

SUMMARIES OF SCIENTIFIC/TECHNICAL ARTICLES

Transtibial energy-storage-and-return prosthetic devices: A review of energy concepts and a proposed nomenclature

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Purpose of the Work. The review examines techniques of performance analysis in energy storage and return (ESAR) prosthetic feet, synthesizes clinical study results reported in the literature, suggests a technically accurate and common terminology, and proposes a novel method of foot classification for use in prosthetic research, design, and prescription. **Procedures.** An array of techniques has been used to evaluate energy-storage-and-return prosthetic foot performance. To overcome inconsistencies in methods among studies and provide an improved tool for comparison and evaluation of the performance of ESAR prosthetic feet, we developed a common nomenclature and a comprehensive “heel-keel (HK)” classification system. **Results.** The HK classification system incorporates the results of reviewed energy analyses with clinical prosthetic fitting experience to form a correlative matrix of the mechanical characteristics of a prosthetic foot, those activities recommended for an individual wearing the foot, and any additional benefits the foot would afford the amputee. **Relevance to the Veteran Population.** The results of the review suggest that an accurate nomenclature and a universal classification system for ESAR prosthetic feet be adopted. The proposed classification system incorporates previous research results with clinical recommendations to improve prosthetic selection and enhance designs by providing a common measure of performance for all types of prosthetic feet.

Brian J. Hafner, BS

Comparison of cycling kinetics during recumbent bicycling in subjects with and without diabetes

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Seymour Levin, MD; Robert Gregor, PhD

Purpose of the Work. The purpose of this study was to compare recumbent bicycle kinetics in subjects with and

without diabetic peripheral neuropathy. **Subjects/Procedures.** Eighteen men (nine per group) participated in the study. Three-dimensional kinematic and force pedal data in a linked-segment model were used to calculate the generalized muscle moment (GMM). **Results.** The GMM patterns were similar between the two groups except for (1) decreased maximum knee flexor moment, (2) increased minimum knee flexor GMM, and (3) maximum hip extensor GMM by the diabetic subjects. Similar to the walking support moment, a summation moment immutable pattern was observed, although the groups accomplished it differently. The diabetic group used the hip during the power phase and the knee during the recovery phase. The nondiabetic group used both joints together during both phases. Differences in ankle GMM were not observed. **Relevance to the Veteran Population.** These data suggest further research with the use of the recumbent bicycle as an exercise modality for diabetic peripheral neuropathy patients to enhance ankle range of motion and strength, commonly observed walking deficits in this population. The recumbent bicycle may be used as a modality to continue to develop ankle strength and mobility without placing the patient at risk for high plantar pressures or falls, since recumbent bicycling is a non-weightbearing task.

Karen L. Perell, PhD

Circuit resistance training in persons with complete paraplegia

Patrick L. Jacobs, PhD; Edward T. Mahoney, MA;
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Purpose of the Work. The purpose of this study was to assess the physiological responses of persons with spinal cord injury paraplegia to a single session of circuit resistance training (CRT) and to determine the caloric cost of the exercise. **Subjects/Procedures.** Six subjects with complete paraplegia (T₅–T₁₂ levels) completed a session of CRT, consisting of isoinertial weight training exercises, interspersed with periods of high-cadence, low-resistance arm ergometry. Subjects were continuously monitored to heart rate (HR) and metabolic activity via portable EKG and open circuit spirometry. Peak arm ergometry testing allowed these assessments to also be considered relative to peak values. **Results.** The CRT testing produced VO₂ values of 11.6 ± 2.4 ml/kg/min (mean ± SD) with HR val-

ues of 136 ± 17 beats/min, which corresponded to 49.0% of peak VO_2 and 76.8% of peak HR. The respiratory exchange ratio values ranged from 0.96 to 1.19. **Relevance to the Veteran Population.** Limited options for beneficial exercise activities are presented to persons aging with spinal cord injury. Unfortunately, the two most common modes generally recommended in this population, arm ergometry and wheelchair propulsions, have been associated with increased risk of upper-limb pain and injury. Circuit resistance training offers a means to increase upper-limb strength and cardiorespiratory endurance in persons with paraplegia. Despite modest absolute VO_2 responses during exercise, CRT satisfies operational criteria developed for cardiorespiratory exercise prescriptions applied in the general population.

Patrick L. Jacobs, PhD

Normative values and determinants of physical capacity in individuals with spinal cord injury

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Purpose of the Work. The purpose was to define normative values for physical capacity parameters in individuals with tetraplegia and paraplegia. A second purpose was to identify important determinants of physical capacity in this population. **Subjects/Procedures.** Data from five studies were combined and reanalyzed. Each study consisted of at least a graded wheelchair exercise test and could additionally include a wheelchair sprint test and/or an isometric strength test. The combined subject population included 166 individuals who varied greatly for age, body mass, lesion level, time since injury, and activity level. **Results.** Ranges in physical capacity were extensive, and normative values for individuals with tetraplegia and paraplegia were established. Multiple regression procedures indicated that 48–80% of the variance in physical capacity could be explained by lesion level and completeness, activity level, gender, age, body mass, and time since injury. Although physical capacity is largely determined by factors that cannot be altered, such as lesion level, age, and gender, changeable factors such as activity level and body mass play an additional role. **Relevance to the Veteran Population.** The physical capacity norms could be used for evaluation of fitness status and training or therapeutic interventions. The results of the regression

analyses underline the importance of staying physically active in this population.

Thomas W.J. Janssen, PhD

Use of data from nonrandomized trial designs in evidence reports: An application to treatment of pulmonary disease following spinal cord injury

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Purpose of the Work. Very little of the scientific literature regarding how best to care for persons with spinal cord injury is in the form of randomized trials. There is much to be learned from nonrandomized studies. The purpose of this work is to describe a general framework by which information from these nonrandomized studies can be summarized and included in evidence reports. **Subjects/Procedures.** This work is primarily conceptual and uses examples from a recent evidence report on preventing complications among patients with spinal cord injury. **Results.** A framework wherein the scientific literature is summarized only to the degree of detail that clinical experts judge to be necessary could facilitate the inclusion of much more of the potentially relevant information. **Relevance to the Veteran Population.** A disproportionate number of veterans have sustained spinal cord injuries. The approach described here can help support formation of more comprehensive evidence reports and, eventually, guidelines for care that have a greater basis in scientific fact.

Gregory P. Samsa, PhD

A database of self-reported secondary medical problems among VA spinal cord injury patients: Its role in clinical care and management

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Purpose of the Work. The spinal cord injury (SCI) rehabilitation team needs feedback on the effectiveness of their therapeutic interventions and programs. A new clinical database in the Hines VA SCI Service was designed for tracking and providing timely feedback to staff about the many issues associated with long-term secondary medical complications. The clinical staff felt that the information was valuable and wanted to continue to

participate in data collection and evaluation. **Subjects/Procedures.** This database uses an interactive data management system, developed by the Hines VA Hospital Cooperative Studies Program Coordinating Center, for interactive data entry in multicenter clinical trials. Data for the first 99 SCI patients visiting the clinic and hospital after the installation of the interactive data management system were collected and reviewed. **Results.** SCI patients reported high rates of current problems with spasticity (53%), pain (44%), and pressure ulcers (38%). Respiratory (12%) and bowel (14%) problems were less commonly reported problems. Pressure ulcers occurred primarily in the sacral, ischial, and trochanter areas. The majority of patients were satisfied with their ulcer prevention program and few wanted to see a therapist to help prevent pressure ulcers. The clinical staff thought the information was informative and collection should continue. Furthermore, they suggested additional questions to include in the database to further clarify the extent of patient problems. **Relevance to the Veteran Population.** This SCI Service level database intervention is expected to improve clinical care via a process of staff review of current rehabilitation programs and outcomes in the areas of prevalence, management, and prevention.

James S. Walter, PhD

A kinematic study of the upper-limb motion of wheelchair basketball shooting in tetraplegic adults

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Purpose of the Work. Because of higher spinal cord lesion levels and resulting arm dysfunction, persons with tetraplegia have some difficulty in joining in and playing wheelchair basketball. Kinematic features of basketball shooting motion of tetraplegic adults were investigated to explore the factors affecting performance and individual mechanics. **Subjects/Procedures.** Two electrically synchronized, high-speed video cameras were used to capture the shooting motion of six tetraplegic wheelchair basketball players and six able-bodied basketball players. The direct linear transformation (DLT) method was used to obtain the 3-D coordinates of a defined series of demarcated landmarks on each player. Angular motions during the shooting were quantified and compared between the two groups. **Results.** The tetraplegic subjects showed a significantly smaller vertical component of ball

velocity at release, which was dependent on their smaller maximum wrist flexion angular velocities. For several specific motions, including shoulder horizontal adduction motion close to ball release, a larger range of shoulder abduction and larger displacements of the right shoulder were observed in the tetraplegic subjects. **Relevance to the Veteran Population.** The findings showed several shooting mechanics specific to tetraplegic individuals, suggesting that their shooting performance may be improved through acquiring shooting mechanics different from those used by able-bodied individuals.

Hiroyuki Nunome, MS

Reliability of biomechanical variables during wheelchair ergometry testing

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Purpose of the Work. Wheelchair ergometer testing is used to characterize wheelchair propulsion mechanics; however, no studies have investigated the reliability of these measures. This study determined the test-retest reliability of biomechanical measurements during a submaximal endurance test on a wheelchair ergometer. **Subjects/Procedures.** Ten nondisabled subjects (seven males, three females), inexperienced in wheelchair propulsion, completed three separate submaximal fatigue tests. An instrumented wheelchair ergometer measured handrim kinetics while 3-D kinematic data were collected. Analysis of variance determined if measurement differences existed across the tests. Intraclass correlation coefficients were calculated to determine the reliability of the measurements. **Results.** The majority of handrim and temporal variables were found reliable. Joint kinematic variables were less reliable, especially those involving wrist movements in the fatigued state. It was concluded that most biomechanical variables obtained during wheelchair ergometry were reliable. **Relevance to the Veteran Population.** It has been proposed that over 50,000 veterans use wheelchairs because of spinal cord injury. Wheelchair ergometer testing is used to characterize wheelchair propulsion mechanics and potential pathomechanics. No studies have investigated the reliability of these measures. This study determined the test-retest reliability of biomechanical measurements during a submaximal endurance test on a wheelchair ergometer.

Margaret A. Finley, MA, PT

Preliminary evaluation of wheelchair occupant restraint system usage in motor vehicles

Linda van Roosmalen, PhD; Gina E. Bertocci, PhD;
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Purpose of the Work. We evaluated the use and satisfaction of currently installed fixed vehicle-mounted wheelchair occupant restraint systems (WORSs) (upper torso and pelvic restraints) for individuals using wheeled mobility devices (WMD) as seats in motor vehicles. **Subjects/Procedures.** We conducted a survey among 33 adults who use their WMD to travel in motor vehicles. Details concerning the use, user comfort, and belt fit of vehicle-mounted WORS were investigated. **Results.** Survey results indicated less than adequate comfort, satisfaction, belt fit, and ease of use of WORSs that are currently installed in paratransit and mass-transit vehicles. The usage of wheelchair occupant restraints installed in private vehicles was quick, easy, and comfortable. Decreased usage, discomfort, difficulty in use, and poor belt fit are results of the various types of WMD and various-sized individuals using wheelchair occupant restraints that are mounted in a fixed location to the vehicle structure in paratransit and mass-transit vehicles. **Relevance to Veteran Population.** Results from this survey suggest the value of exploring alternative wheelchair occupant restraint designs that improve safety, comfort, and ease of use when used by individuals using wheelchairs in transit.

Linda van Roosmalen, PhD

Personal characteristics that influence exercise behavior of older adults

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Purpose of the Work. The two-fold purpose of this study was to create a knowledge base of determinants that influence exercise behavior in older adults and to have health professionals prioritize determinants that affect exercise initiation and adherence in older adults. **Subjects/Procedures.** The knowledge base results of 18 experts (ages 41 to 70) were collected and used to validate the knowledge base for personal characteristics in older adults. **Results.** This study prioritized determinants within the "Personal Characteristics" category that are most important when

designing an exercise plan for older adults. Expert health professionals identified biomedical status, past exercise participation, and education, in order of decreasing importance, as most important during the initiation phase. During the adherence phase, biomedical status, past exercise participation, and socioeconomic status, were selected as most important. **Relevance to the Veteran Population.** Continued exercise activity among older veterans will result in healthier lifestyles and reduced need for medical care. To create exercise programs that older veterans will adhere to on a continued basis, health professionals should have a greater understanding of what determinants influence long-term exercise participation in this age group. In this study, a panel of experts identified the most important determinants for initiation and adherence within the category of the "personal" characteristics category.

Lisa W. Boyette, MEd

Northwestern University Auditory Test No. 6 in multi-talker babble: A preliminary report

Richard H. Wilson, PhD, and Anne Strouse Carter, PhD

Purpose of the Work. The purpose of this project was to develop a spoken word-recognition task that could be used clinically to evaluate recognition performance of individuals with hearing loss in a background noise. **Subjects/Procedures.** Experiment 1 established normative data on 24 listeners with normal hearing and on 50 older adults with high-frequency hearing loss. Experiment 2 examined the effects that age and hearing loss have on understanding speech in multi-talker babble through the study of 15 subjects in each decade interval from 20 to 79 years. The test instrument incorporated monosyllabic words at seven levels over a 35-dB range presented in a background of multi-talker babble that was fixed in level. **Results.** The major finding was that the test instrument provided on average about a 6-dB difference between recognition performances by listeners with normal hearing and listeners with hearing loss. For equal performance, the listeners with hearing loss required a signal-to-noise ratio that was 6 dB more favorable than was required by the listeners with normal hearing. Many of the listeners with hearing loss required more than the 6-dB difference. **Relevance to the Veteran Population.** The current data indicate the speech in multi-talker babble paradigm provides a quick and easy procedure that can be used clinically to assess the ability of patients to understand speech

in a competing message background. The materials described in this report are available on audio compact disc (Department of Veterans Affairs, *Speech Recognition and Identification Materials, Disc 2.0*, 1998).

Richard H. Wilson, PhD

The influence of hospital culture on rehabilitation team functioning in VA hospitals

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Purpose of the Work. Stroke rehabilitation involves learning or re-learning skills. The environment of rehabilitation influences the learning process. This study examines the relationship of the hospital organizational culture on the activities of rehabilitation teams. **Subjects/Procedures.** Surveys of hospital culture and rehabilitation team functioning were administered to rehabilitation professionals and hospital administrators in 50 VA hospitals. **Results.** Rehabilitation team members perceive the hospital culture differently than administrators, and different culture types were associated with different attributes of team functioning. **Relevance to the Veteran Population.** This information will help VA personnel to establish more “user-friendly” and effective rehabilitation environments.

Dale C. Strasser, MD

Iterative design and evaluation of new prone carts for individuals with SCDs: A technical note

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Purpose of the Work: Design and develop new prone carts that can be safely and independently used for mobility by individuals with spinal cord dysfunctions (SCDs) and their caregivers. **Subjects/Procedures.** Veterans with SCDs and caregivers of the Milwaukee and Tampa Veterans Administration Medical Centers (VAMCs) participated in the clinical evaluation of new manual and motorized prone cart prototypes. They completed an evaluation questionnaire that assessed the various features of the new manual and motorized prone carts related to activities of daily living and usage in and out of medical centers. **Results.** The design of the new prone carts was found to solve all the safety and usage problems that were identified in existing models. **Relevance to Veteran Population.** It is anticipated that the new prone carts will be manufactured and commercialized soon and will be made available to veterans who need to use prone carts for mobility.

Pascal Malassigné, MID, FIDSA