

### SUMMARY OF SCIENTIFIC/TECHNICAL PAPERS IN THIS ISSUE

#### **Quantitative analysis of the effects of audio biofeedback on weight-bearing characteristics of persons with transtibial amputation during early prosthetic ambulation**

Daniel H. K. Chow, PhD and  
Chris T. K. Cheng, CPO, MSc (p. 255)

**Purpose of the Work.** With the aid of a load monitoring device, we quantitatively evaluated the effects of an audio-biofeedback on the weight-bearing patterns of persons with transtibial amputation during their early postoperative ambulatory period. **Subjects/Procedures.** Six persons with transtibial amputation were asked to replicate a prescribed amount of weight-bearing using the bathroom scale method during their early postoperative ambulatory training. Their weight-bearing characteristics with and without audio biofeedback were continuously monitored using the load monitoring device and compared with the prescribed load. **Results.** It was shown that the residual limb would be overloaded using the conventional bathroom scale method during early postoperative ambulatory training if no audio biofeedback was provided. **Relevance to the Veteran Population.** Audio biofeedback was demonstrated to be useful in preventing the residual limb from being stressed beyond the prescribed load, particularly when the prescribed load was low.

*Daniel H. K. Chow, PhD*

#### **Force-directed design of a voluntary closing hand prosthesis**

Hans de Visser, MSc and Just L. Herder, MSc (p. 261)

**Purpose of the work.** This work reports the design of a light-weight body powered hand prosthesis. **Subjects/Procedures.** Analysis of the forces applied to the object held, as well as the forces within the mechanism, led to a simple concept of a prosthesis with good force feedback. With this, easy and reliable use are ensured, without jeopardizing natural appearance and comfort of the prosthesis. **Results.** An experimental prototype was constructed which closely resembles the human hand in appearance,

feel and behavior, thanks to an adaptive, flexible mechanism with minimized energy losses. **Relevance to the Veteran Population.** Future developments of the experimental prototype may lead to a hand prosthesis which looks just like a normal hand, is comfortable and easy to use, possesses good control over objects held, regardless of size and shape, and is light-weight and robust, thanks to the absence of batteries and fragile motors and transmissions.  
*Hans de Visser, MSc*

#### **Design enhancement of a solid ankle-foot orthosis: real-time contact pressures evaluation**

Michael D. Nowak, ScD;  
Khamis S. Abu-Hasaballah, PhD;  
Paul S. Cooper, MD (p. 273)

**Purpose of the Work.** To determine the pressures exhibited in a clinically based AFO designed for the neuropathic diabetic adult patient during typical activities of daily living. **Subjects/Procedures.** Four healthy, adult males fitted with clinically based AFOs. The AFOs were of the same design as those designed for the adult diabetic patient with ulcers due to various pathologic conditions. Each subject was fitted with a custom designed AFO which was lined with pressure sensitive pads. Real-time pressure measurements were obtained during four different activities: walking, getting in and out of a chair, stair climbing, and pivoting over the AFO. **Results.** Results that the majority of loading is seen in the shoe insert and lower calf shell regions of the AFO, with limited pressures in the remainder of the calf shell region. **Relevance to the Veteran Population.** Diabetic patients often exhibit plantar ulcers due to increased foot pressures resulting from neuromuscular imbalance. Ankle-foot orthoses (AFOs) are often prescribed to lower forefoot pressure and thus reduce the occurrence of ulcers. However, a significant percentage of patients still require treatment for ulcers either due to non-compliance in wearing the AFO, due to discomfort, or due to a failure of the AFO to reduce forefoot pressure. Currently, a general AFO pattern for the specific use is molded to each patient, then hand trimmed for best fit as determined subjectively by the orthotist. This study may be useful to orthotists in improving basic AFO design and to researchers as a starting point for performing complex analyses on the AFO.

*Michael D. Nowak, ScD*

### **Influence of trunk flexion on biomechanics of wheelchair propulsion**

Mary M. Rodgers, PhD, PT; Randall E. Keyser, PhD; Elizabeth R. Gardner, MS, PT; Pamela J. Russell, PhD; Peter H. Gorman, MD (p. 283)

**Purpose of the Work.** To compare propulsion style differences that may cause overuse injuries in manual wheelchair users (MWCU). **Subjects.** Nineteen MWCU were divided into two groups based on a trunk position of flexion (FG) and non-flexion (NFG). **Procedures.** Participants performed an exercise test to fatigue on an instrumented wheelchair ergometer during which 3D motion analysis, handrim forces and moments, and electromyographic data were collected. **Results.** The FG (n=9) demonstrated greater trunk flexion, shoulder flexion and elbow extension compared to the NFG (n=10) which was more pronounced with fatigue. When fatigued, the FG demonstrated decreased activity in the wrist flexor, triceps and middle trapezius muscles that did not occur in the NFG. **Relevance to Veteran Population.** The flexion style relies more on trunk movement for pushing that may be compensating for muscle weakness. Training programs designed to prevent overuse injuries may need to emphasize triceps strengthening and endurance for veteran MWCU with this style.

*Mary M. Rodgers, PhD, PT*

### **Displacement between the seating surface and hybrid test dummy during transitions with a variable configuration wheelchair: A technical note**

Rory A. Cooper, PhD; Michael J. Dvorznak, BS; Andrew J. Rentschler, BS; Michael L. Boninger, MD (p. 297)

**Purpose of the Work.** Reclining or stand-up wheelchairs can extend the amount of time a person can safely remain seated; however, standing may also impose shear stresses on skin due to relative motion between the person and seating surface. This work examines the displacement between a test dummy and wheelchair during sit-to-stand and sit-to-recline motions. **Subjects and Procedures.** A 50th percentile Hybrid II test dummy (HTD) was seated in an Excelsior powered wheelchair. Motion of the HTD and wheelchair were recorded while the wheelchair was pow-

ered through complete sit-to-stand and sit-to-recline configurations. Two seat cushions were tested. **Results.** Shear displacements were small and within marginal or acceptable limits for all cushion motion combinations except between the HTD back/backrest during sit-to-recline motion. **Relevance to Veteran Population.** Insight into the cause and dangers of shear stresses may aid clinicians in determining the optimal range of seating postures for the client.

*Rory A. Cooper, PhD*

### **Wheelchair caster shimmy II: Damping**

James J. Kauzlarich, PhD; Theodore E. Bruning III; John G. Thacker, PhD (p. 305)

**Purpose of the Work.** This paper reviews the theory and means of reducing wheelchair caster shimmy. **Procedures.** Various techniques were used to observe and quantify the effect of different damping designs on wheelchair caster shimmy. The experiments involved operation of an instrumented wheelchair on a treadmill, but also examined the "footprint" of tires on a glass floor as well as observed "tracks" of a shimmying caster on a flour dusted floor. **Results.** Damping of the spindle bearings, increasing tire/floor friction, and add-on commercial dampers were all found to contribute to reducing the tendency to shimmy. A new concept involving using a very viscous lubricant (silicone) in the caster bearings is discussed. **Relevance to the Veteran Population.** It is important to assure that shimmy dampers are operating and maintained as intended—for example: friction dampers must not be oiled. If properly operating dampers are insufficient to prevent shimmy, it may be possible to improve the performance by using tires with higher friction or using more viscous lubricants in the spindle bearings.

*James J. Kauzlarich, PhD*

### **Comparative biomechanical evaluation of different wheelchair seat cushions**

Maurizio Ferrarin, DrEng, PhD; Giuseppe Andreoni, DrEng, PhD; Antonio Pedotti, DrEng (p. 315)

**Purpose of the Work.** Pressure sores are important complications for wheelchair users. This study report on a

comparative biomechanical evaluation of four antidecubitus wheelchair seat cushions. **Subjects/Procedures.** Thirty wheelchair users (elderly subjects, patients with paralysis of lower limbs with and without cutaneous sensation) were analyzed by means of a sensor matrix that measures the distribution of pressure on subject buttocks. **Results.** No significant differences in pressure peaks were found among the four cushions. However, both the location of pressure peaks and posture were dependent on cushion types. Comparison of the three patient groups showed that elderly subjects had the highest mean pressure and the lowest contact surface, while paraplegics persons presented the highest pressure peaks. **Relevance to Veteran Population.** Many different antidecubitus wheelchair cushions are commercially available. The procedure here developed would help, with objective data, in the choice and/or adaptation of the optimal solution for a given user, according to his specific characteristics.

*Maurizio Ferrarin, DrEng, PhD*

#### Evaluation of the new flexible contour backrest for wheelchairs

Frédéric Parent, MScA; Jean Dansereau, PhD;  
Michèle Lacoste, OT; Rachid Aissaoui, PhD (p. 325)

**Purpose of the work.** The purpose of this study was to compare a new wheelchair backrest (the Flexible Contour Backrest) with two commercially available ones (an adjustable-tension backrest and a back cushion on rigid interface). **Subjects/Procedures.** Fifteen non-handicapped subjects participated. Pressure distribution, back profile accommodation and short-term comfort were measured. **Results.** The New Flexible Backrest offers a more uniform pressure distribution than the adjustable-tension backrest. This pressure was similar to the one offers by the back cushion on rigid interface. Furthermore, the multiple adjustments of the new Backrest allow a better fit. Finally, subjects felt that this new concept is as comfortable as the back cushion on rigid interface and more comfortable than the adjustable-tension one. **Relevance to the Veteran Population.** The Flexible Contour Backrest may be suitable for many wheelchair users in order to offer them more lateral trunk support and a better comfort which could lead to a more functional seated posture.

*Frédéric Parent, MScA*

#### Spectral analysis of surface electromyography (EMG) of upper esophageal sphincter-opening muscles during head lift exercise

Mohammed Ferdjallah, PhD;  
Jacqueline J. Wertsch, MD; Reza Shaker, MD

**Purpose of the work.** Elderly people can have difficulty swallowing. Prior research has shown that a simple head lift exercise can improve their ability to swallow. The purpose of this study was to examine which neck muscles were most affected by this exercise. **Subjects/Procedures.** During the head lift exercise protocol, surface EMG signals were recorded from three muscle groups simultaneously in eleven healthy elderly subjects. The muscle activity was analyzed to assess the fatigue of each of the muscle groups during the exercise. **Results.** Our findings suggest that during the head lift exercise all showed signs of fatigue. However, one of the muscle groups (SCM) fatigued faster than the others. Because of its fatigue rate the SCM muscle group may be a limiting factor in the exercise. **Relevance to the Veterans Population.** This simple head lift exercise may aide elderly veterans who are having difficulty swallowing. Further refinements of this exercise will be possible with the surface EMG technique established by this study.

*Mohammed Ferdjallah, PhD*

#### Lifting characteristics of functionally limited elders

Michael S. Puniello, MS, PT, OCS;  
Chris A. McGibbon, PhD; David E. Krebs, PhD, PT  
(p. 341)

**Purpose of the Work.** Investigate the lifting characteristics of elders with functional limitations, and correlate these characteristics with strength and functional measures. **Subjects/Procedures.** Thirty elders consented to biomechanical analysis of lifting, gait, chair rise, and to isometric strength testing of the hip and knee extensors and shoulder flexors. Jerk, the rate of change of acceleration, was used to measure lifting motion smoothness. We calculated the lifted burden's peak vertical jerk and the trunk's angular momentum during the beginning and middle parts of the lift. **Results.** Hip extensor strength and trunk angular momentum correlated positively with burden jerk. There was a positive correlation between trunk angular momentum during lifting, and during chair rise. **Relevance to**

**Veteran Population.** Weaker elders chose a more conservative, and apparently more stable lifting strategy. Clinicians should test strength and functional measures to more accurately counsel elders on safe lifting strategies.

*Michael S. Puniello, MS, PT, OCS*

#### **Adequacy of power wheelchair control interfaces for persons with severe disabilities: A clinical survey**

Linda Fehr, MS; W. Edwin Langbein, PhD;  
Steven B. Skaar, PhD (p. 353)

**Purpose of the Work.** This article reports on how well people are able to steer power wheelchairs by conventional methods and introduces a new technology of computerized steering for persons who cannot independently control a power wheelchair. **Subjects/Procedures.** We surveyed 200 clinicians for information about their patients with mobility impairments. **Results.** Clinicians indicated 40% of their patients who use power wheelchairs have difficulty with steering tasks; 5-9% find such tasks impossible without assistance. Eighty-five percent of responding clinicians see some number of patients annually who can use neither a manual nor a power wheelchair; nearly half of these would benefit from computerized navigation. **Relevance to Veteran Population.** A computer-controlled power wheelchair would enable veterans with catastrophic injury or progressively disabling illness to maneuver independently throughout a home, office, or institution, providing a degree of autonomy otherwise unattainable and expanding opportunities for outside employment and social interaction.

*Linda Fehr, MS*

#### **Biofeedback therapy using accelerometry for treating dysphagic patients with poor laryngeal elevation: Case studies**

Narender P. Reddy, PhD;

Denise L. Simcox, MA CCCSLP; Vineet Gupta, PhD;

Gary E. Motta, MA CCCSLP;

Jody Coppenger, MS CCCSLP;

Amitava Das, BE; Ojas Buch, MS (p. 361)

**Purpose of the Work.** Dysphagia represents the swallowing disorder, and presents a major problem in the rehabilitation of stroke patients. In our previous studies (Reddy et al

1990,91,94), we have developed techniques for quantitative assessment of dysphagia. This work presents case reports computerized biofeedback therapy using visual display of the quantitative measure of swallowing. **Subjects/Procedures.** In dysphagic patients, noninvasive measures of skin vibration during swallowing were obtained using a miniature accelerometer. The output of the accelerometer was processed and dynamically displayed in real time on a computer screen along with the signal from a representative normal subject. The dysphagic subject was asked to swallow such that his/her acceleration signal matched that of the normal subjects. Each subject received nine biofeedback therapy sessions, with two to three sessions per week. **Results.** The subjects tested showed improvements in the swallowing function. However, further investigation is necessary with more number of subjects. **Relevance to the Veteran Population.** Dysphagia can lead to aspiration and choking. Consequences of dysphagia include inadequate nutrition, pneumonia, and even death. The current therapy procedures do not involve biofeedback. Biofeedback actively involves the patient and may lead to faster recovery from the disease.

*Narender P. Reddy, PhD*

#### **Design of the Advanced commode-shower chair for spinal cord-injured individuals**

Pascal Malassigné, MID; Audrey L. Nelson, RN, PhD;  
Mark W. Cors, BFA; Thomas L. Amerson, PhD (p. 373)

**Purpose of the work.** Design and development a new commode-shower chair that can be safely and independently used by individuals with spinal cord injuries (SCI) and their caregivers. **Subjects/procedures.** Veterans with SCI and caregivers of the Milwaukee and Tampa VAMCs participated in the clinical evaluation of new commode-shower chairs. They completed an evaluation questionnaire that assessed the various features of the new chair related to bowel care, showering, seating and transfer safety to and from the chair. **Results.** The new commode-shower chair solves all the safety and usage problems of existing chairs. **Relevance to Veteran Population.** The chair was patented by the VA, and a wheelchair manufacturer will commercialize it, making it available in 2000 under a VA licensing agreement. It is anticipated that the chairs will be provided to veterans who need to use a wheelchair for bowel care and showering.

*Pascal Malassigné, MID, IDSA*