The effects of transcutaneous spinal cord stimulation on torque produced during functional electrical stimulation

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INTRODUCTION

Functional Electrical Stimulation (FES)

Functional electrical stimulation (FES) involves the delivery of electrical pulses through the skin over a muscle or nerve via electrodes to generate muscle contractions. FES is commonly used in a rehabilitation context for individuals experiencing paralysis or living with a spinal cord injury (SCI). This can be helpful with exercises or activities of daily living (ADL) and is often referred to as FES.

Transcutaneous Spinal Cord Stimulation (tSCS)

Transcutaneous spinal cord stimulation (tSCS) entails the delivery of electrical pulses on the skin of the back over the spinal cord and aids in restoring movement to individuals that experience paralysis after an SCI.

The efficacy of tSCS is based on the excitation of spinal pathways, activating incoming sensory nerves as they reach the spinal cord and "acrossing" weakened signals from the brain along descending pathways to generate movement.

tSCS can improve voluntary movement in individuals with paralysis or SCI after just one session, with improvements remaining after multiple sessions. tSCS produces a quantifiable response in the lower extremity muscles, namely the soleus, however standardized terminology for this response remains unresolved.

HYPOTHESIS & RATIONALE

Aim: Assess whether delivering tSCS and FES together produces larger contractions than delivering FES alone.

Hypothesis: tSCS + FES will produce larger contractions than FES alone, with torque increasing with stimulation intensity.

Rationale: If tSCS boosts voluntary contractions by increasing spinal circuit excitability, then tSCS will also boost voluntary contractions on the volitional pathway during FES.

METHODS

Participants

Nine participants (ages 23-59, 2 females), with no history of neuromuscular injury or disease participated in a single 2-hour session. Plantarflexion torque (i.e., contraction amplitude) was measured during FES alone and FES + tSCS.

Protocol

Experiments conducted in pairs of control (FES) and test (FES + tSCS) trials with each trial containing 5 contractions.

tSCS delivered via electrodes positioned to stimulate the tibial nerve, located behind the knee to elicit plantarflexor contractions, which were measured with a bi-axial dynamometer. Groups of 5 contractions that ran at 0.7% and 1.3% of power were delivered by stim at 0% intensity of stimulation determined by M-H recruitment curve.

tSCS3 delivered through electrodes placed approximately in an intercostal space between T11 and L1 and was on or off a 0.5 mm at 3 different intensities relative to reflex threshold (0.5%, medium 1.0%, high 1.3%) while FES delivered to produce 5 contractions. tSCS3 was delivered at 50% of use a 10 Hz modulation 0.1 Hz step waveform.

RESULTS

Figure 6: Individual force data

1.0x & 1.3x thresholds of tSCS on vs control compared to the 0.7x threshold, however trends were not consistent among participants.

Figure 8: Mean force data & percent change from a representative individual

Figure 7: Group average force traces

Average force traces of soleus for 6 participants of control vs test intensities (0.7x, 1.0x, & 1.3x thresholds of tSCS).

CONCLUSIONS & IMPLICATIONS

Summary

1. tSCS had no consistent increased effect on the amplitude of muscle contractions.
2. Low intensity tSCS may decrease contraction amplitude, while higher tSCS had minimal effect on "acrossing" contraction amplitude when compared to control contractions.

Conclusion

tSCS appeared to have little effect on contraction amplitude and was inconsistent with the intensity of the stimulation. Data collection is still ongoing.

Potential Implications

Bidirectional modulation of spinal excitability may be possible if this trend holds true in a larger, properly powered sample.

- Higher intensity tSCS can generate larger contractions.
- May be beneficial for muscle strengthening.
- Subthreshold intensity decreased contraction amplitude compared to control, which could help reduce spasticity after SCI.

Limitations include comfortability and tolerability with stimulation.

Future Directions

Future studies could explore the following:

- The effects of tSCS on contraction amplitude and duration with "ON" time?
- Could timing of FES & tSCS delivery as signals arrive at the spinal cord impact contraction amplitude?

REFERENCES


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