

SUMMARY OF SCIENTIFIC/TECHNICAL PAPERS IN THIS ISSUE

3-D Imaging of Residual Limbs Using Ultrasound.

Ping He, PhD, PE; Kefu Xue, PhD;

Paul Murka, CPO (p. 269)

Purpose of the Work. The purpose of this study is to develop an ultrasound-based limb scan system that is aimed to improve prosthetic socket design. **Subjects.** This paper reports the results from scanning a pair of wires, a phantom, and a healthy human limb. In addition, 15 lower residual limbs have been scanned by the system. **Procedures.** The limb (or any target) is immersed in water. An ultrasound transducer rotates around the limb at various levels to produce a stack of cross sectional images of the limb. From these images, a three-dimensional model is reconstructed which shows both the external shape and internal bone structure of the limb. This model is then used for computer-aided prosthetic socket design. **Results.** Under the ideal conditions, the scan system achieves an image resolution of 1.5 mm, and a measurement accuracy of ± 1.8 mm. In addition, the system produces high quality limb images that were never before available to prosthetists. **Relevance to the Veteran Population.** A large number of veterans are involved in amputation as a result of trauma, accident, or diabetes. The method described in this paper has the potential to produce an improved prosthetic socket design that will directly benefit them.

Ping He, PhD, PE

Instantaneous Centers of Rotation in Dorsi-/Plantar Flexion Movements of Posterior-type Plastic Ankle-foot Orthoses.

Tadashi Sumiya, MD; Yoshitaka Suzuki, BE;

Tomio Kasahara, BSW; Hajime Ogata, MD (p. 279)

Purpose of the Work. Hingeless plastic ankle-foot orthoses (PAFOs) achieve ankle motion by flexing about the ankle and originate different fit according to their types. The degree of fit depends on distance between orthotic and anatomical axes of ankle movements. Therefore, comparative evaluation of axis location between various orthotic types provides an useful indicator for prescriptions. **Subjects/Procedures.** Thirty posterior-type PAFOs were fabricated by using an uniform

technique. Landmarks on orthoses during ankle movements were photographed, and orthotic axes (instant centers) were obtained geometrically. **Results.** This type of orthosis demonstrated its axis location about the junction between the calf-shell and the shoe-insert, suggesting incongruity with anatomical axis location. This tendency characterized fit of posterior-type PAFOs. **Relevance to the Veteran Population.** Findings of this study support rational prescriptions of hingeless PAFOs to attain the optimal subject-orthosis matching, which is essential for maintaining ambulatory ability of the disabled so that they may enjoy more active lives.

Tadashi Sumiya, MD

Mechanical Advantage in Wheelchair Lever Propulsion: Effect on Physical Strain and Efficiency. Lucas H.V. van der Woude, PhD; Eugenie Botden, MsC; Ingrid Vriend, MsC; Dirkjan Veeger, PhD (p. 286)

Purpose of the Work. The purpose of this current study was to determine possible beneficial effects of five different gear ratios (MAs) in a lever-propelled prototype wheelchair with respect to the physical strain, different physiological parameters and subjective strain. **Subjects and Procedures.** Ten male non-wheelchair users, participated in this study on a voluntary basis. A prototype three-wheeled, lever-propelled wheelchair was propelled on a motor driven treadmill. The levers were coupled to the rear wheels with a chair and racing cycle gear box (5 gears), mounted to the hub of the rear wheels for the left and right lever separately. Mechanical advantage varied from 0.56 (MA1) to 0.28 (MA5). Each subject performed five identical submaximal exercise tests, each at a different MA at a constant speed of 3.5 km/hr and an increasing slope (11% every third minute, range: 0% to 3%). Among others, heart rate, oxygen uptake, power output, and mechanical efficiency were determined together with a rating of perceived exertion (BORG). Results were statistically analyzed with an analysis of variance for repeated measures ($p < 0.05$). **Results.** Mechanical advantage had a significant effect ($p < 0.05$) on oxygen uptake, energy cost, and mechanical efficiency, indicating a lower strain at lower MA, i.e., a slower speed and higher resistance. **Relevance to the Veteran Population.** These results suggest that the implementation of a range of mechanical advantages on a lever-propelled wheelchair

may more readily accommodate different external conditions (slope, surface, climatic conditions in daily life, sports, and recreational conditions) and different user groups, both the highly trained as well as marginal wheelchair user. The higher efficiency of lever-propelled wheelchairs and the use of different gears may improve the social radius of action and freedom of mobility of wheelchair-confined individuals. Moreover, implementation of gears in lever wheelchairs is highly feasible.

Lucas HV van der Woude, PhD

Biomechanical Properties of Human Tibia in Spinal Cord Injury.

Thay Q Lee, MS; Todd A. Shapiro, BS;
David M. Bell, MD (*p. 295*)

Purpose of the Work. In persons with spinal cord injury (SCI), the fracture rate is 10 times greater than that of the general population. This study quantifies the biomechanical properties of tibias of persons with SCI. **Subjects/Procedures.** Four SCI and four non-SCI fresh frozen tibias that were closely matched in size and age were used. Structural properties were determined using non-destructive torsion tests. Geometric properties of the tibial cross-sections were numerically measured. Material properties of the cortical bone were determined using four point bending tests. **Results.** Both the structural and material properties and cortical thickness of SCI tibias were significantly inferior to the non-SCI tibias. However, the polar moment of inertia of the tibial cross-sections showed no significant difference. **Relevance to Veteran Population.** These findings suggest that tibias may undergo micro-structural changes as well as structural adaptation following SCI. Further basic science and clinical investigation may bring progress toward effective prevention and treatment of this difficult complication of a devastating injury.

Thay Q Lee, MS

Sweat Analysis Following Pressure Ischaemia in a Group of Debilitated Subjects.

Adrain Polliack, PhD; Richard Taylor, PhD, MRCPATH;
Dan Bader, PhD (*p. 303*)

Purpose of the Work. The study describes the analysis of sweat collected at sacral tissues of selected debilitated subjects during both loading and unloading periods. **Subjects/Procedures.** Eleven subjects, ages 20–71, attending a rehabilitation unit were assessed on at least

one session. With each subject either seated in a wheelchair or lying in bed, collection was performed with a simple sweat pad for a prolonged period at room temperatures. The pads were subsequently analyzed to measure a series of metabolites. **Results.** In unloaded tissues the metabolite concentrations were similar to those previously reported for nonimpaired subjects. However even at relatively low loads, there was an elevation in the concentrations of some metabolites, lactate and urea. **Relevance to the Veteran Population.** Many veterans with impaired sensation and/or mobility are prone to the development of pressure sores. The proposed technique may be used to monitor changes in sensitive individuals.

Dan Bader, PhD

Dysarthric Speech: A Comparison of Computerized Speech Recognition and Listener Intelligibility.

Philip C. Doyle, PhD; Herbert A. Leeper, PhD;
Ava-Lee MCISc; Marie-Claire Dylke, MSc;
Katherine Rolls, MCISc (*p. 309*)

Purpose of the Work. Speakers with dysarthria may improve articulatory precision and speech intelligibility through training with a computerized voice recognition (VR) system. Limited data on the identification of dysarthric speech by a VR system currently exist. This investigation evaluated VR (IBM VoiceType) to intelligibility by human listeners. **Subjects/Procedures.** Six speakers (3 males and 3 females), aged 15–55 years, served as subjects. Two exhibited mild (>70<90%), two moderate (>40<70%), and two severe (>10<40%) intelligibility deficits. Six age- and gender-matched non-disordered speakers served as controls. Speakers produced 70-item word lists over 5 sessions. Computer-based VR and perceptual judgment scores were obtained and functions plotted by session. **Results.** Data indicate that VR of both dysarthric and normal speech was characterized by initially steep increases in correct recognition with more gradual increases noted during the second through fifth sessions. While severity of dysarthria was found to generally influence VR, individual speaker performance is a critical component of recognition, most notably the consistency of production. **Relevance to the Veteran Population.** Dysarthria is associated with various etiologies including cerebrovascular accident (CVA), degenerative neurological diseases, and traumatic brain injury (TBI) and may range in severity from minimal impairment to the rendering speech unintelligible. Such conditions are seen in both service and non-service con-

nected conditions. The potential utility of VR technology in rehabilitation efforts would seem worthy of further exploration with this population.

Philip C. Doyle, PhD

Monitoring Healing of Acute Charcot's Arthropathy with Infrared Dermal Thermometry.

David G. Armstrong, DPM;
Lawrence A. Lavery, DPM, MPH (*p. 317*)

Purpose of the Work. To describe the use of skin temperature assessment in diabetics with acute Charcot's arthropathy (a progressive and destructive bone disease) to monitor resolution of inflammation longitudinally throughout the course of treatment and to predict development of neuropathic ulcers. **Subjects.** 39 diabetic persons presenting with acute Charcot's arthropathy received thermometric monitoring throughout their treatment course. **Procedures.** Subjects were treated with a standard protocol involving total contact casting, removable cast walkers and subsequent therapeutic shoes. **Results.** There was a steady decrease in temperatures during the healing period. After temperatures normalized, subjects were progressed to custom therapeutic shoe gear and were followed for an average of 2 years. Following bony healing, 8% returned during the follow up period with a new-onset neuropathic ulceration. Temperature gradients taken the visit prior to ulceration were significantly higher in group than for the rest of the population. **Relevance to the Veteran Population.** Skin temperature measurement provides a reliable means of monitoring the healing of acute Charcot's Arthropathy into its post-acute phase. Additionally, elevated temperatures on one foot compared to the other may be predictive of future ulceration.

David G. Armstrong, DPM

The Development and Clinical Evaluation of a Standing Biofeedback Trainer.

Alice M.K. Wong, MD; Ming-Yih Lee, PhD;
Jung-Kun Kuo, MD; Fuk-Tan Tang, MD (*p. 322*)

Purpose of the Work. Stance symmetry in persons with hemiplegia had been reported to be significantly related

to measurement of severity and length of stay. An economical new standing biofeedback training device, including a height adjustable standing table, instrumented sensors for weight bearing under a dual force platform, and a real time visual/auditory feedback system, has been developed for postural training. The real-time weight bearing biofeedback visual display works by two numerical light emitting diodes (LEDS) and light illuminating balance scale mounted on the center portion of the postural correction mirror. An auditory alarming system with choice of three most common spoken languages (Mandarin, Taiwanese, Hakanes) in Taiwan provides additional warning signals to subjects. **Subjects/Procedures.** Forty three male and 17 female persons with unilateral hemiparesis or hemiplegia from first acute stroke or traumatic brain injury were recruited for this study. The average age was 51.3 ± 13.9 years. The subjects were randomized into an experimental and a control group of equal numbers and severity; they received SBT and conventional standing table training for 60 min/day, 5 times/week for a period of 3 to 4 weeks in addition to conventional rehabilitation programs. **Results.** Improvement of the ability to maintain stance by the subjects in percentage of postural symmetry showed that both immediately learning effect and final result were obviously better in experimental group than control group. **Relevance to the Veteran Population.** Hemiplegia resulted from traumatic brain injury or stroke is very common neurological insult in veterans. From clinical assessment, the newly designed standing biofeedback trainer with visual and auditory biofeedback has demonstrated better training effect for hemiplegic persons than the conventional training device. This device is also very suitable for self training of dynamic postural control, a benefit for the prevention of imbalance and falls in elderly veterans.

Alice M.K. Wong, MD