

Neuroplasticity & Functional Electrical Stimulation (FES) Cycling Webinar

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Objectives:

- To discuss the potential benefits of functional electrical stimulation (FES) cycling early after spinal cord injury (SCI)
- To describe the lessons learned from FES cycling early after acute SCI

Disclaimer:

- I have no financial conflicts of interest to disclose

What is FES and why use it after spinal cord injury (SCI)?

- FES = Functional Electrical Stimulation
- Use of electrical stimulation on skin surface (or in muscles) to activate muscles
- Potentially make muscles paralyzed by SCI contract to perform movements
- Cycling movements can be achieved by coordinated stimulation of different leg muscles



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FES Bike: RT300 Sitting



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Neuroplasticity

-**neuroplasticity** describes how experiences reorganize neural pathways in the brain.... Long lasting functional changes in the brain occur when we learn new things or memorize new information. These changes in neural connections are what we call neuroplasticity....
- Rehabilitation training may influence neuroplasticity
- Neuroplasticity may lead to **neurorecovery**



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FES cycling and neuroplasticity?

- FES cycling in chronic SCI (>1 year) can reverse muscle atrophy and improve cardiovascular fitness
- FES cycling in chronic SCI also shown to facilitate neuroplasticity hence neurorecovery
- Animal models have shown that exercise training early after SCI (critical window of 1-2 weeks post injury) may promote neuroplasticity
- FES cycling in acute SCI has also shown to have musculoskeletal benefits but no study so far on neuroplasticity – are we missing a **BIG OPPORTUNITY?**



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Early exercise training after SCI: why FES cycling?

- FES cycling is already available in some rehab centers and community facilities
- Several models of FES cycles commercially available
- Supine FES cycling may allow its use by those without a wheelchair or those who cannot sit up yet after SCI, even potentially in the ICU setting
- **BUT** need to understand how to safely perform SCI cycling in acute SCI and to generate evidence on neuroplasticity in humans



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FES Bike: RT300 Supine

Restorative Therapies
Baltimore, USA

Stimulator
6 Channels

Controller

Motor

Electrodes



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Goals for our study

- To establish safety, feasibility and procedures for early FES cycling starting as soon as possible after SCI in the acute care units at the University of Alberta Hospital (UAH)
- Lessons learned will guide the development of clinical studies for FES cycling after acute SCI
- To build the expertise and experience in early FES cycling after acute SCI among research team members
- To engage the acute SCI team for future clinical implementation of FES cycling



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METHODS: Participants

INCLUSION

- Traumatic or non-traumatic SCI (with acute onset)
- Patients on Neuro, Ortho, Trauma units @ UAH
- At any level: paraplegia or tetraplegia
- Incomplete or complete injury (AIS A-C)
- Injury sustained within 3 months
- 16 - 90 years old (any gender)
- Medically stable



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Acute FES cycling protocol

- 3 days per week
- Goal was 4 weeks cycling
- Up to 3 months with continuation @ Glenrose Rehabilitation Hospital (GRH) and in our lab after discharge
- UAH: RT300 Supine bike, GRH/lab: RT300 Wheel chair
- Stimulation
 - SUPINE: Quadriceps, Hamstrings, Gluteals
 - SIT: + Gastrocnemius, Tibialis Anterior
- FES Defaults: 35 Hz, 300 μ s pulse width
- First session: 15 min @ 20 RPM
- Progress to: 45 min @ 30-50 RPM



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Outcome Measures

- Feasibility

- 1. Practicality

- Timing
Logistics

- 2. Patient Readiness

- Medical
Physiological (Spinal Shock)
Psychological

- 3. Acceptability

- Interest to participate
Retention
Participant
Clinician

- Safety

- Procedure

- Efficacy



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Lessons Learned



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What are the lessons learned?

- 7 participants recruited
- **Feasible:**
- Early FES cycling as early as 12 days post-SCI was possible, despite some medical complications such as rib fractures
- **Safe:**
- 7 adverse events caused by FES (6 pain, 1 spasm), related to stimulation intensity and resolved by lowering amplitude
- No autonomic dysreflexia occurred
- Progression of stimulation parameters was highly individualized



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What are the lessons learned?

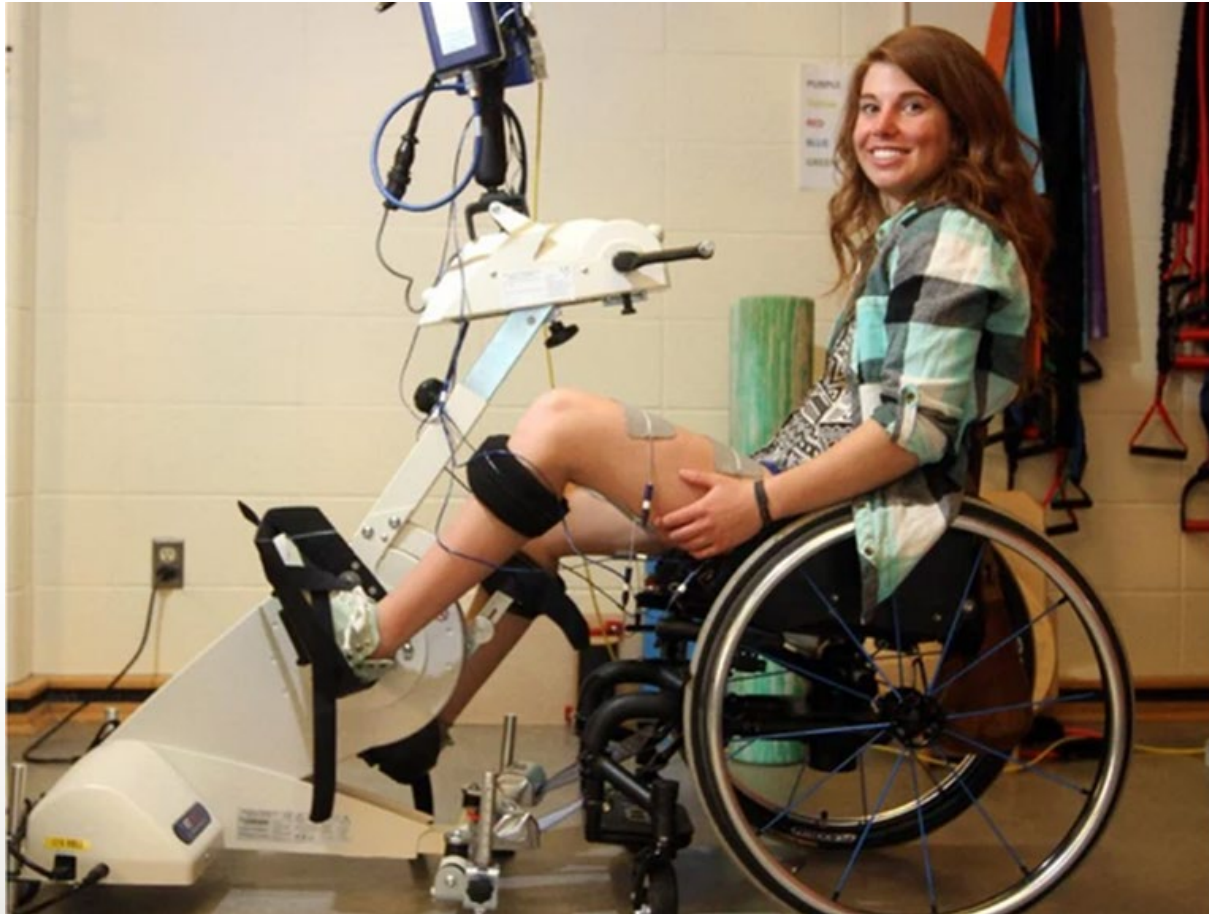
- **Accepted by patients:**
 - Participants were enthusiastic to start, some apprehensive, and missed few sessions (2 medical, 3 personal)
- **Accepted by clinicians:**
 - No practical obstacles encountered and well supported by clinicians
- **Retention:**
 - 5/7 Participants continued FES cycling at YMCA, 1 unable due to COVID-19
- **Logistics:**
 - Early engagement of acute care clinicians and administrators critical
 - Continuity of FES cycling at the rehabilitation program important



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Next Steps



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Next Steps

Clinical:

- Currently FES cycling is mostly available in the community > rehabilitation settings
- Acute care FES cycling may be another useful rehabilitation tool – to promote neuroplasticity?
- Supine FES cycling may be useful in the ICU and acute care settings



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Next Steps

Research:

- To determine if FES cycling has an impact on neuroplasticity
- Funding by Praxis Spinal Cord Institute and Craig H. Nielsen Foundation: pilot studies to determine if early FES cycling has any benefit in neuroplasticity
- Pilot study data will form the basis for a multi-site, randomized, controlled trial on early FES cycling



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Acknowledgment

Funding of FES cycling research:

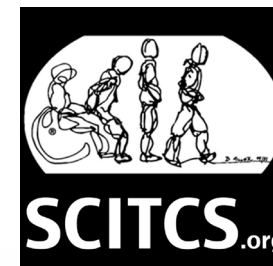
- Alberta Paraplegic Foundation
- Spinal Cord Injury Treatment Centre Society
- Praxis Spinal Cord Institute
- Craig H. Neilsen Foundation

My lab:

- Dirk Everaert, PT, PhD (Research Associate)
- Yoshi Okuma, MS, RN (Research Nurse)
- Vahid Abdollah, PhD (Post-doctoral Fellow)

Collaborators:

- Monica Gorassini, PhD
- Vivian Mushahwar, PhD
- Aaron Hockley, MD, PhD
- Dean Jeffery, MD
- Riccardo Baldini
- Brian Chan, PhD



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