Neuromuscular Electrical Stimulation and Balance in Trans-Tibial Amputees

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INTRODUCTION

The effects of undergoing a lower-limb amputation are life altering. After surgery, the patient face a lengthy rehabilitation process. This process includes limb volume management, wound closure and healing, physical therapy, prosthetic fittings and subsequent gait training. In the immediate weeks and for several months, the health care team will have to work in coordination with the patient to ensure that he or she can return to his or her highest possible level of functioning.

A key component of ensuring optimal functioning following lower limb amputation is restoring efficient and functional gait. Complications to reestablishing effective gait include severity of amputation, comorbidities, quality of the surgery, familial support, patient motivation, and many more. In addition, the act of walking itself is much more difficult for the amputee because of the reduced musculature available, leading to increased energy demand (Douglas G Smith, 2004), and because walking is made exceptionally more difficult as the amputee must devote a great deal more energy to stay balanced(Gailey et al., 1994; Huang et al., 1979; Mengelkoch, Kahle, & Highsmith, 2014; Phil Stevens, 2010). Therefore, it is necessary to incorporate an effective balance training program into the rehabilitation plan for the lower limb amputee so that they can have a more symmetrical and efficient gait (J. Perry, 2004).

In addition to physical and occupational therapy, Neuromuscular Electrical Stimulation (NMES) has been shown to be effective in improving strength (Son, Lee, & Kim, 2014) and reducing pain in amputees(Finsen et al., 1988; Mulvey et al., 2013; Rauck et al., 2012). The use of NMES has also been found to be effective in improving balance-related gait parameters in other populations, such as individuals with chronic stroke and children with cerebral palsy(Daichman, Johnston, Evans, & Tecklin, 2003; Lee, Lin, & Soon, 2007; Park, Seo, Choi, & Lee, 2014; Yavuzer et al., 2006). Applied electrical stimulation as also shown to be particularly effective when combined with exercise on lessening spasticity and improving balance in chronic stroke patients(Park et al., 2014). One study also specifically demonstrated the use of NMES to improve certain gait parameters related to balance by measuring cadence, swing/stance ratio, period of single limb support, and double limb support(Lee et al., 2007). From these studies, it has been demonstrated that the use of NMES has been effective in helping to regain strength and balance in certain patient populations. ***Based on the outcomes demonstrated in previous studies, it is hypothesized that the application of NMES to the muscles of the amputated lower leg will improve balance, as measured by certain gait parameters, in trans-tibial amputees***

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METHOD

This study is a two group randomized controlled trial. 10 participants will be selected to participate. Inclusion criteria for participation in the study is as follows: unilateral transtibial amputee over the age of 18, with at least a 4 inch residual limb and a score of at least 70% (be able to sense 7 out of 10 tests) or higher on a monofilament test. Participants will be excluded from selection if they are self-reported severely diabetic, exhibit Loss of Protective Sensation (LOPS), use a pacemaker, have a cardiac condition (hypertension, congestive heart issues), a BMI over 42 kg/m, and/or have experience with either Trancutaneous Electrical Stimulation (TENS) or NMES in the past 6 months.

Participants will be separated into two age and gender matched groups of 5, one control group and one NMES intervention group. The participants will initially be brought in for a baseline test, which involves having the participant walk on the GaitRite (CIR Systems,Franklin, NJ, USA) . The participants will perform a 10-meter walk test at a self-selected speed. They will complete the walk test 3 times per testing session and the data averaged for all 3 tests. The GaitRite is a portable gait analysis system that has been used as the standard by which other gait analysis systems have been tested, and has also been shown to have both concurrent validity and test-re-test reliability(Baldewijns, Verheyden, Vanrumste, & Croonenborghs, 2014; Bilney, Morris, & Webster, 2003; Egerton, Thingstad, & Helbostad, 2014; Greene et al., 2012). The system consists of a walking mat with force sensors embedded that can capture 41 different temporal and spatial parameters (Figure 1). The accompanying software records and stores this information, which can be combined and exported to another system for analysis. All subsequent walk testing will also be performed on the GaitRite system. Following the baseline test, participants will be instructed to return at 4, 8, and 12 weeks for more walking data collection on the GaitRite.

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At the baseline testing session, the NMES intervention group will be instructed on the use of the Empi Continuum (DJO Global, Vista, CA, USA), an at-home electrical stimulation unit that has 4 settings: Neuromuscular Electrical Stimulation, Transcutaneous Electrical Stimulation, Edema, and Configuration (Figures 2 & 3). The participants will be instructed on the placement of the pads to the quadriceps, tibialis anterior, and gastrocnemius. Additionally, participants will be tested until each of the 5 individuals found the level of stimulation required to generate a forceful quadriceps contraction resulting in full knee extension. This will be done by placing the pads on the quadriceps, tibialis anterior, and gastrocnemius, and the lowest level of stimulus applied. The stimulus will be gradually increased until a level is reached where the participate gets a full extension of the knee without severe pain or discomfort. The level will be noted for the participant to use at home. Intervention participants will be instructed to use the NMES device once a day, for 15 full contractions.

At 4, 8, and 12 weeks, data will be collected from each of the ten patients as they walk on the GaitRite, and the two parameters analyzed for this study are Swing Time and % Swing time of the Sound limb, as well as Heel-to-Heel Base of Support.

Gait analysis studies have shown that individuals with amputation or weakness on one limb will spend less time on that limb during gait in order to stay stable. Therefore, corollary to the hypothesis, it is supposed that the Swing Time and % Swing time of the contralateral (sound) limb should decrease with the use of NMES on the prosthetic side. Additionally, gait analysis studies have shown that individuals with weakness, paralysis, paresis or amputation tend to stabilize themselves during gait by walking with their feet further apart, thereby employing a wider base of support when compared to able-bodied individuals, because a wider base of support reduces the risk of falling(Bolger, Ting, & Sawers, 2014; Hak, van Dieen, van der Wurff, & Houdijk, 2014; Hak et al., 2013; Hordacre, Barr, Patritti, & Crotty, 2015; Tokuno, Sanderson, Inglis, & Chua).

At the conclusion of data collection at 12 weeks, a Pearson's Correlation test and Repeated Measures ANOVA will be used to analyze the outcomes and examine any differences between the intervention and control group.

RESULTS

Data is still being gathered

	BASELINE	WEEK 4	WEEK 8
NMES H-H	13.8	n/a	n/a
Control H-H	11.82	17.11	17.29
NMES % Sw	38.58	n/a	n/a
Con % Sw	35.53	42.22	40.19

Table 1. Figures and Tables should be designed to fit within the column width if possible.

DISCUSSION

Data still being gathered

CONCLUSION

State your conclusion and give a concise explanation.

CLINICAL APPLICATIONS

In an effort to maintain clinical relevance, every abstract will need to include a brief indication of its clinical applications.

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