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# CENTRAL CONTRIBUTION TO "EXTRA TORQUE" DURING NEUROMUSCULAR ELECTRICAL STIMULATION

[1]Matheus Joner Wiest and [1]David F. Collins
[1]Faculty of Physical Education and Recreation, University of Alberta, Edmonton, Canada
email: matheus@ualberta.ca; http://www.ualberta.ca/~dcollins/index.html

## SUMMARY

NMES can generate contractions through central mechanisms[1] which may result in large torque increases (extra torque), besides some disagreements in the literature[2]. Here we tested two different protocols of different research groups aiming to clarify if extra torque generation dependent or not of central mechanisms. Our results showed no differences in extra torque between protocols. However, nerve stimulation seems to induce contractions using central pathways while muscle belly stimulation induces contractions using peripheral mechanisms.

## INTRODUCTION

Neuromuscular electrical stimulation (NMES) generates contractions through peripheral and central mechanisms. The central contribution can be augmented by 100Hz bursts of NMES which can generate "extra" torque. We have shown that extra torque was abolished during a nerve block, providing strong evidence for a central origin [1]. In contrast, Frigon et al. (2011) used a slightly different protocol and showed that the additional torque generated by bursts of 100Hz NMES was not abolished during a nerve block and larger extra torque when the plantarflexors were shortened, providing strong evidence that it was not of central origin.[2] The aim of this study is to compare the torque generated using Frigon's protocol[2] and our own[1].

## METHODS

Twelve subjects participated in this project. NMES (1 ms pulses) was applied to generate plantarflexion torque, measured using a Biodex dynamometer, with the hip at ~90°. Protocol 1 following procedures used by Frigon et al (2011)[2] and consisted of NMES applied over the gastrocnemius muscle (GG). Protocol 2 followed procedures we have used previously in our laboratory where NMES was applied over the gastrocnemius and soleus muscles (GS) and over the tibial nerve trunk behind the knee (Nerve). We also tested both stimulation electrodes over the soleus muscle (SS). For both protocols, we tested knee extended (170°-180°) and the ankle joint angle at 90° and 120°. For each protocol 3 trains of NMES (20–100–20 Hz for 3–2–3 s, respectively) were delivered 60 s apart. Stimulation intensity during the first 3 seconds of NMES was set to evoke 10-15% of the maximal evoked twitch torque generated by 5 pulses delivered at 100 Hz at between 50-100% of the maximal capacity of the stimulator output. Torque was averaged over two time intervals (*Time1*: 2–3 s into the train) and (*Time2*: 7–8 s into the train) and was normalized to two maximum voluntary isometric contractions performed in each position. Extra torque was quantified as the percent increase from Time1 to Time2. EMG was recorded from the soleus muscle (M-waves and H-reflexes) and analyzed in the same time intervals as the torque. EMG was normalized to the larger M-wave (Mmax) identified during a recruitment curve analysis. Repeated-measures analysis of variance (rmANOVA) was used to test each dependent variable (torque, H-reflex and M-wave) to determine the influence of NMES location, ankle position (90 and 120 degrees), and time (Time1 vs. Time2) on the evoked response ($\alpha = 0.05$).

## RESULTS AND DISCUSSION

Extra toque was not different between knee and ankle joint angles or stimulation sites (Figure 1).

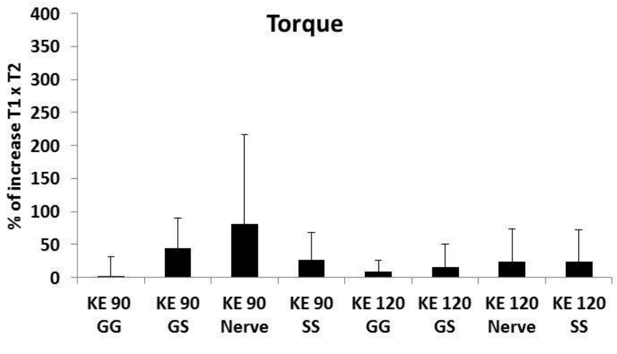


**Figure 1**: Extra torque represented as percent of increase from Time1 to Time2. Knee was tested in an extended position (KE) while the ankle was tested at 90 and 120 degrees. Stimulation was applied over the gastrocnemius muscle (GG), gastrocnemius and soleus (GS), over the tibial nerve (Nerve) or over the soleus muscle (SS).

M-waves did not differ when different muscle lengths were compared (Figure 2). However, we found an interaction between places of stimulation where larger M-waves occurred during muscle belly stimulation (GS) when compared to Nerve stimulation (Figure 2, top right corner graph).

H reflexes were similar for different muscle lengths (Figure 3). Nerve stimulation generated larger H-reflexes when compared to muscle belly stimulation (Figure 3, top right corner graph).

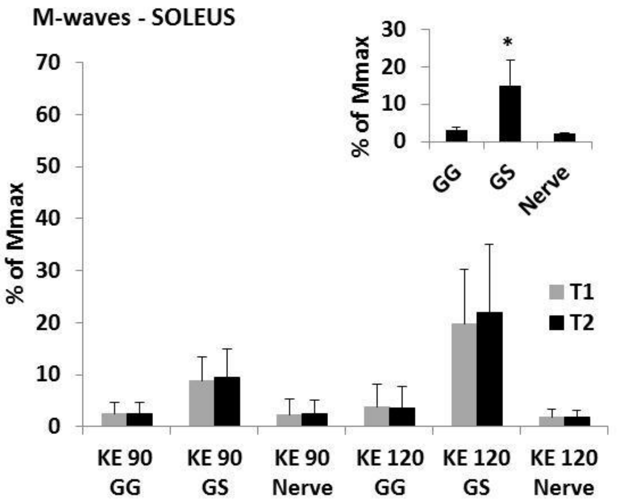


**Figure 2**: M-waves represented as percent of Mmax in Time1 (grey bars) to Time2 (black bars). Knee was tested in an extended position (KE) while the ankle was tested at 90 and 120 degrees. Stimulation was applied over the gastrocnemius muscle (GG), gastrocnemius and soleus (GS), over the tibial nerve (Nerve). Top right graph shows a significant effect of stimulation site (* $p < 0.05$).

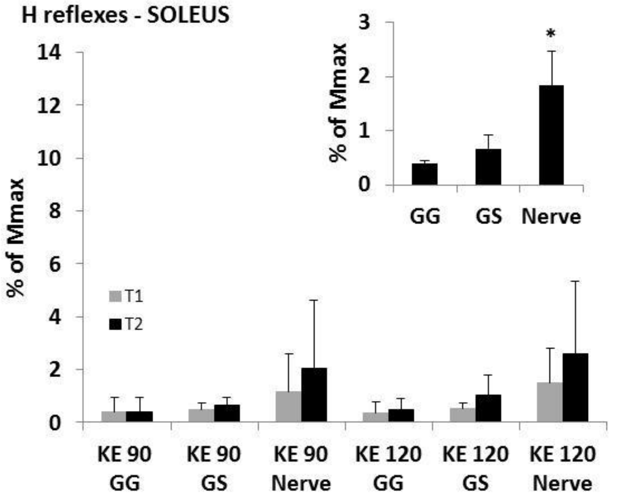


**Figure 3**: Extra torque represented as percent of increase from Time1 to Time2. Knee was tested in an extended position (KE) while the ankle was tested at 90 and 120 degrees. Stimulation was applied over the gastrocnemius muscle (GG), gastrocnemius and soleus (GS), over the tibial nerve (Nerve) or over the soleus muscle (SS). Top right graph shows a significant effect of stimulation site (* $p < 0.05$).

## CONCLUSIONS

Extra toque was not different between protocols. Nerve stimulation generated larger H-reflexes while muscle belly stimulation generated larger M-waves. The data suggest that the mechanism of extra torque generation depends on the place of stimulation in that nerve stimulation has larger central contribution (larger H-reflexes) while muscle belly stimulation involves peripheral mechanisms (larger M-waves).


## ACKNOWLEDGEMENTS

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## REFERENCES


1. Frigon A, et al., *J Neurosci*. **31**:5579-88, 2011.
2. Bergquist A, et al., *Eur J Appl Physiol*. **111**:2409-26, 2011.