Clinical Relevance for the Veteran

SUMMARY OF SCIENTIFIC/TECHNICAL PAPERS IN THIS ISSUE

Energy Expenditure During Ambulation in Dysvascular and Traumatic Below-Knee Amputees: A Comparison of Five Prosthetic Feet.

Leslie Torburn, MS, PT; Christopher M. Powers, MS, PT; Robert Guiterrez, MD; Jacquelin Perry, MD *(p.111)*

Purpose of the Work. Dynamic Elastic Response (DER) prosthetic feet are reported to help persons with amputation walk by reducing the amount of energy required. The purpose of this study was to determine if there were any differences in energy expenditure between the DER feet and the traditional SACH foot. **Subjects/Procedures.** Nine traumatic and seven dysvascular amputees participated in this study. Each subject underwent energy cost testing while wearing five different prosthetic feet (SACH, Flex-Foot, Seattle, Quantum, and Carbon Copy II). A 1-month accommodation period was given for each foot prior to testing. **Results.** There were no differences in energy cost or rate of energy expenditure between any of the prosthetic feet tested. The traumatic amputees had a similar energy cost compared to the dysvascular amputees; however, the rate of energy expenditure was higher in the amputee group. **Relevance to Veteran Population.** This study shows that there is no apparent energy cost savings with the DER feet compared to the traditional SACH foot. This implies that the DER feet do not address the loading of the amputated limb which has been shown through electromyography (EMG) to be the greatest period of muscular demand.

Christopher M. Powers, MS, PT

Gait Initiation of Persons With Below-Knee Amputation: The Characterization and Comparison of Force Profiles.

Stephen A. Rossi, BSME; William Doyle, MS; Harry B. Skinner, MD, PhD *(p. 120)*

Purpose of the Work. Persons with below-knee amputation compensate for lost ankle function in their performance of activities of daily living, especially for the complex task of gait initiation. The goals of this study were to characterize the forces involved in gait initiation and identify the effects of prosthetic alignment. **Subjects/Procedures.** Seven males with below-knee amputation were recruited through the VA Medical Center, San Francisco. These subjects underwent gait initiation trials while varying prosthetic alignment. Force data were collected for each initiation. **Results.** Significant asymmetries were found in the force profiles of the amputated and non-amputated limbs; forces were consistently higher for the prosthetic limb. Changes in prosthesis alignment proved not to have significant effects on generalized force parameters. **Relevance to Veteran Population.** With the large Veteran amputee population, our results indicate that efforts should be directed toward persons with amputation in the early stages of gait training before asymmetries become habits.

Harry B. Skinner, MD, PhD

Prediction of Metabolic Energy Expenditure During Gait From Mechanical Energy of the Limb: A Preliminary Study.

Scott A. Foerster, MS; Anita M. Bagley, PhD; C. Dan Mote, Jr., PhD; Harry B. Skinner, MD, PhD *(p. 128)*

Purpose of the Work. Energy consumption of persons with transfemoral amputation during walking is an important determinant of the maximum distance and speed they can achieve. It would be convenient if relatively easily measured variables, such as the mechanical motions of a prosthesis during gait, gave reliable information about more difficult measurements, such as total metabolic energy consumption. This study was designed to determine if measurement of the energy of prosthesis motion was a reliable indicator of amputee energy consumption. **Subjects/Procedures.** Metabolic oxygen consumption during gait was measured for four transfemoral amputees. And, the work done by their prostheses was determined by measuring the motions and masses of the prosthesis. **Results.** Mechanical work done by the subjects' prostheses was not a good indicator of metabolic oxygen consumption for these amputees. **Relevance to Veteran Population.** While larger numbers of subjects may demonstrate a relation between these variables, the relation is not good enough to be used in managing the rehabilitation of persons with transfemoral amputation.

Harry B. Skinner, MD, PhD

Effects of Thigh Soft-Tissue Stiffness on the Control of Anterior Tibial Displacement by Functional Knee Orthoses.

Stephen H. Liu, MD; J. Michael Kabo, PhD; Aaron Daluiski, MD *(p. 135)*

Purpose. To examine the effects of thigh stiffness (thigh muscle bulk) on the ability of commercial custom functional knee orthoses to control anterior tibial displacement. **Subjects/ Procedures.** Stiffness of the human thigh was measured in 10 competitive, 10 recreational, and 10 sedentary subjects. Three soft tissue analogs were reconstructed with soft and ridged foam layers with similar soft-tissue stiffness as the subjects. The soft-tissue analog was applied to the surrogate knee for testing of the functional knee orthosis. During testing, one of the soft-tissue analogs was randomly selected and attached to the surrogate knee femur and a randomly selected orthosis was applied to the surrogate limb. Anterior tibial forces ranged from 25 to 200 N applied at 25 N increments, and the anterior tibial displacement was recorded following application of each force. Using the sequence, each orthosis was tested 11 times for each soft tissue analog. The anterior tibial displacement at each applied force was recorded. The entire sequence of 11 trials was repeated for the four different custom knee orthoses. **Results.** All three soft-tissue analogs on the control of anterior tibial displacement were variable for the different braces; however, in general, the least stiff soft-tissue analog resulted in greater anterior tibial displacement, especially at high forces. Townsend and DonJoy custom orthoses showed a decrease in average tibial displacement with increasing stiffness at all forces measured. **Relevance to Veteran Population.** Anterior cruciate ligament injuries are common among the young active veteran population. Custom knee orthoses have been used to control knee instability. However, no studies have looked at the effect of improved quadriceps muscle strength and bulk with the use of functional knee orthoses. In our study, we have demonstrated that increased thigh soft-tissue stiffness will facilitate a functional knee orthosis in reducing anterior tibial displacement. Thus, in order to employ the functional knee orthosis most effectively, rehabilitation to improve quadriceps strength and bulk will be important not only for older persons with less muscle mass, but also for persons with quadriceps atrophy following surgery as well as those deconditioned athletes. Physicians should consider this information when prescribing a custom functional knee orthosis to an ACL deficient or ACL reconstructed knee person who plans to engage in strenuous activities.
Stephen H. Liu, MD

Volumetric Determinations With CAD/CAM in Prosthetics and Orthotics: Errors of Measurement.

Magnus Lilja, CPO, LMS and Tommy Öberg, MD, PhD *(p. 141)*

Purpose of the Work. During the next decade, CAD/CAM technique will probably become routine in prosthetics and orthotics, not only as a complement to manual techniques, but also in introducing new possibilities. However, even complex and sophisticated techniques have errors of measurement that must be considered. Such errors are of two principal kinds: systematic errors and random errors. **Subjects.** None. **Procedures.** In the present study, the Swedish CAPOD system has been evaluated with respect to volumetric determinations. Two types of reference objects were used for volume determinations: cylinders and amputation stump models. Three different sizes were examined for each type of object. Volume measurements with CAPOD were compared with volumes obtained by water immersion or mathematical calculation (cylinders only). **Results.** A constant, linear systematic error of +2.5% was found. Such an error can easily be corrected for. The random error, represented by the coefficient of variation, was 0.5%, which means that there is a theoretical possibility of detecting volume changes exceeding 1%. We considered the precision sufficient for clinical practice in prosthetics and orthotics. **Relevance to Veteran Population.** As the CAD/CAM technology is making entry into the fields of prosthetics and orthotics, it is of great importance that such systems are evaluated for accuracy and precision. The present study fulfills such a need.
Magnus Lilja, CPO, Lic Med Sci

An Animal Model and Computer-Controlled Surface Pressure Delivery System for the Production of Pressure Ulcers.

Richard Salcido, MD; Steven B. Fisher, PA-C; James C. Donofrio, PhD; Mark Bieschke, BS; Charles Knapp, PhD; Rongzhao Liang, MD, PhD; Edmund K. LeGrand, DVM, PhD; John M. Carney, PhD *(p. 149)*

Purpose of the Work. In order to better serve patients who develop bed sores, it is important that the medical

community learn more about their causes. Bed sores have been a persistent problem resulting in additional suffering and sometimes death in the patients who develop them. The economic costs to society are also high. Unfortunately, the scientific study of bed sores in a medical setting is often impossible due to their complex nature, patient considerations, and the difficulty in finding adequate control subjects. The development of an animal model for the study of bed sores avoids many of these problems and allows us to safely study how bed sores form. **Subjects/Procedures.** An animal model was developed for the study of bed sores. Rats were selected as the animal of choice because so much is known about their body chemistry and the effects of drugs on them. Computer control is used to achieve a highly controlled and closely monitored environment. **Results.** The computer-controlled model is described. Bed sores were consistently produced after five daily, 6-hour pressure sessions. The model is reliable and inexpensive and produces early bed sores over the hips, which allows us to study how bed sores form. The importance of the model and a review of the literature is discussed. **Relevance to Veteran Population.** Bed sores are an important health care problem with a major impact on large segments of the veteran population, including the aged and individuals with spinal cord injury.
James C. Donofrio, PhD

Experiments in Dysarthric Speech Recognition Using Artificial Neural Networks.
Gowtham Jayaram, MS and
Kadry Abdelhamied, PhD *(p. 162)*

Purpose of the Work. In order to facilitate the use of speech recognition technology by individuals with dysarthria, the recognition system must account for the high variability in dysarthric speech. The present study employs artificial neural networks for this purpose. **Subjects/Procedures.** Speech utterances produced by an individual with cerebral palsy were recorded and used to train and test two networks. The recognition rates of the networks were evaluated against the intelligibility ratings obtained by human listeners and also against the recognition rates obtained by the Introvoice commercial speech recognition system. **Results.** The networks successfully recognized dysarthric speech despite its large variability. The networks outperformed both the human listeners and the Introvoice commercial system. **Relevance to Veteran Population.** This study demonstrates the usefulness of neural networks in developing an effective speech recognition system for individuals with dysarthria. For dysarthric individuals with physical disabilities resulting from cerebral palsy, traumatic brain injury, stroke, and other neurogenic disorders, such a system is needed for computer access, environmental controls, and communication.
Kadry Abdelhamied, PhD