

Prevalence and characteristics of chronic pain in veterans with spinal cord injury

Diana H. Rintala, PhD; Sally Ann Holmes, MD;
Richard Neil Fiess; Daisy Courtade, MA;
Paul G. Loubser, MD

Purpose of the Work. This study assessed pain characteristics in veterans with spinal cord injury (SCI), including prevalence, duration, frequency, exacerbating factors, severity, quality, body areas affected, and effect on daily activities. **Subjects and Procedures.** Veterans with SCI completed a pain questionnaire and other measures during a telephone survey. **Results.** Of the participants, 76% reported at least one chronic pain. Most pains occurred daily and lasted most of the day. On a 0 to 10 scale, pain intensity averaged 6.7 the week before the interview and 8.6 at its worst. Two-thirds of the pain components interfered somewhat with daily activities. **Relevance to the Veteran Population.** Chronic pain is very common among veterans with SCI. We estimate that 11,400 veterans with SCI receiving care from the Department of Veterans Affairs have chronic pain and that 6,270 have severe chronic pain. The number of veterans with SCI and chronic pain is likely to increase because of aging and increased time since injury. Research to identify causes of and better ways of preventing, assessing, and treating chronic pain are needed.

Diana H. Rintala, PhD

Chronicity of pain associated with spinal cord injury: A longitudinal analysis

Yenisel Cruz-Almeida, MSPH;
Alberto Martinez-Arizala, MD;
Eva G. Widerström-Noga, DDS, PhD

Purpose of the Work. This study examined the stability of clinical pain characteristics and pain-induced interference with sleep and daily activities in people with spinal cord injury (SCI). **Subjects and Procedures.** People with chronic pain and SCI completed two surveys 18 months apart. Their pain history data (location, descriptors, intensities, temporal aspects, and pain-induced interference) were compared between the surveys. A confirmatory factor analysis (CFA) determined the stability over time of previously observed pain patterns (neuropathic pain below

the level of injury, upper-limb pain in tetraplegia, and severe, persistent pain). **Results.** The CFA confirmed that participants' pain patterns were stable over the 18-month period. Specifically, the two surveys were strongly correlated on pain locations, pain descriptors, pain intensities, and temporal aspects of pain. "Aching" pain and interference with sleep significantly increased. **Relevance to the Veteran Population.** Many veterans with SCI experience chronic pain. Information about the long-term course of pain in the SCI population is important to improve pain evaluation and management.

Yenisel Cruz-Almeida, MSPH

Video-capture virtual reality system for patients with paraplegic spinal cord injury

Rachel Kizony, MSc; Liat Raz, MSc; Noomi Katz, PhD;
Harold Weingarden, MD; Patrice L. Tamar Weiss, PhD

Purpose of the Work. This feasibility study reported on the use of the Gesture Xtreme (GX) virtual reality (VR) system with patients who had sustained a spinal cord injury (SCI) at the level of the second thoracic (T2) vertebra and below (i.e., a paraplegic injury). This included examination of relationships between performance on a standard test of static balance and performance within the virtual environments (VEs) as well as differences in performance within the VEs between patients with SCI and nondisabled subjects. Since those with disabilities may not function at the same level as the nondisabled, testing control subjects in this preliminary work is important. **Subjects and Procedures.** Subjects included 13 patients (9 male and 4 female), aged 21 to 53 years (mean age 33.6 ± 12.4 standard deviation [SD]), with 10 who had sustained complete SCI, 2 incomplete SCIs according to the American Spinal Injury Association's impairment scale at the T3 to L2 (second lumbar) level, and 1 with an injury at the cauda equina level. They each experienced three VEs. Results from the patient group were compared with data from a parallel study of a group of 12 (6 male and 6 female) nondisabled subjects, aged 20 to 55 years (29.6 ± 9.5 SD), who performed a similar protocol, while sitting on a chair with their hands supported on arm rests. **Results.** Their responses to the Short Feedback Questionnaire showed high levels of presence. Performance in the VEs was compared with the

group of 12 nondisabled. Response times for the patient group were higher, and percent success was lower. In addition, moderate correlations were found between performance within VR and balance ability. **Relevance to the Veteran Population.** Our findings show the potential of patients with SCI using the GX-VR system as an additional tool during the rehabilitation, although further clinical trial studies are needed to demonstrate the efficacy of such a treatment, compared with conventional balance and performance training. Moreover, they point to the potential for using the VR platform for a postrehabilitation exercise program, especially for patients who are unable to participate in regular sports activities.

Rachel Kizony, MSc

Effects of vibratory stimulation on sexual response in women with spinal cord injury

Marca L. Sipski, MD; Craig J. Alexander, PhD;
Orlando Gomez-Marin, MSc, PhD;
Marissa Grossbard, BS; Raymond Rosen, PhD

Purpose of the Work. Spinal cord injury (SCI) is a priority area of health services research for veterans. Many female and male veterans with SCIs suffer from sexual dysfunction. This work evaluated a potential treatment method for sexual dysfunction following SCI. **Subjects and Procedures.** Subjects included 46 women with SCIs and 11 nondisabled control subjects. The study consisted of alternating baseline, vibratory stimulation, and manual clitoral stimulation periods. **Results.** Results revealed increased vaginal pulse amplitude and subjective arousal with vibratory stimulation and manual stimulation versus baseline. **Relevance to the Veteran Population.** We believe that vibratory stimulation is a potentially viable way to improve genital responsiveness in women with SCIs. This subject matter warrants increased attention as it pertains to the quality of lives of male and female veterans.

Marca L. Sipski, MD

Heart rate as a predictor of energy expenditure in people with spinal cord injury

Amy M. Hayes, PT, MS; Jonathan N. Myers, PhD;
Monica Ho; Matthew Y. Lee, MS; Inder Perakash MD;
B. Jenny Kiratli, PhD

Purpose of the Work. To evaluate the accuracy of heart rate (HR) calibrated from a maximal exercise test for

predicting energy expenditure during five activities of daily living (ADL) and rest in participants with spinal cord injury (SCI). **Subjects and Procedures.** Thirteen individuals with SCI (mean age 50 years) underwent maximal exercise testing followed by portable HR and metabolic testing during rest and five ADL. Regression equations were developed for each subject from HR and oxygen uptake from the maximal exercise test. Based on these individualized equations, HR measured during ADL was used to estimate energy expenditure for each participant. Predicted energy expenditure from HR was compared with that measured directly by oxygen uptake. **Results.** HR derived from the individualized equations explained 55% of the variance in measured energy expenditure (from 28% to 88% for the different ADL), compared with only 8.3% from HR alone. However, calibrated HR consistently overestimated the actual kilocalories used; on average, the estimated energy expenditure was roughly 25% higher than that measured directly. Energy expenditure estimated from individualized HRs tended to be more accurate for higher intensity activities. **Relevance to the Veteran Population.** Veterans with SCI are at particularly high risk for cardiovascular disease. A major risk factor for cardiovascular disease in the SCI population is physical inactivity. Methods are needed to improve the estimation of energy expenditure in veterans with SCI. In this study, we observed that HR can be used as a reasonable estimate of energy expenditure during higher-intensity ADL in people with SCI, but only when individual calibration of HR from maximal exercise testing is used.

Amy M. Hayes, PT, MS

Effect of a vitamin D analog on leg bone mineral density in patients with chronic spinal cord injury

William A. Bauman, MD; Ann M. Spungen, EdD;
Nancy Morrison, RN; Run-Lin Zhang, MD;
Ernest Schwartz, MD

Purpose of the Work. Persons with chronic spinal cord injury (SCI) have severe osteoporosis of the paralyzed limbs. Vitamin D metabolites and analogs have been shown to be efficacious in increasing bone mineral density (BMD) and reducing fracture occurrence in osteoporosis that is associated with various clinical conditions. A double-blind placebo-controlled trial was performed that determined the effect of a vitamin D analog (1-alpha-hydroxyvitamin D₂ [1-D₂]) on the bone mass of

patients with chronic SCI. **Subjects and Procedures.** We enrolled 40 subjects with chronic, complete motor SCI. Either 4 μg 1-D₂ or a placebo was administered daily for 24 mo. Regional lower-limb dual-energy x-ray absorptiometry was performed at baseline and at 6, 12, 18, and 24 mo. Results are expressed as mean \pm standard deviation and percent change from baseline values. **Results.** In the 1-D₂ group compared with the placebo group, leg BMD was increased at 6 mo ($2 \pm 4\%$ vs $1 \pm 5\%$; $p < 0.05$) and sustained at 12, 18, and 24 mo. **Relevance to the Veteran Population.** The small increase in leg BMD occurred by 6 mo and was preserved on drug over the ensuing study period. The drug was safe, with only a few subjects having to reduce calcium and/or drug intake. In this controlled trial, a vitamin D analog appeared to be of limited efficacy in increasing BMD of the legs in veterans with chronic SCI.

William A. Bauman, MD

A multicriteria decision analysis of augmentative treatment of upper limbs in persons with tetraplegia

J. M. Marjan Hummel, PhD; Govert J. Snoek, MD;
Janine A. van Til, MSc; Wouter van Rossum, PhD;
Maarten J. IJzerman, Prof PhD

Purpose of the Work. Persons with a spinal cord injury (SCI) at the cervical level suffer from impairment of the arm-hand function. This strongly decreases their independence in daily activities. To choose between reconstructive treatments, persons are advised by treatment teams. Their opinions influence the advice. A technique for decision support is introduced that supports the treatment team in sharing their opinions in an efficient and comprehensive manner. **Procedures.** The team systematically compared the performance of two treatments. Performance characteristics included functional results, risks, treatment intensity, user friendliness, and social acceptance of the treatments. These characteristics were weighted by the team and by persons with tetraplegia. **Results.** For certain persons with a C6-level SCI with active elbow flexor muscles and one active wrist extensor muscle, the team preferred the functional results of surgery combined with Functional Electrical Stimulation. Regarding all performance characteristics combined, it slightly preferred tendon transfer. The persons with tetraplegia gave relatively more weight to the treatment intensity, whereas the treatment team gave more weight to the functional outcomes of the treatment. **Relevance to the Veteran Population.** The rationale behind the preferences for treatment options was explicit.

Discussions about these rationales can enhance the team's advice to the potential recipient. The differences in judgments between the treatment team and the persons with tetraplegia show the importance of them sharing information to make a suitable decision for a therapy. Furthermore, the results are important for the further development of treatment protocols.

J. M. Marjan Hummel, PhD

Efficacy of gabapentin in treating chronic phantom limb and residual limb pain

Douglas G. Smith, MD; Dawn M. Ehde, PhD;
Marisol A. Hanley, PhD;
Kellye M. Campbell, MN, ARNP;
Mark P. Jensen, PhD; Amy J. Hoffman, BS; Asaad B.
Awan, PharmD; Joseph M. Czerniecki, MD;
Lawrence R. Robinson, MD

Purpose of the Work. This study evaluated the effectiveness of gabapentin to treat chronic phantom limb pain (PLP) and/or residual limb pain (PLP) in persons with limb amputations. **Subjects and Procedures.** Twenty-four adults with PLP and/or RLP were randomly assigned to receive gabapentin or a placebo. After a 5-week period of no medication, they were switched to the other treatment. Pain intensity, pain interference, depression, life satisfaction, and functioning were measured. **Results.** Participants' scores before and after treatment did not significantly differ on any of the measures. However, more than half the participants reported meaningful pain decreases while receiving gabapentin, while about one-fifth reported meaningful decreases while receiving placebo. In this study, gabapentin did not substantially affect pain; however, a subset of people with PLP or RLP may benefit from gabapentin treatment. **Relevance to the Veteran Population.** Limb loss is a common disability among veterans, and treatments to relieve chronic pain and associated disabilities are needed.

Douglas G. Smith, MD

Colorimetric analysis of silicone cosmetic prostheses for upper-limb amputees

Mauro Bicchierini, BSc; Angelo Davalli, BSc;
Rinaldo Sacchetti, BSc; Sauro Paganelli, BSc

Purpose of the Work. This project was conducted to study and devise a system capable of automatic detection of the

color of human skin by comparison with a database of standard silicone samples. **Procedures.** We thoroughly analyzed the color identification systems available on the market and aimed to identify the system that could guarantee the best results. We also assessed the possibility of introducing such a system into the production cycle of the silicone prostheses. **Results.** We found that, because of intrinsic factors of the materials, automatic color detection of human skin for prosthesis production is complex. Therefore, any of the systems we tested will require further development for full satisfaction of the needs of prostheses manufacturers. **Relevance to the Veteran Population.** We conducted an important analysis of automatic color detection by identifying the devices available on the market with the best characteristics. The use of this kind of instrument in the production cycle of the prostheses could optimize prosthesis production times and costs.

Mauro Bicchierini, BSc

Relationship between foot type, foot deformity, and ulcer occurrence in the high-risk diabetic foot

William R. Ledoux, PhD; Jane B. Shofer, MS;
Douglas G. Smith, MD; Katrina Sullivan, DPM;
Shane G. Hayes, CPed; Mathieu Assal, MD;
Gayle E. Reiber, PhD

Purpose of the Work. Previous research has indicated that foot shape (both foot type and foot deformity) can affect foot ulcer occurrence. This study further explored the relationship between foot type or foot deformity and ulcer occurrence on a large-scale prospective population. **Subjects and Procedures.** Four hundred study subjects were enrolled from two Western Washington healthcare organizations and followed for 2 years. The parameters studied included foot type (flatfoot, neutrally aligned, and high-arched), foot deformities (hallux valgus, hallux limitus, claw toes), loss of sensation, and the presence or absence of foot ulcers. We examined the relationship between foot type, foot deformity, and ulcers that developed because of mechanical causes. **Results.** We found a strong relationship between foot deformity (fixed claw toes and hallux limitus) and ulceration, and between foot deformity and foot type. Our results do not preclude a relationship between foot type and plantar ulcer occurrence, because the lack of sensitivity in our foot type classification may have contributed to the negative findings. **Relevance to the Veteran Population.** Diabetes and the associated complications, including foot ulceration, are important considerations for the aging

veteran population. Understanding how foot shape and foot deformity relate to ulceration will improve the standard of care.

William R. Ledoux, PhD

Enhanced cognitive-behavioral therapy for vocational rehabilitation in schizophrenia: Effects on hope and work

Paul H. Lysaker, PhD; Gary Bond, PhD;
Louanne W. Davis, PsyD; Gary J. Bryson, PsyD;
Morris D. Bell, PhD

Purpose of the Work. This study looked at the types of services that help veterans with schizophrenia return to productive and rewarding community lives. We studied whether cognitive-behavioral therapy (CBT) helped veterans engage in more productive work activity over a 6-month period. **Subjects and Procedures.** Fifty veterans received either standard support services or CBT and were offered 6-month work placements. **Results.** Veterans who received CBT worked more weeks and had better work performance than veterans receiving standard support. They also continued to have higher levels of hope and self-esteem. **Relevance to the Veteran Population.** These results show that inclusion of CBT along with work services may help veterans participate and succeed in existing programs. These services can be used in other Department of Veterans Affairs settings and may create previously unavailable opportunities for veterans with schizophrenia.

Paul H. Lysaker, PhD

Short-duration robotic therapy in stroke patients with severe upper-limb motor impairment

Margaret A. Finley, PT, PhD; Susan E. Fasoli, ScD;
Laura Dipietro, PhD; Jill Ohlhoff, BA;
Leah MacClellan, MSPH; Christine Meister, OTR;
Jill Whittall, PhD; Richard Macko, MD;
Christopher T. Bever Jr., MD; Hermano I. Krebs, PhD;
Neville Hogan, PhD

Purpose of the Work. This study investigated the effect of robotic therapy on motor function and robot-derived performance measures in patients with chronic, severe upper-limb (UL) impairments after stroke. **Subjects and Procedures.** We studied 15 individuals with chronic stroke (minimum 6 mo postonset) and a maximum Fugl-Meyer UL score of 15 (maximum possible score = 66). Each participant performed

18 sessions of robot-assisted UL rehabilitation intervention that consisted of goal-directed, planar reaching tasks over a period of 3 weeks. Outcome measures were the Fugl-Meyer Test of UL Function, the Motor Power Assessment, the Wolf Motor Arm Test Assessment, and robot-derived measures of aiming error, mean speed, peak speed, mean:peak speed ratio, and movement duration. **Results.** Training produced significant improvements from baseline to discharge in the Fugl-Meyer and Motor Power Assessment and movement quality as quantified by a reduction in aiming error and movement duration with increases in mean speed and speed ratio variables. **Relevance to the Veteran Population.** UL dysfunction because of weakness and spasticity from stroke is a leading cause of chronic disability in veterans. Our findings demonstrate that robot-assisted UL rehabilitation reduces UL impairment and improves the quality of motion in patients with UL impairments following stroke.

Margaret A. Finley, PT, PhD

Use of the Delphi Technique for developing national clinical guidelines for prescription of lower-limb prostheses

Harmen van der Linde, MD, PhD; Cheriell J. Hofstad, MSc; Jacques van Limbeek, MD, PhD; Klaas Postema, MD, PhD; Jan H. B. Geertzen, MD, PhD

Purpose of the Work. This project aimed to develop a combination of evidence- and consensus-based clinical practice guidelines for lower-limb prosthesis prescription for achieving transparency and consensus among clinicians, manufacturers, and insurance companies. A modified Delphi Technique, which is based on different methods of collecting evidence, and its role in the development of national clinical guidelines for prosthesis prescription are described. **Procedures.** We used a multi-method approach to develop guidelines for the clinical practice of prosthesis prescription for lower-limb amputees. Our pragmatic approach to guideline development involved various methods: a systematic review, a survey of national clinical practice on prosthetic prescription, and interviews with experts. These activities resulted in 45 postulates about prosthesis prescription. The views of the national expert panel were then presented at a consensus development conference. **Results.** The participants in the Delphi Technique sessions reached a consensus on 37 of the postulates on prosthesis prescription for lower-limb amputees. The postulates were categorized according to

amputation level and partitioned into different domains. The prescription format that consisted of 37 theses was based on the scientific evidence derived from a systematic review of critically appraised literature and integrated with the expert opinions of clinicians. The total process resulted in the development of draft clinical guidelines comprising guidance for prescription of prostheses for the lower limb. **Relevance to the Veteran Population.** The subject of this review, amputees and prosthetic prescription, fits within one of the priority areas of the *JRRD*.

Harmen van der Linde, MD, PhD

An initial study on lip perception of electrotactile array stimulation

Wei Liu, MS; Hui Tang, PhD

Purpose of the Work. This work evaluates the sensitivity and spatial discriminating ability of the upper and lower lips for electrotactile presentation on the lips. The eventual goal is to build wearable tactile aids on the lips for sensory rehabilitation. **Subjects and Procedures.** The human subjects consisted of eight sighted volunteers (six young adults and two seniors). Three stimulator arrays of different size were applied on the lip surfaces of the subjects. Experiments of threshold measurement and rating of two-line separation were conducted on the lower and upper lips. Each experiment on the same subject, array, and lip location was repeated in three visits. **Results.** The upper and lower lips were shown to be highly sensitive to electrotactile stimulation. On an array of stimulators 1.55 mm in diameter, average thresholds were as low as 6.3 V on the lower lip and 7.1 V on the upper lip, and average intensities for strong and comfortable perception were 10.4 V on the lower lip and 12.5 V on the upper lip. The lips also showed excellent spatial discriminating capability, with the upper lip slightly more sensitive to spatial difference. The sensitivity indices indicated that a center-to-center spacing of 2.4 mm was adequate for separate perception. **Relevance to the Veteran Population.** A novel lip-based electrotactile display may serve as a wearable tactile aid for veterans with sensory disabilities. In addition, the tactile aid may be used to provide hands-free tactile feedback for veterans with physical disabilities.

Hui Tang, PhD