gait biomechanics. Kinetic and kinematic data were captured at 1000 Hz and 100 Hz, respectively during all walking trials. The backward margin of stability (BW-MOS) was calculated during both conditions, and for both the intact and prosthetic limbs, to represent dynamic balance ability.

Results:

As shown in Figure 1, controlling the symmetry of step length and step frequency influenced the magnitude of the BW-MOS, with an increased BW-MOS observed in the intact limb (5.3%, d=0.16), although this affect was more marked in the prosthetic limb (26.4%, d=0.45). There were large variations in the responses to symmetrical walking, as demonstrated by the large standard deviations (Figure 1).

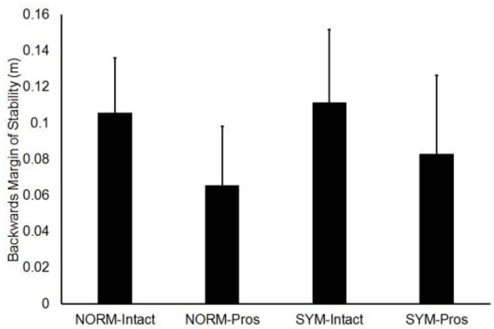

Figure 1. Backwards margins of stability (BW-MOS) of UTAs during both SYM and NORM conditions from both the intact and prosthetic limbs.

Conclusions:

Results from the preliminary analysis (n=4) in the current study show that the BW-MOS is influenced by changes to symmetry in temporal-spatial aspects of gait. The increases in BW-MOS stability, particularly in the prosthetic limb, suggest that dynamic balance may be improved with increased symmetry although caution must be exercised when drawing conclusions from such preliminary analysis. Further analysis of this data set will elucidate the underlying effects causing the changes observed in the current study.

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Title: **An Analysis of Agreement between Medicare Functional Classification Levels and The Amputee Mobility Predictor Assessment Tool: A Retrospective Study**

Presenter: **R McBride, Prosthetics and Orthotics Graduate, Miss**

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Objective:

To determine the inter-rater reliability of two methods that categorise an amputee's ambulatory potential.

Design:

A retrospective study to assess agreement between prosthetist reported K-Levels using Medicare Functional Classification Levels (MFCL) and physiotherapist calculated K-Levels using Amputee Mobility Predictor (AMP).

Subjects:

Sample of 68 patients with a unilateral trans-femoral amputation was selected from a large limb-fitting centre in Scotland. Patient's ambulatory ability was tested using their current prosthesis in a clinical setting.

Methods:

Statistical analysis using SPSS (V24) was preformed for descriptive statistics and correlations. Weighted Kappa test was used to ascertain inter-rater reliability.

Results:

The results were statistically significant ($p=0.004$) and show only slight agreement between the two methods of determining K-Levels ($\kappa <0.2$).

There was 48% agreement between AMP and MFCL scoring methods. It was also found that there was a clustering of results around High K3 and Low K4 with 42.6% scoring between 42-44 points on the AMP Scoring Scale.

Conclusion:

With the data provided, this study has found there is poor inter-rater reliability between these K-Level assessment methods within this rehabilitation centre. This has the potential to have serious clinical implications for those referred for prosthetic fitting and may affect their ability to gain access to state of the art prosthetics.

Title:	**Early Amputation Vs Limb Salvation - Comparing the impact on Quality of Life (QOL) in short and long term**
Presenter:	**Dr Ramesh Munjal, Consultant**

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BACKGROUND

When it comes to considering amputation, limb salvation is preferred by both patients to keep body image, avoid disability etc. and by surgeons due to intention to preserve and also due perhaps to lack of knowledge about modern prostheses and rehabilitation. For these reasons patients continue to consent to repeated surgery subjecting themselves to many years of suffering, and surgeons continue to attempt limb salvation till amputation becomes life saving

AIM

Our aim is to find out the difference in the patients' Quality of Life before and after amputation. The surgical intervention may have been either repeated joint replacements or reconstructive surgeries but eventually led to amputation.

METHODS

This study was conducted as a one to one interview between patient and medical registrar or consultant and was based on a structured questionnaire and studying previous medical records. The questionnaire was re-designed following a trial on 4 patients. We included 16 patients who were attending Amputee rehabilitation Clinic at the Mobility and Specialised Rehabilitation Centre at Sheffield University Teaching Hospitals, United Kingdom, between the period 1.02.16 and 31.08.16. Inclusion Criteria: 1) Patients had traumatic leg injury or Severe Osteoarthritis before Amputation 2)They had three or more reconstructive surgeries or multiple ankle or knee replacements before Amputation.3) They were using their prosthetic limbs and majority had outdoor mobility.

RESULTS

Of the 16 patients, all showed improvement in pain, mobility and mood after amputation. Pain improved significantly on the visual analogue pain scale ($p = 0.000$). 62.5 % of patients were able to walk less than 50 meters prior to amputation compared to only 18.8 % after amputation. 12.5% were able to walk without aid prior to amputation compared to 37.5% was walking without aid after amputation. Overall health was much improved in 12 patients (75%) and all patients (100%) improved in their self-care. All patients improved in their physical health and social activities post amputation ($p= 0.000$). All patients 100% agreed that they would recommend early amputation to anyone in similar situation or choose amputation themselves if they were well informed and if the clock could be turned back.

CONCLUSION

Early amputation as opposed to repeated limb reconstructions or joint replacements has positive effect on Quality of Life such as pain, mobility, mood, overall health. Early Amputation is recommended by all patients in our study sample. Repeated surgery for limb salvage resulted in prolonged suffering, infections, several hospital admissions loss of earnings and low mood. This is a small study but we are convinced that a larger study will reveal similar findings. Amputation should be considered as an early option to expensive repeated surgery.

REFERENCE

1. Busse JW1; 2007 & J Orthop Trauma

Title: **A Heavy Reckoning: War, Medicine and Survival in Afghanistan and Beyond**

Guest Speaker: **Dr Emily Mayhew, Historian in Residence, Imperial College, London**

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Much of Britain's infrastructure of prosthetic limb replacement and expertise evolved during the Great War in response to an unprecedented cohort of over 40,000 amputees, from the specialist casualty evacuation training to rehabilitation. Today we have a new military amputee cohort, smaller in number but with very similar complex injury patterns. History indicates that outcomes for the Great War amputee cohort were generally unsatisfactory. Dr Mayhew will highlight the factors that limited outcomes a century ago and discuss how we have yet to resolve the challenges of this injury and its aftermath.

Title: **Osseointegration: the Australian system; MoD/NHS evaluation and future plans**

Guest Speaker: **Group Captain Jonathan Kendrew, RAF Consultant Trauma & Orthopaedic Surgeon, Queen Elizabeth Hospital, Birmingham, UK**

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Advances in Trauma Care from point of wounding through to Rehabilitation Centres has led to unprecedented numbers of severely wounded soldiers surviving complex injuries. Some of these patients have struggled to mobilise as their rehabilitation has progressed. Osseointegration surgery may provide a solution. A joint NHS and MOD clinical evaluation is assessing the results.

The Blatchford Lecture 2017

Title: **Rehabilitation after Osseointegration**

Guest Speaker: Dr Kerstin Hagberg, Associate Professor, Sahlgrenska University Hospital, Gothenburg, Sweden

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This lecture will cover 25 years' experience of working with patients with lower limb osseointegration in Sweden, focussing on rehabilitation aspects and patient-reported outcome. The presentation will also cover updates on recent research, including complications and health economic assessments, and discuss the current status of the treatment given in Sweden.

The OETT Lecture 2017

Title: **Instrumented gait analysis: is it clinically useful in prosthetics and orthotics?**

Guest Speaker: **Mr Roy Bowers, Principal Teaching Fellow, National Centre for Prosthetics and Orthotics, Department of Biomedical Engineering, University of Strathclyde, Glasgow**

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An ability to analyse gait is a critical skill for clinicians hoping to achieve success in lower limb prosthetics and orthotics. Gait analysis can be performed in a variety of ways, ranging from the purely observational assessment of joint and segment kinematics to the use of highly technical and sophisticated instrumented gait analysis systems which present 3-dimensional kinetic information, sometimes combined with electromyographic data. The wide range of different options available incur varying, and sometimes very considerable costs, and require varying levels of knowledge and expertise. Access to sophisticated 3-dimensional motion analysis technology is limited even in well-resourced high income countries, while in the low-income economies, access is close to impossible. This presentation will consider the practicalities, advantages and the challenges of using instrumented gait analysis in a clinical setting, and suggest ways in which clinical decision making can be enhanced by the implementation of different approaches to analysing gait.

Title: **Developing services and training in gait analysis: Cambridge experience**

Guest Speaker: **Dr Thomas Stone, Clinical Scientist, Addenbrooke's Hospital, Cambridge**

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Around three years ago Cambridge University Hospital had the opportunity to develop Clinical Movement services. Supported by both new prosthetic funding for veterans and the Addenbrookes Charitable Trust, we have been able to establish a room and equipment to deliver state-of-the-art motion capture and motion analysis facilities. Establishing these services is multifaceted and, beyond the capital cost and infrastructure requirements, there are a number of considerations cultural and professional to attend to. Workflow, regulation and skill-set, in addition to ongoing strategic vision for such facilities, are vital considerations to ensure their longevity.

Title:	**The longitudinal changes in functional and psychosocial outcomes after wearing a passive dynamic ankle-foot orthosis (PD-AFO) in UK military.**		

Presenters:	**Mr Peter Ladlow, Higher Scientific Officer, Academic Department of Military Rehabilitation (ADMR), DMRC Headley Court, and** **Mrs Nicole Bennett, Lead Orthotist, DMRC Headley Court, Blatchford Clinical Services.**		
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Aims and Objectives

In 2009 the US military began utilising a specific passive dynamic ankle-foot orthosis (PD-AFO) named the Intrepid Dynamic Exoskeletal Orthosis (IDEO™). Improved outcomes with regards to pain, functional capability and reductions in elective amputation rates[1] are now well documented in their military limb salvage populations. The UK Defence Medical Rehabilitation Centre (DMRC), Headley Court, has utilised this style of orthosis (commercially available as the 'Momentum Brace'®), since 2013. This is the first time the UK military will present its clinical outcomes in relation to PD-AFO's. Tracking UK military patient's rehabilitation journey over time will enable clinicians and patients to reflect on the functional and psychosocial impact of this combined orthotic and exercise rehabilitation intervention and investigate the rate of any subsequent elective amputations post-implementation.

Methodology

To date, 60 personnel have received this specific PD-AFO through DMRC. The data presented will reflect the 16 patients who received multiple inpatient admissions to our complex trauma department. Patient demographic, injury characteristics and length of rehabilitation will be recorded, including clinical outcomes collected at 4 time points: pre-prescription, 1st and 2nd admission post and final admission to DMRC. The outcomes recorded include six minute walk distance (6WMD), ability to walk and run independently, depression (PHQ-9), anxiety (GAD-7), pain status and strength of medication. These outcomes will be compared against our previous published data of below-knee limb salvage (BK-LS) and elective below-knee amputee (e-BKA) outcomes[2] achieved at last admission, prior to the availability of this specific PD-AFO.

Results

Wearing this specific-AFO significantly increased patient's 6MWD at each admission ($p<0.01$) with a large effect (Cohens d=1.05) occurring from pre (440±75 metres) to 2nd admission post (519±73 metres). Before wearing the brace, 31% were able to walk and 6% able to run independently. After one 3-week admission this increased to 100% and 44%, respectively. By their last admission, 69% of patients were capable of running independently. Previously, 6% BK-LS and 53% of e-BKA cases were able to run independently. Moderate symptoms of depression and anxiety were reported in 13% before wearing the brace. By the second admission, moderate symptoms had disappeared in depression and anxiety. Previous BK-LS and e-BKA cases reported 15% and 20% prevalence of moderate symptoms, respectively. The prevalence of patients reporting 'no pain' increased from 6% pre-prescription to 13%, 31% and 38% at each data point thereafter. BK-LS and e-BKA cases reported 'no pain' 15% and 40%, respectively. All brace users were able to 'control their pain' by their second admission post. The prescription of strong opioids and neuroleptic medication remain relatively unchanged, however there was a notable drop in the number of patient prescribed weak opioid medication over time (pre=44%, last-admission=17%).

Conclusions

Wearing this specific PD-AFO demonstrated significant improvements in mobility, depression, anxiety and pain status with each admission to DMRC, Headley Court. When compared to our previously reported foot and ankle trauma outcomes[2], users of this brace achieved superior functional mobility, mental health and pain responses compared to BK-LS patients. These outcomes were comparable or superior to previous e-BKA.

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Title: **Optimising plantar-pressure sensor distribution for centre-of-pressure estimation**

Presenter: **Lou-Ann Raymond, Research Engineer, Ms**

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INTRODUCTION

The trajectory and velocity of centre-of-pressure (COP) motion during walking has been linked with stability and the likelihood of falls, particularly for elderly people and those with lower-limb pathologies[1]. To-date, in-shoe plantar-pressure measurement of COP has been achieved with systems containing high-density sensor matrices, which are expensive and exhibit high power consumption required to measure and process signals from multitude of sensors. There is potential to continually measure and monitor COP motion during community walking, with systems containing sparse matrix of sensors. For orthosis users, such a system could be incorporated into the orthosis, itself. This work explores potential for implementation of such sensor system and is a part of MovAiD project, which aims at development of new generation of smart orthoses.

AIM

Use an optimisation procedure to determine the number and spatial distribution of a sparse matrix of plantar-pressure sensors to provide accurate estimation of COP trajectory.

METHODS

Barefoot walking data were collected for three able-bodied participants, using a plantar-pressure mat. Data were collected for slow (80spm), normal (100spm) and fast (120spm) cadences, controlled by a metronome. Optimisation was applied to a single step, for a single participant, at a normal walking cadence. The individual sensor cell locations of the pressure mat were used to represent the locations of where small, in-shoe sensors might be applied. COP was estimated using between four and eight ‘sensors’ and compared to that calculated by the pressure mat.

RESULTS

For the step being optimised, the best resultant root mean square error (RMSE) between the pressure mat calculation and the limited sensor estimation was 2.94mm, achieved with eight sensors. Even with only four sensors, RMSE was 4.10mm. When the same eight sensor locations were used to estimate COP for slow and fast steps of the same participant, the RMSEs were 4.04mm and 4.45mm, respectively (RMSE was increased with fewer sensors). When the eight locations were applied to another participant of the same foot size, RMSE increased to 16.2mm. When applied proportionately to a participant with a larger foot, RMSE was 54.4mm. However, upon optimisation for this larger foot size, the RMSE reduced to 3.96mm.

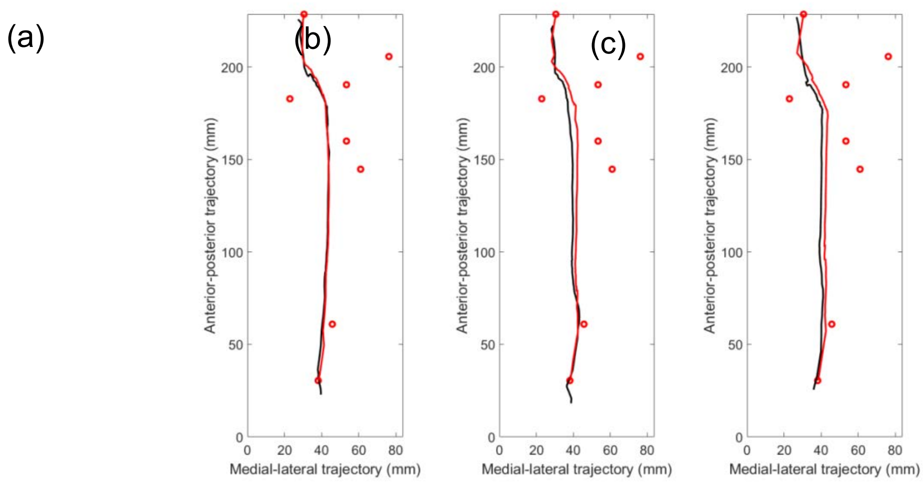

Figure 1: Optimal sensor locations (red dots) and COP prediction (red) against actual COP trajectory (black) for (a) the optimised step (b) a slow step of the same person (c) a fast step of the same person

CONCLUSION

The acceptable degree of error for COP prediction has been previously cited as 4mm in both x and y directions, or 5.6mm resultant[2]. By this measure, an optimal distribution of eight plantar-pressure sensors can be determined for an individual user, regardless of walking speed. This study suggests that this distribution will vary between users but the optimisation provides a robust method when bespoke to the individual.

The application of this research will be in the future development of orthotic insoles, as part of the MovAiD project. The long-term data provided could be used to determine patient K-levels or continuous monitoring of the efficacy of the orthotic device.

ACKNOWLEDGEMENTS

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 680754.

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Title:	**Prosthesis use outside the clinic – An objective approach**		
Presenters:	**Alix Chadwell, Medical Engineer/PhD Student, Miss**		

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A myoelectric prosthesis offers a level of functional restoration to a person with limb loss/absence. When a person with unilateral upper limb absence chooses not to use their prosthesis, they become heavily reliant on their unimpaired arm. Over time this can lead to overuse injuries; nevertheless around 30% of users reject myoelectric prostheses.

To date the main methods of evaluating user performance with a prosthesis have been clinical tests of functionality, and self-reported usage statistics (which are reliant on accurate and unbiased recall). Wrist worn activity monitors (accelerometers) offer the potential to objectively quantify use of a prosthesis outside of the clinical environment [1]. Here we report the preliminary results from a study capturing data from wrist worn activity monitors to assess myoelectric prosthesis use.

Data collection is ongoing, with a recruitment target of 20-30 unilateral trans-radial myoelectric prosthesis users and 20-30 participants with no upper limb mobility impairments for comparison. Participants wear activity monitors on both wrists (anatomical and prosthesis) for one week, allowing comparison of the amount of upper limb activity between the two arms.

Using spiral plots [1], we have visualised detailed temporal patterns of upper limb prosthesis use/non-use (e.g. regular evening removal). Initial analysis suggests that anatomically intact participants generally rely on both of their arms to a similar extent (median ≈ 50% contribution from each arm); whilst prosthesis users are heavily reliant on their intact arm (median ≈ 70-90% contribution from anatomical arm).

[1] Chadwell et al. (2017) Prosth. & Orth. Int.

Title: **The effect of a lower-limb prosthesis on skin temperature**

Presenters: **Laura E Diment, DPhil student in Engineering Science, Mrs**

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54% of prosthesis users report thermal discomfort inside their prosthetic socket, with this number even higher in warmer climates such as India. Exposed skin decreases in temperature during exercise due to changes in vasoconstriction and evaporative cooling rate. However, little is known of the effect of wearing a prosthesis. This exploratory study aimed to assess the effect of wearing a prosthesis on skin temperature in amputees in Bangalore during rest and exercise.

Following ethical approval, 24 unilateral lower-limb amputees were recruited from the Mobility India limb fitting clinic. Participants completed an exercise test on an ergometer, exercising for 2-minute intervals, with a 1-minute break between intervals. The workload on the pedals was increased every interval until the participant was unable to maintain 50 rpm or asked to stop. Skin temperature was measured using a non-contact temperature thermometer (Generation Guard, Australia – resolution 0.1˚C) on both the residual limb and on the contralateral limb at four matched locations. Temperature was recorded before and after the test, as well as during each break between exercise intervals. Participants also completed a Short-form McGill Pain Questionnaire (SF-MPQ2) before and after the trial to provide information on discomfort experienced during the trial. Difference in temperature of each location, and all locations combined, was tested between the amputated and contralateral side using two-sided paired Student's t-tests, as data followed a normal distribution. A positive relationship was expected between the measured difference between temperatures before and after exercise, and the perceived change in heat for both the amputated and contralateral side. This was tested using a Spearman correlation coefficient.

In the resting condition, whilst wearing a prosthesis, participants showed no difference in skin temperature between the amputated and contralateral legs ($p>0.05$). On average, participants were unable to exercise long enough to detect a significant change in temperature at most locations on either leg. The only locations on the amputated leg that displayed a higher temperature than the contralateral leg following exercise were the femoral epicondyles (increase of 0.45˚C, $p<0.05$). The SF-MPQ2 results showed that 33% of participants felt that their amputated limb had heated more than their contralateral limb. The Spearman correlation coefficient between perceived and measured temperature changes was $R = 0.02$ for both the amputated and the contralateral limbs, demonstrating no correlation.

Generally, there was no detectable difference in skin temperatures between the amputated and contralateral legs during rest or exercise with a prosthesis. Local shear forces between socket and skin could have contributed to local hot-spots at the femoral epicondyles. Although the measured temperature changes were minimal, and less than expected human skin thermosensitivity, amputees perceived that their residual limb had increased in temperature during the test. This suggests that the prosthesis may have influenced thermoregulation and blood flow to the muscles underlying the skin. Skin temperature may not be helpful in understanding prosthetic thermal discomfort. It is recommended that further study is undertaken to understand the thermoregulatory and heat-loss processes of the body to understand how prosthetic socket design affects thermal comfort.

Title: **Use of a hydraulically articulating versus rigidly attached prosthetic ankle-foot device improves gait and walking performance in unilateral transtibial amputees with lower activity levels**

Presenters: **Dr. Cleveland T. Barnett, Senior Lecturer in Biomechanics**

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Aims and Objectives:

Developments in prosthetic ankle-foot devices that incorporate a hydraulic articulation between the pylon and prosthetic foot are a relatively new. These devices have been shown to benefit the gait of more active (K3) lower limb amputees [1], improving progression and limb loading symmetry. Recently, it has been reported that lower limb amputees with lower activity levels (K2) self-report a preference for such hydraulically attached devices [2]. Despite this, the functional benefits of using hydraulic ankle-foot devices in unilateral transtibial amputees (UTA) with lower activity levels are yet to be determined. Therefore the aim of the current study was to compare the gait of UTAs with lower activity levels (K2) when using a non energy storing and returning foot attached with a hydraulic component, compared to the same rigidly attached foot, during level walking.

Methods:

A nine camera motion capture system and two force plates recorded three-dimensional kinematic and kinetic data respectively as five individuals with UTA, deemed K2 activity level by their prescribing physician, performed two two-minute walk tests (2MWT) followed by ten overground gait trials. Participants performed these trials under two conditions; (HYD) using a hydraulically articulating ankle foot device (Avalon^{K2}) and (RIG) using a rigidly attached ankle foot device (Navigator; both Chas A. Blatchford & Sons, Basingstoke, UK).

Results:

On average, walking speed was increased by 6.5%, when participants completed the 2MWT in the HYD condition, compared to the RIG condition (d = 0.4). Participants loaded the intact and affected limbs more symmetrically (d = 0.8), increased minimum forward centre of pressure velocity (d = 0.8), increased peak shank rotational velocity (d = 1.0) and decreased prosthetic energy efficiency (d = 0.7) when using the HYD compared to RIG device.

Conclusions:

Results from the current study show that UTAs walk faster and thus further when using a foot with a hydraulically articulating attachment when compared to the same foot rigidly attached.
This effect was consistent across all participants and supports previous reported of patient preferences for such devices.
This increase in walking speed was likely a result of a reduced braking effect in early stance phase, due to the action of the hydraulic component present in the articulating attachment, and subsequent improvement in progression. These devices may benefit the wider population of UTAs and have the potential to increase activity levels and improve the health of such individuals.

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Title:	**Articulating, hydraulic prosthetic ankles compared to rigid attachments: a literature review**		
Presenter:	**Michael McGrath, Research Scientist, Dr**		

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INTRODUCTION

Although biological ankles act as a joint, most prosthetic feet are rigidly attached to the shank-pylon and rely on the deflection of carbon foot springs to achieve 'dorsiflexion' and 'plantarflexion' effects. Over the last decade, articulating, hydraulic ankle mechanisms have been used, designed to mimic the viscoelastic behaviour of muscle.

AIM

Perform a review of published literature comparing prosthetic feet with rigid ankles (RA) and those with hydraulic ankles (HA), with respect to biomechanical measures and user perception.

METHODS

A literature search was performed using Google Scholar, PubMed and ScienceDirect. Both scientific journal papers and conference abstracts were considered. The reference lists of selected articles were checked for further relevant publications. Additional publications known to the authors were assessed and included if they were deemed relevant. Data for both transtibial and transfemoral amputees was included.

RESULTS

Twenty publications were selected for inclusion in the review – 12 journal papers and eight conference abstracts. These were subdivided into categories, dependent upon the activity levels of the participants in the study. Furthermore, a separate category was created for those HA with microprocessor-control.

With respect to moderate to high activity participants (MFCL3 and 4), compared to RA, HA produce faster, smoother and more symmetrical gait patterns. Kinematic compensations are reduced with HA during level walking and during slope descent. This leads to improved inter-limb loading symmetry at various walking speeds. The loading of the joints of the intact limb is reduced by up to 17%[1].

Prosthetic toe clearance during swing increases 18% with HA[2] and balance is improved on level and sloped ground, reducing the likelihood of falls. Socket interface pressures and loading rates are reduced by approximately two-thirds during various activities of daily living (ADLs). Users perceive improvements, notably so among bilateral amputees.

With respect to low activity participants (MFCL2), inter-limb symmetry of stance phase timing improves with HA compared to RA, while users perceive significant improvements in prosthesis and gait satisfaction.

More recently, microprocessor-control has been used to further adapt the hydraulic resistances. During slope descent, stability improves while improving symmetry with the biological ankle. During ramp ascent, walking speed, prosthetic toe clearance and inter-limb symmetry all increase. The effects of microprocessor-control HA have been shown to be reproducible over time.

CONCLUSION

Compared to RA mechanisms, HA provide beneficial biomechanical effects which may help to reduce the risk of falls, improve long-term joint health and decrease the likelihood of pressure ulcer development. Furthermore, these benefits are perceived by users across a range of functional mobility levels. Microprocessor-control of HA devices can further enhance stability and reduce gait compensations, particularly on sloped ground.

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Title: **Advanced prosthetic components improve standing balance and limb load symmetry for transfemoral amputees**

Presenter: **Michael McGrath, Research Scientist, Dr**

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INTRODUCTION

Studies have shown that lower limb amputees, particularly transfemoral amputees (TFA), have reduced balance control during quiet standing, and rely disproportionately on their sound limb for support[1]. In recent years, microprocessor knees (MPK) have sought to assist TFAs with enhanced standing support. Other prosthetic components, such as articulating, hydraulic ankles have shown to improve standing balance in transtibial amputees, on level and inclined surfaces[2].

METHODS

A mixed cohort of K2 and K3 TFAs (n=3), along with able-bodied controls (n=3), volunteered for this study. Each TFA was fitted with an MPK with enhanced standing support (Orion3, Endolite). Two different prosthetic feet were tested in a randomised order; a hydraulic ankle (HA – Echelon, Endolite) and a rigid ankle (RA – Elite, Endolite). The participants stood facing down a 5° slope for 15 second periods at a time. For the TFAs, four conditions were performed: standing support on and off for each of the two feet. Both participant and experimenter were blinded as to whether standing support was activated. The ground reaction force (GRF) and centre-of-pressure (COP) under each foot was measured and compared for symmetry. Kinematics were recorded to identify compensatory strategies.

RESULTS

For the fixed ankle foot, the activation of standing mode improved vertical GRF degree of asymmetry (DOA) between the intact and prosthetic limbs from 14% to 3%. GRF DOA in the anterior-posterior direction (down the slope) also improved from 36% to 3%. At the joints, the intact ankle and knee moments were reduced by 28% and 38%, respectively. In terms of balance, although there was no significant difference in COP RMS under the prosthetic foot, with standing mode active, this factor was reduced under the intact limb, indicating a balance improvement.

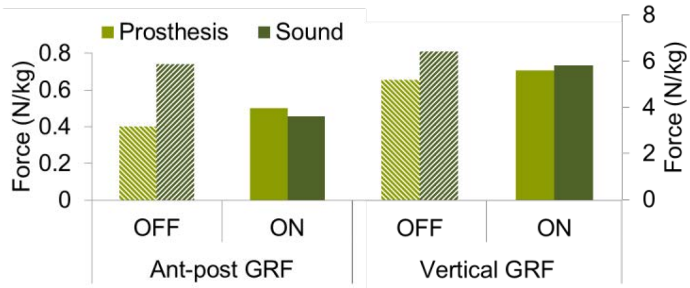

Figure 1: Mean load distribution with enhanced standing support active (ON) and deactivated (OFF)

The addition of an HA was shown to enhance the benefits of standing mode. When compared to the RA with standing mode active the RA required more kinematic compensations. As a result, the hydraulic ankle reduced the moments at the intact ankle (8%), knee (7%) and hip (45%). COP RMS beneath the prosthesis decreased.
Of the four prosthetic conditions, the combination of standing support active and an HA brought the TFA results closest to those of the control participants.

CONCLUSION

Enhanced standing support improves indices of balance and symmetry of loading for TFAs, during quiet standing on sloping ground. These advantages are further augmented when used in combination with a hydraulic ankle.
Improvements in balance are beneficial for TFAs, as they are particularly susceptible to the risk of falling. Symmetrical loading is believed to help combat the development of back pain, osteoarthritis and osteoporosis.

SIGNIFICANCE

The prescription of advanced technology could be beneficial to a patient's quality of life by reducing the likelihood of falls injuries and comorbidities associated with long-term prosthesis use.

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DISCLOSURE

The authors are employees of the manufacturer of the prosthetic components tested in this research.

Title: **Amputee activity-monitoring through non-invasive prosthetic foot spring deflection measurements**

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INTRODUCTION

Since steady-state walking is only one aspect of human locomotion[1], recently, with developing sensor technology, there has been a shift from gait analysis towards activity monitoring[1,2] for determining the effectiveness of a prosthetic intervention. Common, market-leading activity monitors use motion sensors to count steps and categorise levels of activity during normal community living.

AIM

Design and test a non-invasive method for long-term activity monitoring that uses direct load-based measurements.

METHODS

Two piezo-electric sensors were placed on the carbon-fibre heel and toe springs of a trans-tibial amputee's prosthetic foot. Data were collected for self-selected slow, normal and fast walking velocities, as well as for walking up and down a 5° ramp. The number of steps was manually counted by the participant and investigators, individually. Each condition was repeated. The first set of data was used to develop an algorithm for step identification and classification, while the second set was used to test the success of the algorithm.

RESULTS

In the preliminary investigation, the system detected 203 out of 204 steps taken and identified one false positive. Both the missed step and the false positive occurred at gait termination during slope walking. For each step, the cadence could be quantified and thus the slow, normal and fast walking bouts could be classified as such, albeit with some crossover due to the speeds being 'self-selected' rather than stringently controlled.

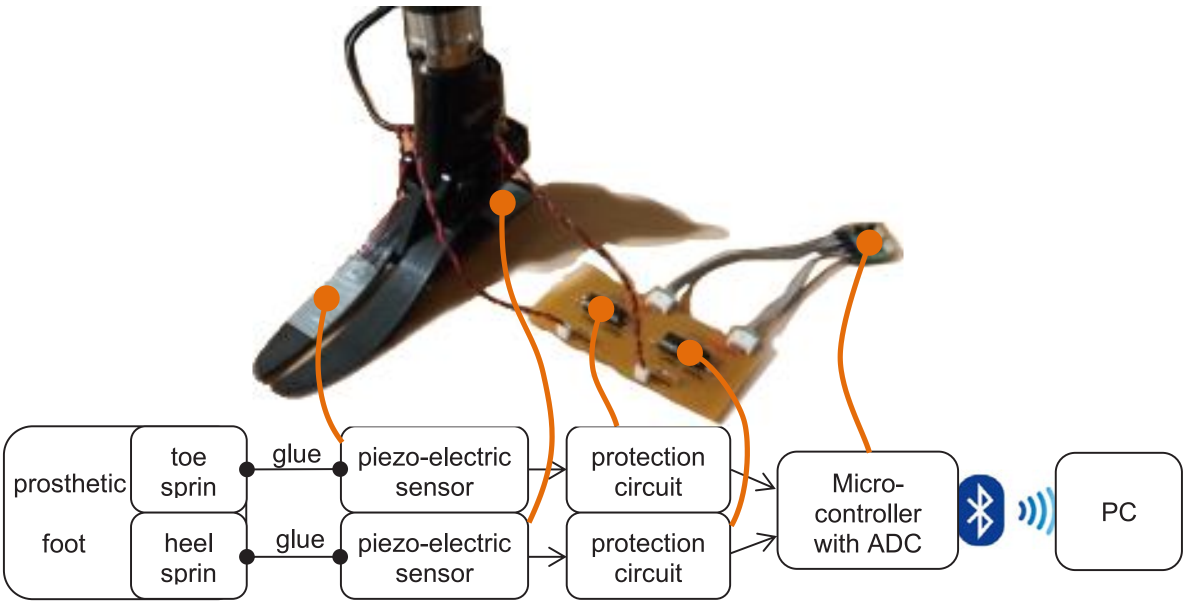

Figure 1: The developed activity monitoring system attached to prosthetic foot springs

From this initial testing, the system can calculate 15 out of 27 metrics provided by the market-leader. If worn for an entire day, the system could provide all 27 metrics. Additionally, this system showed potential for differentiating between walking gradients and direction.

CONCLUSION

The results from this preliminary development testing provided proof-of-concept for step identification and long-term patient monitoring. Future testing ought to focus on long-term monitoring in a less controlled environment, validating the results of the developed method against those measured by a market-leading device.

The system could also be exploited in other ways. There was good potential for speed/environment classification, which could potentially be integrated into current microprocessor prostheses to provide extra data for decision making. In addition, since the underlying technology relies on foot spring strain, rather than inertial measurements, it could potentially be utilised as an alignment assistance tool.

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Poster Exhibition

"The clinical justification for an independently mobile young transradial amputee undertaking 4 week inpatient rehabilitation at specialist amputee centre"
Ms J Barnes, Amputee Physiotherapist, Guy's & St Thomas' NHS Foundation Trust, London

"Clinical reasoning in the provision of prosthesis in amputee rehabilitation"
Mrs R Bettinelli – Amputee Rehab Unit Specialist Physiotherapist, Guy's & St Thomas' NHS Foundation Trust, London

"Effects of Transtibial Amputation on Neuromuscular Function of the Quadriceps"
Ms A R Sibley, Research Student, University of Roehampton, London

"The need to assess risk of Osteoporotic Fractures in Elderly Diabetic lower limb amputees"
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"A Review of Free-to-Use Observational Gait Analysis Applications for Mobile Devices in the Field of Prosthetics and Orthotics"
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Notes

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