Transcutaneous Spinal Cord Stimulation for Motor Facilitation During Cycling in Individuals with Spinal Cord Injury: A Proof-of-Concept Study

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INTRODUCTION

Spinal Cord Injury (SCI) and stroke can lead to the loss of movement control in the upper and lower limbs, significantly reducing the independence of those affected. Transcutaneous Spinal Cord (tSCS) stimulation is a promising non-invasive, accessible, motor rehabilitation technique [1].

This paper presents the following **key contributions**:

Effect of tSCS on motor facilitation during cycling in SCI individuals

Effect of combined tSCS and volitional effort

Effects on autonomic and muscle spasticity (side benefits) of tSCS - cycling

METHODS

SUBJECTS

Adults with motor- and sensory-complete or incomplete chronic spinal cord injury (classified as AIS A or B), who have no residual motor ability required for cycling, and who are otherwise healthy with stable medication regimens.

	Lesion type	Lesion level	Time since the lesion	Metal implants	Session	Medication
Sub. 01	A (complete)	D4	52 months	D1-D7	2	baclofen, movicol, resolor
Sub. 02	A (complete)	D3	23 months	D3-D9	2	ossibutinine, urimesk
Sub. 03	B (complete)	D12	29 months	None	2	baclofen, lyrica
Sub. 04	B (incomplete)	D2	~ 12 months	none	1	ossibutinine, urivesch

Table 1 – **Subjects characteristics.**

EXPERIMENTAL SETUP

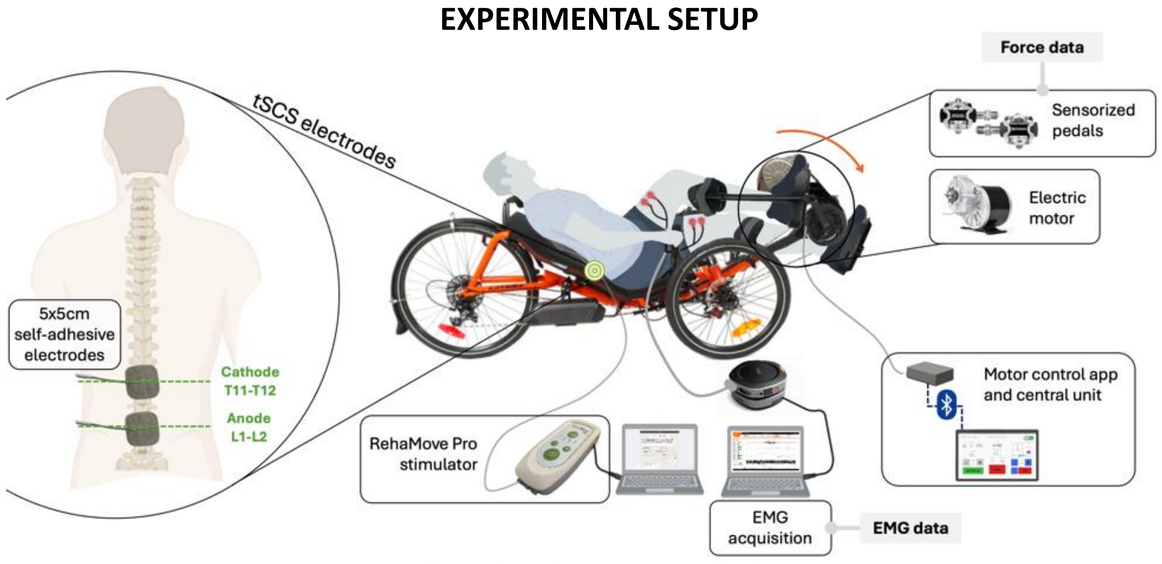


Fig.1 – **Experimental setup [2 - 3].**

EXPERIMENTAL PROTOCOL

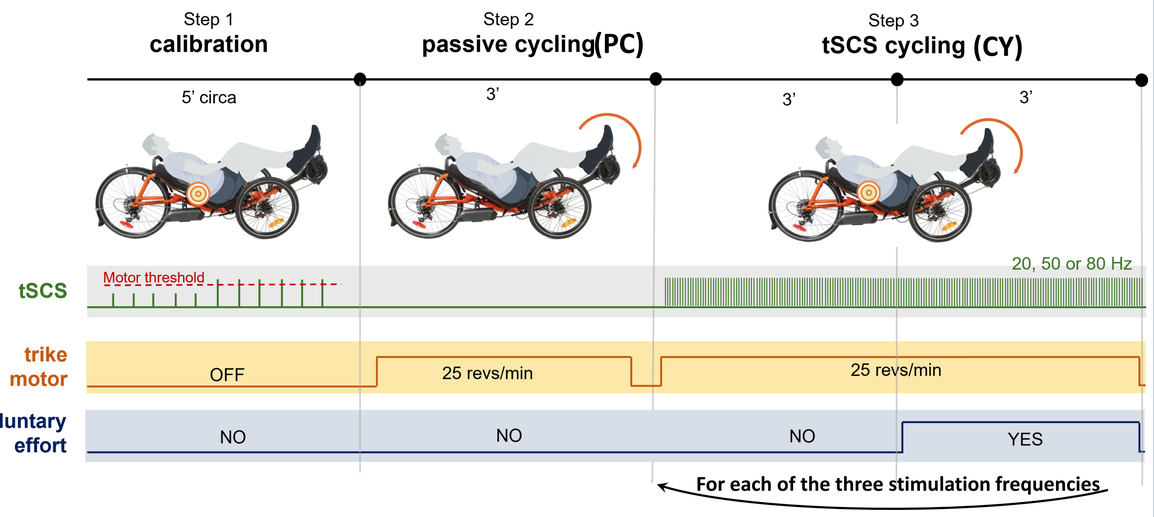


Fig.2 – **Experimental protocol: Calibration** to determine motor threshold using single tSCS pulses, **Passive Cycling (PC)** on a motor-assisted trike without stimulation, and **tSCS Cycling (CY)** with continuous stimulation at 20, 50, or 80 Hz (in a randomized order), performed with and without voluntary effort.

Two training sessions

EMG measure: rectus femoris, biceps femoris, tibialis anterior and gastrocnemius.

Questionnaire for each stimulation frequency

Feedback call in the 24/48 h after the session

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RESULTS

	S01	S02	S03	S04
EMG (PC vs CY)	Amplification (50 Hz) / Reduction (80Hz) of the signal	Amplification (50 Hz)/Reduction (80Hz) of the signal	Amplification (50 Hz)/Reduction (80Hz) of the signal	Amplification (50 Hz)/Reduction (80Hz) of the signal
Force at the pedals (PC vs CY)	Small increase during the pulling phase	Small increase during the pulling phase	Increased active contribution	Increased active contribution especially for tSCS+vol
Perception	No discomfort	Tingling, heating	Mild discomfort	Low discomfort
Secondary effects	None reported	Reduced spasticity, improved bladder/bowel sensitivity	Reduced spasticity, rigidity, improved bladder/bowel sensitivity	Reduced spasticity, rigidity, improved bladder/bowel sensitivity

Table 2 – **Main results**

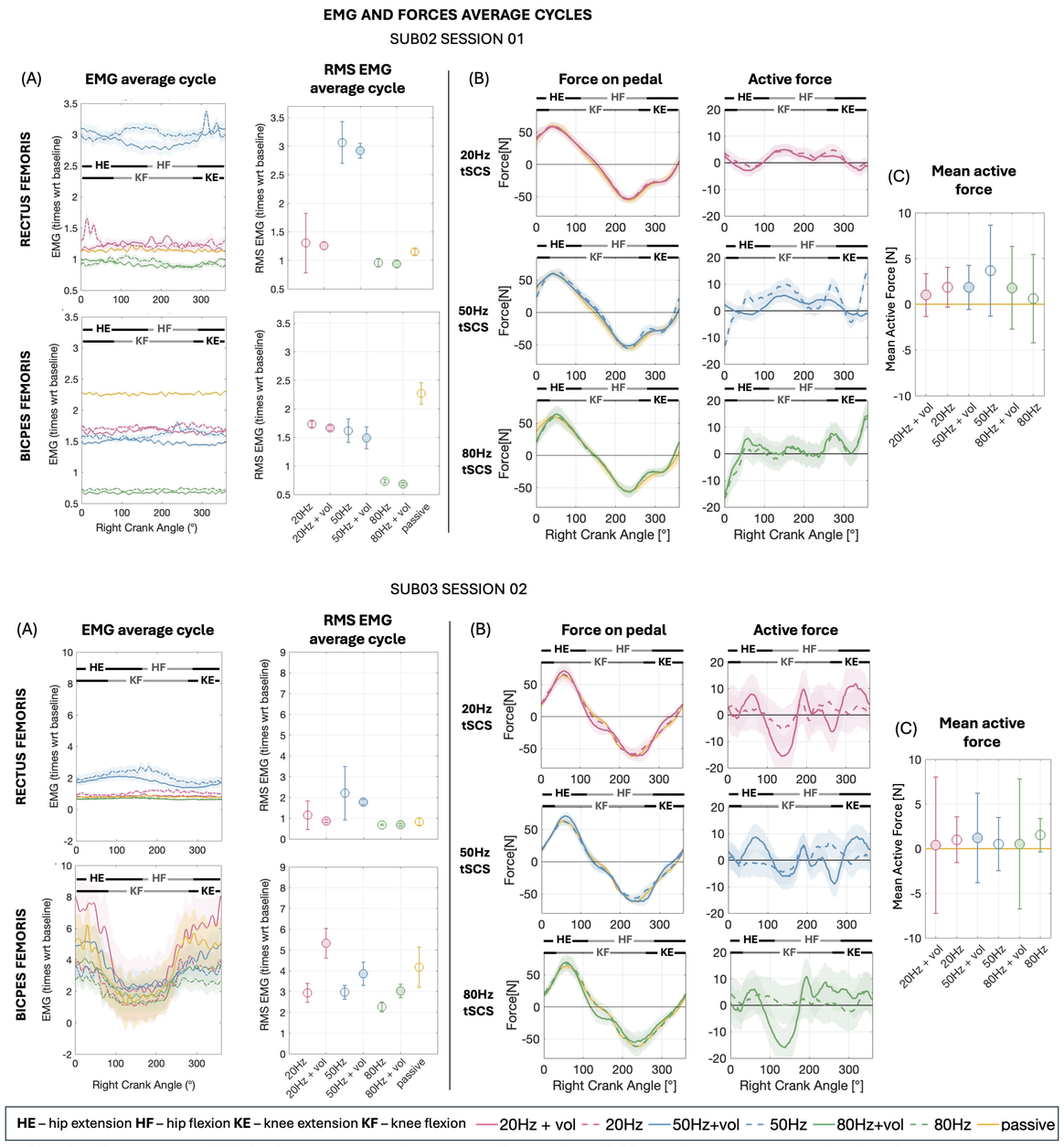


Fig. 3 – **Samples of EMG (A) and pedalling force (B) during tSCS cycling**: muscle activation is modulated by tSCS, decreasing spasticity (stretch reflex) in SUB03 and increasing muscle activation during 50Hz stimulation in absence of spasticity (SUB02). Force results reveal enhanced pedaling force when combining stimulation with volitional effort in SUB 02.

CONCLUSIONS

The study showed that **tSCS combined with cycling** is a **feasible** and **promising approach** for **SCI neuromotor rehabilitation** and carries **multiple** interesting **side benefits**.

tSCS modulates muscle activation during movement depending on stimulation frequency, muscle groups and subjects

Potential amplification of residual volitional signals

Spasticity reduction and autonomic benefits

REFERENCE

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2. Hoover C. Et al.: Neuromodulation through spinal cord stimulation restores ability to voluntarily cycle after motor complete paraplegia, Journal of Neurotrauma, vol 41, pp. 1163-1171, 2024
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