ACADEMY OF SPINAL CORD INJURY PROFESSIONALS

FUNCTIONAL ELECTRICAL STIMULATION CYCLING COULD SAVE MUSCLE VOLUME FOLLOWING ACUTE SPINAL CORD INJURY

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BACKGROUND

- Muscle atrophy develops rapidly during the first few months after a spinal cord injury (SCI).[1]
- Muscle atrophy predisposes individuals to metabolic syndrome and related diabetes and cardiovascular disease.[2,3]
- Current evidence indicates that FES-cycling could prevent or even reverse muscle atrophy in people living with chronic SCI (≥ 1-year post-injury).[4]
- The FES effects within the first 3 months of new SCI have not been investigated extensively.

OBJECTIVES

- To determine if early FES cycling starting within 14-21 days post-injury could help maintain lower extremity lean muscle cross-sectional area (LM-CSA) within the first 3 months of SCI.

METHODS

- Participants: **24** (AIS A=8; B=3; C=4; D=7, 7 females; 44.5 ± 15.5 yrs.).
- Randomly assigned to:
  - Intervention group: FES cycling and standard SCI care.
  - Control group: standard SCI care.
  - CT at baseline and 3 months
- Four CT scanners: two Siemens SOMATOM, a GE, and a Toshiba Aquilion.
- Image acquisition parameters: KVP: 120 kV, pixel spacing of 0.98×0.98 mm (rows: 512, columns: 512.
- Spiral CT imaging from L2 to toes.
- Six axial slices were extracted from 30 to 80% of the femur length and 14% to 64% of the tibia (every 10%, Fig. 1).
- Image processing was performed offline with MATLAB-based software.[5,6]
- **k-nearest-neighbor algorithm** was used to segment bone and muscle from adjacent tissue.
- Hounsfield-unit threshold between -29 and 150 was used to calculate LM-CSA.[7]
- Mean of six slices were calculated for each side. Mean difference percentage of changes (MDP) was calculated for each group $MDP_{3M} = \frac{CSA_{3Month} - CSA_{Baseline}}{CSA_{Baseline}} \times 100$.

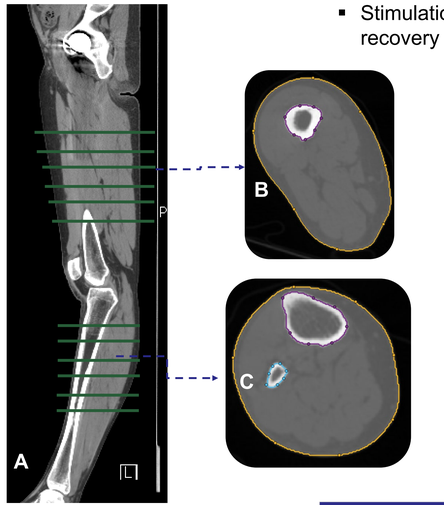

Fig 1. a) Axial Slice Extraction Locations, B) thigh CSA at 50% of femur length; and C) Shank CSA at 34% of shank length

EARLY FES CYCLING may reduce muscle atrophy in people with AIS A-B SCI

INTERVENTION: FES CYCLING

- RT300 Supine (Fig. 2) or SLSA bike (Fig. 3) (Restorative Therapies, Baltimore, MD, USA)
- Stimulating 3-5 muscle groups/leg
- 15-45 min/session
- 3 days/week (21±7 sessions per participant)
- Pulse width: ≥ 300 µs; Frequency: 40 Hz
- Stimulation amplitude: As tolerated and deemed appropriate for level of recovery

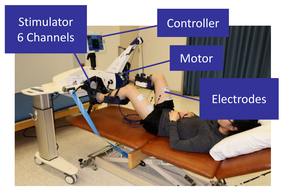

Figure 3. RT300 SLSA FES Bike

Figure 2. RT300 Supine FES Bike

RESULTS

- A total of 1152 slices were analyzed, 576 from each side of the right and left thigh and 576 from each side of the right and left shank.

Table 1 Mean ± SD for LM CSA before and after intervention in early and control group

				Before	After	MDP	
				Mean ± SD	Mean ± SD		
Shank	Right	A + B	Early	50.7±17.7	47.0±12.4	-7%	Early > Control
			Control	55.2±19.2	44.1±15.8	-20%	
		C + D	Early	60.5±15.3	67.1±10.5	11%	Early > Control
			Control	69.3±9.5	74.6±14.8	8%	
	Left	A + B	Early	50.1±17.4	46.0±12.1	-8%	Early > Control
			Control	55.4±20.3	43.6±15.2	-21%	
		C + D	Early	59.6±14.5	64.5±14.3	8%	Early ≈ Control
			Control	70.9±10.8	77.2±16.1	9%	
Thigh	Right	A + B	Early	84.0±27.5	81.8±13.5	-3%	Early > Control
			Control	99.2±25.8	79.1±24.0	-20%	
		C + D	Early	115.1±28.9	112.2±19.9	-3%	Early < Control
			Control	111.6±20.5	124.1±29.2	11%	
	Left	A + B	Early	83.2±25.4	82.3±12.1	-1%	Early > Control
			Control	101.1±29.2	78.6±24.3	-22%	
		C + D	Early	117.0±30.2	114.2±22.3	-2%	Early < Control
			Control	118.9±21.7	134.3±33.0	13%	

- At 3 months, there were **no significant differences** between mean LM-CSA for control and intervention.

DISCUSSION & CONCLUSION

- People with AIS A and B SCI may benefit more from early FES cycling than controls.
- The effects of early FES cycling in people with AIS classification and D might not be as immediately noticeable as initially anticipated.
- However, it is important to acknowledge that while the immediate effects might not be easily observable, early FES cycling can still have significant long-term benefits for these individuals.
- More research is required to corroborate this preliminary observation.

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REFERENCES

1 Pamar S, et al. (1993). Paraplegia;31:298–302.
2 Baldi JC, et al (1998). Spinal Cord;36:463–9.
3 Hicks AL, et al. (2011). Spinal Cord;49:1103–27.
4 Pacy PJ, et al. (1988). Clin Sci;75:481–7.
5 Abdollah V, et al. (2018). Biomed Tech (Berl); 63(4):453-460.
6 Abdollah V, et al. (2022). Eur Spine J; 31(8):1979-1991.
7 Long DE, et al. (2019). PLoS One ;14(2):e0211629.