Hypothesis: FES + tSCS will produce larger contractions and H-reflexes than FES alone.

Functional electrical stimulation (FES) and transcutaneous spinal cord stimulation (tSCS): Better Together? Leverett JA, Porozni IO, Bronder LB, & Collins DF

Human Neurophysiology Laboratory, University of Alberta, Edmonton, Alberta, Canada

INTRODUCTION

Aim: Determine whether delivering FES and tSCS “together” produces contractions that are “better” for rehabilitation than those produced by FES alone.

Hypothesis: FES+tSCS will produce larger contractions and H-reflexes than FES alone.

Functional electrical stimulation (FES) and transcutaneous spinal cord stimulation (tSCS)

A. The big picture

- FES “neuromodulates” circuits that control the arms and legs and can help restore motor function after a SCI
- tSCS can be used to “boost” voluntary commands

B. The schematic

- FES at 20 Hz can be used to increase the excitability of circuits that control movement
- tSCS is thought to increase excitability

Rationale: We propose that if tSCS “boosts” or amplifies voluntary commands after a SCI by increasing the excitability of spinal circuits (including motoneurons), as is generally accepted, then tSCS will also amplify contractions produced via reflex paths during FES.

Predictions:
1. H-reflexes evoked by single pulses will increase as soon as tSCS is turned on.
2. tSCS will amplify contractions produced via reflex paths during FES.
3. Torque and H-reflexes during 20 Hz trains of FES will be larger when tSCS is “on” than “off”.
4. Torque and H-reflexes during 20 Hz trains of FES will increase in amplitude as tSCS intensity increases.

METHODS

Participants: Four participants (ages 23-59, 1 woman) with no history of neuromuscular injury or disease took part in a single 2-3 hour session.

Protocol: M-waves, H-reflexes and torque were compared when FES was delivered over the tibial nerve with and without tSCS. Two intensities of FES and three intensities of tSCS were tested.

Torque: Isometric plantarflexion torque about the ankle joint was recorded while participants sat in a Biodex System II dynamometer (ankle ~90°, knee ~120°).

RESULTS

A. Raw torque traces

B. Mean torque (+5% for each mean)

Figure 5. Experimental protocol. Trials were conducted in pairs of control trials and test trials conducted at the same FES intensity.

DATA ANALYSES:

Torque: Torque over 1s intervals at the beginning and end of each contraction was averaged together to provide a measure of the amplitude of each contraction. Torque was normalized to each participant’s maximum voluntary contraction (MVC).

M-waves and H-reflexes: Responses were measured peak-to-peak and normalized to each participant’s maximal M-wave (Mmax). Statistical analyses were not performed due to the low sample size.

CONCLUSIONS & IMPLICATIONS

SUMMARY

1. When tSCS was turned on, H-reflexes were not immediately larger, instead they appeared to progressively decrease in amplitude as tSCS intensity increased.
2. During FES trains, H-reflexes did appear to get progressively larger as tSCS intensity increased. This effect was much greater during low FES.
3. During FES trains, tSCS did appear to increase as tSCS intensity increased and the effect was greater for low FES.

CONCLUSION

tSCS may increase the excitability of neural circuits and amplify the “reflexive” component of FES-activated contractions.

POTENTIAL IMPLICATIONS

If FES+tSCS produces larger contractions than FES alone, we propose the contractions would also be more fatigue-resistant, due to synaptic recruitment in the spinal cord; both outcomes would be beneficial for rehabilitation.

FES+tSCS may also hold promise for neuromodulation, as their impact on CNS circuits may be additive. Further, FES of specific nerves or muscles may focus our augment neuromodulation to specific motor pools or pathways.