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Fall 10-16-2015

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Recommended Citation

Chan, Katherine SPT; Milhem, Rachel SPT; and Hampton, Casey SPT, "Neuromuscular electrical stimulation (NMES) on the tibialis anterior muscle and the effects on strength and gait mechanics on stroke patients: A systematic review." (2015). *Physical Therapy Research Symposium*. 5.
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Neuromuscular electrical stimulation (NMES) on the tibialis anterior muscle and the effects on strength and gait mechanics on stroke patients: A systematic review

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Introduction

BACKGROUND

- After a stroke, many people are left with various functional deficiencies, including impairments to one's gait pattern. These impairments can lead to a higher risk for injuries and falls, increased energy expenditure, and decreased walking velocity—all affecting functionality, independency, and quality of life.
- Currently, many different rehabilitation treatment methods exist to treat gait impairments, including ankle foot orthoses (AFO), conventional rehabilitation programs (CRP), and the use of NMES on the Tibialis Anterior muscle.
- Many review articles have concluded that NMES can improve gait, functional ability, and motor function in patients with chronic stroke; however, the results do not consistently compare NMES to the use of CRP or AFOs.

PURPOSE

- To establish the effects of neuromuscular electrical stimulation (NMES) on the tibialis anterior (TA) muscle on chronic stroke patients in order to improve gait mechanics.

Methods

SEARCH STRATEGY

- Databases: PubMed, PEDro, Cinahl, and Cochrane.
- Timeframe of search: October 2013- April 2015.
- Key Words: Stroke, electrical stimulation, tibialis anterior, strength, drop foot, MMT or EMG or active range of motion.

INCLUSION CRITERIA

- Outcome measured strength of tibialis anterior
  - Strength can be defined by MMTs
- EMG study, or active range of motion
- Subjects are greater than 6 months post-stroke
- Published in 2005 or later
- Published in English
- Parameters of electrical stimulation must be defined
- Patients must present with stroke that impairs motor function
- Peer-reviewed experimental and quasi-experimental

EXCLUSION CRITERIA

- Experimental interventions other than electrical stimulation for experimental group and standard of care.
- Systematic reviews or case studies.

REVIEW PROCESS

- Articles scored by 2 raters independently using PEDro score.
  - Articles scoring ≥ 6/10 accepted for review.
  - Total of 7 articles met all inclusion criteria.
- Standardized form used for data extraction.

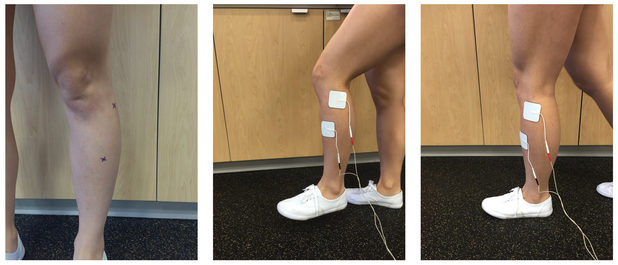

Figure 1: Marker placement of surface electrodes on the Common Peroneal Nerve for innervation of the Tibialis Anterior.

Results

Study	Participants N=, time from stroke	Intervention Parameters	Outcome Measures	Results
Bethoux et al. 2014 PEDro = 6	$N_{Experimental}$=242, 6.90 ±6.43yrs $N_{Control}$=253, 6.86±6.64yrs	Placement: Surface electrodes over peroneal nerve, controlled by tilt sensor and accelerometer. Intervention duration: - 2 week adaptation period - 5 mos, 2 wk full time wear	Primary: - Gait Velocity (6MWT) - SIS Composite Secondary: - FAP Score - Total mEFAP - mEFAP subtasks of floor time - Obstacle Course	Intervention and control groups both improved with primary and secondary outcomes, no statistically significant difference between groups
Pilkar et al. 2013 PEDro = 6	N=4, 57.2±19mo	Placement: Surface electrodes over peroneal nerve with custom molded cuff, controlled by tilt sensor and accelerometer. Intervention duration: - During community ambulation for 4 wks	- TA activation during walking - BDSI - TA activation in initial double stance - Single support - Terminal double stance - Swing	BDSI scores significantly increased. No significant difference between pre- and post- tests for all other outcome measures
Sabut et al. 2010 PEDro = 6	$N_{Experimental}$=16, 20mos $N_{Control}$=14, 15mos	Placement: Anode placed on TA motor point and cathode over peroneal nerve Intervention Duration: - 30 min/day, 5x/wk, for 12 weeks total	- Walking speed - Cadence - Step Length - Stride Length - Physiological Cost Index - RMSmax	Intervention group improved TA voluntary max contraction, but no more effective than CRP for gait parameters
Sabut et al. 2011 PEDro = 6	$N_{Experimental}$=27, 17.3 ±18.8mos $N_{Control}$=24, 18.2±11.8mos	Placement: Tibialis Anterior over common peroneal nerve Intervention Duration: - 20-30 min/day, 5x/wk, for 12 weeks total	- PF MAS - MMT of DF - DF AROM - Ankle PROM - Lower-extremity motor recovery (FMA)	Intervention group improved more with MAS, DF MMT, DF AROM, FMA, and ankle PROM.
Van Swigchem et al. 2012 PEDro = 6	N=24, 35.9±30.8mos	Placement: Common peroneal nerve at tibialis anterior muscle Intervention Duration: - 2 week adaptation period, up to 6 hrs/day -6 weeks full time	- Obstacle Avoidance - Motricity Index	FES greater obstacle avoidance than AFO
Kottnik et al. 2008 PEDro = 7	$N_{Experimental}$=14, 9.07 ±9.29yrs $N_{Control}$=14, 5.67 ±4.64yrs	Placement: Implanted under epineurium of the superficial peroneal nerve and under the epineurium of the deep peroneal nerve. Intervention Duration: - 26 wks	- RMSmax with knee in flexion - RMSmax with knee in extension - TA muscle activity during swing phase - Walking speed - Correlation between RMSmax of the TA muscle and walking speed	No therapeutic effect of implantable peroneal nerve stimulation
Kottnik et al. 2007 PEDro =7	$N_{Experimental}$ = 14, 9.07 ±9.29yrs $N_{Control}$ = 15, 5.67±4.64yrs	Placement: Implanted under epineurium of the superficial peroneal nerve and under the epineurium of the deep peroneal nerve. Intervention Duration: - 26 wks	- 6MWT - walking speed of 10m - Assessment of Activity Level using activePAL (accelerometer)	No significant difference at 12 weeks between between groups for all outcome measures No significant difference at 26 weeks between groups for walking speed or active PAL Significant difference at 26 weeks for 6MWT between groups, intervention > control

Discussion

STUDY QUALITY

- The average PEDro score suggested fair quality, with an average of 6.3.
- Blinding is not practical, as the NMES device are worn externally.
- Populations varied widely in baseline characteristics between studies.

SIGNIFICANCE OF RESULTS

- NMES is effective in improving parameters of TA function and gait.
- Results were calculated based on statistical significance, but improvements did not exceed MCID in all studies.
- Studies which found NMES more effective than CRP or AFO examined impairment outcome measures, whereas studies that found NMES non-inferior to AFO or CRP examined functional outcomes.

CLINICAL APPLICATION

- Some subjects respond well to NMES, depending on functional status and tolerance to electrodes and current.
- Dropout occurred in NMES groups as well as AFO groups.
- NMES is an active treatment like CRP, but AFO is a passive restraint.
- NMES may be viable treatment for patient with drop foot as a result of chronic stroke.

Conclusion

- NMES was supported by the research to be an effective treatment for drop foot following stroke.
- NMES was as effective as AFO or CRP.
- The parameters of prescription and application of NMES to treat drop foot vary in each study; future research could address standardizing parameters.

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