THE EFFECTS OF TRANSCUTANEOUS SPINAL CORD STIMULATION ON PROPRIOCEPTION IN INDIVIDUALS WITH SPINAL CORD INJURY

Saba Allahgholiloo[1,2,3], Tania Sharifi[1,2], Monique Yuan[2,3], Darren J. Mann[2,3], and Vivian K. Mushahwar[1,2,3]
[1] Neuroscience and Mental Health Institute, University of Alberta, Edmonton, AB, Canada
[2] Institute for Smart Augmentative and Restorative Technologies and Health Innovations (iSMART), University of Alberta, Edmonton, AB, Canada
[3] Division of Physical Medicine and Rehabilitation, Department of Medicine, Faculty of Medicine and Dentistry, University of Alberta, Edmonton, AB, Canada
Email: Sallahgh@ualberta.com

INTRODUCTION

Spinal cord injury (SCI) disrupts sensorimotor pathways, producing motor and sensory deficits that limit daily function. Transcutaneous spinal cord stimulation (tSCS), a non-invasive neuromodulation method, has shown promise for upper-limb recovery after SCI [1]. Since tSCS likely recruits large-to-medium diameter dorsal column afferents which are primarily proprioceptive and modulate supraspinal motor control [2], we hypothesize that its motor benefits are mediated by improved proprioception.

MATERIALS AND METHODS

Seven individuals with incomplete cervical SCI (AIS C/D) and 18 neurologically intact (NI) controls performed two proprioceptive KINARM tasks without visual feedback. In the Position Matching task, the robot moved the left arm to nine positions and the participants moved their right arm to the mirror positions. In the Movement Matching task, the robot moved the left arm between three targets while the dominant arm simultaneously mirrored its speed and trajectory. Each task was completed without and with tSCS consisting of 40 Hz trains of 1 ms pulses with a 10 kHz carrier frequency. Stimulation was delivered through electrodes placed over C3–C4 and C6–C7 with return electrodes on the iliac crests, and amplitude was set at the lowest level that evoked a potential in the biceps brachii muscle for each participant.

RESULTS AND DISCUSSION

For the Position Matching task, participants with SCI demonstrated slightly better position-matching accuracy than NI controls ($p = 0.0023$). However, tSCS did not significantly affect endpoint error in either group. In the Movement Matching task, we calculated reaction time, movement time, offset delay, the number of speed peaks, and trajectory error (Fig. 1). Movement time and offset delay were significantly longer in individuals with SCI compared to NI controls (both $p < 0.0001$), indicating slower movements and delayed termination of motion. Additionally, the number of speed peaks was significantly higher in the SCI group ($p < 0.0001$), suggesting less smooth trajectories. Within the SCI group, tSCS significantly reduced offset delay ($p = 0.033$) and showed a borderline reduction in the number of peaks ($p = 0.052$). In the NI group, tSCS significantly reduced trajectory error ($p = 0.021$).

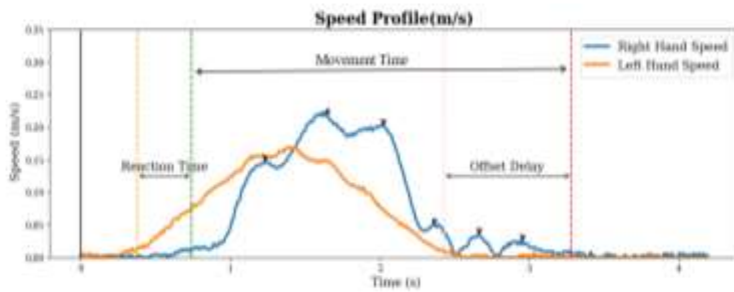

Fig 1 Representative speed profiles of the right and left hands, illustrating reaction time, movement time, offset delay, and peaks in speed during the movement.

CONCLUSIONS

Our results suggest that tSCS can enhance proprioceptive processing and movement timing after SCI, leading to smoother, more coordinated upper-limb movements. tSCS targets the proprioceptive loop, offering a promising avenue for restoring movement fluency. Further studies are needed to clarify its effects on both stationary and motion proprioception.

REFERENCES

[1] Inanici F et al. *IEEE Trans Neural Syst Rehabil Eng* **29**:310-9, 2021
[2] Sayenko DG et al. *J neurotrauma* **36(9)**: 1435-50, 2019