Outcomes relative to proposed aims:

- **Aim 1: Establish the recruitment network and infrastructure (equipment and personnel) necessary to carry out locomotor studies involving subjects following incomplete SCI as well as non-injured individuals. Status: Completed (on-going)** Over the past four years we have expanded our capabilities for research through development of laboratories as well as recruitment of well-trained group of individuals to perform rehabilitation research studies. Staff supported directly by the award include a research physical therapist and a biomedical engineer. In addition to these project funded staff, we currently have one other physical therapist, 2 research coordinators, an exercise physiologist and 6 PhD students currently working in the locomotor research labs as well as 5 DPT students funded off work-study grants. In addition to staff, we upgraded the capabilities of the labs to incorporate a Woodway split-belt treadmill. Existing labs that have benefited from equipment purchased from this award include:

  **Locomotor Energetics and Assessment Laboratory (LEA):** The LEA is a 1350 square foot laboratory located with the College of Health Professions Research Building on the campus of Medical University of South Carolina. The laboratory is a shared resource of the college and is supported in part by the Department of Health Sciences and Research. The laboratory is located in the same building as the offices of the PI, Co-I and staff. It features equipment capable of collecting kinematic, kinetic, electromyographic, strength, and metabolic data. The motion analysis laboratory is adjacent to a small workshop available for the construction, repair, and alteration of simple mechanical devices.

  **The Locomotor Rehabilitation Laboratory (LRL)** is a state-of-the-art treatment laboratory, designed to offer a full range of locomotor interventions for those with impaired walking secondary to neurologic injury. The LRL is an 811 square foot laboratory located on the second floor of the College of Health Professions Research Building, Room C-213. The laboratory houses a ZeroG mobile body weight support system designed to create a permissive environment for retraining walking ability not only over a treadmill, but also over level ground and environmental obstacles. Research participants will have access to a Woodway split-belt treadmill alongside clinically utilized balance equipment for training cardiovascular endurance as well as lower extremity stabilization.

  **The Neuro-Stimulation Laboratory (NSL)** is located on the 2nd floor of the College of Health Professions Research Building on the campus of Medical University of South Carolina (room C223). NSL studies use electromagnetic approaches as either research tools investigating neuroscience questions or as investigational or FDA approved treatments for brain diseases. Techniques actively being used by NSL researchers and their collaborators include transcranial magnetic stimulation (TMS) and transcranial direct current stimulation (tDCS).

  **The Motor Performance Laboratory (MPL)** is housed in the College of Health Professions research building at the Medical University of South Carolina. The MPL is designed to investigate the metabolic and muscular mechanisms underlying abnormal neuromuscular function and the development of effective interventions. Major equipment includes an isokinetic dynamometer to measure muscular strength, ultrasound for muscular architecture analysis, metabolic system to analyze cardiovascular utilization, gait training area with rail support system, and seven different cardiovascular, strength and power exercise machines. This lab has both treatment and
measurement capabilities making it ideal for developing new clinically relevant neuromuscular therapeutic interventions.

- **Aim 2: Develop database describing the biomechanical characteristics of walking in individuals with incomplete SCI as well as non-injured individuals.** Completed (on-going)

Following completion of the funding period, we have a database of 27 individuals following incomplete SCI who have participated in laboratory-based studies at MUSC (see table below). 21 of these subjects have completed data collections for quantitative biomechanical analyses of their walking at various speeds and during different adaptive conditions. Many of the subjects have completed locomotor testing at multiple time points. We have also tested 18 neurologically healthy subjects across a range of walking speeds and conditions as a means for comparison for cross-sectional studies. Data collected include full kinematic (joint angles and angular velocities); kinetics (ground reaction forces and center of pressure) and electromyographic (muscle activity from lower extremity muscles {soleus, medial gastrocnemius, lateral gastrocnemius, tibialis anterior, rectus femoris, vastus lateralis, biceps femoris, gluteus medius} information. These data are collected during conditions that include: self-selected walking speed, fastest comfortable walking speed, incline walking, decline walking, split-belt walking.

<table>
<thead>
<tr>
<th>Racial Categories</th>
<th>Ethnic Categories</th>
<th>Not Hispanic or Latino</th>
<th>Hispanic or Latino</th>
<th>Unknown/Not Reported</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Female</td>
<td>Male</td>
<td>Unknown/Not Reported</td>
<td>Female</td>
<td>Male</td>
</tr>
<tr>
<td>American Indian/Alaska Native</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Asian</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Native Hawaiian or Other Pacific Islander</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Black or African American</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>White</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>More Than One Race</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Unknown or Not Reported</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>11</td>
<td>16</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

**Aim 3: Determine biomechanical, physiological and clinical predictors of walking performance in persons following incomplete SCI.** Completed (on-going)

Data collected to date emphasize the importance of physiological capacity (strength and metabolic capacity) on walking performance (gait speed). Specifically, significant correlations between lower extremity muscle strength (MVIC) of both the more- and less-involved KE and PF muscle groups significantly correlate with self-selected walking speed (see figure below). Lower extremity motor score (LEMS) determined during ASIA evaluation was also significantly correlated with walking speed (r = 0.606). These same measures also correlated significantly with spatiotemporal characteristics of walking; contralateral step length, % single limb support. The full description of these results is described in a recent publication (DiPiro et al, in press) and were the foundation for a grant submitted (“Neuromuscular plasticity and locomotor recovery after incomplete SCI”) to the VA Rehabilitation Research and Development service as well as 2 student-directed proposals (“Aerobic exercise and locomotor recovery after incomplete SCI” and “Aerobic exercise to treat depression following incomplete SCI”) funded to study individuals following incomplete SCI.
Aim 4: Perform strategically designed pilot studies on adaptations to interventions that target mechanisms underlying impaired walking in persons following incomplete SCI. Completed (on-going) We have completed several studies during the funding period examining interventions aimed at understanding the mechanisms underlying improvements in locomotor function. Specifically, we recently completed a study of a non-task-specific (see picture at right) aerobic exercise program aimed at improving locomotor function. The results suggest significant improvements in walking speed as well as the potential to improve secondary health conditions (depression, pain and fatigue) in ambulatory individuals following incomplete SCI (see figure below illustrating changes in walking speed and clinical outcomes in individual subjects).

Presentations, publications and grant applications:

Manuscripts
2. RJ Downey, MJ Bellman, H Kawai, CM Gregory & WE Dixon. Comparing the Induced Muscle Fatigue Between Asynchronous and Synchronous Electrical Stimulation in Able-bodied and


Presentations at Conferences


Funded Grant Proposals:

Higher-Than-Replacement Testosterone Plus Finasteride Treatment After SCI
Agency: VA Rehabilitation R&D Service
Dates: 10/1/14 – 9/30/19
Type: Merit Award
Direct Costs: $1,100,000
Role: Co-investigator (PI: Yarrow)
- Our goal is to determine if higher-than-replacement testosterone plus finasteride will safely improve musculoskeletal integrity, neuromuscular function, and metabolic health in men with incomplete SCI.

Aerobic exercise to treat depression following incomplete SCI
Agency: South Carolina Spinal Cord Injury Research Fund
Dates: 11/1/2013-10/31/2014
Direct Costs: $14,578
Role: Co-I (PI: Fritz at University of South Carolina)
- The goal of this proposal is to establish a collaborative relationship between rehabilitation researchers at the University of South Carolina (USC) and the Medical University of South Carolina (MUSC). Ongoing research at MUSC is investigating the impact of aerobic exercise training (AET) on depression in individuals following SCI. This proposal will fund the purchase of equipment at USC to match that at MUSC so as to be able to quantify the effects of AET on depressive symptomology,
secondary health conditions and clinical outcomes in ambulatory individuals with chronic incomplete SCI.

**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
- **Direct Costs:** $36,320
- **Role:** Co-mentor (PI: DiPiro)
  
  - The overall goal of this project is to quantify the effects of aerobic exercise training on depressive symptomology and clinical outcomes in ambulatory individuals with chronic SCI.

**Grant Submissions:**

- **Neuromuscular plasticity and locomotor recovery after incomplete SCI**
  
  - **Agency:** VA Rehabilitation R&D Service
  - **Type:** Merit Award
  - **Direct Costs:** $1,100,000
  - **Status:** Submitted (not funded)
  - **Role:** PI

Effects of Aerobic Exercise Training on Walking and Health Related Outcomes in Individuals with Incomplete Spinal Cord Injury

SUMMARY

Nicole Stylianos, MS, LTA, Action Injury, P.T., NSC

PURPOSE

The purpose of this study was to evaluate the effects of aerobic exercise training on walking and health-related outcomes in individuals with incomplete spinal cord injury (SCI).

METHODS

Participants were randomly assigned to an aerobic exercise group (n=15) or a control group (n=10). The aerobic exercise group performed a 12-week program of aerobic exercise, consisting of cardiovascular endurance training, while the control group maintained their usual activity level.

RESULTS

The aerobic exercise group showed significant improvements in walking speed and distance, as well as in measures of physical fitness compared to the control group. There were also improvements in health-related quality of life and mood.

CONCLUSIONS

Aerobic exercise training appears to be an effective intervention for improving walking ability and health-related outcomes in individuals with incomplete SCI.
PARTICIPANTS NEEDED
Spinal Cord Injury Exercise Research Study

Have you had a spinal cord injury, but are still able to walk?
If so, then we need your help.

- 6 week exercise program
- walking & health-related testing

Eligible participants will receive compensation and parking.

For more information, contact Nicole
Center for Rehabilitation Research in Neurological Conditions
Locomotor Research Labs
843-792-9894
debarge@musc.edu

MUSC COLLEGE OF HEALTH PROFESSIONS

RB Number: Pro0021879
Date Approved 10/23/2013

UNIVERSITY OF SOUTH CAROLINA
Arnold School of Public Health
Effects of Aerobic Exercise Training on Fitness and Associated Secondary Outcomes in Individuals with Spinal Cord Injury

Nicole DiPirro, AS, M.A., Chris Gregoire, PhD, PT, and James Nettles, PhD

College of Health Professions, Department of Exercise Science & Athletic Training, Medical University of South Carolina

OBJECTIVES: The purpose of this pilot study was to determine if aerobic exercise training would improve maximal oxygen uptake (VO2peak), physical performance, and health-related quality of life in individuals with spinal cord injury. Secondary outcomes included quality of life, depression, physical performance, and physical function.

METHOD: Participants completed an exercise program consisting of 30 minutes of aerobic exercise, 3 times per week for 12 weeks. VO2peak was measured using a treadmill protocol, and physical function was assessed using the Six-Minute Walk Test (6MWT).

RESULTS: Exercise training resulted in a significant increase in VO2peak and functional endurance. Quality of life and depression scores also improved significantly.

CONCLUSIONS: Aerobic exercise training is an effective intervention for improving VO2peak, physical function, and quality of life in individuals with spinal cord injury.

Figure 1: Participants engaged in aerobic exercise training.