Physiological Predictors of Locomotor Function in Persons Following Motor Incomplete SCI

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Project Goals

Develop the environment necessary to successfully compete for external funding for projects incorporating biomechanical measures of walking in persons following incomplete SCI.

Aim 1: Establish the recruitment network and necessary infrastructure

Aim 2: Develop database describing the biomechanical characteristics of walking

Aim 3: Determine biomechanical, physiological and clinical predictors of walking performance in persons following incomplete SCI

Aim 4: Perform strategically designed pilot studies
Aim 1: Establish the recruitment network and necessary infrastructure

Center for Rehabilitation Research in Neurological Conditions

LABORATORIES
• Locomotor Rehabilitation
Aim 1: Establish the recruitment network and necessary infrastructure

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LABORATORIES

• Locomotor Rehabilitation
• Energetics and Assessment
Aim 1: Establish the recruitment network and necessary infrastructure

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Laboratories
- Locomotor Rehabilitation
- Energetics and Assessment
- Brain Stimulation (TMS)
Aim 1: Establish the recruitment network and necessary infrastructure

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LABORATORIES

• Locomotor Rehabilitation
• Energetics and Assessment
• Brain Stimulation (TMS)
• Motor Performance
Aim 1: Establish the recruitment network and necessary infrastructure

One Step At A Time

"Do you want to try it now?"

The woman, dressed in black cycling shorts and a pink T-shirt, eagerly agreed. Surrounded by the team of professionals who had been guiding her progress, Lisa Von Bergen jumped. While four inches off the ground might not seem like a big deal, reconsider the jump in light of her C46 spinal cord injury.

Von Bergen spent 10 days in the company of researchers at the Medical University of South Carolina in Charleston. The 46-year-old welcomed the physical demands of two studies currently being conducted at MUSC’s Center for Rehabilitation Research in Neurological Conditions. The studies, funded in part by the South Carolina Spinal Cord Injury Research Fund, focus on walking after incomplete spinal cord injury.

For people whose lives haven’t been changed by a spinal cord injury, walking doesn’t require a concerted effort. Yet Mark Bowden, PhD, PT, an assistant professor at MUSC, knows there is a lot more to the process of putting one foot in front of another. In MUSC’s Locomotor Neuroergonomics and Assessment Laboratory, he uses high-tech equipment to evaluate the complex factors that go into each step an individual makes. In his current study, participants walk on a specialized mat and treadmill at various speeds and inclines, while detailed measurements are recorded through electronic sensors. Data is collected on the performance of the joints and muscles in the legs and the force generated by the individual.

The researchers utilize a body weight support system, in which participants are secured with a harness mounted to an overhead track. Because a spinal cord injury affects an individual’s ability to hold himself upright, this support enhances walking by taking over the burden of a designated percentage of his weight.

One Step At A Time (Continued From Page 1)

Using this system allows researchers to take a different approach than traditionally found in rehab. “If you are given braces and taught to use them, that’s something totally new to the nervous system. If the brain is taken away using body support, then we can reteach your nervous system the way you used to do things,” Bowden said.

Chris Gregory, PhD, PT, an assistant professor at MUSC, is leading a study on the strength and power involved in walking after incomplete injury. Using the data collected by Bowden, Gregory continues the evaluation process in the Locomotor Rehabilitation Lab. Secured in a harness with or without body weight support, participants are tested to define exactly how they walk, including the pattern of steps, number of steps per minute, and the positioning of their feet. “We want to challenge people to reach the point of failure during a task, because we won’t know their ability level unless they fail,” Gregory explained. “With the body weight support system they won’t hit the ground and get hurt when they lose their balance.”

During 18 sessions in the lab, individualized training regimens are implemented to address specific physical deficits that affect walking ability. “We look at what changes in muscle use and cardiovascular fitness are associated with being able to walk better. We want to make sure that each person gets the best program to maximize function,” said Gregory.

Von Bergen isn’t a typical participant at the center in that she traveled to MUSC from Alaska. Having read about Bowden and Gregory’s work in a physical therapy magazine, she knew she wanted to get involved. Since her injury in a car accident six years ago, she has defied predictions that gave her less than a five percent chance of walking again. Through her own persistence she no longer uses a wheelchair for mobility, yet she would ultimately like to discard her walker as well. At MUSC, Von Bergen appreciated how the staff helped push the limits of her ability.

“The first word that comes to mind when I think of our focus is intensity,” said Aaron Embery, PT, DPT, a research physical therapist working with the studies. “We believe that the intensity of what we develop for participants absolutely matters,” he said.

What happens after the studies is an important consideration to the researchers. “Our ultimate goal is for participants to be able to continue something on their own or at their local fitness center,” said Bowden. Another aim is to eventually develop assessment and treatment options that can be used by the therapists in rehab facilities. “It’s all about getting the knowledge back into the community and into the hands of clinicians,” said Lindsey Perry, PT, DPT, another physical therapist on the team.

By the time Von Bergen left MUSC, she had built up enough muscle strength to achieve that four inch jump. She had also increased her leg strength by 50 percent and progressed to doing some walking with a cane instead of a walker. She returned to Valdez, Alaska, with a set of recommendations to keep working on strengthening her muscles, improving her aerobic capacity and increasing her endurance. Her continued progress at home is what the researchers hope to impact. “It’s not true that at the end of a year after injury you will have gotten back all that you will get back. There is potential for change and performance for the rest of your life,” said Gregory.

Participants are currently being recruited for the two studies. Potential participants have to have been diagnosed with an incomplete spinal cord injury, be at least six months post injury, and be able to walk without assistance from another person (walking with braces or assistive devices are acceptable). To find out more about qualifications and to volunteer, contact Lindsey Perry at 843-792-3302 or perryl@musc.edu.
Aim 2: *Develop database describing the biomechanical characteristics of walking*

1. Kinematics
2. Kinetics
3. EMG
**Aim 2:** Develop database describing the biomechanical characteristics of walking

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Aim 3: Determine biomechanical, physiological and clinical predictors of walking performance in persons following incomplete SCI
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Aim 4: Perform strategically designed pilot studies

- Atrophy
- Shift to fast phenotype
- Decreased voluntary activation
Aim 4: Perform strategically designed pilot studies

- Deficits in lower extremity strength are associated with:
  - increased levels of dependence
  - greater risk of falls
  - decreased walking speeds (Bean et al, 2003a; Chan et al, 2007)
Aim 4: Perform strategically designed pilot studies

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- Non task-specific aerobic exercise results in increased walking speed and suggests the potential to improve secondary health conditions (depression, pain and fatigue) in ambulatory individuals following incomplete SCI.
Effects of Aerobic Exercise Training on Walking and Health Related Outcomes in Individuals with Incomplete Spinal Cord Injury

Nicole DiPiro, MS; 1 Aaron Embry, PT, DPT, MSCR; 1, 2 Lindsay Perry, PT, DPT, NCS; 1, 2 Patrick Morgan, MS; 1 James Krause, PhD; 1 Chris Gregory, PhD; 1

1Department of Health Sciences and Research; 2Division of Physical Therapy College of Health Professions, Medical University of South Carolina

ABSTRACT

INTRODUCTION: Spinal cord injury (SCI) often results in chronic motor and sensory deficits that are associated with residual functional impairments and activity limitations. The physical sequelae of SCI can have significant long-term effects on function, fitness, and health, all of which may play into a debilitating cycle. Of particular interest in this study were the effects of SCI on aerobic capacity (VO2peak) walking related outcomes, and secondary health conditions (SHC), and the potential role for aerobic exercise training (AET) as a rehabilitation strategy.

METHODS: Twelve ambulatory individuals with chronic motor incomplete SCI were recruited for participation in a 6-week AET intervention. The primary outcomes were VO2peak and self-selected overground walking speed. Secondary outcomes included walking-related clinical assessments (WMVT, NSCIR, BBS, CCI, walking economy daily step counts, depressive symptomatology (PHQ-9), pain (BPI), fatigue (MFIS), cardiometabolic risk factors (dyslipidemia, impaired fasting glucose, impaired glycemic control) and QoL (KSS, 22-46).

RESULTS: Ten participants completed all testing and training. The 6-week intervention resulted in significant improvements in the primary outcome measures. Of the secondary outcomes, significant improvements were found only in daily step counts.

CONCLUSIONS: The results suggest that 6-weeks of exercise based on published guidelines improves aerobic capacity and walking speed in individuals with chronic incomplete SCI. This study builds a foundation for further investigation aimed at the development of exercise-based rehabilitation strategies to target functionally limiting impairments and SHC in ambulatory individuals with chronic SCI.

PURPOSE

Quantify the effects of a 6-week AET intervention on VO2peak, walking outcomes, SHC (depressive symptomatology, pain, fatigue, and cardiometabolic risk factors), and quality of life (QoL) in individuals with chronic incomplete SCI.

METHODS

INCLUSION CRITERIA:
- 18-75 years old
- AIS C or D, motor incomplete SCI
- Chronic SCI (> 9 months)
- Diagnosis of first time SCI (traumatic or vascular)
- The ability to walk independently at self-selected speed (0.1 - 1.15 m/s)
- Medically stable

EXERCISE PROTOCOL:
- 6-weeks moderate-intensive AET on a NuStep®
- Voluntary total body recumbent stepping exercise
- Intensity based on initial VO2peak
- Intensity progressed 5% per week, starting at 40% VO2R
- 16 sessions, 33 minutes per session

SUMMARY

- This study is the first, to our knowledge, to examine the impact of voluntary progressive aerobic exercise on walking and health related outcomes in ambulatory individuals with chronic incomplete SCI.
- 25 individuals were screened for inclusion in the study.
- 13 signed the ICF and enrolled
- 9 withdrew prior to completing pre-testing assessments
- 9 began the AET Intervention
- 9 participants completed all testing and training
- 1 dropped out due to transportation issues; last observation carried forward.

- The 6-week AET intervention resulted in significant improvements in the primary outcomes.
  - Aerobic capacity: 2.96 ± 2.91 ml/kg/min (P = 0.01; d = 0.91)
  - Walking speed: 0.66 ± 0.07 m/s (P = 0.02; d = 0.86)
- Improvements were observed in all of the walking related secondary outcomes.
  - Only daily step counts significantly improved (P = 0.02; d = 0.95)
  - Improvements were noted in many of the assessed SHCs though none were significant.
  - Participants were not recruited based on SHC presence, thus many were within normal ranges.
  - Future research including a larger sample of individuals with the selected SHC is necessary to determine if AET may significantly impact these outcomes.

CONCLUSIONS

- This study provides valuable data to fill a void in the literature regarding the potential role of AET in rehabilitation after chronic incomplete SCI.
- A better understanding of the impact of AET on walking and health related outcomes may help medical professionals, as well as individuals with SCI, develop and implement appropriate exercise programs to reach goals.
- The findings from this study will be used to develop future studies aimed at improving health and QoL after SCI.
- There is a need for future research to focus on the critical elements of training (frequency, intensity, type and duration) that impact outcomes.
- Future studies should also address the role of SHCs may play in initiating and maintaining exercise programs.
Manuscripts


Presentations at Conferences


Funded Grant Proposals:

**Higher-Than-Replacement Testosterone Plus Finasteride Treatment After SCI**
- **Agency:** VA Rehabilitation R&D Service (PI: Yarrow)
- **Dates:** 10/1/14 – 9/30/19
- **Type:** Merit Award

**Aerobic exercise to treat depression following incomplete SCI**
- **Agency:** South Carolina Spinal Cord Injury Research Fund
- **Dates:** 11/1/2013-10/31/2014
- **Role:** Co-I (PI: Fritz at University of South Carolina)

**Aerobic exercise to treat depression following incomplete SCI**
- **Agency:** South Carolina Clinical & Translational Research Institute
- **Dates:** 8/1/13 – 3/31/15
- **Type:** TL1 Pre-doctoral Award

Grant Submissions:

**Neuromuscular plasticity and locomotor recovery after incomplete SCI**
- **Agency:** VA Rehabilitation R&D Service
- **Type:** Merit Award
- **Role:** PI

Changing What’s Possible
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