Spinal Cord Stimulation to Modulate Contact Heat Evoked Potentials

Shepherd Center — Hulse Spinal Cord Injury Lab

Georgia State University — Byrdine F. Lewis School of Nursing and Health Professions

Farrell BJ[1,2], Crossland E[2], Posey A[2], Sethman J[2], McKay WB[1], Kramer J[1] and Shaw E[1]

[1]Department of Physical Therapy, Georgia State University, [2]Crawford Research Institute Shepherd Center, Atlanta, GA

Introduction

Neuropathic pain is a common complaint for individuals with spinal cord injury, failed back surgery syndrome, and other neurologic conditions. Generally, pharmacological interventions are used to treat chronic neuropathic pain, however there are undesirable side effects associated with long term use of pain medications (e.g. addiction, drowsiness, cognitive impairment). Further, these prescription drugs often provide little pain relief for neuropathic pain. One effective, non-pharmacological treatment has been epidural spinal cord stimulation (eSCS) . Unfortunately, eSCS is an invasive and expensive procedure with a relatively high rate of failure (~30%; Wolter 2014). One technique that may be an alternative or predictive of eSCS success in transcutaneous spinal cord stimulation (tSCS). tSCS is an inexpensive and non-invasive stimulation, that may reduce responsiveness to peripheral inputs (Hofstetter et al 2013) and may be a viable treatment option.

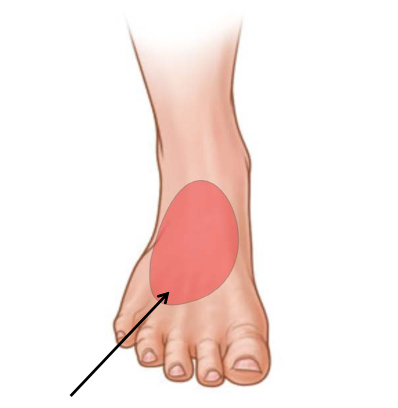
Purpose

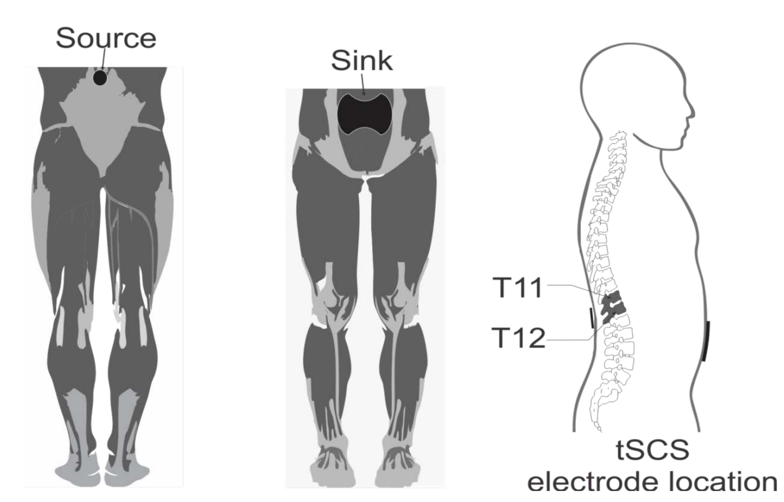
Goal: To quantify the effect of transcutaneous spinal cord stimulation on contact heat evoked potential (CHEPs) amplitude and perceived heat pain in non-injured individuals

Hypothesis :Transcutaneously delivered spinal cord stimulation can reduce both perceived pain and the evoked potential amplitude

Methods

- Ten healthy adults subjects with an age 18-60 and no history of neurologic conditions were recruited for the study
- To evaluate the response to heat stimuli, a CHEPS thermode (Pathway, Medoc) was placed on the dorsum of the foot and temperature was quickly ramped up from 40^{o}C to 54^{o}C and then back to 40^{o} and then randomly moved to another location on the dorsum of the foot.
- A total of 15 thermal stimuli were delivered with 8-14 seconds between stimuli for each assessment.
- Each subject was instructed to rate the pain of each stimuli on a 0-10 rating scale (0 = no pain and 10 = most pain one could experience) within 3-5 seconds after each stimulus
- After the initial baseline contact heat assessments, transcutaneous spinal cord stimulation was delivered through stimulating electrodes placed over the T-11/T-12 spinous processes (source) and on the abdomen (sink) (300Pv, EMPI)
- Tonic stimulation parameters were set as follows: frequency was 100 Hz, pulse width was 400 µs, and intensity was chosen based on either the presence of paresthesia in the feet, or if paresthesia was not reported, the highest intensity the subject could comfortably maintain for 10 minutes.
- In total, two bouts of tonic tSCS was delivered with each bout lasting 10 minutes and followed by a contact heat evoked potential assessment.
- After a 10 min wash-out period, evoked potentials and perceived pain were assessed to monitor for any lasting effects.
- Peak-to-peak amplitude (N2 to P2) was calculated and averaged across subjects and tested for significance ($p < 0.05$) with a student's paired t-test





Results

- Transcutaneous spinal cord stimulation resulted in a significant ($p < 0.05$) reduction in peak-to-peak evoked potential amplitude immediately after each bout of stimulation and after a 10 minute washout period
- Immediately after spinal cord stimulation there was a 21% reduction in contact heat evoked potential amplitude.
- After the 10 minute washout period, there was a 28% reduction in the evoked potential amplitude.
- The perceived pain associated with each thermal stimuli was also reduced after spinal stimulation.

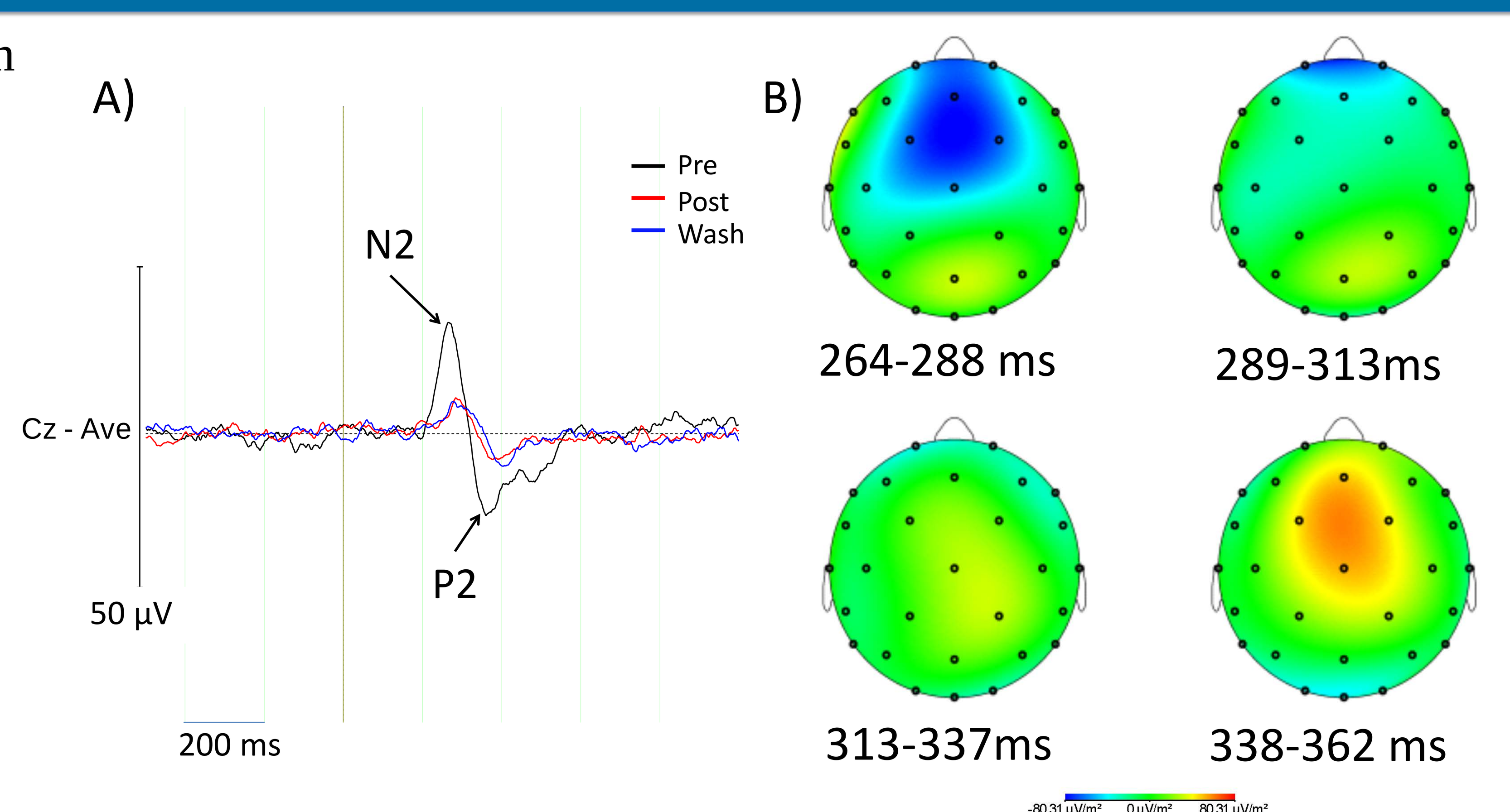


Figure 1: A) Example CHEPs data recorded before a bout of stimulation, after 10 min of tSCS and after a 10 min washout period. B) Cortical mapping for the pre-stim protocol. The mapping starts at the first peak (N2) and continues until the second peak (P2). Each map represents a 24ms time window.

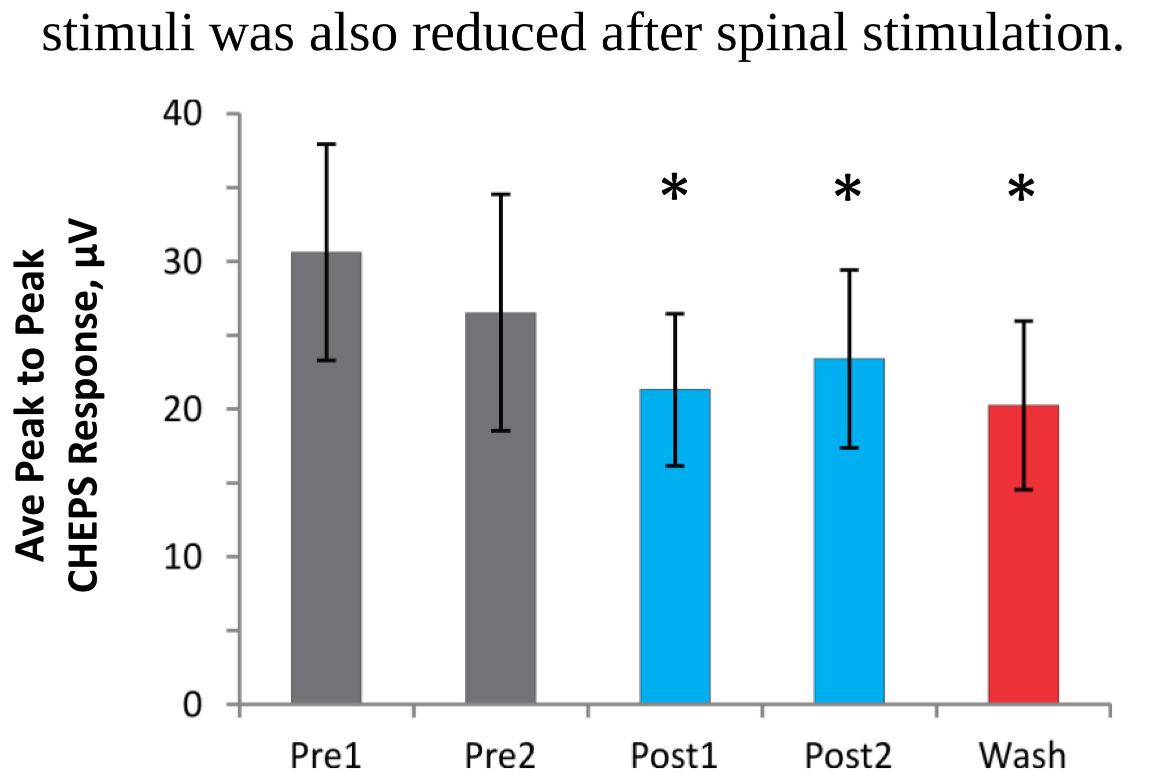


Figure 2: Average CHEPs peak to peak (N2-P2) responses during each condition. Pre (gray), Post tSCS (Blue) and Washout (Red)

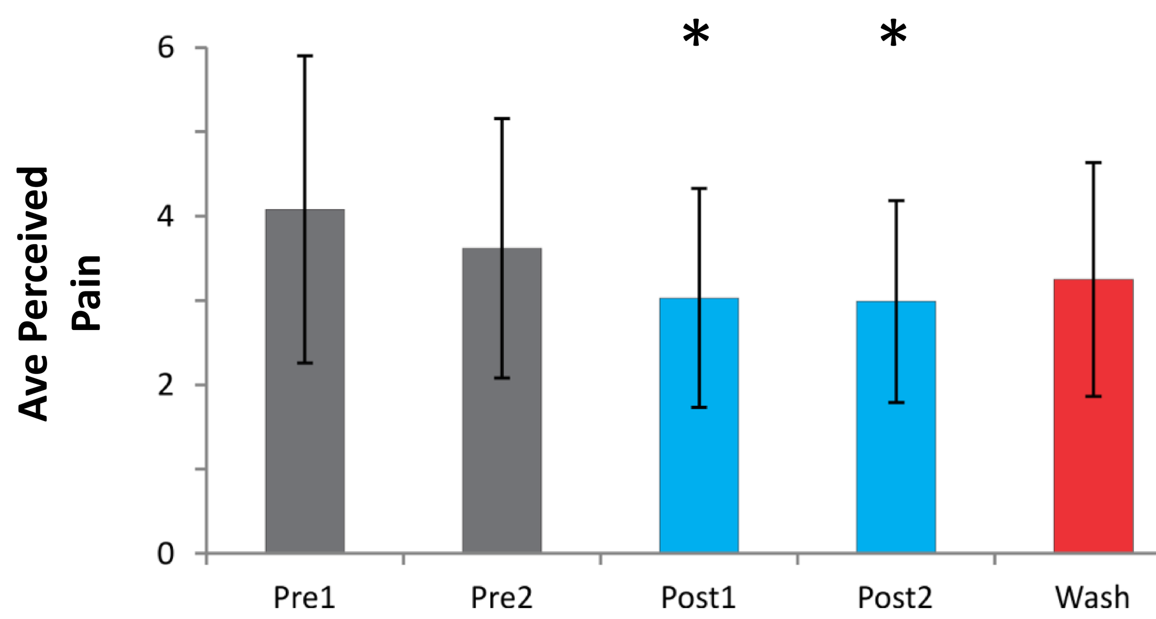


Figure 3: Average perceived heat pain responses during each condition. Pre (gray), Post tSCS (Blue) and Washout (Red)

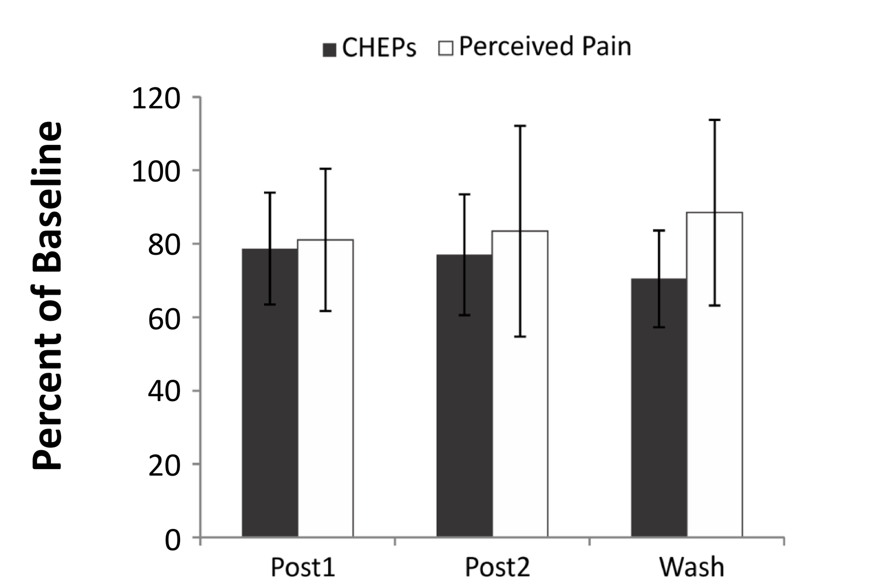


Figure 4: Average modulation as a percent of baseline. Note smaller number indicate more modulation

Discussion

- We hypothesize that these changes are due to up-regulation of inhibitory circuitry within the spinal cord given the continued depression of perceived pain and CHEPs after tSCS removal
- These preliminary results need to be confirmed in individuals with neuropathic pain
- In future studies, responsiveness to transcutaneous spinal cord stimulation may be used to predict who will respond to an epidural spinal cord stimulation or used for short term analgesia

Conclusions

- Transcutaneous spinal cord stimulation decreases the responsiveness to nociceptive input, as measured by the contact heat evoked potentials.
- Since it appears that depression of nociceptive input in response to tSCS continues after stimulus removal, it may be a viable option to acutely reduce neuropathic pain.

References

Xia B, Hong L, Bin-Lin C, Xin L, Xeu-quang W. Effects of Transcutaneous electrical nerve stimulation on pain in patients with spinal cord injury: a randomized controlled trial, Journal of physical therapy science, 27:23-25, 2015

Boldt I, et al. Non-pharmacological interventions for chronic pain in people with spinal cord injury. Cochrane database of systematic review 2014. issue 11.

Haefeli J, Kramer J, Blum J, Curt A. Heterotopic and homotopic nociceptive conditioning stimulation: Distinct effects of pain modulation. European Journal of Pain, September 2014. 18(8).

Wolter T. Spinal cord stimulation for neuropathic pain: current perspectives. Journal of Pain Research, Nov 2014. 7:651-663.