The Effects of Combined Neuromuscular Electrical Stimulation on Muscle Fiber Type and Cross Sectional Area in People with Spinal Cord Injury

Kyle Hsu[1], Grace Goodall[2], Payton DeBrow[3], Jared Mims[4], Matheus De Souza[4], Jia Li[5], Mualla Eraslan[5], Ceren Yarar-Fisher[5]

[1]The Altamont School, [2] UAB SIBS, [3] UAB CORD Summer Science Institute III, [4] UAB Department of Physical Sciences, [5]UAB Department of Physical Medicine and Rehabilitation

INTRODUCTION

- As soon as 6 weeks after spinal cord injury (SCI) affected skeletal muscles become 25-45% smaller compared to able-bodied controls.
- Slow oxidative type I muscle fibers convert into fast glycolytic type IIa or IIx muscle fibers within 6 months after SCI.
- The transformation of muscles from a slow oxidative to a fast glycolytic phenotype following SCI yields a muscle tissue that is insulin resistant.
- There is a significant need for innovative and practical strategies that can preserve the integrity of the skeletal muscle early after injury to improve health outcomes.

PURPOSE

To test the effects of combined neuromuscular electrical stimulation (Comb-NMES) on muscle fiber type and cross-sectional area (CSA) in individuals with subacute traumatic SCI.

METHODS

Participants:
- were between 18 and 60 years
- diagnosed with traumatic SCI at the cervical or thoracic level
- chosen within 14 days of the SCI and medically stable
- had no history of metabolic syndrome and diabetes
- were randomly assigned to the control and Comb-NMES intervention groups.

Intervention group
- NMES-resistance exercise involves:
  - Four sets of 10 actions evoked using 50 Hz trains of 450 us biphasic pulses through surface NMES
  - Contractions initiated by increasing the current from zero to the target level (50-200 mA) in 3 to 5 seconds, resulting in a tetanic muscle contraction that evokes full knee extension.
  - Both legs rained in an alternating order
  - Weights progressively increased by 2 lb. on a weekly basis after achieving 40 repetitions of full knee extension in a session
- NMES aerobic exercise involves:
  - Twitch electrical stimulations applied to the quadriceps through surface NMES at 175 mA (pulse duration/interval=200/50 us)
  - Training sessions where the intensity and duration of electrical stimulation progressively increases from 2Hz/10 min up to 10 Hz/60 m

Control group receives standard care plus passive dynamic exercise of the lower legs (sham treatment for NMES-RE) and transcutaneous electrical nerve stimulation (TENS, sham treatment for NMES-aerobic exercise)
- Passive dynamic lower leg exercise involves:
  - Passive movement of participant's lower leg to a full knee extension and flexion for a similar duration used for NMES-RE (3-5 seconds to attain knee extension and flexion).
- TENS intervention involves:
  - Using 1/3-1/4 of the current needed to aerobically train the muscle.

Myofiber type distribution and type-specific myofiber CSA were assessed by myosin heavy chain isoform immunohistochemistry, performed by the same technician, and all image analyses were blinded.

RESULTS

- Six patients completed the study (3 Comb-NMES and 3 control).
- The Comb-NMES group increased Type I and IIa fiber distribution (Figure 2).
- The Comb-NMES group increased Type I CSA by 1%, where the control group saw a 11% decrease in Type I CSA (Figure 3).
- Type IIa and IIx CSA decreased from 5-20% in both the control and Comb-NMES groups, respectively.

Figure 2. Myofiber type distribution

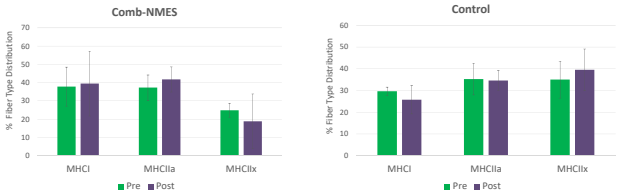


Figure 3. Type-specific myofiber cross-sectional area

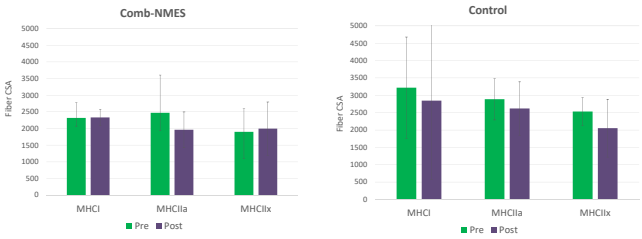
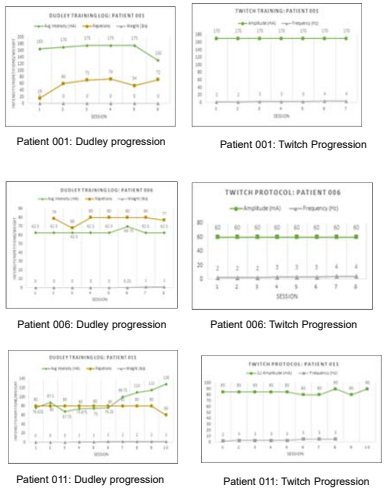


Figure 1. Comb-NMES training progression



CONCLUSION

The preliminary findings suggest that Comb-NMES may increase the size and distribution of Type II fibers and maintain the CSA of Type I fibers after SCI. The study is still ongoing so the results of this study may be further validated through an expanded sample size.

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