Optimising Electrical Stimulation to Recruit Axons in a Human Nerve

Isaac O. Porozni, Lucas B. Bronder, Jessica A. Leverett, David F. Collins

Human Neurophysiology Laboratory, Faculty of Kinesiology, Sport, & Recreation, University of Alberta, Edmonton, Alberta, Canada

INTRODUCTION

Why Use Electrical Stimulation?

Pulses of electrical stimulation (ES) are used to stimulate human nerves for a wide-range of applications, from testing reflexes in a doctor's office, to generating contractions for people with a spinal cord injury. For the former, sensory axons are the preferred targets, for the latter it is motor axons. The duration of "monophasic" stimulus pulses can be adjusted to favor the activation of one of the other, however these pulses are being replaced by "kilohertz frequency alternating pulses" (KFAP) and whether the "phase duration" of KFAP influences how axons are recruited is still not known.

When ES is delivered over a peripheral nerve it activates both motor and sensory axons, producing M-waves ("motor" waves) and H-reflexes (Hoffman reflexes), respectively. Thus, in the present study changes in M-waves and H-reflexes between different KFAPs provide outcomes of axonal recruitment.

Purpose

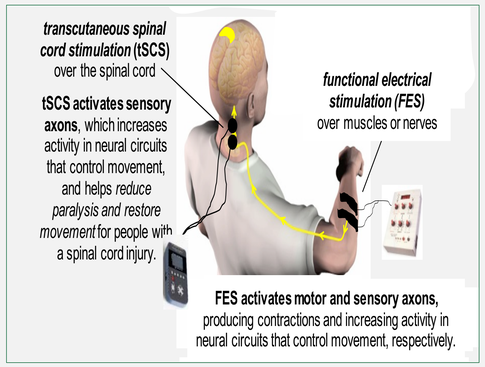
The purpose of this study is to examine the effects of two separate phase durations of KFAPs on recruiting motor axons in the human tibial nerve. A second focus will include the impact of KFAP on sensory fibre recruitment and if these reflex's can be strengthened when using a wide phase duration.

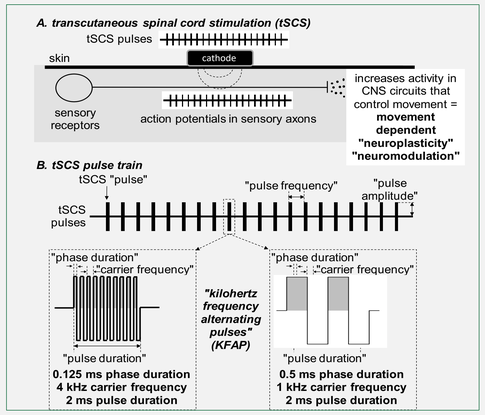
Hypotheses

Pulses with longer phase durations will more effectively recruit motor and axons.

Predictions:

1. Pulses with longer phase durations will produce M-waves (a measure of stimulating motor axons) at a lower threshold (less current).
2. Pulses with longer phase durations will produce M-wave (a measure of stimulating motor axons) recruitment curves that have a steeper slope.
3. Maximal responses will be different between pulses for both sensory and motor fibres.



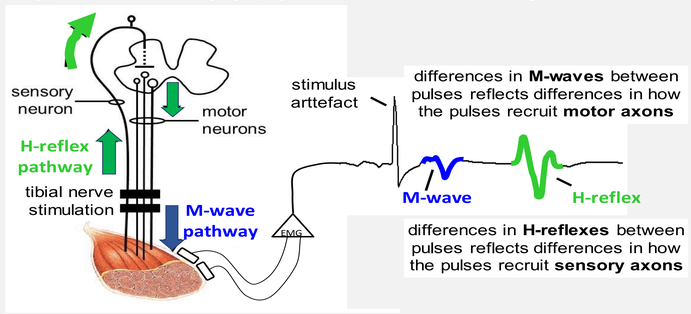


METHODS

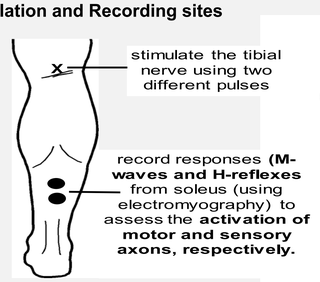
Figure 2. Reflex Pathway, Locations, KFAP

- 5 subjects were recruited for this study
- Pulses of ES were applied via surface electrodes over the tibial nerve at the back of the knee. Pulse duration remained constant at 2 ms, phase duration was manipulated between wide (1kHz 0.5 ms) and narrow (4kHz 0.125 ms) bursts.
- Intensities ranged from below threshold, to those which evoked maximal responses (10-180 mA).
- Muscle activity was recorded using electromyography from soleus, the muscle involved in plantarflexing the ankle, to plot M-wave/H-reflex recruitment curves.

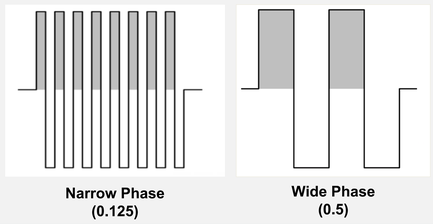
A. Hypothetical electromyography recorded from soleus during ES over the tibial nerve.



B. Stimulation and Recording sites



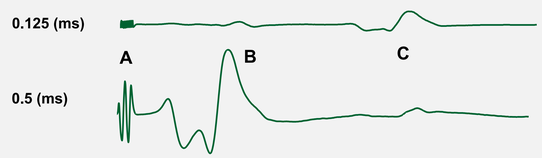
C. Kilohertz Frequency Alternating Pulses (4kHz) & (1kHz) @ 2ms pulse duration



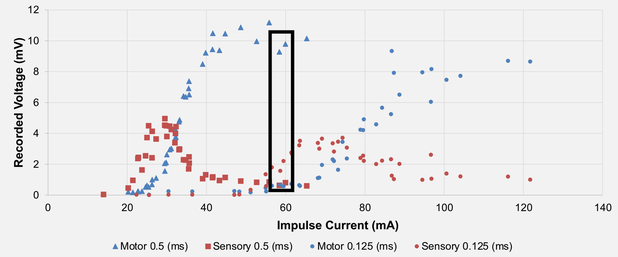
RESULTS

Figure 3. Single Subject

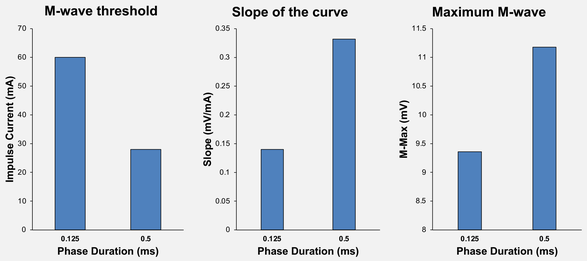
A. Waveform (1kHz vs 4kHz): Impulse (a) M-wave (b) H-reflex (c)



B. M-waves and H-reflexes: range of intensities different phase durations



C. M-waves (motor axons): threshold, slope and maximum



D. H-reflexes (sensory axons): threshold, slope and maximum

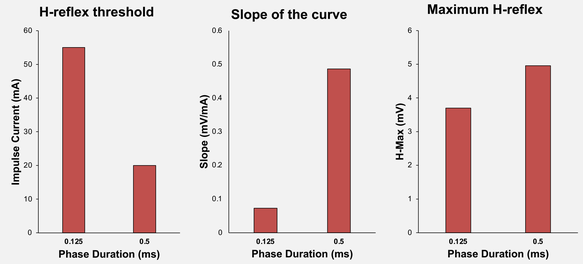
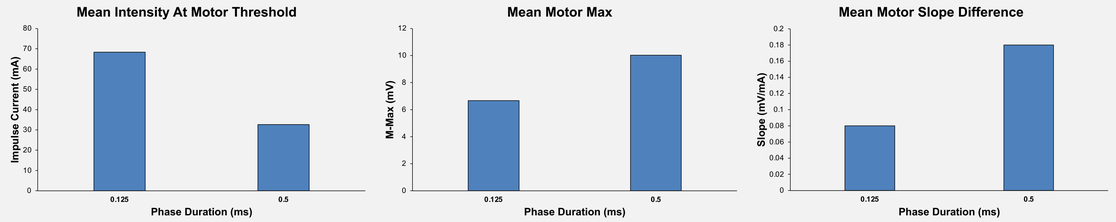
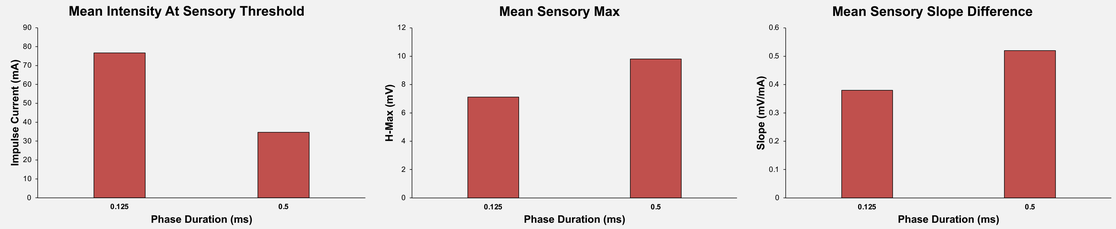


Figure 4. Group data (n=5): Threshold, Slope and Maximum

A. Mean M-waves (motor axons): threshold, slope and maximum (n=4)



B. Mean H-reflexes (sensory axons): threshold, slope and maximum (n=5)



CONCLUSION

- Similar to monophasic pulses, phase duration strongly influences the recruitment of motor & sensory axons when using KFAP.
- The phase duration of KFAP can be tailored to recruit motor axons with wider phases being favourable compared to narrow KFAPs. Wide phase durations (1kHz) recruit motor fibres at a lower input intensity while also achieving greater maximum values. .

REFERENCES

1. Barss, et al. (2018) *Archives of physical medicine..,99*(4),779-791
2. Lagerquist, et al. (008) *Muscle & nerve* 37, 483–489
3. Panizza, et al. (1989) *Muscle & nerve* 12, 576–579

Acknowledgments

Special Thanks to Alex Ley the coolest lab tech to ever grace the earth.