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The Impact of Electrical Stimulation and Exercise on Independent Static Standing Balance

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INTRODUCTION

Impairments in balance can lead to accidental falls which places individuals at risk for injury and decreases quality of life. Each year in the United States one-third of older adults experience a fall.[1] Balance is typically treated with therapeutic exercise to address neuromuscular components. Incorporating electrical stimulation in conjunction with a balance-focused exercise program will address the somatosensory and sensorimotor aspects of balance.

Transcutaneous Electrical Nerve Stimulation (TENS) is the use of low level electrical current to transmit sensory and proprioceptive information through the skin. It is primarily used in rehabilitation settings as conventional TENS by applying the gate theory for pain modulation.[2] Previous studies have shown the effectiveness of TENS on balance by enhancing motor control.[3,4] TENS provides a consistent level of sensory stimulation and would be simple to incorporate into everyday life to improve balance.

Neuromuscular Electrical Stimulation (NMES) is a modality which uses a therapeutic dose of electrical stimulation to produce a visible muscle contraction as well as sensory input. Using NMES to decrease muscular fatigue and increase strength and endurance of the lower extremities may lead to improved control and increased independent standing balance, thus decreasing fall risk.

There appears to be a link between electrotherapeutic modalities and the improvement of independent static standing balance. However, limited studies have examined the effects of TENS or NMES and compared them to the effects of exercise.

Figure 2. Electrode placement for NMES and TENS group.

PURPOSE

To examine the effects of electrical stimulation on independent standing balance during single leg stance (SLS) using either NMES with exercise, TENS with exercise or exercise alone.

SUBJECTS

Fourteen participants between the ages 18 and 44 (4 males and 10 females) were recruited through a convenience sample on the University of Puget Sound's campus.

Parameters		
	TENS	**NMES**
Waveform	Biphasic, modulated	Biphasic
Frequency	120 pps	35 pps
Pulse Duration	80µs	100µs
Intensity	Sensory response without muscle contraction (self determined)	Comfortable muscle contraction
Channels	2 (PF and DF)	2 channel, reciprocal setting (PF and DF) On/off time: 7sec on/21sec off
Treatment time	1 hour	1 hour

Table 1. Parameters of NMES and TENS units. Plantarflexion (PF), Dorsiflexion (DF) TENS: Rehabilicare, Maxima 2 NMES: Rehabilicare, EMS+2

EXCLUSION CRITERIA

Subjects were excluded if they had a pacemaker; current fractures to lower extremity bones; back, hip, knee or ankle injuries (or other factors that prevent full weight-bearing on either limb); history of significant cardiovascular, pulmonary, metabolic, musculoskeletal, or neurological disease; history of falls; use of specific medications known to impair balance or strength; use of an assistive device to maintain balance; pregnant females or those who planned to become pregnant within the course of the study.

METHODS

This study was a randomized control trial. Subjects participated in this study five times per week for a total of six weeks. Participants were randomly assigned into each group: NMES with home exercise program (HEP), TENS with HEP and HEP-only. The experimental groups performed 60 minutes of electrical stimulation and all groups received the same HEP. Exercises can be found in Figure 1. Timed SLS balance assessments were performed on the dominant limb of each participant prior to intervention and at six weeks. Parameters of each electrical stimulation unit can be found in Table 1 and electrode placement can be found in Figure 2.

	Single Leg Stance Time			
	Pretest (Seconds)		**Posttest (Seconds)**	
	Eyes Open	**Eyes Closed**	**Eyes Open**	**Eyes Closed**
Group 1	59.33 (±1.16)	10.24 (±6.86)	57.97 (±3.52)	11.39 (±9.35)
Group 2	47.50 (±25.00)	16.87 (±11.68)	54.50 (±11.01)	18.00 (±28.03)
Group 3	52.08 (±17.70)	13.22 (±9.43)	47.77 (±17.62)	12.53 (±12.08)

Group 1 = NMES + exercise; Group 2 = TENS + exercise; Group 3 = exercise only

Table 2. Average single leg stance time in seconds at pretest and posttest (6 weeks) with eyes open and eyes closed including standard deviations..

ANALYSIS

SPSS version 23 was used to perform a three (group) x two (time) x two (condition) ANOVA with repeated measures on time and condition. A bonforoni correction was used for post hoc analysis and alpha was set at 0.05.

RESULTS

Means and standard deviations of SLS time can be found in Table 2. Change in SLS over time showed no significant difference ($p=0.67$; power=0.10). There was no significant difference between groups ($p=0.96$; power=0.05). There was a significant difference in SLS time between eyes open versus eyes closed ($p<0.001$; power=1.00).

Figure 1. HEP: 1) Single leg heel raise, 10 on each lower extremity. 2) Single leg stance, 60 sec. 3) Toe walk, 2 x 10 feet. 4) Heel walk, 2 x 10 feet

CONCLUSIONS

For the parameters used in this study electrical stimulation in conjunction with a 6 week balance-focused exercise protocol may not have an effect on independent static standing balance. There was no significant difference between the use of NMES, TENS or exercise alone. It does however confirm that visual input is a significant contributor to independent static standing balance.

LIMITATIONS

NMES units have the capacity to recruit motor nerve fibers, however this study's pulse duration set on each NMES unit was not long enough to truly stimulate a muscle strengthening response.

Accommodation effects were not accounted for and consistent intensity was not received.

Voluntary muscle activation was not required of subjects. Participants were asked to wear the electrodes and have the NMES units on while they were carrying about normal activities of daily living,.

Additional limitations include, a small sample size of 14 attributing to a low statistical power, short duration of intervention, and researchers not present during the intervention to verify daily participation.

RELEVANCE

This study suggests that applying electrical stimulation with Table 1 protocols may not have an effect on independent static standing balance. Further research should be done that incorporates other protocols and parameters to further investigate the effects of applying a therapeutic modality on independent standing balance.

References

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IRB Approval
This study was granted approval for participation by human volunteers from the Institutional Review Board of the University of Puget Sound on August 18, 2014; Protocol #1314-089.