Clinical Gait Analysis in the Management of Post Polio Syndrome

Presenter: Dr Denis RW May, Clinical Scientist
Contact Address: Kings College Hospital Rehabilitation Centre, Bowley Close, Farquhar Road, London, SE19
Tel: 020 7346 5252
Fax: 020 7347 5234

Introduction: Crystal Palace Rehabilitation Centre has since the gait facility opened in 1997 been compiling a Database of some 7200 sets of clinical measurements on very many patient groups. Measurements have been recorded on 818 Patients ranging from 3.7 - 97 years of age; these include 383 Prosthetic patients (all levels), 175 Orthotic patients, 112 other Rehabilitation Patients as well as 148 “Normals”. The above cases include nine patients (7 males and 2 Females) who have been referred to assist in the management of the Late Problems of Polio, so called Post Polio Syndrome. Polio is now virtually extinct, the last serious outbreak in Europe occurred in the 1950s and in China in the late 1970s. The late problems include muscle atrophy, joint instability and progressive weakness with increased chronic fatigue. Treatment includes intensive Physiotherapy and Occupational therapy with Orthotic interventions. Surgery includes Osteotomies, Arthrodeses, the Chinese Bone Block and joint replacements. Amputation and Muscle Transfers are rarely successful.

Method: Rigorous protocols are always adhered to such that comparisons between different runs and indeed different patients can be achieved, taking into account the individual capabilities of each patient. The database of clinical measurements also allows comparisons with peers and cohorts and even comparisons within the bands or range of Normalcy.

Results: In all the nine cases gait analysis successfully showed where excessive loading was exacerbating the joint stresses and resulting in unsustainable moments. Tuning of the prescribed Orthotic Devices, Orthopedic Shoes and Insoles has resulted in improved load distribution and weight transfer. The prescription of a Dictus Band in one male case greatly increased his mobility and reduced the fatigue of walking. In the female amputation case, fit and alignment of the prosthetic appliances marginally improved the mobility of the patient. In one severe case where joint instability resulted in recurvatum of some 80° and mobile varus of some 20° gait analysis predicted the appropriate angles for the orthopedic surgeon to reconstruct the mechanical axes of the limb. This resulted in a dramatic improvement in the mobility of this patient and a quantum advance in his daily activities. These cases will be discussed before and after gait intervention and comparisons made. As polio is a progressive degeneration all are reviewed annually where any progression of the condition can be monitored.

Conclusions: Clinical Gait Analysis has proved to be an essential tool in the optimization of the complex problems associated with Polio. The difficulties of obtaining fine tuning in complex Ankle Foot Orthoses, and the associated Orthopaedic footwear and insoles are really only possible with the use of Force Vector Visualisation. This has led to very significant improvement in the mobility of these patients, a reduction in the progressive fatigue problems and therefore an improvement in their daily activities.


The Assessment of Mechanical Properties of Insole Materials Under Normal Simulated Use

Presenter: Chakradhar R Birudavolu, Orthopaedic Surgeon (MCh (Orth)), Dr
Contact Address: Institute of Motion Analysis and Research (IMAR), TORT Centre, Ninewells Hospital and Medical School, DUNDEE, DD1 9SY
Tel: 01382 496332
Fax: 01382 496347
E-Mail: chakrivinatha@yahoo.com

Other Authors: GP Arnold, Bioengineer, IMAR, University of Dundee, Mr
TS Drew, Lecturer - Bioengineer, IMAR, University of Dundee, Dr
RJ Abboud, Director of IMAR - Bioengineer, University of Dundee, Dr

Background: Shock absorbing insoles have proved to be effective in the treatment of various foot pathologies; especially in people with diabetes and sports injuries. They have been in clinical use for a long time. Many studies in the past have evaluated the efficacy of insoles with considerable discrepancy in their outcomes. Most of the studies were conducted using new insoles. Very few studies looked at the long-term performance of insoles after prolonged usage.

Aims & Objectives: The aim of the present study was to assess the mechanical properties of commonly used insole materials under normal simulated use. The objectives of the study therefore are to investigate the rigidity/compliancy and shock absorbency of each insole material and to compare them accordingly, over a period of 50,000 cycles, by using a Universal Testing Machine.
Materials & Methods: Six insole materials [Astroshock, Plastazote, Poron, Professional Protective Technology (PPT), Evazote (EVA), Noene] were tested for repeated compressions by using a Universal Testing Machine. The force versus strain curves of the insoles were recorded at various cycles up to 50,000 cycles of compression. This approximately equates to 12 hours of continuous walking or 10 - 12 weeks of walking in a normal person. The compliance of the material was assessed by measuring the gradient of the curve. By measuring the area underneath the force/strain curve, the amount of shock absorbed by the insole material was calculated.

Results: Amongst all materials tested, Astroshock was shown to be the best shock absorber (excluding Plastazote and Evazote).

Conclusions: All the materials tested showed deterioration of shock absorbency and compliance with repeated compressions, with marked variations in between. Accelerated degradation of properties was found in the first 5000 cycles of compression, with more gradual deterioration thereafter. The compliance of the insoles was not uniform throughout the loading cycle. Insoles were more compliant in the early phase of the loading cycle and more rigid in the latter part. Astroshock was found to be the most promising shock absorbing insole, even after 50,000 cycles of compression. Evazote was the least shock absorbing material amongst all tested. Poron was the least rigid material.

Shoes influence lower limb muscle activity and may predispose the wearer to lateral ankle ligament injury

Presenter: R Kerr, Medical Student, University of Dundee, Mr
Contact Address: Institute of Motion Analysis and Research (IMAR)
TORT Centre, Ninewells Hospital and Medical School
DUNDEE DD1 9SY
Tel: 01382 496332 Fax: 01382 496347
Email: r.z.kerr@dundee.ac.uk

Other Authors: GP Arnold, Bioengineer, IMAR, University of Dundee, Mr
TS Drew, Lecturer - Bioengineer, IMAR, University of Dundee, Dr
L Cochrane, Statistician, IMAR, University of Dundee, Dr
RJ Abboud, Director of IMAR - Bioengineer, University of Dundee, Dr

Introduction: The lateral ankle ligaments are perhaps the most frequently injured structures in an athlete’s body, and are stressed by weight-bearing on an inverted foot. Foot position is controlled by the lower limb muscles and awareness of it is impaired by wearing shoes (Robbins et al. 1995). Therefore, the aim of this study was to determine the influence of wearing shoes on lower limb muscle activity.

Methods: Electromyography (EMG) was used to record evertting peroneus longus muscle activity in response to sudden, unanticipated inversion of the ipsilateral foot to 10° and 20°. The apparatus, with one footplate rotating in the frontal plane for each of the subjects’ feet, was driven by compressed air to rotate at 100°/s, with the degree of angulations controlled by a computer software program which also collected EMG data. The study design was a cross-over. Each of the 62 subjects, all with no previous or existing ankle injuries, underwent the same sequence of footplate movements, both barefoot and in shoes, in a random order.

Results: Following inversion of the foot the EMG signal showed an initial peak in amplitude followed by a sustained contraction of constant amplitude. Both these parameters were significantly greater when wearing shoes compared to being barefooted for all degrees of inversion; from 0-10°, 0-20°, and 10-20°. The reaction time of peroneus longus was unaffected by wearing shoes.

Conclusions and recommendations: The force of muscle contraction following sudden inversion of the foot is significantly greater when wearing shoes compared to being barefooted. Shoes increase the tendency of the foot to invert. Therefore, this greater muscular contraction may be an intrinsic mechanism to resist the increased tendency to injure the lateral ankle ligaments created by wearing shoes. It has been proposed that the proprioceptively impaired increase their muscle activity to stiffen body posture (Bloem et al. 2002). Shoes impair foot positional awareness (Robbins et al. 1995), so this may also account for the increased muscle activity observed whilst wearing shoes. Future footwear developments should minimise any proprioceptive impairment created by wearing shoes.

References:
Plantar pressure measurements were recorded from under the heel, across the forefoot and under the great toe. Differences were seen between walking and running trials on a treadmill. No significant difference was observed between shoes and test occasions in terms of comfort.

Results: Plantar pressure measurements were recorded from under the heel, across the forefoot and under the great toe. Differences were seen between models and between brands in relation to cost. The medium and high cost models from Brands A and B provided better pressure attenuation under the heel. Increasing pressure was recorded with rising cost from Brand C. Brand A performed better than Brands B and C under the forefoot. Increasing pressure under the great toe was registered from Brands A and B with rising cost. The opposite was seen from Brand C. Shoe performance was comparable between walking and running trials on a treadmill. No significant difference was observed between shoes and test occasions in terms of comfort.

Conclusions: Each of the brands performed differently with changes in cost. Therefore, no definitive conclusions with relation to cost and comfort could be made across all three brands. However, it would appear that running shoe performance is not always related to cost. In other words, spending more money on a pair of running shoes will not necessarily mean that they are better than cheaper alternatives from the same brand.

Analyses of Prosthetic Episodes in Trans-femoral Amputees

The provision and maintenance of prostheses in a 100 trans-femoral amputees was retrospectively analysed over a 10 year period. The aim of the study was to assess the need for repairs and replacements to a trans-femoral prosthesis. The study intended to answer the following questions. On an average over a 10 year period how often did a trans-femoral prosthesis need replacing? How frequently were major or minor repairs carried out? Were there variations of requirements depending on the age of the amputee?

A retrospective case note review was carried out. The inclusion criteria for the study was:

1) Unilateral trans-femoral amputee
2) Age >16 years
3) Patients were using a trans-femoral prosthesis for at least 10 years at the time of the study. The amputees had to be attending the DSC at Stanmore between 1993 and 2002.

Over the 10 year period of the study the Trans-femoral amputees needed 0.96 new prostheses, 2.31 major repairs, 3.36 component changes, 21.85 minor repairs and 3.15 new sockets. Younger patients needed significantly more component changes (p=0.40)

The most significant finding of this study was that the trans-femoral amputees in this study needed an average one new prosthesis every ten years. They needed either a major repair or replacement of major components every 2 years, a new socket every three years and at least 2 minor repairs a year. It was evident during data collection that some amputees attended the DSC far more frequently than others. However by calculating an average for a 100 amputees over a 10 year period we were able to arrive at an approximate estimation of the prosthetic needs of a trans-femoral amputee. This information can be of relevance to patients, their employers, and providers of prostheses as well as for the purpose of costing insurance claims.

References

Datta D, Vaidya SP, Alsindi Z. Analyses of Prosthetic episodes in trans-tibial amputees. Prosthetics and Orthotics International 1999; 23:9-12
Effects of advanced multidisciplinary interventions in prosthetic rehabilitation – Can they be measured? A Pilot Study.

Presenter: Toby Carlsson, Prosthetist/Orthotist, Mr

Contact Address: PACE Rehabilitation Ltd 36 Brook Street Cheadle SK6 5PG

Tel: 0161 4285500 Fax: 0161 4285853

E-mail: tcarlsson@pacerehab.com

Other Authors: Richard R Hirons, Prosthetist, Ernest R E Van Ross, Dr

The authors have established a multidisciplinary amputee rehabilitation service that primarily treats clients whose amputations are connected with trauma. Treatment is often funded by accident insurers that are liable to restore the victims to as close to their pre-accident status as possible. A common scenario is that initial prosthetic rehabilitation is provided locally within the NHS with later interventions from a team including and managed by the authors. Interventions are typically multidisciplinary and include provision of prostheses. They are individually tailored, focused and often intense. Anecdotal evidence from clients indicates such interventions are of considerable value. Until recently, there has been no objective evidence collected to confirm this. Such evidence will not only aid in the planning of programmes, but may also demonstrate to payers that interventions have tangible value.

The aim of the pilot study was to investigate if the impact of interventions can be identified in objective measurements. Such measurements would need to record changes in the characteristics of the prosthesis and its use, as well as any change in the subject’s perception of his/her situation. A literature review was undertaken and two data collection tools were chosen. The PAM (Patient Activity Monitor), having been validated for use with prostheses (J Bussman et al, 2004), was used to measure changes in prosthetic characteristics and use. The Trinity Amputation and Prosthetic Experience Scales (Gallagher and MacLachlan, 2000) was used to measure any change in the subject’s perception of their situation. Potential subjects were recruited and where consent was obtained, they were enrolled. The PAM was applied according to the manufacturer’s instructions and TAPES questionnaire completed by the subject prior to treatment commencing. The process was repeated again within six months of the intervention finishing and the results analysed for the population as a whole and for the individual subjects.

The results of the pilot study indicate that it is possible to measure changes resulting from an intervention of advanced prosthetic rehabilitation. The PAM results pertaining to use and characteristics of the prosthesis, including step count, level of impact, step length and walking speed, provided a variety of useful indicators of prosthetic use. The TAPES results appear to mirror the PAM readings although the number of subjects has been too small for any statistical analysis to be carried out. The knowledge gained during the execution of the study assisted in further defining a protocol to be used for similar measurements on a larger population in the future. This should be of interest to clinical teams in amputee rehabilitation in general and is of considerable importance for the type of organisation within which the authors operate. It is noteworthy that these measurements do not relate to any one individual factor of the treatment but only measured the effect of the intervention as a whole.

References


Qualitative description of turning gait, through 90°, in amputee subjects

Presenter: Mr MJD Taylor, Biomechanics PhD student

Contact address: School of Human and Life Sciences, Roehampton University, Whitelands College, Holybourne Avenue, London SW15 4JD, UK.

Tel: + 44 (0)20 83923546 Email: S.Strike@RUS.ROEHAMPTON.AC.UK

Other authors: Dr SC Strike* -

The ability to turn is a requirement for full functional mobility, and the ability to turn rapidly is required when avoiding obstacles. Those studies that have reported turning gait have traditionally labelled a turn away from the ipsilateral limb (stance), as ‘step-turn’, (i.e. land left turn right, land right turn left) and a turn toward the ipsilateral limb as a ‘spin turn’ (i.e. land left turn left, land right turn right). However, it has become apparent from the literature that confusion exists with such terminology. This maybe due to the lack of qualitative descriptions accompanying the vast majority of turning gait research. The aim of this study was to qualitatively analyse both amputee and able-bodied (AB) subjects performing both the ‘step turn’ and the ‘spin turn’. From this it was hoped a clearer description of turning gait could be developed and establish if amputees turn using similar strategies to AB.

Five male trans-tibial amputees (age 43.6 ± 7.5 years) volunteered and all wore their own prosthesis. Ten AB subjects (5 male and 5 female, age 22.8 ± 5.2 years) acted as a control for comparison. All subjects were instructed to perform 12 abrupt 90° turns toward the left and right.

A conventional step turn was performed by eight of the ten AB subjects for all trials when performing the step turn. When performing the ‘spin turn’, six of the ten subjects didn’t spin, these turns were labelled ‘ipsilateral crossover’ and the remaining four subjects did use a spin, were labelled ‘ipsilateral pivot’. For the amputee subjects, varied turning strategies were employed from a 2-step strategy to those similar to AB (table 1).
<table>
<thead>
<tr>
<th>Prosthetic side</th>
<th>Intact side</th>
<th>Prosthetic side</th>
<th>Intact side</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 step turn</td>
<td>2 step turn</td>
<td>2 step turn</td>
<td>2 step turn</td>
</tr>
<tr>
<td>2 step turn</td>
<td>AB 'ipsilateral pivot'</td>
<td>2 step turn</td>
<td>AB 'ipsilateral pivot'</td>
</tr>
<tr>
<td>Step-pivot†</td>
<td>AB 'ipsilateral pivot'</td>
<td>Attempted 'ipsilateral pivot'</td>
<td>Attempted 'ipsilateral pivot'</td>
</tr>
<tr>
<td>Step-pivot†</td>
<td>AB 'ipsilateral pivot' amputated limb</td>
<td>Attempted 'ipsilateral pivot'</td>
<td>Attempted 'ipsilateral pivot'</td>
</tr>
</tbody>
</table>

Table 1. Turning strategies of all amputees (A). † Pivot became more pronounced during trials.

The amputee subjects showed a more varied spread of turning strategies compared to AB, and between and within subjects (intact vs. amputated). The intact side was generally similar to the AB population, however a step-pivot strategy, not seen for the AB was employed by 2 of the amputees on the intact side (A4, A5). When employing a one step turning strategy, amputee turning was generally asymmetrical and will be dependent upon the prosthesis’ ability to restrain tibial advancement, and rotate toward the new direction. The two-step strategy for A1 and A2 suggests that these amputees could not perform an abrupt turn on the prosthetic side; instead stability was more of a concern. A two-step turn on the intact side (A1) suggests that the amputated limb in swing was unable/unwilling to be swung completely into the new direction. These findings emphasise the importance of firstly incorporating quantitative analysis into turning gait, and secondly analysing amputees as single subjects. Future work is underway analysing the three-dimensional biomechanics of these turns to establish how and why amputees turn differently from AB and from each other.

The experience of wearing an upper limb prosthesis following amputation

Presenter: Adam Saradjian, Trainee Clinical Psychologist, University of Sheffield

Contact Address: 168 Thompson Hill
High Green
Sheffield
S35 4JW

Tel: 0114 284 5164 E-mail: asradj@aol.com

Other Authors: Dr D Datta, Consultant in Rehabilitation Medicine, Northern General Hospital NHS Trust, Sheffield
Dr Andrew Thompson, Clinical Psychologist & Senior Lecturer, Clinical Psychology Unit, University of Sheffield

The aim of the study was to gain an ‘insider perspective’ of what it is like to have an upper limb amputation and wear a prosthesis.

The qualitative method of Interpretative Phenomenological Analysis (IPA) was employed. In line with this methodology, purposive sampling was used to recruit participants. Semi-structured interviews were carried out with eleven males who had undergone unilateral upper limb amputations and who wore their prosthesis at least weekly. The average age of participants was 52 years old and the average time between amputation to the time of interview was 28 years.

All the participants in the study may be considered to have positively adjusted to their amputation. The predominant theme underlying the impact of the amputation was an ongoing awareness of a difference in their physical appearance to other people and some sense of being ‘disabled’. Consequently participants identified two themes of adjustment: functional and psychosocial. Functionally, participants described the process of adaptation, which included a process of compensation by means of their prosthesis, an increased use of the intact arm, the assistance of technology and employing problem solving cognitive strategies. Participants’ successful functional adaptation was exhibited in their apparent high self-efficacy and perception of self as independent. This was particularly important to participants’ sense of worth. Psychosocially participants described how some adjustment was made to their social relationships, interactions, recreational activities and occupations. An important cognitive element was apparent in successful psychosocial adjustment. The prosthesis was integral to the majority of participants’ adjustment as it concealed their difference, facilitating a ‘normal’ appearance. A further theme concerned the role of the prosthesis and the terms of its use. The process of adjustment to the prosthesis itself was highlighted which for some culminated with the prosthesis becoming integrated to their body image. Some of the practical problems related to prosthesis and their limits were also identified. Indeed participants pattern of use of their prosthesis may be considered in terms of a continual cost-benefit analysis. The last major theme to emerge was the coping style of participants that facilitated such positive adjustment. Participants exhibited very positive and accepting attitudes. Participants engaged in life without much restriction and demonstrated an openness to new experience and possibilities. Participants also tended to engage with services who they saw as responsive to their needs. It was also evident how participants’ pride in their positive adjustment also contributed to their sense of worth.

Prostheses played a fundamental role in facilitating participants’ positive adjustment to upper limb amputation through reducing the difference in appearance and ability that such amputation causes. Also of fundamental importance is the positive coping style that people adopt. These findings have implications for the clinical rehabilitation of patients who undergo upper limb amputations, as well as for future research into the use and value of prostheses in facilitating the adjustment to this experience. These will be discussed along with the limits of the research.
The Psychosocial Implications of Lower Limb Amputation and Prosthetic Rehabilitation

Presenter: Dr. Teresa O’Reilly, Pre-Registration House Officer, Contact Address: 97 Blackness Road, Dundee DD1 5 PD
Tel: 01382 201952 E-mail: teresaoreilly@hotmail.co.uk

Project Supervisor: Mr Amar Jain, Consultant Orthopaedic Surgeon, Ninewells Hospital and Medical School, Dundee

Aims and Objectives: The aim of this study was to assess the psychological and social implications for patients having undergone a lower limb amputation, who were subsequently fitted with a prosthesis. Though amputee care is presently of a high standard, it was proposed that the psychological welfare of patients and social difficulties they may encounter following their amputation, may possibly be neglected once their initial medical treatment is completed. This study covered various aspects of post-operative amputee care and daily living, with a view to identifying areas that the amputees felt required modification in not only the medical and Professions Allied to Medicine field but in their local environment too, in order to provide an even better approach to their future management.

Areas assessed included: prosthesis satisfaction; how the patients rated their current physical ability and their capacity for social involvement/interaction; their use of public transport services; inpatient and outpatient care/support from the various members of the multidisciplinary team; the impact their amputation had on their psychological wellbeing; behavioural modification in response to the amputation and lastly, a few questions related to phantom limb pain.

Methods Used and Study Subjects: A questionnaire concerning the psychological and social difficulties facing patients having had a lower limb amputation was piloted to patients within the regions of Tayside and Fife, Scotland. Questionnaires were distributed either by being directly handed out at Outpatient Clinics in the Tayside Orthotics and Rehabilitation Technology Centre, Ninewells Hospital, or by being posted to patients’ home addresses. The questionnaires were anonymous and posted back to the project supervisors’ office at Ninewells Hospital, Dundee. The questionnaires were coded into the spreadsheet computer programme Microsoft Excel, and analysed. The statistical analysis was kept simple, using 95% confidence intervals.

The study subjects were patients (male and female) aged 55 to 75 years with either a transfemoral or transtibial amputation, within the past 12 months. 48 possible participants were identified.

Results Summary: 29 of the 48 questionnaires that were piloted were returned (60% response rate). 69% of the patients were either satisfied or reasonably satisfied with their prosthesis, though only 55% actually found their prosthesis comfortable. 41% considered their physical ability to be excellent or very good, with 86% feeling confident in the use of their prosthetic limb. 32% felt either very or often limited in their ability to participate socially and 56% have some degree of difficulty using public transport, with 31% not using any at all since their amputation. 67% felt that all, or most, of their problems were addressed by the multidisciplinary team post-amputation, and lastly 72% of subjects experienced phantom limb pain, which improved in 40% in the months following amputation.

Conclusions/Recommendations: Care of the patient having had an amputation, with regard to the psychosocial implications is of a high standard within Tayside and Fife, though several areas require consideration to further improve patient care and satisfaction.

Effects of Lycra® pressure garments on children with cerebral palsy.

Presenter: Jes Attard B.Sc (Hons), Senior Orthotist, Mr Contact Address: Orthotics Department, Royal National Orthopaedic Hospital, Brockley Hill, Stanmore, Middlesex, HA7 4LP Tel: 0208 909 5418 Fax: 0208 385 7652 E-mail: Jes.Attard@rnoh.nhs.uk

Other Author: Shyam Rithalia Ph.D, Reader, University of Salford

Aims and Objectives: Lycra® pressure garments are being used in the management of cerebral palsy to enhance proprioceptive feedback and improve function as well as mobility (Blair et al, 1995; Edmondson et al, 1999). However, it is still not known whether they affect the physiology of the wearers, or if the forces applied on the body can be altered by varying the garment design. The present study investigated the changes in interface pressure (IP), temperature, humidity and skin blood flow (SBF) at the patient-garment interface.

Method: Initially, a total of seventeen children with cerebral palsy participated in the study. Their ages ranged from 5.5 years to 14.4 years (mean ± SD, 9.6 ± 2.8 years). Each child was fitted with a garment that was suitable for his/her needs. One child had to be withdrawn from the study as he needed to
Power Knee: A Bionic motorised prosthetic knee joint

Presenters:  
**Kim De Roy**, MSc PT, BSc P&O,  
**Richard Hiron**, MSc SRPons MBAPO

Contact Address  
Ossur Hf  
Grjóthals 5  
Reykjavík  
Tel: +354 664 1007  
Fax: +354 515 1366  
E-mail: kderoy@ossur.com  
Iceland

The vision of powered lower limb prosthetic joints capable of self monitoring, autonomous function and true internal and environmental adaptability is one that is now ready to enter the mainstream clinical arena. The 'Power Knee' is a prosthetic knee joint that provides mechanical power to replace knee joint kinematics and compensates for lost muscle power and control allowing unprecedented function for transfemoral amputees.

A motorised actuator generates power according to the users need to adequately endure different portions of locomotion. Portions requiring specific power management are level ground walking, stair ascent and descent, ramp ascent and descent, sitting down and raising from a chair. The actuator operates in both an eccentric and concentric manner substituting muscular effort during these types of activities.

Powered function demands new control and monitoring systems. Actions of the Power Knee are partially controlled by sensory data collected from the sound side. High and low level layers of artificial intelligence operate to continuously observe the state of the whole human/system interface. Finally, a user interface (software) is available for individual fine tuning of the prosthesis during the different portions of locomotion. Adjustments can be made based on inter-individual anthropometrical differences, personal physical conditions and the level of required or actual rehabilitation.

Laboratory and external testing has illustrated areas such as periods of adaptation required, level of rehabilitation attainable, user ability to trigger appropriate portions of locomotion and the functional benefits. In a preliminary study with 10 unilateral healthy transfemoral subjects aged between 20 – 65 years, the functional advantages were listed as sustained prosthesis comfort for longer distances, gait quality, cadence change adaptation, support/assistance during incline walking, increased walking speed, ability of reciprocal step ascent and general system stability during ambulation over irregular terrain. This was after a period of adaptation in an uncontrolled home environment whereby the user adapt to using an active prosthesis. A second protocol investigated the ability to trigger the various portions of locomotion. Different subjects demonstrated various levels of ability, the most complex being stairs related. Gradual increase in the power provided by the prosthesis led to earlier adaptation and progression through the programme. Another investigative protocol looked specifically at the time required for the user to obtain full control of the prosthesis to perform and complete all different portions of locomotion. On average subjects require 3-4 sessions totalling 7-9 hrs of supervised training in a controlled environment.

It is concluded that the Power Knee is a new concept that requires a new approach to user training and gait re-education. It offers unprecedented functional possibilities irrespective of the users’ initial ability to execute new tasks of varying complexity. Testing continues to evaluate the robustness, repeatability, usability and stability of the Power Knee.
Holy Grail of Prosthetic Foot Design

Reviewer: S Zahedi, Bioengineer

Contact Address: Chas A Blatchford & Sons Ltd
Innovation Centre, U6, Sherrington Way, Basingstoke, RG2 2LU
Tel: 01256 316601 Fax: 01256 810540 E-mail: SaeedZ@blatchford.co.uk

Other Authors: G Harris; Design Engineer, C Smart; Design Engineer, A Evans Polymer Scientist, J McCarthy; Prosthetist, J Ross; Prosthetist

Review of current prosthetic feet has identified further new challenges for the design engineers to address the needs of the today’s amputee. Prosthetic feet can store and return energy during walking and running to enhance rehabilitation and restore lost function. Over 50 years ago with introduction of SACH feet, it was possible to address the cushioning requirements in stance phase of gait as well as stance support during dorsiflexion. By mid 70s the evolution of feet design was benefiting from multiaxial rotation and ability to comply with uneven ground. In the 80s the replacement of the rigid keel with resilient material for the first time enables some form of strain energy collection and return. It was in 90s that carbon fibre feet were rapidly became acceptable devices capable of shock absorption and assisting propulsion.

During 2005 a review of energy storing concepts by researchers from Seattle USA (2) showed the need for better understanding of the nature of Heel and Keel action during walking and running action. Review of several researches, which compared many common advanced feet, showed deficiencies in many of the concepts and the main inability to closely match the performance of the feet to the amputee’s activity, weight and lifestyle. Their review identified the energy intake in ankle joint, the efficiency of springs in the form of power time curve and developed an evaluation system for categorisation of Heel and Keel design.

The combination of the need for independent heel and keel findings - alongside the requirements of ideal foot design as explained at ISPO World Congress 2004 keynote lecture (1) identified the need for shock absorption, ground compliance and propulsion, matched to optimum geometric configuration for rolling action - for the first time enabled designers to draw the basic requirements of an advanced energy storing foot. Taking into account many novel features in the few innovative devices in the market, it was possible to identify the specification for shock absorption for heel transient removal as well as enhancing rollover to dorsiflex the foot and maximise the energy provided by the ankle dorsiflexion moment, thereby capturing the full strain energy created for later release at late stance. The next challenges was to provide an accurate means of identifying the requirements of the individual and match the selection of independent heel and keel to the amputee’s need. This was achieved through a series of field trials and gait analysis studies for validation of the findings.

The principal of design and biomechanical factors considered in creation of concept were verified by review of ground reaction forces. Several research programs investigated the sensitivity of selection guidelines and the effect on the amputee. The results from six amputees where the selected keel and heel were challenged and higher and lower rated values were trialled on amputees and the gait pattern of each pair of selections compared for maximum energy storage and return and maximum efficiency of the spring. A new guidelines for selection to match amputees life style is created.

References:
1- ISPO World 11th World Congress Hong Kong July 2004 Keynote lecture by Dudley Childress, The Technical Dimensions of Innovations. The approach of the Engineer Working to improve Prosthetic and Orthotics