Clinical Relevance for the Veteran

The relationship between energy expenditure and lean tissue in monozygotic twins discordant for spinal cord injury

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Purpose of the Work. The objective of this study was to determine energy expenditure and fat-free mass (FFM), as well as the relationships between these parameters, in persons with spinal cord injury (SCI). **Subjects and Procedures.** Thirteen pairs of monozygotic twins discordant for SCI were studied. Basal energy expenditure (BEE) and resting energy expenditure (REE) were determined by indirect calorimetry. Measurements for FFM and fat mass were obtained by dual-energy x-ray absorptiometry. Total body potassium (TBK) was determined by a 4π whole-body counting chamber. Values are expressed as mean ± standard deviation. **Results.** BEE and REE of the twins with SCI were significantly less than the able-bodied co-twins (1387 ± 268 vs. 1660 ± 324 kcal/d, $p < 0.005$, and 1682 ± 388 vs. 1854 ± 376 kcal/d, $p < 0.05$, respectively). Regardless of the group, direct and highly significant relationships were evident among BEE or REE and FFM or TBK. Thus, twins with SCI had lower energy expenditure than their able-bodied co-twins. Regardless of paralysis, direct linear relationships existed between energy expenditure and measures of lean mass. **Relevance to the Veteran Population.** For the maintenance of body weight, the caloric content of the diet should be directly related to energy expenditure. In persons with SCI, lean mass is reduced, and the magnitude of this reduction is directly related to energy expenditure. Because the relationship of lean mass to energy expenditure is similar in those with SCI and able-bodied persons, the prescription of energy needs for individuals with SCI may be computed if a surrogate measure of body composition providing a measure of lean tissue is employed.

William A. Bauman, MD

Effect of variable loading in the determination of upper-limb anaerobic power in persons with tetraplegia

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Purpose of the Work. The assessment of anaerobic power provides useful information regarding the ability of an individual to perform relatively high bursts of muscular force. This study examined a range of resistance loads during arm Wingate Anaerobic Testing (WAnT) in persons with different levels of cervical spinal cord injury (SCI). **Subjects and Procedures.** Thirty-nine persons with motor-complete SCI tetraplegia (13 persons each at C5, C6, and C7) performed six bouts of arm-crank WAnT with relative loads equivalent to 1.0, 1.5, 2.0, 2.5, 3.0, and 3.5 percent of body mass (BM). Values of peak power and mean power were determined and compared between loading levels for each subject group. **Results.** The resistance loads that provided the greatest values of mean power varied between the three groups: C5 = 1.0 or 1.5 percent of BM, C6 = 1.5 or 2.0 percent of BM, and C7 = 2.5, 3.0, or 3.5 percent of BM. **Relevance to the Veteran Population.** The appropriate external load for arm WAnT is specific to the level of tetraplegia. This simple and quick test may provide useful assessment of upper-body power in persons with cervical-level SCI.

Patrick L. Jacobs, PhD

Effects of spinal cord injury on lower-limb passive joint moments revealed through a nonlinear viscoelastic model

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Purpose of the Work. This study quantified the effects of spinal cord injury (SCI) on the lower-limb passive joint moments during both sagittal and nonsagittal motions, including the effects of joint rotational velocity and the positioning of adjacent joint angles. **Subjects and Procedures.** Isokinetic tests, which were performed on a sample of four subjects with SCIs and five uninjured individuals, measured the passive moments at the ankle, knee, and hip joints throughout their ranges of motion in the sagittal and coronal planes. **Results.** A repeated measures analysis of variance (ANOVA) that compared the passive moment curves of the two groups indicated a statistically significant ($p < 0.01$) difference for every joint except the knee. Except for the hip (abduction/adduction) and the ankle (plantarflexion/dorsiflexion) joints of the SCI group, joint velocity had a statistically significant influence on the passive moment at all joints for both groups. The majority of results also indicated that adjacent joint positions significantly influenced passive joint moments. **Relevance to the Veteran Population.** Veterans comprise approximately 11% of the U.S. population but account for 25% of

all individuals with SCI in the United States. Measuring and modeling the changes in passive properties following an SCI will allow for the development of better lower-limb musculoskeletal models, which can be used to develop better functional electrical systems for standing and walking.

Kofi Amankwah, MS

Variable-frequency-train stimulation of skeletal muscle after spinal cord injury

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Purpose of the Work. Variable frequency train (VFT) stimulation has received considerable interest for countering the fatigue that occurs in the skeletal muscle of able-bodied (AB) individuals during electrical stimulation. This study investigated the effectiveness of VFT stimulation on reducing fatigue in the quadriceps femoris muscle of complete spinal cord injured (SCI) subjects. **Subjects and Procedures.** Participating in the study were 22 SCI and 10 AB controlled subjects. Each subject had their quadriceps femoris muscle electrically stimulated with constant frequency train (CFT) and VFT stimulation before and after a fatigue protocol. **Results.** All groups experienced significant muscle fatigue during electrical stimulation. When compared to CFT stimulation, the VFT stimulation failed to augment the torque-time integral in SCI subjects to the same extent as AB subjects. **Relevance to the Veteran Population.** There is much interest in using electrical stimulation for the rehabilitation of veterans with SCI. These data provide the first evidence that VFT stimulation may not be effective at reducing fatigue without prior conditioning with electrical stimulation. These results may lead to improving the clinical use of electrical stimulation.

C. Scott Bickel, PT, PhD

A portable, 8-channel transcutaneous stimulator for paraplegic muscle training and mobility—A technical note

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Purpose of the Work. This study designed and developed a portable, 8-channel, neuromuscular stimulator for use by individuals with paraplegia. **Subjects and Procedures.** The target audience for this device are those impacted by neurological disorders that impair lower-limb mobility, mainly the spinal cord injured population. Our intent was to develop a versatile neuromuscular stimulator for a variety of uses, including exercise (leg strengthening, cycling), mobility (prolonged standing, walking), and preventive skin care (pressure relief). **Results.** The stimulator successfully met the design criteria and also passed all relevant safety and reliability testing, making it suitable for home use. **Relevance to the Veteran Population.** Over the past 25 years, functional electrical stimulation has become a viable rehabilitative and mobilization tool for the paraplegic population. During this time, many stimulators have been introduced, but relatively few have found widespread use throughout the paraplegic community. We believed the technology was available to develop a versatile neuromuscular stimulator that would appeal to researchers, as well as meet the requirements for home use.

Scott Simcox, MSEE

Effects of neostigmine and glycopyrrolate on pulmonary resistance in spinal cord injury

Miroslav Radulovic, MD; Ann M. Spungen, EdD; Jill M. Wecht, EdD; Mark A. Korsten, MD; Gregory J. Schilero, MD; William A. Bauman, MD; Marvin Lesser, MD

Purpose of the Work. This study assessed the effects of neostigmine alone or neostigmine combined with glycopyrrolate on pulmonary resistances. **Subjects and Procedures.** Eleven subjects with spinal cord injury (SCI) were studied (three with tetraplegia and eight with paraplegia). Pulmonary resistances at 5 Hz (R5) and 20 Hz (R20) were measured using an impulse oscillation system (IOS) with patients in the supine position before and after intravenous administration of 2 mg of neostigmine. On a separate day, R5 and R20 were measured before and after intravenous administration of neostigmine combined with glycopyrrolate (0.4 mg). **Results.** We found that R5 and R20 increased significantly from baseline (25% and 18%, respectively) after administration of neostigmine, revealing that the agent caused significant bronchoconstriction. Following administration of neostigmine combined with glycopyrrolate, R5 and R20 fell significantly from baseline (9% and 7%, respectively), demonstrating that bronchodilation had occurred. Also, we observed that baseline IOS values obtained on the 2 separate days were highly reproducible, indicating that measurement of IOS parameters in the supine position may be preferable. **Relevance**

to the Veteran Population. The findings demonstrate that administration of neostigmine alone in patients with SCI causes bronchoconstriction, which may worsen respiratory status. The administration of glycopyrrolate combined with neostigmine prevents bronchoconstriction. Therefore, when neostigmine is administered to patients with SCI to facilitate bowel evacuation, the agent should be administered in combination with glycopyrrolate.

Miroslav Radulovic, MD

Bronchodilator responses to metaproterenol sulfate among subjects with spinal cord injury

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Purpose of the Work. This study compared bronchodilator responsiveness to metaproterenol sulfate between veterans with chronic tetraplegia (injury level C4 to C7) and low paraplegia (injury below T5) using standard spirometric techniques and whole-body plethysmography. **Subjects and Procedures.** Stable subjects with tetraplegia (n = 5) and low paraplegia (n = 5) underwent spirometry and measurement of specific airway conductance (sGaw) by body plethysmography at baseline and 30 minutes after inhalation of metaproterenol sulfate, a beta-2 adrenergic agonist. **Results.** Following inhalation of metaproterenol sulfate, bronchodilator responses were seen among subjects with tetraplegia as determined by significant increases in spirometric parameters and sGaw. Among subjects with paraplegia, only sGaw increased significantly, although the magnitude of this increase was less than that observed among subjects with tetraplegia. Body plethysmography was a more sensitive technique than spirometry for assessing bronchodilator responsiveness. **Relevance to the Veteran Population.** Among subjects with tetraplegia, respiratory problems are a significant cause for morbidity and mortality. The use of agents to promote bronchodilation, or opening of the airways, may help these subjects to clear mucous and reduce the incidence of pulmonary complications. The finding in this study of significant bronchodilation among subjects with tetraplegia (cervical spinal cord injury) suggests that these subjects may benefit from chronic use of a beta-2 adrenergic agonist such as inhaled metaproterenol sulfate. Longer-term studies are therefore warranted.

Gregory J. Schilero, MD

The effect of rear-wheel position on seating ergonomics and mobility efficiency in wheelchair users with spinal cord injuries: A pilot study

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Purpose of the Work. The wheelchair is a central assistive device in the rehabilitation process of the spinal cord injured (SCI) user. The matching process to get the wheelchair to fit the user is not always easy. Physiotherapists and occupational therapists who are involved in this process have a need for more evidence-based knowledge. We conducted this study to get more knowledge in the relation between seating and propulsion ergonomics. **Subjects and Procedures.** A randomized sample of SCI paraplegic wheelchair users participated in this study. We collected data using one active wheelchair and a change of rear-wheel position. All subjects performed two different activities: propulsion on a treadmill and computer work in both positions. Mechanical efficiency, estimated perceived exertion and breathlessness, stroke angle and frequency, estimated seating, and propulsion comfort were all collected and analyzed from the treadmill session. Pelvic position, as well as estimated comfort and activity performance, was measured and analyzed from the computer session. **Results.** The change of rear wheel position had a significant effect on seat inclination, weight distribution, stroke angle, and push frequency. However, mechanical efficiency, estimated breathlessness, perceived exertion, seating and propulsion comfort, pelvic position, and activity performance did not follow these changes. No significant differences were found in those aspects. **Relevance to the Veteran Population.** Increased knowledge in wheelchair qualities and how one aspect might affect another are important to every wheelchair user. The wheelchair is an assistive device aimed for mobility, but it is also in many cases the only chair used. Future development of the handrim wheelchair should include more thoughts and ideas around seating ergonomics to reduce secondary complications such as pressure sores, deformities, and pain.

Kersti A.M. Samuelsson, OT, PhD

Predicting consistency of pain over a 10-year period in persons with spinal cord injury

Diana H. Rintala, PhD; Karen A. Hart, PhD; Michael M. Priebe, MD

Purpose of the Work. This longitudinal study was designed to test the hypothesis that persons who consistently report pain at three (women) or four (men) measurement points across 10 years (1988–1998) are different

from those who inconsistently or never report pain. **Subjects and Procedures.** Participants were 96 persons with spinal cord injury (SCI) living in the community who participated at every measurement point. Measures included consistency of reports of pain (i.e., reported having had problems with pain in the 12 months prior to all, some, or no measurement points); demographic and injury-related data; and measures of physical and psychological health, function, and social support. **Results.** Approximately half of the men and three-fourths of the women consistently reported pain at each point. Phase 1 predictors of the consistency of pain reports for men were being less impaired, being more independent, experiencing more stress, and receiving less social support. Women consistently reporting pain had more stress at Phase 1 than women inconsistently reporting pain. **Relevance to the Veteran Population.** Chronic pain is a prevalent and serious problem for veterans with SCI. Persons with SCI at risk for chronic pain should be identified and referred to a multidisciplinary pain management program. Healthcare providers need to be aware that pain after SCI can become chronic and does not necessarily decrease even a long time after injury. If pain is routinely assessed and better interventions are found, veterans with SCI may experience a decrease in pain with a resulting improvement in their quality of life.

Diana H. Rintala, PhD

Common carotid and common femoral arterial dynamics during head-up tilt in persons with spinal cord injury

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Purpose of the Work. This study determined the effect of the level of spinal cord injury (SCI), i.e., tetraplegia and paraplegia, on common carotid arterial (CCA) and common femoral arterial (CFA) function supine and during head-up tilt (HUT). **Subjects.** Participants included individuals with tetraplegia (n = 7), paraplegia (n = 8), and able-bodied controls (n = 8). All were healthy males between the ages of 19 and 60 years. **Procedures.** We used Doppler ultrasound to determine vessel diastolic diameters and flow velocities while supine and at 45° HUT. **Results.** Supine CCA diameter and flow were increased in the tetraplegia compared with the paraplegia group. CCA_{flow} was significantly reduced from supine to 45° HUT in the tetraplegia group. CFA diameter and flow were significantly reduced in the SCI groups compared with the control group, and CFA_{flow} was reduced from supine to 45° HUT in the tetraplegia group. **Relevance to the Veteran Population.** Increased resting CCA diameters and flows compared in individuals with tetraplegia may contribute to orthostatic tolerance seen in individuals with long-term injuries. The significant reduction in CFA_{flow} from supine to 45° HUT in the tetraplegia group may be related to the completeness of lesion rather than the level of lesion.

Jill M. Wecht, EdD

Difficulty with evacuation after spinal cord injury: Colonic motility during sleep and effects of abdominal wall stimulation

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Purpose of the Work. Management of spinal cord injury (SCI) in veterans is an important mission of the VA healthcare system. In this respect, difficulty with evacuation (DWE) adversely affects the quality of life after SCI, and its treatment consumes an inordinate level of resources. The studies described in this paper were designed to improve our understanding of the pathogenesis of DWE and to facilitate its management. **Subjects.** Although the studies were performed in a veteran population, the results can certainly be generalized to nonveterans with SCI. **Results.** In brief, our results indicate that motility may be especially depressed during sleep after SCI and that this may exacerbate an already sluggish colon transit time. It also appears that measures that increase contraction of abdominal wall muscles may facilitate defecation. This seemed especially helpful in subjects with higher cord lesions where volitional control over the abdominal wall musculature was lacking. **Relevance to the Veteran Population.** To the extent that these results are confirmed, the long-term costs of bowel care programs in veterans might be significantly reduced.

Mark A. Korsten, MD

Lack of justification for routine abdominal ultrasonography in patients with chronic spinal cord injury

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Purpose of the Work. This retrospective study has three aims. First, we wanted to assess whether the practice of

performing routine annual abdominal ultrasonography resulted in detection of any treatable pathology that otherwise would not have been found. Second, we sought to determine if any interventions occurred as a result of these findings. Third, we sought to determine if information from a single baseline ultrasound would be adequate or if longitudinal studies are necessary for surveillance of treatable pathology. **Subjects and Procedures.** Electronic records of 174 individuals with spinal cord injury (SCI) or disorders were reviewed. Results of their abdominal ultrasound studies were recorded with specific attention to evaluations of the liver, kidney, spleen, common bile duct, and gallbladder. **Results.** In this population of patients, we found a high incidence of abnormal findings in the liver (66%–90%), and frequent abnormalities in the pancreas, spleen, gallbladder, and kidney. There were no aortic aneurysms or renal masses detected and no abnormalities in the common bile duct. No specific interventions (such as liver biopsy, cholecystectomy, nephrectomy) resulted from detection of the abnormalities in the liver, gallbladder, and kidney. No added benefit was found to performing two or three exams as compared to doing a single examination. **Relevance to the Veteran Population.** This study has a direct application to patient care. Since SCI is a chronic illness with effects on organ systems that are unique to the disorder, specific surveillance measures must be taken to prevent treatable secondary disease and subsequently promote general health. On the other hand, health resources must be judiciously used and patients should not be asked to undergo tests that are unnecessary. Guidelines for assessments and surveillance should be based on evidence-based research. This paper aims to provide the starting point for this type of research.

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