Clinical Relevance for the Veteran

SUMMARY OF SCIENTIFIC/TECHNICAL PAPERS IN THIS ISSUE

The Effect of Five Prosthetic Feet on the Gait and Loading of the Sound Limb in Dysvascular Below-Knee Amputees

Ronald D. Snyder, MD; Christopher M. Powers, MSPT; Catherine Fontain, MPT; Jacquelin Perry, MD *(p. 309)*

Purpose of the Work. Certain types of prosthetic foot components have been reported to reduce the ground reaction forces during walking. The purpose of this study was to determine the effects of prosthetic foot design on the forces experienced by the sound and amputated limbs in a group of dysvascular below-knee amputees. **Subjects/Procedures.** Seven dysvascular amputees participated in this study. Each subject underwent motion, forceplate, and stride analysis while wearing five different prosthetic feet (SACH, Flex-Foot, Seattle, Quantum, Carbon Copy II). A 1-month accommodation period was given for each foot prior to testing. **Results.** All foot components resulted in greater sound loading forces compared to normal, except for the Flex-Foot which resulted in significantly lower forces. **Relevance to Veteran Population.** These results suggest that the intact lower limb is susceptible to excessive floor impact, and that prosthetic foot design can have an effect in reducing these forces. This has significant implications for this population as increased loading may contribute to the development of sound limb problems.
Christopher M. Powers, MS, PT

Design Methodology for a Multifunctional Hand Prosthesis

Robert Vinet, DSc; Yves Lozac'h, BSc; Nicolas Beaudry, BEng; Gilbert Drouin, PhD *(p. 316)*

Purpose of the Work. Major functional prehensile weaknesses are generally associated with the pincer type conventional hand prosthesis. This study explains how our research team managed to design a new multifunctional hand prosthesis, taking into consideration a new plane of action of the thumb. **Subjects/Procedures.** Computer-aided design (CAD) was used to obtain the hand morphology and the internal mechanisms. A laboratory hand prosthesis was built and after some modifications, a clinical version was produced. Three units have been fitted to patients already wearing an Otto-Bock myoelectric hand prosthesis. **Results.** A comparative functional evaluation of the prehension performance has shown the following advantages: it minimized arm and body compensatory movements during prehension; it allows a better orientation of the objects held for use; it provides a stable grip with a lower prehension force; and it improves the working visibility and the cosmesis. **Relevance to Veteran Population.** This study shows that it is possible to design a better hand prosthesis using CAD techniques and to obtain a more useful and a more accepted hand prosthesis by the veteran and non-veteran amputee population.
Robert Vinet, DSc

Biomechanical Basis of Choosing the Rational Mass and its Distribution Throughout the Lower Limb Prosthesis Segments

Boris S. Farber, DSc, PhD and Ijekusijel Sh. Moreinis, PhD *(p. 325)*

Purpose of the Work. To determine the rational distribution of mass throughout lower limb prostheses in prosthetic fitting. **Subjects.** None **Procedures.** Differential equations of motion were used. A dynamic model of a human walking in the form of a 9-link biokinematic chain with 11 degrees of freedom of motion were presented. The equations presented may be determined as formulae which determine the movements of muscular forces having the data on generalized coordinates, changes, ground reaction, and its load point. **Results.** It was determined that the mass of a prosthetic limb should be in proportion identical to that of the sound limb. To achieve complete agreement between inertial characteristics of prostheses and theoretical recommendations, the techniques of balancing were suggested. An objective clinical, physiological, and biomechanical technique proved that the rational distribution of mass throughout a prosthesis favorably influences the final

result of prosthetic fitting—it reduces energy expenditure and overloading and normalizes the characteristics of walking. **Relevance to Veteran Population.** Rational prosthetic fitting results in less energy expenditure and overloads are decreased enabling a normalized gait pattern in walking.
The Editor, for and in the absence of the author

An Above-Knee Prosthesis with a System of Energy Recovery: A Technical Note
Boris S. Farber, DSc, PhD and
Jacob S. Jacobson, PhD *(p. 337)*

Purpose of the Work. To develop a new single-axis prosthetic knee unit that could approximate the action of the anatomic knee as far as possible during the gait cycle and cost less energy than conventional knee units. **Subjects/Procedures.** Six subjects were fitted with the new knee unit and their walking performance was studied in detail to determine the energy consumption and gait pattern as compared with conventional artificial knee units. **Results.** There were significant reductions in the energy costs of walking. They were from 20 to 45% lower in comparison with walking with conventional AK prosthetic knee units. This may be attributed to the newly designed knee unit. **Relevance to Veteran Population.** Walking becomes more efficient and requires negligible energy consumption by our veterans with above-knee amputation allowing them to participate with nondisabled people for longer periods of time and comfort.
The Editor, for and in the absence of the author

Stress Distribution in the Ankle-Foot Orthosis Used to Correct Pathological Gait
Tai-Ming Chu, PhD and Narender P.
Reddy, PhD *(p. 349)*

Purpose of the Work. Abnormal motion of the ankle-foot complex presents a major problem in the rehabilitation of stroke patients. The purpose of this investigation is to study the drop-foot problem and to determine the stress distribution in the orthosis due to various loading conditions during stance phase of the gait. **Subjects/Procedures.** No subjects were used. The analysis and simulations conducted are through a computer-aided mathematical model. The 3-D finite element model (FEM) of a clinically available ankle-foot orthosis (AFO) together with the ankle-foot system was developed using PATRAN, and finite element analysis (FEA) was conducted using ADINA. **Results.** The maximum peak stress occurs in the neck, heel, and side-arc region of the AFO. However, the neck region of the AFO experienced the largest amount of stress. High stress concentration in the neck region observed is consistent with the common clinical observations that AFOs break down in the neck region. **Relevance to Veteran Population.** Although the orthotist considers the ankle joint and the subtalar joint motions during the swing phase to be important in the orthosis design, stress distribution in the orthosis from the stance phase is the key characteristic in designing the AFO. The present results provide general useful information with regard to the types of stresses and stress concentrations developed at various locations in the orthosis.
Tao-Ming Chu, PhD

Peak and Submaximal Physiologic Responses Following Electrical Stimulation Leg Cycle Ergometer Training
Steven P. Hooker, PhD; A.M. Erika Scremin, MD;
Deborah L. Mutton, MA; Charles F. Kunkel, MD;
Gordon Cagle, PhD *(p. 361)*

Purpose of the Work. Neuromuscular electrical stimulation (NMES) leg cycle ergometers were introduced 11 years ago. Suggested training programs usually call for exercise three times per week for at least 12 weeks. This study was designed to determine if training only two times per week on an NMES leg cycle ergometer would improve cardiovascular (CV) fitness in persons with spinal cord injury (SCI). **Subjects/Procedures.** Eight males with SCI completed 24 NMES leg cycle training sessions over 12 weeks. The ergometer's resistance was adjusted each training session to allow for 30 total minutes of exercise. **Results.** Peak oxygen uptake (indicator of CV fitness) increased 10% and peak power output (indicator of leg muscle endurance/strength) increased 25% as a result of the NMES leg cycle training. **Relevance to Veteran Population.** This study suggests that a two-time per week NMES leg cycle training program will significantly improve CV fitness and exercise capacity in persons with SCI. This finding is noteworthy since scheduling and staffing of NMES exercise training sessions are difficult at times.
Steven P. Hooker, PhD

Wheelchair Stability: Effect of Body Position
R. Lee Kirby, MD; Maria T. Sampson, BScK; Fredrik
AV Thoren, BSc; Donald A MacLeod, MScK *(p. 367)*

Purpose of the Work. When a person in a wheelchair reaches and leans, the stability decreases in the direction of the lean and increases in the opposite direction. The purpose of this study was to determine the extent of this effect. **Subjects/Procedures.** We studied 21 nondisabled subjects in a representative wheelchair, measuring the forward, rear, and sideways stability on a tilting platform. **Results.** Reaching and leaning away from the tip added stability (by up to 125%), whereas reaching and leaning toward the tip reduced stability (by as much as 50%). Reaching forward had a greater effect on stability than did reaching back or to the side. **Relevance to Veteran Population.** Wheelchair users with the ability to control their body position can profoundly affect the stability of their wheelchairs.

R. Lee Kirby, MD