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Presentation Abstracts 1–35

1 A fall prevention program for manual wheelchair users with spinal cord injuries: Pilot study

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Objective: To describe the impact of an education program to prevent falls in full-time manual wheelchair users (MWU) living with Spinal Cord Injury (SCI).

Design: Pre/post. At baseline, participants reported the frequency of falls over the past six months and completed the Community Participation Indicators(CPI) and the World Health Organization Quality of Life (short version - WHO-QOL BREF) assessment. Transfer quality to and from a mat table was assessed using the Transfer Assessment Instrument (TAI) and boundaries of seated stability were evaluated using standardized procedures. After baseline testing, a structured education program designed to decrease fall frequency was implemented. After the intervention, participants were asked to prospectively track fall frequency for 12 weeks. After 12 weeks, the assessment, as described above, was repeated.

Participant/methods: 18 fulltime MWUs with SCI participated in the study. Participants were an average of 35.78 ± 13.89 y.o. and lived with their SCI for an average of 17 ± 15 years. The majority of participants were female ($n = 11$, 61.1%). Level of injury ranged from C4-L3, AIS A-C. To examine the differences in outcomes pre and post exposure to the education program, seated stability was evaluated using a paired t-test. Non-parametric Wilcoxon tests were used to evaluate all other variables due to the ordinal or non-normally distributed nature of the data.

Results: After exposure to the intervention, fall frequency significantly decreased, (Pre: 1.37 ± 1.62 falls per month, Post: 0.67 ± 0.82 , $p = 0.047$). A trend in the data indicated improvements in seated stability (Pre: $1.22 \pm .26$, Post: $1.35 \pm .26$, $p = 0.06$). Finally, significant improvements were found in the WHO-QOL Physical Health (Pre: 67.83 ± 15.96 , Post: 75.61 ± 16.38 $p = 0.05$) and Psychological (Pre: 69.06 ± 14.67 , Post: 76.17 ± 17.62 , $p = 0.040$) domains. No significant differences were found among TAI or CPI scores.

Conclusion: The structured fall prevention education program specifically designed for MWUs living with SCI appears to have potential to reduce fall frequency and improve quality of life. Additional research in the form of a large-scale, controlled investigation of the program is needed to further assess program effectiveness.

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2 Arm crank ergometer exercise improves acute glucose kinetics in paraplegia

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Background: Whole body exercise stimulates non-insulin mediated glucose transport to improve glucose effectiveness (Sg) and insulin sensitivity (Si) in able bodied (AB) individuals, but the timing and extent of such changes have yet to be characterized for upper extremity work or for persons with spinal cord injury (SCI). **Objective:** To determine the effect of a single session of upper extremity exercise on carbohydrate metabolism immediately following and 24 h after exercise in individuals with and without SCI.

Design: Prospective; Clinical hospital, academic setting

Participants/methods: Twelve persons with paraplegia (M/F 10/2, age 34.0 ± 11.2 y, body mass index [BMI] 26.8 ± 6.4 kg/m²; T1-T11; ISNCSCI A&B) and 5 AB controls (M/F 3/2, age 25.6 ± 10.2 y, BMI 25.0 ± 5.7) were included in this IRB-approved study. Individuals with metabolic disease, uncontrolled autonomic dysreflexia, or upper limb heterotopic ossification were excluded. All participants underwent baseline arm crank ergometer (ACE) maximal graded exercise tests, assessment of percent body fat (%BF) via DXA, and basal metabolic rate (BMR) via indirect calorimetry, as well as an intravenous glucose tolerance test (IVGTT) to determine Sg and Si. The following day, participants performed 45 min of ACE exercise at 75% VO_2Peak followed by an immediate and 24-hour assessment of BMR and IVGTT. Data normalized to baseline values and change scores were calculated. Welch two sample t-test was used to evaluate differences between groups. $\alpha < 0.05$.

Results: Baseline values were similar between persons with SCI and AB ($P > 0.05$); however, VO_2Peak was significantly lower in SCI vs. AB (SCI 22.3 ± 3.99 , AB 30.8 ± 3.19 ml/kg/min, $P = 0.0001$) and %BF approached a significant difference between the groups (SCI 26.9 ± 12.6 vs. AB 17.3 ± 6.8 , $p = 0.07$). Immediately and 24 h after the exercise, Sg significantly increased (SCI 0.03 ± 0.01 , AB 0.02 ± 0.01 ; $P = 0.03$) then decreased (SCI 0.02 ± 0.01 , AB 0.02 ± 0.01 ; $P = 0.01$), respectively, in SCI vs. AB. However, there were no significant differences in the change score between baseline and 24 h after the exercise bout ($P > 0.05$). Si and BMR were not significantly different between the groups at all time points ($P > 0.05$).

Conclusion: A single bout of moderately intense upper extremity exercise helped to acutely control glucose in those with SCI; however, this was not sustained past 24 hours, providing support for regular engagement in exercise for this population.

Support: PVA 2256

3 Autologous micro-fragmented adipose tissue injection for shoulder pain in spinal cord injury

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Background: Rotator cuff disease is the most common cause of shoulder pain in persons with spinal cord injury (SCI). It usually resolves with non-operative treatments such as pharmacological agents and physical therapy;

however, when these fail, surgery may be the only option. Autologous adipose tissue injection has emerged as a promising treatment for joint pain. Adipose can be used to provide cushioning and filling of structural defects and has been shown to have an abundance of bioactive elements and regenerative perivascular cells. Injection of autologous micro-fragmented adipose tissue isolated using the Lipogems® System has shown promise in treatment of shoulder injuries in non-SCI populations; however, its use in SCI has not been reported. **Objective:** To determine the safety and efficacy of autologous, micro-fragmented adipose tissue injection for chronic shoulder pain due to rotator cuff disease in persons with SCI.

Design: Case series.

Participants/methods: Two individuals with SCI and rotator cuff disease unresponsive to nonsurgical treatments for longer than 6 months underwent treatment. Micro-fragmented adipose tissue was obtained using the Lipogems® system and then was injected into the tendons under continuous ultrasound guidance. After 24 hours subjects began a standardized stretching protocol and after 4 weeks subjects began a formal strengthening program. Participants were followed for adverse events and changes in shoulder pain intensity on an 11-point numerical rating scale, the Wheelchair User's Shoulder Pain Index (WUSPI), and a 5-point subject global impression of change (SGIC) scale. Subjects were examined at 4, 8, and 12 weeks.

Results: Both subjects had a greater than 75% reduction in shoulder pain at the 12-week follow-up visit. Average pain NRS scores in each subject dropped from 5 to 0 and WUSPI scores dropped from 48 to 0 and 66 to 3, respectively. Global impression of change reported by both subjects was "very much improved".

Conclusion: Results suggest that a single injection of autologous micro-fragmented adipose tissue can improve pain and function scores in persons with SCI with recalcitrant rotator cuff disease, thus avoiding surgery. Lack of blinding and a suitable control group might be relevant issues in the interpretation of trial results. Longer term follow-up in a larger sample, followed by a randomized controlled trial is warranted.

Support: Supported by Derfner Foundation.

4 Biomechanical analysis of wheelchair athletes with paraplegia during cross-training exercises

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Objective: To quantify shoulder joint kinematics of novice, intermediate, and experienced wheelchair athletes during cross-training exercises.

Design: Observational study

Participants/methods: Three male wheelchair athletes, average age of 37.1 ± 4.6 years, with spinal cord injury levels of T8, L2, and T10, were novice, intermediate, and experienced with cross-training, respectively. Motion capture was performed during multiple trials of three cross-training exercises: battle rope, sled pull, and overhead press. Our custom upper extremity kinematic model was applied to determine three-dimensional joint angles. A ten-repetition average was calculated per subject for each exercise.

Results: Moving from novice to intermediate to experienced athlete during the overhead press exercise, there was a trend towards increased peak elevation angle (95.6° , 153.0° , and 171.4°) resulting in increased ROM. The experienced athlete had the least amount of internal rotation when the weight was at peak height. The battle rope exercise trended towards increased peak flexion (71.2° , 93.7° , and 99.9°), increased axial rotation ROM (16.5° , 19.9° , and 27.0°) and adduction (-8.9° , -8.6° , and 5.9°). The sled pull exercise trended towards increased abduction (-33.1° , -42.4° , and -54.9°). Additionally, multiple parameters demonstrated differences among the athletes, including sagittal plane ROM (56.8° , 79.5° , and 41.4°) and peak internal rotation (49.7° , 42.0° , and 70.4°).

Conclusion: During cross-training exercises, shoulder joint kinematics of wheelchair athletes vary with experience. These findings may help to reduce or prevent injury through improved guidelines for prescription of sports activity and proper technique. Research is underway to characterize the thorax and comprehensive

upper extremity joint kinematics and determine the influence of spinal cord injury level on performance during cross-training exercises.

Support: We thank the Medical College of Wisconsin Research Affairs Committee and the study's certified personal trainer, Justin Plesnik..

5 Ernest Bors Award for scientific development brain stimulation for spinal cord injury: To focus or not to focus

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Objective: To determine if the amount of current delivered to cortical sites representing paretic upper limb, using transcranial direct current stimulation (tDCS), can influence gains in upper limb function in patients with cervical incomplete spinal cord injury (iSCI).

Design: Randomized, sham-controlled, blinded, clinical trial.

Participants/methods: 16 subjects with chronic iSCI (age: 52.9 ± 10.8) were enrolled. Subjects were randomly assigned to receive rehabilitation + tDCS or rehabilitation + sham stimulation for 10 sessions. From pretest to posttest, we assessed change in upper extremity motor score, manual muscle testing and dexterity. We also assessed cortical representations devoted to both muscles caudal and rostral to the lesion using transcranial magnetic stimulation (TMS). The amount of current from tDCS being targeted to the cortical sites defined with TMS was determined using the HD-Explore. A linear mixed methods model was used for analysis, where significance was set as $p < 0.05$.

Results: We found that tDCS + rehabilitation, in comparison to sham, improved upper limb function. Specifically, subjects in the tDCS + rehabilitation group displayed: (1) improvements in dexterity (by 25%), (2) gains in manual muscle testing (by 15%), and (3) more benefit in arm grasp/grip function (by 10%). Benefits were maintained for three months following the intervention. The extent of improvement after tDCS was related to the amount of current targeting motor cortical areas dedicated to the weak muscles ($p < 0.05$). Of note, subjects in the tDCS group demonstrated 4X greater improvement in manual dexterity if a higher amount of current was able to target motor cortical areas dedicated to the weak muscles.

Conclusion: Rehabilitation can improve upper limb function after iSCI. However, improvements are slight and frustratingly slow in being realized. We report here that a promising experimental technique known as tDCS can improve upper limb function up to 25% more than rehabilitation alone. We also observed that the amount of current targeted to motor cortical areas dedicated to the weak muscles can influence the amount of upper limb recovery after intervention. This suggests that tDCS can be optimized to generate even greater improvements. Specifically, our work recommends that focal tDCS would result in greater targeting to cortical areas dedicated to the weak muscles and larger improvements in upper limb function.

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6 Charcot spine following spinal cord injury: Lessons from big data

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Background: Charcot spine, a degenerative disease of the vertebral bodies, is a relatively rare condition that can occur after spinal cord injury (SCI). Given its rarity, most of our knowledge is based upon case reports and small case series. While these are able to disseminate some awareness of the condition, information such as the frequency of clinical presentations and radiographic findings, risk factors (including long mechanistic lever arms from post-traumatic fusions), and management approaches are severely lacking. This leads to a prolonged gap between symptom onset and diagnosis.

Objective: To improve collective understanding of Charcot spine following SCI.

Design: Systematic review of all published cases.

Participants/methods: Searching all published literature, available cases of Charcot spine following SCI were extracted from manuscripts and compiled into a database. Cases were excluded if the neurologic deficits were due to peripheral neuropathy or demyelination alone, or if the case described fracture through a laminectomy site without previous spinal fusion. Demographics, ISNCSCI classification/grade, length of initial fusion, presenting symptoms, radiologic findings, management, and recurrence were all extracted from these cases in a standardized manner. Descriptive statistics were calculated for demographic, presentations, and management details. Length of initial spinal fusion relative to location of Charcot joint was analyzed with a linear regression.

Results: 51 manuscripts were identified with 192 total cases of Charcot spine after SCI meeting our criteria. Over 93% of cases occurred following neurologically complete injuries, with 83.4% of patients having thoracic injuries. The most common presenting symptoms were back pain, spinal deformity, and crepitus. Radiographically, vertebral body destruction, osteophytes, and endplate destruction were most commonly used to identify Charcot spine. The mean time from symptom onset to diagnosis was over 16 months. The greatest number of Charcot joints occurred at L4-L5, with over 75% of all Charcot spine managed surgically. Length of initial fusion did not correlate with closer proximity of the Charcot spinal joint to the distal fusion end ($R^2 = 0.25$).

Conclusion: Charcot spine has stereotypic findings associated with it. Appreciation of these emerging details may assist in timely diagnosis of Charcot spine and informed management.

7 Distress levels in veterans with amyotrophic lateral sclerosis and caregivers

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Objective: To study the effects of interventions by Psychology and Social Work to lower the distress levels of Veterans with ALS and Caregivers.

Design: Retrospective chart review, archival chart review of assessment results during annual and follow-up sessions for psychology and social work.

Participants/Methods: 151 Veterans diagnosed with ALS between January 2012 and December 2017 who had more than one distress score on the Distress Thermometer and Checklist. 57 Patients resided in Tampa VA Catchment Area and 48 Patients had Social Work Interventions. Veteran's demographic and phenotype were analyzed.

Results: Mean Age when diagnosed: 64.9 (SD 10.99, Median 66.0, Range 23-89) White: 91.9% (n = 151), non-Hispanic origin 93.5% (n = 141) Married 81.9% (n = 151) Baseline DATA among 151 patients who had more than one distress score: Mean P-distress score: 5.1 (SD 2.35, median 5.0, range 0-10) Baseline P-distress score > 5.0 (mean 6.6): 60.3% (n = 91) Mean S-Distress: 6.8 (SD 2.55, median 7.0, range 0-10) Baseline S-Distress score > 5.0 (mean 7.4): 60.9% (n = 92) Comparison of Patient-Distress score between two groups (Psychological & SW Intervention Group (Group 1) and Only Psychological Intervention group (Group 2) Group I Baseline P-Distress: 5.5 Overtime Change Group 1: 4.2 Group II Baseline : 4.8 Overtime Change Group II : 4.2 •Baseline P-Distress score was higher on Group I (5.5 vs. 4.8) •Patients distress score was reduced overtime in both groups, but more significantly on Group I (5.5 to 4.2) it was statistically significant on Global phenotype ALS patients (p < .000) Comparison of S (Caregiver)-Distress score between two

groups (Psychological & SW Intervention Group (Group 1) and Psychological Intervention group (Group 2) Group I Baseline S-Distress 7.3 Overall Change Group I: 5.5 Group II Baseline 6.4 Overtime Change Group II: 6.4 •Caregiver displayed much higher distress score at start in both groups (7.3 vs. 5.5 and 6.4 vs. 4.8) •Caregivers receiving both psychological and SW intervention showed significantly reduced distress score from 7.3 to 5.5 ($p < .000$).

Conclusion: Overtime reduction of patient's and caregiver's distress were observed with both psychological and SW intervention implemented.

8 Effect of ambulation training on lower extremity venous compliance in spinal cord injury

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Background: Our group has previously reported that lower extremity venous compliance (LEVC) is significantly reduced in persons with spinal cord injury (SCI) compared to age-matched healthy controls. Reduced LEVC was not dependent on level of SCI, and we speculate that chronic inactivity and limited daily orthostatic challenge may contribute to atrophic changes in the venous vasculature of the leg. Robotic exoskeletal-assisted walking (EAW) has the ability to increase daily levels of activity and provide orthostatic stress, which, in turn, may serve to improve LEVC.

Design: Prospective, repeated-measure, cross-sectional study.

Participants/methods: Venous occlusion plethysmography (VOP) was used to determine changes in LEVC before and shortly after EAW training in 19 individuals with chronic SCI. Individuals with SCI had a duration of injury from 1 to 20 years, with 74% having motor-incomplete lesions (AIS C and D classifications) and the level of lesion ranging between C-4 to L-2. VOP was acquired from the thickest section of the shank of the leg using the appropriate strain gauge for a given shank's circumference. The thigh cuff was inflated to 20 mmHg below the diastolic blood pressure (BP) while the ankle cuff was inflated to 100 mmHg above the systolic BP. VOP was measured for 3 minutes, or until a plateau in LEVC was reached.

Results: On an individual basis, the LEVC was increased post EAW training in 8 of the 19 subjects tested ($19.1 \pm 19.7\%$), but it was unchanged or reduced in the remaining 11 subjects ($-32.9 \pm 27.6\%$). There was marked variability in the LEVC change between subjects that requires further study. While the characteristics of SCI did not significantly differ between the subsets by response, the total number of EAW training days was increased, albeit not significantly, in those who had increased LEVC compared to those with no change or reduced LEVC (187 ± 160 days versus 132 ± 69 days).

Conclusion: Our preliminary findings suggest EAW training may increase LEVC in a subset of individuals with SCI. The relationship between the effects of EAW training on the venous vasculature and the characteristics of the SCI is unclear and requires further analysis. We speculate that prolonged ambulation time in the upright position may play a role in increasing LEVC. The data collection for this work is currently ongoing.

Support: VA RR&D Service (grants B9212-C B2020-C) and NJ Commission on SCI (grant CSCR131RG013).

9 Effects of robotic exoskeletal-assisted walking on cardiac vagal tone in persons with chronic spinal cord injury

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Objective: To determine heart rate (HR) responses to the deep-breathing test (DBt) in individuals with SCI before and after EAW training.

Background: Although anatomically intact, we have previously reported functional deficits in cardio-vagal tone in persons with spinal cord injury (SCI), regardless of the level of lesion. We speculate that this deficit relates to the profoundly sedentary lifestyles adopted by many individuals with SCI due to skeletal muscle paralysis. The advent of robotic exoskeletal assisted walking (EAW) may offer individuals with SCI the ability to increase levels of daily activity, which may, in turn, improve cardio-vagal function.

Design: Prospective, repeated-measure, cross-sectional study.

Participants/methods: The inter-beat-interval (IBI) of HR was recorded on 2 separate laboratory visits in 7 individuals with chronic SCI prior to initiating the EAW training (Pre-1, Pre-2) and then again once at the completion of training (Post). Individuals with SCI were injured for 1 to 17 years with predominantly motor-incomplete lesions (AIS C and D classifications) with levels of SCI between cervical-4 and thoracic-12. Subjects performed the Dbt, which consisted of breathing at a rate of 6 breathes/minute for 8 inspiratory/expiratory cycles while seated in their wheelchair. A 3-lead ECG was used to record continuous beat-to-beat HR during the Dbt. The difference between the minimum and maximum IBI (IBI-diff) was calculated within each 8-breathe cycle as a marker of cardio-vagal tone.

Results: Data from 1 subject was discarded due to errors in data collection. There was no significant difference in IBI-diff comparing the Pre-1 and Pre-2 visits (415.3 ± 131.7 and 383.0 ± 142.1 msec). However, when compared to the average of Pre-1 and Pre-2 IBI-diff (399.2 ± 135.6 msec), IBI-diff was increased Post EAW training (469.5 ± 210.7 msec; $p = 0.0432$). Increases in IBI-diff Post-EAW testing were noted in 4 of the 6 subjects.

Conclusion: Our preliminary data suggest that EAW training can improve cardio-vagal tone in a subset of persons with chronic SCI. The increased cardio-vagal effect of EAW training would be anticipated to improve cardiovascular health and longevity. Data collection is still ongoing in several EAW training trials.

Support: VA RR&D Service (Grants B9212-C B2020-C)

10 Efficacy of online mindfulness for people with spinal cord injury

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Objective: Populations with reduced sensory and motor function are at increased risk of depression, anxiety, pain, and reduced quality of life (QoL). Internet-delivered interventions can enhance self-management for people with reduced motor function, therefore reducing burden and cost to patient and healthcare services. This study explored the efficacy and feasibility of web-based mindfulness training for people with spinal cord injury (SCI).

Design: A between-subjects, randomized controlled feasibility study.

Participants/methods: Participants (N = 67) from a UK community sample were randomly allocated to an eight-

week online mindfulness intervention (N = 36), or to internet-delivered psychoeducational materials (N = 31). Measures of depression, anxiety, QoL, pain perception, pain catastrophizing, and mindfulness, were taken before (T1), at completion of, (T2), and three months following the intervention (T3).

Results: At T2, ten participants had discontinued mindfulness training, and five had discontinued psychoeducation, with those who discontinued more likely to be older. A further nine participants were lost to follow-up. At T2, mindfulness training reduced depression, anxiety, pain unpleasantness, and pain catastrophizing, significantly more than psychoeducation. Specific facets of mindfulness (acting with awareness, non-reactivity to inner experience, describing, and total scores) improved significantly more in mindfulness training. At follow-up, mindfulness training produced significantly greater reductions in severity of anxiety, depression, and pain catastrophizing.

Conclusion: Internet-delivered mindfulness training offers unique benefits, and is viable for people with reduced sensory awareness. Further work should explore the feasibility of combined psychoeducation and mindfulness training, for optimum benefit, and the use of brief interventions to maximize participant retention.

11 End of life care: New team approach

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Objective: To address the complexities and challenges experienced by individual services included in interdisciplinary team working with seriously ill patients in the rehabilitation setting.

Background: The large degree of inter-patient variability is challenging for VA SCI Centers, with some patients who have MS or ALS requiring respiratory support and others having relatively prolonged survival. Nearly 60-70% of seriously ill patients are unable to speak for themselves when the time comes to decide whether to limit treatment. The consequence of such uncertainty in survival treatment and intervention is not only difficult for patients and their families, but also for the interdisciplinary team taking care of patients during their final days. The general aims of assessment and delivery of interventions is to assist with symptom management, coping, support, and advocacy for patients and caregivers.

Methods: As medical knowledge and technology increase, so are the options for healthcare. Conversations about goals and life sustaining treatment (LST) decisions often are initiated too late, usually after a medical crisis or loss of decision-making capacity has happened. When decisions arise concerning the treatment of dying patients, these options present complex ethical dilemmas.

In order to address this issue, the VA began a national quality improvement initiative in October of 2017 to promote personalized, proactive, patient-driven care for Veterans with serious illness.

Significance for SCI practice: Increased life expectancies due to medical advances can lead to significant complications at end of life for patients with SCI/D. Coordination by the James A. Haley's primary care physician's with Mental Health services and Social Work are integral to addressing the complexities and challenges experienced by interdisciplinary teams working with terminally ill patients in rehabilitation settings, including ethical questions and what should be done in the face of uncertainty or conflict with family or team members values.

Conclusion: The ethical issues surrounding end of life care continue to gain importance to all members of society. Therefore, it is important to institute measures that guide treatment teams to help people to make these decisions before the crisis happens, diminishing the ethical concerns.

12 Examining predictors for superutilizers and 30-day readmissions post spinal cord injury

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Objectives: (1) To examine predictors for superutilizers within one year of onset of SCI and 30-day readmissions. (2) To describe frequent diagnoses for superutilizers and 30-day readmissions.

Design: Retrospective Cohort

Participants/methods: A retrospective cohort was employed at a local Level 1 trauma acute care facility. 543 patients who admitted with a diagnosis of traumatic SCI between January 1, 2003 and June 30, 2014 were identified from the hospital trauma registry. Subjects were matched with the Dallas Fort Worth Hospital Council registry which tracks admissions data for hospital systems within the Dallas Fort Worth Metroplex. Characteristics of patients with emergency (ED) superutilization, inpatient superutilization, and 30-day readmissions were described. Superutilization was defined as having two or more emergency or inpatient healthcare encounters within one year of the onset of injury. Multiple logistic regression was used to determine which factors were significantly associated with ED superutilization, inpatient superutilization, and 30-day readmissions. The top diagnosis codes for superutilization, and 30-day readmissions were also described.

Results: Subjects were primarily male (73.1%) with private insurance (41.1%) aged 46 ± 18.7 years. Factors associated with ED superutilization included public insurance ($p = 0.0006$), no insurance ($p = 0.0041$), and other cause of injury ($p = 0.0351$). Factors associated with inpatient superutilization included public insurance ($p = 0.0487$), rehabilitation discharge disposition ($p = 0.0041$), and skilled nursing/long-term care discharge disposition ($p = 0.0041$). Factors associated with 30-day readmission included age ($p = 0.0088$), and skilled nursing/long-term care discharge disposition ($p = 0.0089$). Frequent diagnosis codes for superutilization and 30-day readmission included pressure ulcers, bladder infections, digestive issues, and dehydration.

Conclusion: This data highlights those at highest risk for superutilization and readmission across a diverse population of SCI at a large medical center. Interventions such as health literate education or patient navigation may help mitigate superutilization and readmission for at risk patients.

13 Factors associated with return to education after spinal cord injury

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Objective: Return to work (RTW) after spinal cord injury (SCI) has been associated with improved quality of life, increased longevity, identity development, and financial stability. However employment rates after SCI remain low at 34%. Post-injury education is modifiable factor that has been found to highly correlate with RTW. The current literature has not yet identified factors associated with return to education (RTE). The objective of this study is to identify factors associated with RTE after SCI.

Design: This is a retrospective analysis of existing longitudinal follow-up data to describe the associations between RTE with demographic and injury characteristics in traumatic SCI.

Participants/methods: Participants include individuals with acute traumatic SCI age 18 to 65 at time of enrollment in the SCIMS National Database from 2000 to 2016 who have completed a Form I interview and a follow up Form II interview. Participants were excluded if they were retired, had less than an 8th grade

education, or had a doctoral degree prior to injury. The main outcome variable is a change in highest formal educational level completed. Descriptive statistics were obtained and the appropriate bivariate test performed to assess differences in the likelihood of RTE by the demographic and injury characteristics. Differences in the odds of RTE by selected covariates were assessed using multivariate logistic regression.

Results: 3,343 people enrolled in the SCIMS Database met inclusion criteria. 27% of participants reported an increase in the level of education completed (RTE). There was no significant difference in RTE by injury severity or gender. The distribution in RTE differed by race such that African Americans were underrepresented among people who RTE ($\chi^2(3) = 9.86$, $Pr = 0.020$). Students at the time of injury were more highly represented among people who RTE ($\chi^2(4) = 189.62$, $Pr = 0.000$). The odds ratio of RTE by age groups was also significant. Those aged 18-25 were 2.9 ($p = 0.000$) times more likely to RTE than those 55-65. The odds ratio for those aged 25-34 was 1.5 ($p = 0.016$). There was no significance in the odds of RTE for the age groups 35-44 and 45-54.

Conclusion: These results suggest that individuals with SCI who are students and younger at time of injury were more likely to RTE. African Americans were less likely to RTE. These characteristics may help target interventions to enhance RTE and ultimately RTW after SCI.

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14 Feasibility of integrating robotic exoskeleton gait training in inpatient rehabilitation

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Objective: Technological advances have introduced robotic exoskeletons to allow improved mobility and function for the patient while decreasing physical demands on therapy providers. While studies have demonstrated the safety of exoskeleton use, little research has been directed towards assessing the feasibility of integrating these devices into inpatient rehabilitation. Thus, the purpose was to identify the feasibility of exoskeleton use during Inpatient rehabilitation from the prospective of clinicians and patients.

Design: A cross-sectional design and convenience sample was used to assess four areas of feasibility including: process, resources, management, and scientific merit.

Participants/methods: Participants included 7 SCI patients and 5 clinicians. The therapists had each completed the required exoskeleton training and were using the device in an inpatient rehabilitation setting. Therapists engaged in a focus group and completed a survey at baseline and six months after initial Ekso training. Patients completed a survey indicating their satisfaction with using the Ekso. Outcome measures were extracted from the patients' electronic medical record.

Results: 7 different patients used the Ekso an average of 7.4 sessions during their inpatient rehabilitation admission (average length of stay = 54.7 days; range 25-84 days). The focus group feedback revealed four meta-themes, identified as: (a) technical challenges (e.g., screening and inclusion/exclusion criteria), (b) resource limitations (e.g., staffing, set up time), (c) perceived benefits (e.g., patient feedback, clinical judgement), and (d) comparison with traditional therapy (e.g., body weight supported treadmill training (BWSTT)). Results of patient feasibility surveys reveal positive responses after using Ekso as part of their inpatient therapy. It was feasible to integrate Ekso data collection with other clinical outcomes such as MMT, MAS, SCIM, WISC II, FIM, etc.

Conclusion: Clinician challenges to feasibility of exoskeleton use are limited staffing time (e.g., for screening, setup, treatment) and a lack of evidence of the benefit in the inpatient setting when compared to traditional modes of therapy. Patients indicated satisfaction with using Ekso during inpatient rehabilitation. Findings suggest that it is feasible to integrate SCI outcomes and collect Ekso data into clinical practice in the inpatient rehabilitation setting.

15 First ever SCI virtual coach improves health self-management in feasibility trial

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Objective: Virtual coaches are animated characters that people interact with on computers or other electronic devices. The objective of this project was to develop the first virtual coach for individuals with SCI. The SCI coach focused on behaviors to prevent pressure ulcers. The aim of this study was to determine the feasibility and acceptability of the SCI coach, and to explore preliminary evidence of efficacy.

Design: Phase I/II randomized controlled trial in the community.

Participants/methods: An iterative process was used to develop the coach, with input obtained from a peer panel of persons with SCI. Next, a series of lab-based tests were conducted on 10 people with SCI using a prototype version of the SCI coach. The coach was further modified after the lab-based testing. Total of N = 40 people were enrolled in the RCT who were 6 months to 10 years post SCI. The intervention group used the Virtual Coach in their home for 2 months, with the goal of using the coach at least 3 times per week. Adherence to the coach was monitored by the system itself. Skin care knowledge, behaviors, self-efficacy and other outcomes were assessed by a blinded outcome assessor at baseline and 2-month follow-up compared to controls receiving usual care.

Results: N = 40 persons with SCI were recruited into the study. The participants were an average of 2.2 years post-injury and were evenly divided between people with paraplegia and tetraplegia. People used the coach mean 19.3 days out of the 60 days and mean 18.6 minutes per session. People who used the SCI Virtual Coach had a greater improvement in the Patient Activation Measure compared to the control group. The change in this measure was an average of 8.6 points higher (95%CI 4.1, 13.1) in the coach group compared to the control group. Changes in measures of skin care behavior and knowledge showed a trend of being higher in the intervention compared to the control group, but the findings were not statistically significant.

Conclusion: The SCI Virtual Coach was used by subjects with SCI for 2 months in their home at the frequency and duration as prescribed. Although a small feasibility trial with people not recently injured, significant changes were observed in some outcomes of interest. We plan to expand the content of the coach based on feedback from participants, and to apply for funding to evaluate the coach further in a phase III RCT. Support: Craig H. Neilsen Foundation

16 Grief/loss due to SCI: What is known? what is needed?

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Objective: Many individuals with a spinal cord injury (SCI), across various durations and levels, experience grief/loss due to their injury. It is possible that grief after injury may facilitate adjustment to SCI. Research is mixed on how to define grief, specify 'normal' or 'unhealthy,' and how to address it. The objective was to help healthcare professionals identify and take steps to address grief/loss due to injury in persons with SCI.

Design: Qualitative interviews to learn how health providers define healthy grief/loss due to SCI, and their perspectives on current (actual) approaches and ideal approaches to dealing with grief due to SCI.

Participants/methods: Interviews with health providers (n = 15) caring for persons with SCI. Health providers were mostly women (86.7%), aged 50-64 (66.7%), held various positions and provided SCI care for an average of 10.3 years (range:1-30). Interviews were audio-recorded, transcribed, coded, and analyzed using content analysis methods, following a mixed inductive-deductive approach.

Results: Several key themes were identified, including: defining grief/loss due to SCI, describing normal/healthy grief after SCI, effects of grief/loss on clinical outcomes and quality of life, current and ideal approaches to address grief/loss due to SCI. Our findings show that providers recognize the importance of addressing grief and loss due to SCI; that it is a unique concept (distinguished from depression) and believe that focused-provider education is needed. Several similarities/differences across profession types emerged to define healthy grieving due to SCI and ideal treatments.

Conclusion: In general, providers noted that grief/loss care is delegated to mental health professionals, but that all health care professionals would benefit from training to help identify and address grief/loss due to SCI so appropriate steps can be taken at the point-of-care. Our findings fit the Dual Process Model of Grief and highlight alternate ways of dealing with grief/loss due to SCI. Education around grief/loss due to injury and shared responsibility to identify and address this should be embraced by a multidisciplinary team and across the continuum of care. These findings are the first step in the development of an educational curriculum geared to health professionals to help them identify and address grief/loss due to SCI, including what providers need to fully implement the approaches that best approximate the ideal.

17 Group intervention addressing executive functioning weaknesses in spina bifida

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Objective: To explore if implementation of Goal Management Training (GMT) is an effective tool for addressing executive functioning weaknesses in adults with medical diagnoses of spina bifida, and other childhood-onset conditions.

Design: This study examined pre-and post-group participation self and observer ratings to assess intervention efficacy in a group of young adults. The first of two groups also were instructed in various psychological approaches to anxiety.

Participants/methods: Group members participated in eight or nine 2-hour small group sessions during which they were introduced to and practiced standard GMT exercises. Individuals were assigned to one of two groups based upon time of referral and availability. Of the seven total participants, the first group contained 4 individuals who also identified anxiety as a predominant concern. Of the seven participants, 2 were women and five had diagnosis of spina bifida. Age range was from 19-63 years with average age of 31. Four group members were in their 20's.

Results: Anxiety self-ratings: The mean pre-group Beck Anxiety Inventory (BAI) summed score = 28.5 (range 19-56) and the mean post-group BAI summed score = 9.75 (range 1-23). GMT self-ratings: The mean self-rating score for the six patients who correctly completed the rating form prior to group participation = 7.07 with range of mean scores from 3.29 to 10. The mean self-rating for the six patients who completed the rating form following group participation = 3.60 with range of mean scores from 1.0 to 7.58. Five of the participants noted decline in mean scores and one participant had an overall mean increase of .06 points. GMT observer-ratings: The mean observer-rating for six patients = 4.89 prior to group and the mean observer-rating for four patients = 3.8 following group. Three observers provided lower scores post group and one observer provided higher scores following group participation.

Conclusion: Simple data analysis of self and observer reports indicates group members benefited from the intervention. Although not the primary focus of the study, participants in the first group reported significant benefit from learning anxiety management strategies within a group context.

Support: Apart from salary and provision of manuals from employer Gillette Children's Specialty Healthcare, no other financial resources supported this study.

18 HDL-C changes after 50,000 steps in a powered exoskeleton

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Objective: Previously, we reported HDL-c levels in 15 participants after 36 sessions of exoskeletal-assisted walking (EAW). We now report on 12 additional (N = 22) participants after 36 sessions of EAW.

Background: Serum high density lipoprotein cholesterol (HDL-c) levels below 40 mg/dL (an independent risk factor for cardiovascular disease) have been reported in 64% of persons with tetraplegia and 60%, with paraplegia. As a result of this lipoprotein abnormality, as well as other risk factors, persons with spinal cord injury (SCI) have an increased risk for the development of cardiovascular disease (CVD), which is one of the leading causes of death in the SCI population. Increased physical activity is an important factor to increase serum HDL-c levels.

Design: Prospective, three-site (ongoing) interventional study in participants with chronic SCI.

Participants/methods: Twenty-two participants with chronic SCI have completed the study to date. Participants trained in the exoskeleton for 36, one-hour sessions over a 3 month period. Fasting blood samples were collected to determine serum HDL-c levels before and after completion of the training sessions. Serum samples were sent to Quest Diagnostics Laboratory for analysis using an automatic assay analyzer. The absolute change of the serum HDL-c value in a given participant was used to determine a clinically significant change. The minimal significant change accepted for clinical significance was ≥ 2.0 mg/dL.

Results: Eleven of 22 (50%) participants had an increase in serum HDL-c of ≥ 2.0 mg/dL after the EAW intervention (mean $\pm$ SD = 7 ± 4 mg/dL). Additionally, participants who completed $\geq 50,000$ total steps, 64% (7 of 11) versus 36% (4 of 11) demonstrated a clinically significant change in serum HDL-c levels. In those who completed $\geq 50,000$ total steps, HDL-c improved by an average of 3.5 ± 6.0 mg/dL (range: 2.0 to 14.0 mg/dL) and had slightly more number of steps per session than those who did not have a clinically significant change ($1,475 \pm 541$ vs. $1,230 \pm 575$ steps, $p = 0.26$). No significant changes were noted in the serum triglycerides or low density lipoprotein cholesterol.

Conclusion: In the majority of persons with chronic SCI, EAW of at least 50,000 steps performed in 3 sessions a week, for 12 weeks, resulted in favorable changes in the serum HDL-c. The observed increase in serum HDL-c would be anticipated to reduce the risk for the development of CVD. Support: DOD/CDMRP Award: W81XWH-14-2-0170. VA RR&D JJPVAMC - B9212-C, B2020-C.

19 Incidence of metabolic syndrome in spinal cord injury

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Objective: Previous studies suggest the prevalence of metabolic syndrome (MS) in persons with spinal cord injury (SCI) is higher than that of the general population. Part of the controversy relates to the differing

definitions provided for MS and the characterization of obesity following SCI. The International Diabetes Federation (IDF) definition of MS emphasizes the role of central obesity. We aimed to examine the incidence of MS following SCI.

Design: Cross-sectional; Clinical hospital and academic setting Participants/Methods: Four hundred and seventy-three veterans with SCI (98.5% male, 55.4% white, age 56 ± 13.1 y, body mass index [BMI] 25.9 ± 6.3 kg/m², 45.9% ASIA A, 49.6% with tetraplegia) whose data was available in the computerized personal record system (CPRS) was assessed for MS according to IDF criteria. IDF criteria includes central obesity (waist circumference ≥ 94 cm in men, ≥ 80 cm in women) plus any 2 of the following: dyslipidemia (triglycerides ≥ 150 mg/dl or on treatment; high-density lipoprotein (HDL) < 40 mg/dl for men, < 50 mg/dl for women or treatment), hypertension (≥ 130 mm Hg systolic or ≥ 85 mm Hg diastolic, or on treatment), fasting glucose ≥ 100 mg/dl or previously diagnosed with type 2 diabetes. Because waist circumferences are not routinely available in CPRS, the SCI-corrected BMI > 22 kg/m² was used as a substitute marker for central obesity. 95% confidence intervals (CI) were used to estimate the prevalence of MS using a BMI > 22 kg/m² and the incidence of each MS factor. The odds ratio comparing the odds of having each non-obesity MS risk factor, for those who were defined as obese versus those who were not defined as obese, was estimated.

Results: Over 57% of the veterans assessed were determined to have MS by modified IDF criteria, including 76.7% with BMI > 22 kg/m², 55.1% with or under treatment for hypertension, 49.7% with or previously diagnosed with diabetes, and 69.7% with or under treatment for HDL < 40 mg/dl. The odds of hypertension, diabetes, elevated triglycerides, and reduced HDL were 2.22, 1.93, 1.88, and 1.68 times greater for obese patients as compared to non-obese patients using BMI ≥ 22 kg/m² as the definition of obesity.

Conclusion: Metabolic syndrome and its components appear to be more prevalent in veterans with SCI than in the general population, suggesting a greater need for identification and treatment interventions in this special population.

20 Initial outcomes of a spinal cord oncology program

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Objective: This study evaluated outcomes of the first ten months of a two-week abbreviated inpatient rehabilitation (IPR) program for persons with spinal cord injury (SCI) from metastatic cancer. In addition to improving patient independence in self-care and mobility, program goals focused on SCI education, family training, equipment selection, and resource identification to facilitate a quick and safe discharge home with family.

Design: Retrospective chart review compared individuals participating in the first ten months of the SCI Oncology program with historical controls. Both groups had SCI due to metastatic disease, and matching was based on Functional Independence Measure (FIM) on admission to IPR.

Participants/methods: A discharge database was used for patient selection and to collect outcomes including demographics, length of stay (LOS), admission FIM, discharge FIM, FIM change, discharge destination, and the involvement of the Palliative Care team. Twelve patients participating in the SCI Oncology program from March 1, 2016 through December 31, 2016 were identified. These individuals were matched with twelve historical controls who completed IPR February of 2016 or prior. Significant differences in FIM change and length of stay between the two groups were examined using independent samples t-tests. Differences in discharge location, and involvement of Palliative Care between the two groups were determined using Fisher's exact tests.

Results: Although findings did not reach statistical significance on any measure, it was noted that an increased number of patients in the SCI Oncology program (7) discharged to home compared to 4 in the control group. 10 patients in the Oncology program had Palliative Care consults during IPR compared to 6 in the control group. Average LOS for those in the SCI Oncology program was 15.3 days, compared to 21.3 days in the control group. Total FIM change in the Oncology group (17.5) was 11 points lower than the historical

comparison group (28.8).

Conclusion: The results of this study were limited by small sample size. These preliminary findings suggest that there is potential for FIM change in an abbreviated program. Many participating in the Oncology program were able to discharge home with family after a short LOS. The increased involvement of Palliative Care in the Oncology program may have been beneficial to achieve discharge goals. Because of this initial analysis, components of the program were changed.

21 Level of injury dictates body composition, energy expenditure and caloric intake in spinal cord injury

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Objective: Current research demonstrates inconsistent findings regarding the influence of level of injury (LOI) on body composition and energy expenditure following spinal cord injury (SCI). This may result from a lack of dietary monitoring. The aim of this study was to compare body composition, energy expenditure (EE), and energy intake in paraplegia (PSCI) and tetraplegia (TSCI).

Design: Cross-sectional; Clinical hospital and academic setting

Participants/methods: PSCI (n = 30, age 43.3 ± 11.7 y, W 85.2 ± 20.1 kg, H 176.7 ± 8.2 cm, time since injury (TSI) 14.5 ± 10.5 y) and TSCI (n = 15, age 47.4 ± 9.9 y, W 77.1 ± 17.6 kg, H 167.4 ± 8.2 cm, TSI 14.4 ± 12.7 y) were included. Participants were excluded for recent deep vein thrombosis, pressure injuries > grade 2, or uncontrolled metabolic disease or spasticity. Bone mineral content (BMC) and density (BMD), lean body mass (LBM), body fat (BF), and %BF were acquired via DXA. Daily caloric intake was assessed by a 3 day dietary recall and averaged, while total daily EE (TDEE) and basal metabolic rate (BMR) were obtained via published methods. The difference in caloric intake and TDEE was calculated. EE and nutritional data were normalized to bodyweight (data is presented as non-normalized). Mann-Whitney U test were used to assess differences. $\alpha < 0.05$.

Results: Demographic data did not differ between TSCI and PSCI ($P > 0.05$). BMC (PSCI 3.17 ± 0.6 , TSCI 2.71 ± 0.5 g), LBM (PSCI 50.0 ± 8.6 , TSCI 40.96 ± 8.8 kg), and %BF (PSCI 36.45 ± 8.0 , TSCI 41.82 ± 9.1) were significantly different between groups ($P < 0.05$). BMD (PSCI 1.19 ± 0.1 , TSCI 1.16 ± 0.1 g/cm²) and BF (PSCI 32.14 ± 13.2 kg, TSCI 32.73 ± 12.5 kg) did not differ ($P > 0.05$). TDEE (PSCI 1782.79 ± 539.4 , TSCI 1468.3 ± 468.2 kcal/d), BMR (PSCI 1516.6 ± 398.0 , TSCI 1223.6 ± 390.2 kcal/d), and the difference between caloric intake and TDEE (PSCI 10.33 ± 14.4 , TSCI 3.01 ± 11.2 kcal/d) were significantly higher in PSCI vs. TSCI ($P < 0.05$). Total caloric (PSCI 1516.4 ± 548.4 , TSCI 1619.1 ± 564.3 kcal/d), fat (PSCI 58.6 ± 27.4 , TSCI 65.8 ± 29.7 g), and protein (PSCI 62.7 ± 23.2 , TSCI 71.5 ± 30.9 g) intake were significantly higher in TSCI vs. PSCI ($P < 0.05$). Total carbohydrate intake (PSCI 185.4 ± 69.5 , TSCI 182.3 ± 55.2 g) approached significance ($P = 0.098$). Micronutrients did not differ between groups ($P > 0.05$).

Conclusion: The current results show that LOI influences body composition, EE, and caloric intake following SCI. These findings may help explain differences in metabolic profiles between individuals with PSCI and TSCI.

22 Leveraging big data methods to measure pressure ulcer risk

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Background: Pressure ulcers (PrUs) are among the most significant complications of treated in the VA Spinal Cord Injury/Disorders (SCI/D) System of Care. Currently the VA employs the Braden Scale to measure PrU risk in both the inpatient and outpatient setting. While the Braden Scale PrU risk assessment tool is widely used, it was validated in nursing home populations and may not adequately measure risk in Veterans with SCI.

Objective: To use information from the VA electronic health record (EHR) to develop improved risk models.

Design: A 5-year (FY 2009-2013) longitudinal retrospective cohort design.

Participants/methods: The VA national EHR includes structured (coded) and narrative (text in clinical notes) data. Structured data can describe inpatient and outpatient care in the VA, care paid for in the community by the VA, medication use, laboratory results, equipment provided, etc. Inpatient and outpatient clinical text notes contain narrative description of assessment, planning and care provided from which information can be extracted for analysis. Inclusion criteria were; 1) Veterans with SCI, cared for in the SCI/D System of Care during FY 2009, 2) with no evidence of a PrU in the prior year, and 3) who had at least one Comprehensive Preventive Health Evaluation in the study period. The SCI/D Centers are required to offer the preventive health exam to Veterans annually. This first annual exam became a reference point for the analysis, with risk factors being identified before the exam and the first recorded PrU being treated as an incident case. Nearly 100 potential risk factors were included.

Results: A total of 5,949, predominantly male (96%), Veterans with a mean age of 57 years were included. Using structured data alone there was strong evidence of a PrU in 815 (13.7%) during the study period. However, by including results from text analysis this number more than doubled to 1,755 (29.5%). In this workshop, we will provide details about how structured and text data for this study were obtained and synthesized to the patient-level and assess the added value of text. Predictive classification models of PrU survivorship using training/testing data will be developed; again, model performance will be compared between the two data types. Finally, we will compare the results of our new risk models with those currently using the Braden Scale.

Conclusion: Longitudinal data from a large EHR can be used to improve prediction.

23 Lower extremity bone loss in persons with spinal cord injury: Research and clinical implications

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Objective: To describe clinical and research imaging methods, present original data on fracture threshold, and discuss the findings of advanced rehabilitation strategies on bone health in persons with SCI to assist clinicians to better appreciate the treatment options and its inherent risks.

Background: Osteoporosis, muscle atrophy, and increased adiposity represent major adverse body composition changes that are well recognized to occur after SCI. After SCI, the immediate unloading of the skeletal results in the pathophysiological scenario of the uncoupling of bone formation from resorption, with accompanying rapid and severe bone loss of the sublesional skeleton. To quantify BMD at the hip and knee regions, dual energy x-ray absorptiometry (DXA) measurements of bone densitometry are routinely employed in the clinical and research settings. The advent of powered exoskeletal-assisted ambulation for persons with SCI, as well as other advanced rehabilitation medicine interventions, have made the reliability of information

and cutoff values for BMD at the DF and PT essential to permit safe participation in weight-bearing activities.

Significance for SCI Practice: To quantify BMD at the lower extremity, DXA is routinely employed in the clinical medicine and research studies, while peripheral quantitative computed tomography is employed almost exclusively in research settings. A detailed review of imaging methods to acquire and quantify BMD at the DF and PT has not been performed to date but, if available, would serve as a reference for clinicians and researchers. With the advent of increased loading and muscle forces during clinical therapy or research protocols such as powered exoskeletal-assisted ambulation for persons with SCI, there is increased multidirectional forces placed on the skeleton in upright posture. The relevance of identifying those individuals who are at heightened risk of fracture is becoming increasingly necessary. Furthermore, knowledge of DXA precision error is integral to obtain the sensitivity and reliability of the measurement of BMD to any change, whether due to advancing age or after a targeted intervention to improve bone mass and strength.

Conclusion: Clinicians need to be aware of current information to best serve the needs of their patients and when providing risk assessment for various rehabilitation interventions, including that of powered exoskeletal-assisted walking.

24 Donald Munro Memorial Lecture neurogenic obesity and its relationship to metabolic syndrome in spinal cord injury

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Background: Positive energy balance results in the rapid and excessive accumulation of adipose tissue termed neurogenic obesity, as well as the relationship between obesity and metabolic syndrome, i.e., insulin resistance, hypertension, dyslipidemia, thromboembolism and coronary artery disease.

Objective: To provide guidance based on review of the influence of spinal cord injury (SCI) on whole body physiology as the result of obligatory sarcopenia, anabolic dysfunction, sympathetic blunting, bone loss and fluid shifts that markedly reduce energy metabolism.

Findings: Recent studies demonstrate the specific relationships between neurogenic obesity, metabolic syndrome and proinflammatory cytokines.

Conclusion: The care plan for individuals with SCI should include recommendations for neurogenic obesity assessment, surveillance and interventions.

25 Neurological and functional outcome in patients with acquired infections after acute spinal cord injury

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Objective: To investigate whether prevalent hospital-acquired pneumonia and wound infection affect the clinical long-term outcome after acute traumatic spinal cord injury (SCI).

Participants/methods: This was a longitudinal cohort study within the prospective multicenter National Spinal Cord Injury Database. We screened datasets of 3,834 patients enrolled in 20 trial centers from 1995 to 2005 followed up until 2016. Eligibility criteria were cervical SCI and American Spinal Cord Injury Association impairment scale A, B, and C. Pneumonia or postoperative wound infections (Pn/Wi) acquired during acute medical care/inpatient rehabilitation were analyzed for their association with changes in the motor items of the Functional Independence Measure (FIMmotor) using regression models (primary endpoint 5-year follow-up). Pn/Wi-related mortality was assessed as a secondary endpoint (10-year follow-up).

Results: A total of 1,203 patients met the eligibility criteria. During hospitalization, 564 patients (47%) developed Pn/Wi (pneumonia $n = 540$; postoperative wound infection $n = 11$; pneumonia and postoperative wound infection $n = 13$). Adjusted linear mixed models after multiple imputation revealed that Pn/Wi are significantly associated with lower gain in FIMmotor up to 5 years after SCI (-7.4 points, 95% confidence interval [CI] -11.5 to -3.3). Adjusted Cox regression identified Pn/Wi as a highly significant risk factor for death up to 10 years after SCI (hazard ratio 1.65, 95% CI 1.26 to 2.16).

Conclusion: Hospital-acquired Pn/Wi are predictive of propagated disability and mortality after SCI. Pn/Wi qualify as a potent and targetable outcome-modifying factor. Pn/Wi prevention constitutes a viable strategy to protect functional recovery and reduce mortality. Pn/Wi can be considered as rehabilitation confounders in clinical trials.

26 Paired stimulation to improve hand muscle transmission and function

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Objective: Half of all spinal cord injured (SCI) individuals in the United States are incomplete, leaving some neurons still intact. Previous research into invasive epidural stimulation has shown the possibility of activating lower motor neurons after an incomplete SCI. We paired Transcranial Magnetic Stimulation (TMS), which we used to mimic muscle activation triggered by the upper motor neurons, with peripheral nerve stimulation and cervical electrical stimulation both stimulating at the lower motor neuron. We aim to use these forms of non-invasive, stimulation paired at various synaptic arrival times to help improve the neuronal connection between the upper and lower motor neurons. We hypothesized there would be an improvement in synaptic neural transmission after interventions pairing a pulse TMS five milliseconds prior to a CES pulse.

Design: Single-blind pilot clinical crossover study.

Participants/methods: We recruited individuals with chronic (>12 months) SCI and non-disabled (ND) volunteers. Six SCI and 12 ND participants have undergone one Baseline and seven intervention sessions with varying pulse timing and stimulation combinations. Electromyography outcomes such as TMS motor-evoked potentials (MEP) and clinical outcomes of pinch strength and finger agility are measured.

Results: In baseline experiments combining single pulses of TMS with subthreshold cervical electrical stimulation (CES), we observed a timing-dependent two-fold increase in TMS MEP amplitude of the abductor pollicis brevis (thumb) muscle. In intervention experiments combining repetitive pulses of different stimuli, we observed a non-specific increase in MEP amplitude for up to 30 minutes after multiple interventions. After repetitive combinations of CES paired with TMS, performance on a finger agility task tended to improve in ND volunteers but not in the first four SCI participants.

Conclusion: We hypothesized an improvement in synaptic neural transmission after interventions pairing two types of electrical stimulation with TMS at varying time intervals. The electrophysiological response of the targeted hand muscles exhibited a non-specific increase in amplitude after repetitive combined stimuli at

suprathreshold levels, and a timing-specific increase after single combinations of stimuli at subthreshold levels. Hand dexterity tended to increase in non-disabled participants as observed by a decrease in time needed to complete hand tasks. Lack of similar response in SCI participants

27 Perceived injustice after spinal cord injury: A risk factor for depression

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Objective: To determine if perceived injustice is a significant predictor of depressive symptoms after SCI. Perceived injustice is defined as the belief that one's pain/injuries are undeserved and attributable to another's error or negligence.

Design: Longitudinal study design involving completion of self-report measures in an inpatient rehabilitation program. Measures were completed at the time of inpatient rehabilitation (baseline), 3-, and 12-months post-discharge.

Participants/methods: Participants included 50 (33 male) adults admitted to an inpatient facility in the Southwestern United States following acute hospitalization for SCI. Mean age of participation was 51 years. Time since injury ranged from 13 to 337 days with a mean of 78 days. A third of participants were motor complete, either AIS A (24.4%) or B (9.8%). Perceived Injustice was assessed using the Injustice Experience Questionnaire (IEQ). Depressive symptoms were measured with the Patient Health Questionnaire-8 (PHQ-8). A mixed model procedure with repeated measures, unstructured correlations was used to assess change in perceived injustice as a predictor of change in depressive symptoms within the first 12 months after discharge from acute rehabilitation. Factors with p-values < 0.10 in the univariate mixed models, as well as factors that were deemed clinically significant (gender, age, time post injury, pain) were assessed in multivariate models.

Results: In multivariable models, participants with motor incomplete SCI had greater depressive symptoms than those with motor complete SCI. Pain was also positively associated with depressive symptoms. After adjusting for pain and motor completeness, there was a significant positive association between change in perceived injustice and change in depressive symptoms. One unit increase in injustice was associated with 0.13 unit increase in depressive symptoms ($p = 0.0001$).

Conclusion: Results indicate that above and beyond injury characteristics and pain, changes in perceived injustice predict changes in depression over time, such that those who develop higher perceptions of injustice over time also report increased depressive symptoms.

28 Pilot testing the peer-led group online: GoHealthySCI weight management intervention

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Objective: Our objective was to develop and pilot test a group, peer-led weight management program for people with SCI. The program was developed with input from community advisors and built upon GoWoman, an

intervention for women with mobility limitations. GoHealthySCI consists of 16 weekly sessions using videoconferencing with monthly in-person sessions, followed by 2 months of tapered sessions.

Design: Randomized controlled pilot test

Participants/methods: Overweight or obese individuals with SCI were randomly assigned to the intervention or a control group that received materials at the end of the study. Of the 36 enrolled, 27 completed the post-test (14 intervention, 13 control; 25% attrition). The sample was 78% white, 59% non-Hispanic, 63% male, and middle-aged (Mean age = 41.85, SD = 13.18). Most had paraplegia (59%) and had been living with their injury for many years (Mean = 19.89 years, SD = 15.52).

Results: GoHealthySCI intervention participants lost 8.07 (7.11) pounds over 16 weeks compared to 1.35 (7.87) pounds in controls (Cohen's $d = 0.90$). Intervention participants also had a greater reduction in waist circumference (WC) than controls (1.67 [2.94] versus 0.24 [2.52], Cohen's $d = .52$). Weight loss was greater among men than women in the program (10.0 [8.51] versus 5.50 [4.0], Cohen's $d = .67$) but WC reduction was greater among women (2.72 [3.77] versus .89 [2.01], Cohen's $d = .60$). In terms of engagement, 4 intervention participants dropped within the first 2 weeks due to family/work conflicts or health issues. The remaining 14 participants attended 12.93 (1.9) of the 16 sessions on average. Program ratings strongly support the acceptability of the program, with 100% rating the program as good (21%) or excellent (79%), and 100% 'definitely' recommending the program. All reported making 'important' (93%) or 'minor' (7%) positive dietary changes, and all reported making 'important' (71%) or 'minor' (29%) changes in physical activity. In addition, 43% reported meeting or exceeding their weight loss goal, with 29% reporting good progress toward their goal. Perceived support in the predominantly online program was strong, with 100% describing that they felt supported by facilitators and fellow group members and 86% describing facilitators as 'very effective.'

Conclusion: Results provide preliminary evidence of the feasibility, acceptability, and efficacy of the GoHealthySCI program.

Support: Craig H. Neilsen Foundation.

29 Anthony DiMarco Lecture pulmonary function and health in chronic spinal cord injury

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Background: Although pulmonary physiologic changes after spinal cord injury (SCI) influence pulmonary function, the relationship between pulmonary function and health has not been emphasized in the care of patients with SCI.

Objective: To explore clinical factors associated with respiratory health in individuals with chronic SCI and their relationship to pulmonary function.

Design: Since 1994, investigators at the Veterans Affairs Medical Center in Boston have conducted longitudinal health studies assessing respiratory health in patients with chronic SCI.

Participants and methods: Adults with chronic SCI (≥ 1 year after injury) were recruited from VA Boston and the community, for this longitudinal assessment of pulmonary function, chest illness, hospital admissions, and mortality

Results: Longitudinal assessment of pulmonary function after SCI has identified that continued smoking, an increase in body mass index, and report of persistent wheezing is associated with a decline in forced expiratory volume in one second (FEV₁). Differences in neurologic level or completeness of SCI are not associated with longitudinal change in pulmonary function. Longitudinal assessment of chest illness risk has also identified positive associations with lower pulmonary function, wheeze history, obstructive lung disease, and previous chest illness history. A lower FEV₁, independent of neurologic level or completeness of SCI, is also associated with greater risk of cardiopulmonary hospitalization and an increase in mortality. Finally, there are strong cross sectional relationships between pulmonary function and circulating biomarkers of systemic

inflammation (C-reactive protein and interleukin-6) and leptin, an adipose tissue associated biomarker.

Conclusion: Taken together, these observations suggests that efforts to maintain, improve, or prevent reduced pulmonary function in SCI patients may prevent chest illness, hospitalization, and death. These epidemiologic findings suggest that clinicians screen for and treat asthma/COPD, measure pulmonary function, limit weight gain, stress smoking cessation, and consider factors that influence systemic inflammation in their care of SCI patients. It is also appears that there is more “susceptible” sub-population of patients with chronic SCI who experience more frequent chest illness.

30 TLC Distinguished Lecture – Rehab on the road: Advancing client outcomes through professional excellence

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Summary: Participation in meaningful, essential and enjoyable life activities is the primary focus of the work we do as rehabilitation specialists who support people with spinal cord injuries and disorders (SCI/D). Whether our client is fully self-sufficient or reliant on others, the education and training we provide, the problem-solving strategies we facilitate, and the assistive technologies and medical equipment we recommend are instrumental in supporting the individual to participate to their greatest capacity in a multitude of environments. Too often, the unique and valuable services we provide are delivered in controlled clinical settings in and around a medical center with limited opportunity for interaction in alternative environments and for long term follow up to gauge the results of our work as a benefit to the client. To address this deficit, many professionals in SCI/D have taken the initiative or received the unique opportunity to advance their professional skills and interdisciplinary collaboration by providing medical and rehabilitative services in non-conventional settings. Most find that applying clinical knowledge, skills, and insight to support client participation in wide range of contexts including home, school, work, recreation, and travel allows us to advance our clinical competency and facilitate optimal client outcomes. Examples include problem solving for inaccessible environments, self-care and medical management in unfamiliar settings, emergency management, advanced mobility training for challenging situations including transfers and wheelchair skills performance, and strategies to prioritize safety, such as skin protection and joint preservation, with all activities. Exceptional client outcomes result from professional excellence in transitioning clinical care to real life applications. There are opportunities for SCI/D professionals to support client participation in varied environments and to advance professional skills beyond institutional settings.

31 Risk factors for preventable deaths including unintentional drug poisoning

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Objective: To present 3 interrelated studies to assist in preventing early mortality. Our objectives include: (1) classify causes of death among 693 individuals into underlying and contributing causes; (2) categories utilize longitudinal data to identify the relationship of changing utilization of prescription medication to treat pain, spasticity, sleep, and effect on probability of all-cause mortality, (3) identify behavioral risk factors for unintentional deaths due to prescription drug poisoning, including opioid poisoning.

Design: Prospective cohort study was initiated in 1997–98, based on the theoretical risk and prevention model, to identify long-term predictors of morbidity and mortality ($n = 1386$). A follow-up was conducted in 2007–09, at which time a second cohort was enrolled ($n = 1684$).

Participants/methods: Two cohorts of adult participants, with traumatic SCI, AIS A–D, all of whom were a minimum of 1-year post-injury. There were 3070 participants. Self-report assessments were completed by mail, with the assessment including five classes of predictor variables: (1) demographic & injury, (2) psychological, (3) socioenvironmental, (4) behavioral, and (5) health. Mortality status and causes of death were determined through 2014 using the National Death Index.

Results: The most common causes of death were external (25.1%) and heart and blood vessel diseases (20.1%). All-cause mortality was related to the frequency of using medications to treat pain, sleep, and affect. Additionally, increased use of pain or sleep medication were associated with additional risk. Of greatest concern, sensation seeking behaviors, prescription medication use, and binge drinking were highly related to unintentional death due to drug poisoning, including opioid overdose. Demographic and injury factors, including age and injury severity, were unrelated to these causes of death. The pattern of risk factors was distinctive from other causes of mortality. In contrast, non-overdose related deaths were predicted by neuroticism and smoking.

Conclusion: Prevention of early mortality requires an interdisciplinary effort. Nonpharmacological approaches need to be implemented for treating pain and other secondary health conditions. Screening for red flags of substance misuse should be conducted by all professionals providing services to those with SCI.

Support: Administration for Community Living, NIDILRR grant numbers 90RT5003 and 90IF0066.

32 Routine duplex screening in rehabilitation after acute spinal cord injury

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Background: Recent Consortium for Spinal Cord Medicine guidelines published in 2016 recommend against routine duplex surveillance for deep vein thrombosis (DVT) in asymptomatic individuals with spinal cord injury (SCI) on admission to rehabilitation.

Objective: To determine the rates of distal versus proximal DVT found with routine duplex screening performed prior to the newer guidelines, as well as the likelihood of DVT propagation for persons with an asymptomatic distal DVT. Possible risk factors associated with a proximal DVT were also assessed.

Design: Retrospective chart review.

Participants/methods: 189 patients with traumatic SCI admitted to acute rehabilitation within 2 weeks of initial injury underwent routine duplex surveillance for DVT. Duplex scans were assessed for distal and/or proximal DVT. Subsequent duplex scans of those with initial distal DVT were also reviewed. Chi square analysis was performed to evaluate for significant associations between potential risk factors and positive duplex scans.

Results: Of these patients, 16.4% (31 of 189) had a positive initial duplex scan for DVT: 9 of 31 (29.0%) (4.8% of total population screened) had a proximal DVT and 22 of 31 (71.0%) had an isolated distal DVT. Of the 22 patients with isolated distal DVT, 19 (86.4%) completed further duplex surveillance. Two other individuals were transferred out for acute respiratory distress and were diagnosed with pulmonary embolism. Over time in their rehabilitation hospital course, 31.8% of patients with isolated distal DVT developed thrombus propagation. Gender, severity of injury, level of injury, history of malignancy, presence of prophylaxis, type of prophylaxis, presence of inferior vena cava filter, and recent lower extremity fracture were not significantly associated with positive duplex scans for proximal DVT.

Conclusion: A clinically significant portion of individuals with isolated distal DVT eventually developed thrombus propagation. Duplex surveillance may therefore be merited. Additionally, further study of risk factors associated with proximal DVT would be beneficial to better understand who may be at increased risk for DVT development.

Support: In part by a grant from NIDILRR (90SI5026); SCI Clinical Educational funding from Craig H. Neilsen Foundation.

33 SCiPad: Telemedicine using ipads for individuals with spinal cord injuries

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Objective: Spinal cord injury (SCI) often requires lengthy travel to access specialized providers (1-5). Real time video conferencing using FaceTime with an iPad may alleviate this barrier. The objective of this study was to manage secondary complications and improve quality of life through live telemedicine (TM) consultation at a county hospital over a 6-month period post-discharge.

Design: Prospective clinical trial

Participants/methods: Adults with SCI at any neurological level were enrolled in a 6-month iPad-based TM program. For non-emergency SCI concerns, participants contacted research staff who forwarded their concerns to a SCI-specialized provider. The SCI specialist provided a TM visit within 24 hours if needed and/or a routine follow-up visit. Participants completed monthly follow-up interviews, which included Reintegration to Normal Living Index (RNLI), Life Satisfaction Index-A (LSI-A), and Patient Health Questionnaire-9 (PHQ-9) at baseline and 6 months.

Results: 83 participants with SCI were enrolled (58 tetraplegia & 25 paraplegia; 65 males & 18 females) with an average age of 41.21 (+ 16.21) years. To date, 69 participants completed the program. The monthly follow-up results included the following healthcare utilization: in-person physician visits = 34–66; ER visits = 5–18; re-hospitalization = 3–10; sought advice = 12–24; TM visits = 17–38. Over this study period, 213 TM visits were conducted. TM discussion topics included 48% follow-up, 12% urology, 7% spasticity, 6% pain, 5% pressure sores, and 22% others. 100% of participants reported the advice given to be helpful. Of the 62 participants who completed the 6-month program, LSI-A improved significantly ($p = .042$), but there were no statistical difference in RNLI ($p = .23$) and PHQ-9 ($p = .58$) from baseline to 6-month follow-up. Program satisfaction surveys were collected from 47 respondents: 78% agreed that the care received through TM was as good as in person care; 83% were satisfied with the video & audio quality; and 85% of participants expressed interest in continuing TM appointments.

Conclusion: The SCiPad program is the first successful program to provide TM services within the SCI population through FaceTime on an iPad. The positive feedback from participants suggests that TM consultations are acceptable in the SCI population while maintaining quality of care.

Support: The Craig H. Neilsen Foundation funded this research.

34 Essie Morgan Lecture: The caregiver continuum

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Summary: Family caregivers may have many difficulties balancing the multiple roles of parent, spouse and caregiver, and may have other commitments such as employment. When caregivers are unable to cope effectively with all role responsibilities, their health and well-being, as well as that of the care recipient may be jeopardized. Approximately 70% of people with spinal cord injury (SCI) receive care from family members and while the impact of caregiving can be both positive and negative, the consequences of caregiving are

likely to be experienced for decades. A number of actors related not only to family caregivers, but also to health professionals providing care to people with SCI, can contribute to healthcare provider burnout. Strategies to address burnout in both the home and healthcare setting can help family members and health professionals identify and address their own sources of caregiver distress.

35 Vital sign differences between septic patients with tetraplegia versus paraplegia

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Objective: The autonomic nervous system plays an important role in maintaining physiological homeostasis and responding to stressors such as infection. Autonomic dysfunction is common among patients with spinal cord injury (SCI), varying with neurologic level of injury. We sought to explore the relationship between level of injury and physiologic response to systemic infection. Compared to patients with paraplegia, we hypothesized that patients with tetraplegia would have less body temperature elevation, less heart rate (HR) elevation, and lower blood pressure (BP) in the setting of sepsis.

Design: Retrospective chart review. **Participants/methods:** All patients with SCI (n = 29) who were transferred from the VA Puget Sound SCI Unit to the Intensive Care Unit (ICU) with a diagnosis of sepsis from Jan 1, 2010 to Dec 31, 2016. Maximum temperature (Tmax), maximum HR, lowest BP, and presence of altered mental status (AMS) in the 24-hour period prior to transfer were compared between patients with tetraplegia versus paraplegia. The Mann-Whitney U test was used to compare continuous data, while Fisher's exact test was used to compare categorical data.

Results: Twenty-nine patients were transferred from the SCI Unit to the ICU in the specified time period, 16 (55%) of whom had tetraplegia and 13 (45%) of whom had paraplegia. The most commonly suspected source of sepsis in patients with tetraplegia and paraplegia was pulmonary and urinary tract, respectively. Tmax (100.6oF versus 102.6oF, P = 0.021) and HR (103 versus 122 beats/minute, P = 0.012) were both significantly lower in patients with tetraplegia compared to paraplegia. Systolic and diastolic BP were also lower among patients with tetraplegia, though these differences were not statistically significant. There was no apparent relationship between completeness of injury and vital signs, though the skewed distribution of motor incomplete injuries precludes a definitive statement regarding this relationship. Finally, AMS was significantly more common among patients with tetraplegia versus paraplegia (81% versus 23%, p = 0.003).

Conclusion: Patients with tetraplegia are less able to mount a fever or elevate HR during systemic infection compared to patients with paraplegia, possibly due to a greater degree of autonomic dysfunction. These findings suggest that using different vital sign cutoff values for patients with tetraplegia may be necessary to optimize diagnosis of sepsis in the SCI population.