The Bipedal Exchange

Official Organ of the American Academy of Orthotists and Prosthetists Gait Society

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Gait Society Mission: To promote gait analysis as a method for advanced clinical care and research and to further educate orthotists, prosthetists and other medical professionals about the analysis and treatment of gait disorders in order to improve the functional abilities of physically challenged individuals in our community.

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Letter from the Editor

Dear Members,

Thank you very much for the positive response that we received for reviving *The Bipedal Exchange*. During the Gait Society business meeting, several suggestions for the content of this newsletter were offered. We did our best to incorporate those suggestions and encourage our members continue to give us their feedback.

The purpose of *The Bipedal Exchange* is to educate on gait analysis basics, inform about innovations in devices and research, and facilitate communication among Gait Society members. A list of Gait Society members may be found on the following webpage: http://www.oandp.org/assets/upload/SocietyGait.html.
In order to ensure a balanced viewpoint and varied content, I urge you all to contribute articles that support the purpose of this newsletter. Submissions may be emailed to me directly at tchou@orthocareinnovations.com.

This newsletter is created by volunteers of the Gait Society. The views expressed in *The Bipedal Exchange* are those of the authors and not necessarily those of the American Academy of Orthotists and Prosthetists.

Best Regards,

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New Gait Society Officers & Advisory Committee

Chairman: Sue Ewers, CPO
Vice Chairman: Peter Harsch, CP
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Ed Ayyappa, CPO, FAAOP
Gary King, CPO
Stefania Fatone, PhD
John Russell, CPO, FAAOP
Ray Burdett, PhD, PT, CPed
Sander Nassan, CPO, FAAOP

We are very thankful for their interest in contributing to the Gait Society. Officers will be selected every two years with the start date of July 1st.

Abstracts of Guest Lecturers at the 2008 Academy Annual Meeting Sponsored by the Gait Society

Prosthetics and Orthotics through Instrumented Gait Assessment
Facilitator: Ed Ayyappa, CPO, FAAOP

This Gait Society Symposium addressed the purpose and interpretation of instrumented gait analysis as applied to prosthetic and orthotic use. Unfortunately, Dr. Kenton Kaufman, PhD, PE, was unable to present his research at the symposium, but his abstract is included with our presenters, Dr. Stefania Fatone, PhD, BPO and Mr. Russell Ward, CPO.

Presentation 1: Outcome Measures in Prosthetics Research

Kenton R. Kaufman, Ph.D., P.E.
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The current emphasis in medical disciplines is on evidence-based medicine. Evidence-based medicine requires a bottom up approach that integrates the best external evidence with health care provider clinical expertise and patient choice to provide individual patient care. Practice guidelines need to be developed which draw upon various domains of outcome science to aid the decision making process of the practitioner regarding appropriate health care for specific clinical patients.

In 1993, the National Center for Medical Rehabilitation Research (NCMRR) of the National Institutes of Health proposed a conceptual model (Figure 1) for judging the impact of medical treatment on a patient with chronic disability [1]. The individual is considered to be the primary focus of this model. The model presents five areas (pathophysiology, impairment, functional limitation, disability, and societal limitation) which overlap and demonstrate impact on a person with disability as well as impact on others.

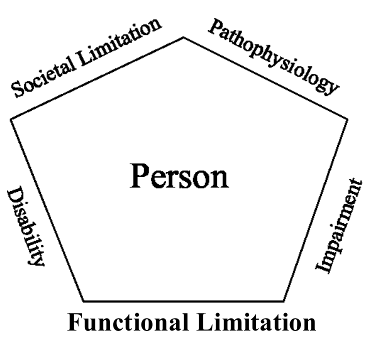

Figure 1. Model of Disablement

This conceptual model can be applied to an individual with an amputation who wears prosthesis. The pathophysiology which led to the amputation may be a traumatic injury, or as a result of a physiological process such as diabetes or bone cancer. The resulting impairment is the loss of a limb. This leads to functional limitation in terms of gait and mobility. The resultant disabilities are activity limitations and participation restrictions. Societal limitations may result. For example, without financial assistance to purchase prosthesis, an immobile individual may not be able to get to the work site, and thereby reduce chances of employment.

Typically, objective quantification a treatment effect in prosthetics research has focused on measuring joint motion or energy consumption to verify biomechanical or physiologic changes. However, the model of disablement challenges clinicians to look beyond functional limitations alone and ask whether the individual functions better or experiences less disability in their daily life as a result of the interventions. Suitable outcome measures exist to assess functional limitations, disability, and societal limitations (Table 1).

Table 1. Outcome measures in prosthetics research

Domain	Outcome measures
Functional limitation	Gait, balance, energy consumption
Disability	Activity level (steps/day, total daily energy expenditure)
Societal limitation	Questionnaire (SF-36, PEQ)

Functional limitation can be assessed with three complimentary techniques. Three dimensional motion analysis provides a tool to assess functional parameters such as velocity, stride length, joint kinematics, and joint kinetics. Balance can be assessed with computerized dynamic posturography. Energy consumption measurement using indirect calorimetry provides an estimate of the physiological demand placed upon the individual during locomotion. A prosthetic intervention which lowers functional limitations should demonstrate improvements in gait and balance along with less energy consumption for locomotion. These improvements should result in reduced disability for the individual. Disability can be measured by monitoring the activity level during daily activities. Currently, devices are available to measure activity by counting steps per day. A gold standard for measuring activity level is doubly labeled water which provides a direct measurement of total daily energy expenditure. An improved prosthetic outcome would be signified by an increase in activity level. Finally, societal limitations can be assessed through questionnaires. Health related quality of life questionnaires are either general or disease specific. The general health questionnaire allows comparisons to be made across diseases, but this type of instrument is not specific to a disease or type of treatment. The Symptom Factor-36 (SF-36) general health questionnaire is the most frequently used health status measure in the United States. The appropriate disease specific questionnaire for prosthetic studies is the Prostheses Evaluation Questionnaire (PEQ). Hence, outcome measures exist to assess a range of domains relevant to outcome in persons using a prosthesis.

Reference: [1]. National Institutes of Health: Research Plan for the National Center for Medical Rehabilitation Research, 1993. Bethesda, MD.

Presentation 2: Assumptions and Limitations of Gait Models: Application to Prosthetics and Orthotics.

Stefania Fatone, PhD, BPO (Hons)
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A model is an idealized representation of an object or process developed in order to predict or gain insight into a mechanism or function [1]. The general goal of a model is to be as simple as possible while still capturing enough behavior of the system to enhance understanding. Assumptions used to help simplify the system being modeled introduce errors into the calculations. Errors may be classified as follows: (1) marker errors, (2) issues involving segment length, (3) issues involving joint assumptions, and (4) issues involving anthropomorphic data [1]. Errors may be larger when prostheses and orthoses are used if segment lengths vary (e.g. shock absorbing pylons), joint motion does not occur where expected (e.g. prosthetic feet with solid ankles), joints are not ideal hinge or ball-and-socket joints (e.g. four-bar-linkage knee joints), and/or masses vary from anthropometric data (e.g. wearing a knee-ankle-foot orthosis). Marker location and the device/components being tested must be described in sufficient detail if data are to be interpreted appropriately.

Many of the models used in gait analysis are based on an idealized link-segment model. Motion is measured and then joint torques estimated using inverse dynamics [2]. Skin-mounted markers are used to define segments: two markers can be used to define a line (2D), while three markers are used to define a plane (3D). For gait analysis, the model typically de-fines foot, shank, thigh and pelvic segments. Segments may be defined using markers placed over key anatomical landmarks (as in the Helen Hayes marker set [3]) or by using marker triads (as in the Cleveland Clinic marker set [4]). Joint centers are then calculated from the markers. In 2D experiments, markers are often assumed to lie over joint axes, whereas in 3D, the calculations are more complex and can vary by joint. For example, algorithms have been developed that calculate the location of the hip joint center from the relationship between anatomical landmarks established initially by imaging studies [6].

Given a rigid link model of the lower limbs, the motion of the segments and the ground reaction force, joint angles, angular velocities, segmental velocities and accelerations, forces and joint moments can be calculated. Calculations are performed from the ground up starting with the foot. However, this inverse-dynamics technique has many assumptions [7] including that the length of each segment remains constant; the joints are frictionless, ideal hinge or ball-and-socket joints; and the mass moment of inertia of each segment is constant.

These assumptions are important to understand when applying inverse dynamics to normal human locomotion as well as to ambulation with prosthetic and orthotic devices and may lead to a number of limitations. For example (1) the foot and trunk are not well represented with only a single rigid segment and few joints are represented well by a simple hinge or ball-and-socket mechanical systems/components may also not be truly rigid, e.g. the limb-socket interface, especially when pistoning is present; (2) only net joint moments can be calculated, which does not take into account muscle co-contractions or joint contractures; (3) joint forces cannot be meaningfully interpreted since, for example, muscle co-contractions can create joint compressive forces much greater than the calculated values; (4) cannot take into account storage of elastic potential energy by muscles and tendons; (5) joint centers are calculated from markers placed on the skin, which is known to move relative to the underlying skeletal structure.

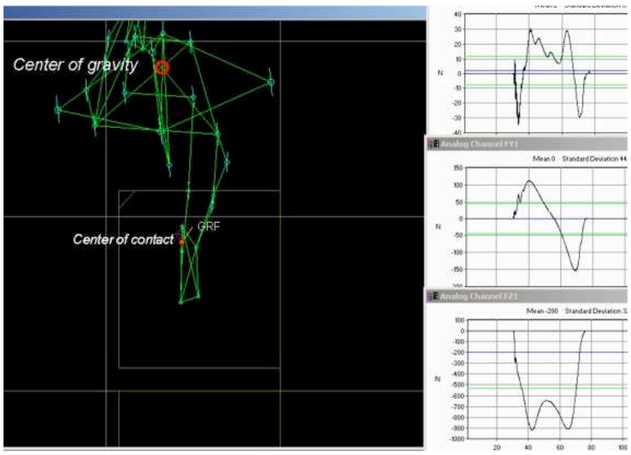
Ultimately, the assumptions inherent in our gait analysis models lead to errors in the measurement of motion. For example, where should markers be placed when anatomical landmarks are obscured by an orthosis? What is being measured when markers are distributed between an orthosis and the anatomical limb? Unstable joints, as may occur with hip dislocation or certain congenital deficiencies, may not only alter segment length but also the assumption that joints are ideal hinges. Anthropometric data used in many models is generally based on average adult male cadavers but children have different mass distributions. The presence of bony deformity may also affect mass distribution as will the presence of prostheses or orthoses. These issues will be presented and discussed.

References: **[1]** Miller L. Gait model basics: assumptions and limitations for P&O. In: AAOP Advanced Training Course: Overview of Gait Analysis for Prosthetists and Orthotists, 2004. **[2]** Bresler B, Frankel JP. Trans ASME, 1950;27-36. **[3]** Kadaba M, et al. J Orthop Res, 1989;7:849-60. **[4]** Castagno P. Gait Posture 1995;3(2):87. **[5]** Orthotrak Reference Manual, Motion Analysis Corporation, Santa Rosa, CA. **[6]** Davis RB, et al. Hum Mov Sci, 1991;10:575-87. **[7]** Winter DA. Biomechanics and Motor Control of Human Movement, 2nd ed, John Wiley & Sons, Inc., NY, 1990.

Presentation 3: Three-Plane Function of the Foot

Russell Ward, CPO
VA Medical Center, Long Beach, California, USA

Function of the foot in bipedal gait can be divided into three stages: shock absorption, stabilization, and propulsion. During gait, the foot converts from a flexible, adaptive mechanism to a rigid structure, while body weight progresses over its area of support. This presentation examines how these mechanisms work and how they may be compared to componentry used in the fabrication of prostheses and orthoses. The presentation is almost entirely graphical. The three-dimensional nature of force and motion vectors is presented, in conjunction with stick-figure animations derived from motion analysis on live, normal subjects. New, more technical material related to maintenance of the center of gravity over the base of support is also presented. Rearfoot bone structure and motion is reviewed in an animated, graphical format. Finally, the presentation includes video documentation of a case study showing a unilateral BK amputee walking on a modified composite pylon.



How to Perform a Literature Search

For those interested in learning about advances in orthotics and prosthetics research, a scientific literature search is needed. However, not everyone has been taught how to find scientific literature. The most common place to go is the PubMed database:
http://www.ncbi.nlm.nih.gov/sites/entrez?myncbishare=uutahlib&holding=uutahlib_fft.

To search this database, type in your keywords of interest and separate your keywords with an "and", "or", or "not". An example would be "c-leg and amputee." A keyword can be a subject or author. If you wish to search by author, only type the last name and the first and middle initial if you know it (i.e. Hafner, Hafner B, or Hafner BJ). If you get too many articles, you may further narrow your search by adding more keywords and/or going to the limits tab. Under limits, you may specify a date range, type of article, and other choices.
Another good database for research is Google Scholar: http://scholar.google.com/. This search engine will assume that there is an "and" between all keywords. If you wish to search for phrases or authors, you should consider using the advanced scholar search option.

Google Scholar more often will link you to an online full article whereas PubMed may only lead you to the abstract if you are not on a server that subscribes to journals. If you would like to read the full article of an abstract not available to you online, you can usually pay for it ($25 - $35) or see if your local library can get it cheaper through the interlibrary loan option. If you have friends connected to a University or hospital, he/she may be able to get the article for you for free.

Recommended Reading

Topic 1: Balance Deficiencies
The individuals we work with most of the day have balance deficiencies. One of the goals of our lower extremity orthosis or prosthesis is to improve the balance and prevent falls. Can we measure the effectiveness of our service? A number of clinical outcome measures have been developed. You can learn more about them in a number of books and articles. Here are some options:

Physical rehabilitation outcome measures.
2^{nd} ed. Finch, Brooks, Stratford and Mayo
http://www.amazon.com/Physical-Rehabilitation-Outcome-Measures-Elspeth/dp/0683180029/ref=sr_1_1?ie=UTF8&s=books&qid=1214178694&sr=8-1

Assessment of balance control in humans. Winter DA, Patla AE, Frank JS. http://www.ncbi.nlm.nih.gov/pubmed/2138696?ordinalpos=4&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_RVDocSum

In this article, Winter describes the fundamentals of balance control and initiates the discussion of its assessment. Maintaining the center of gravity (COG) within the base of support (BOS) is of primary importance during stance; however, during a dynamic activity such as walking the COG passes in-and-out of the BOS as we move from single-limb-support to double-limb-support. Thus, Winter states, the walking person is in a 'continuous state of imbalance'.

Topic 2: Validity and Reliability of Balance Measures
With the increased need for outcome assessment and clinical measures, there also comes the need to validate the measures we use. Listed are a several articles that have evaluated the validity and reliability of balance measures:

Reliability of clinical measures used to assess patients with peripheral vestibular disorders. Hall CD, Herdman SJ http://www.ncbi.nlm.nih.gov/pubmed/16796772?ordinalpos=3&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_RVDocSum

Reliability, internal consistency, and validity of data obtained with the functional gait assessment. Wrisley DM, Marchetti GF, Kuharsky DK, Whitney SL. http://www.ncbi.nlm.nih.gov/pubmed/15449976?ordinalpos=4&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_RVDocSum

Unipedal stance testing as an indicator of fall risk among older outpatients. Hurvitz EA, Richardson JK, Werner RA, Ruhl AM, Dixon MR. http://www.ncbi.nlm.nih.gov/sites/entrez

Gait assessment in the elderly: a gait abnormality rating scale and its relation to falls. Wolfson L, Whipple R, Amerman P, Tobin JN. http://www.ncbi.nlm.nih.gov/pubmed/2295773?ordinalpos=7&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_RVDocSum

A systematic review of mobility instruments and their measurement properties for older acute medical patients. de Morton NA, Berlowitz DJ, Keating JL. http://www.ncbi.nlm.nih.gov/pubmed/18533045?ordinalpos=2&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_RVDocSum

Usefulness of the Berg Balance Scale in stroke rehabilitation: a systematic review. Blum L, Korner-Bitensky N. http://www.ncbi.nlm.nih.gov/pubmed/18292215?ordinalpos=5&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_RVDocSum

Prognostic validity of the Timed Up-and-Go test, a modified Get-Up-and-Go test, staff's global judgement and fall history in evaluating fall risk in residential care facilities. Nordin E, Lindelöf N, Rosendahl E, Jensen J, Lundin-Olsson L http://www.ncbi.nlm.nih.gov/pubmed/18515291?ordinalpos=1&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_RVDocSum

The reliability and validity of the Four Square Step Test for people with balance deficits secondary to a vestibular disorder. Whitney SL, Marchetti GF, Morris LO, Sparto PJ.

http://www.ncbi.nlm.nih.gov/pubmed/17207683?ordinalpos=2&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_RVDocSum

Concurrent validity of the Berg Balance Scale and the Dynamic Gait Index in people with vestibular dysfunction. Whitney S, Wrisley D, Furman J. http://www.ncbi.nlm.nih.gov/pubmed/14730722?ordinalpos=1&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_Discovery_RA&linkpos=2&log$=relatedarticles&logdbfrom=pubmed

Are measures employed in the assessment of balance useful for detecting differences among groups that vary by age and disease state? Brotherton SS, Williams HG, Gossard JL, Hussey JR, McClenaghan BA,Eleazer P. http://www.ncbi.nlm.nih.gov/sites/entrez

Multiple balance tests improve the assessment of postural stability in subjects with Parkinson's disease. Jacobs JV, Horak FB, Tran VK, Nutt JG. http://www.ncbi.nlm.nih.gov/sites/entrez

Selected Vocabulary Terms

From North American Society for Gait and Human Movement (1993) and the Academy's Gait Society (1994)

1. **Stance phase (ST):** The period of time when the foot is in contact with the ground. Approximately 62% of the GC.
2. **Swing phase (SW):** The period of time when the foot is not in contact with the ground. In those cases where the foot never leaves the ground (foot drag) it can be defined as the phase when all portions of the foot are in forward motion. Approximately 39%of GC.
3. **Double support (DS):** The period of time when both feet are in contact with the ground. This occurs twice in the gait cycle, at the beginning and end of stance phase. Also referred to as left and right double limb stance or LDLS and RDLS respectively. For example, LDLS refers to the DS after left initial contact.
4. **Single support (SS):** The period of time when only one foot is in contact with the ground. In walking, this is equal to the swing phase of the other limb.
5. **Terminal contact (TC):** The point in the gait cycle when the foot leaves the ground: this represents the end of the stance phase or the beginning of swing phase. Also referred to as foot off. Toe off should not be used in situations where the toe is not the last part of the foot to leave the ground. Note: For those cases of pathology where the foot never leaves the ground (foot drag), the termination of stance and the onset of swing may be somewhat arbitrary. The termination of stance and the onset of swing are defined as the point where all portions of the foot have achieved motion relative to the floor. Likewise, the termination of swing and the onset of stance may be defined as the point when the foot ends motion relative to the floor.

Literature Review Summary

Literature Review Summary
Article title: Gait characteristics of persons with bilateral transtibial amputations
Author(s): Po-Fu Su, MS; Steven A. Gard, PhD; Robert D. Lipschutz, CP; Todd A. Kuiken, MD, PhD.
Journal: Journal of Rehabilitation Research & Development
Page (& volume) numbers: Pages 491–502: Volume 44, Number 4
Month & year of publication: 2007

1. **Problem statement:** Due to an absence of published quantitative

gait analysis research, there is a limited understanding of the gait characteristics and the unique patient needs of persons with bilateral transtibial amputations.

2. **Objectives:** The author notes that the "data presented in this article were actually collected as baseline information for a more comprehensive study on the effect of prosthetic ankle mechanisms in persons with bilateral transtibial amputations".

3. **Significance:** Information gained from quantitative gait analysis of individuals with bilateral transtibial amputation will illuminate "deficiencies in current prosthetic componentry" and help lay a foundation for further research that could drive improvement in prosthetic function and gait training.

4. **Methods:**
    a. *Participants:* 19 bilateral transtibial amputees were recruited from "clinics and prosthetic fitting centers in the Chicago metropolitan area". Due to the small available population the inclusion criteria were broadened. These inclusion criteria required participants to be "a minimum of 2 years post-amputation and an independent, functional ambulator with no serious medical conditions or physical symptoms of musculoskeletal, cardiac, or other significant health issues". Participants were evaluated for proper prosthetic fit prior to the study, but no conditions were placed on age, weight, height or residual limb length.
    b. *Prosthetic Components:* A CPO fitted each subject with Seattle Lightfoot II prosthetic feet two weeks prior to quantitative gait analysis. This is a commonly used dynamic response foot with a Delrin keel and no articulating ankle joints.
    c. *Gait Data Acquisition:* Collection and analysis of data took place at the Department of Veterans Affairs (VA) Chicago Motion Analysis Research Laboratory (VACMARL) with an eight camera Motion Analysis Corp system (EvaRT at 120 Hz) and six AMTI forceplates (at 960 Hz). Participants were instructed to ambulate at a freely selected walking speed, their fastest comfortable walking speed and their slowest comfortable walking speed. The participants were allowed to rest at any time during the 10-15 trials at each speed where data were collected. Joint moments and powers were calculated using OrthoTrac software.
    d. *Data Analysis:* Participant data were compared to 14 nondisabled control subjects already on file in a lab database. In order to account for the factor of a generally slower natural gait speed in amputees when compared to that of nondisabled persons the researchers decided to

compare the slow walking speed of the nondisabled controls to the freely selected pace of the bilateral transtibial amputee after discovering there was no significant difference between the two.

5. **Results/Discussion:** The speed-matched comparison showed the bilateral transtibial amputees walked with less stance-phase ankle dorsiflexion, less stance-phase knee flexion, reduced peak ankle plantar flexion moment, and less ankle power generation than nondisabled controls. The researchers also observed increased hip power generation during early to midstance and at the time of toe off as well as greater pelvic obliquity and bilateral hip hiking during swing phase, which they connect to increased energy expenditure.

   The researchers were surprised to find stance and swing phases that were symmetrical comparable to the nondisabled controls. This opposes the gait characteristics found in unilateral amputees "who typically demonstrate a longer stance phase, shorter swing phase, and shorter step length on the sound side compared with the prosthetic side."

   An outcome of concern to the authors was the hip motion on the trailing leg of the bilateral transtibial amputee during loading response (LR) on the opposite side. They observed the pelvis being elevated during this stage as opposed to the pelvic drop observed in most nondisabled gait patterns. They argued that this abnormal pelvic motion in combination with reduced stance phase knee flexion decreases shock absorption and may increase ground reaction force (GRF) magnitude. This is clinically relevant if there is an increased risk for osteoarthritis of the knee in bilateral transtibial amputees as a result.

   The authors proposed that use of multiaxial prosthetic ankles could help mitigate the lack of ankle motion and increased hip power generation requirements of the amputee gait and contribute to a more stable and efficient gait pattern in bilateral transtibial amputees. In conclusion, the authors called for additional studies to "further identify prosthetic deficiencies and ultimately develop solutions for improving gait in persons with amputations".

6. **Reviewer's comments:** The research team managed to collect and analyze an impressive amount of data. They mentioned this study was a precursor to a forthcoming study comparing various prosthetic ankle components. Since this study limited the participants to one type of dynamic response foot with no articulating ankle components there is a question whether the results can be generalized to the population of bilateral transtibial amputees. The subsequent study ought to shed more light on this.

   The factors that made this an ambitious and pioneering study also provided some limitations. The authors acknowledged limitations and provided solid justification for method of control; however the potential influence of some limiting factors was left for debate. The authors did well to make their case while acknowledging there may be some disagreement.

The most obvious factor is the discrepancy in average age between the amputee and control groups. The average age was 52.8 years for the bilateral transtibial amputees as opposed to an average age of 26 years for the nondisabled control group. One would assume that age could influence gait characteristics especially related to stability and metabolic cost. The authors pointed to studies which have shown the male gait is typically unchanged through the age of 60 (28. Blanke DJ, Hageman PA. Comparison of gait of young men and elderly men. Phys Ther. 1989;69(2):144–48.[PMID: 2913584]). Of course the question remains as to whether or not the study cited can be generalized to include bilateral transtibial amputees, or female bilateral transtibial amputees.

Speed matching data from the freely selected amputee gait with the slow nondisabled walking speed was a creative and effective method of control. The authors addressed concerns about the potential influence of using the nondisabled slow walking speed as a baseline for gait analysis data: "One concern about the use of data from the slow walking speed of nondisabled individuals is that this gait pattern may not necessarily reflect their most energy efficient gait. However, data from Waters and Yakura indicate that nondisabled individuals can walk across a relatively broad range of speeds with little variation in their metabolic energy cost".

One final concern is what role the use of a single prosthetic foot type had on amputee gait. In a clinical setting Prosthetic foot choice is always tailored to help the patient achieve their most stable, efficient and comfortable gait. There may have been participants who just don't do well in the Seattle Lightfoot II and will not grade out well when gait efficiency is measured. The Seattle Lightfoot II is a dynamic response foot that should be used for amputees at K-level 3 or 4. The condition for participant inclusion of "independent, functional ambulator" most likely means no participant was at least a K-level 3, but a discussion of this matter for clarity might be helpful to the reader.

This was an illuminating study, which could be extremely useful in the fields of prosthetics and physical therapy. The researchers must be credited for dealing with the very challenging issue of population sample availability. They should also be commended for finding creative ways to maintain reliability and validity.

Reviewed By – Greg Ferguson, UW P&O Student, Class of 2009
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(7/3/08)

Job Positions in Gait Analysis

If you wish to advertise a job position among Gait Society members, please pass on a brief announcement to *The Bipedal Exchange* Editor, Teri Chou: tchou@orthocareinnovations.com.

Guidelines of posting job positions:
1) Academic positions can be posted. These can include faculty positions, technical personnel, and graduate assistantships.
2) Company positions can be posted. However, please do not include text that can be considered an advertisement for the company's products or services.
3) Recruiting firms cannot post in this newsletter.