Stimulus phase duration, not and waveform, influence the variability of responses evoked by stimulation of axons in human peripheral nerve

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Introduction

Electrical stimulation can be used to evoke reflexes for a clinical exam, a research study or to produce contractions for rehabilitation. Electrical stimulation recruits both motor and sensory axons, producing M-waves and H-reflexes, respectively (Figure 1). To evoke H-reflexes, a 1 ms phase duration is recommended to preferentially recruit sensory axons and produce larger reflexes. Whether phase duration or waveform also influences response variability is not presently clear. High variability may make data collection and interpretation difficult and may increase the number of trials required to achieve sufficient statistical power.

Objective

Characterize the effect of stimulus phase duration and waveform on the variability of responses evoked by stimulation of motor (M-waves) and sensory (H-reflexes) axons in a human peripheral nerve.

Method

PARTICIPANT SET UP
• n = 20 participants; 8 female, 12 male; 28 ± 9 years
• no neuromuscular injury or disease
• seated in a Biodex System 3 Dynamometer (Figure 3)
• ankle and knee secured at 90°
• right tibial nerve stimulated in popliteal fossa (Neurodyn, Ibamed or Digitimer D57A)
• electromyography recorded from right soleus (Neurolog, Digitimer)

EXPERIMENTAL DESIGN
• two phase durations (0.5 ms, 0.1 ms) were tested using three waveforms (monophasic, biphasic, kHz) in random order
• 1 and 2 ms phases were also tested using monophasic pulses only
• the maximal M-wave (Mmax) was found with each stimulation type
• twenty stimuli were delivered for each stimulation type at an intensity that produced an M-wave that was ~5% of Mmax
• two phase durations and three waveforms: Group data
• M-waves were most variable when using kilohertz frequency waveforms.
• H-reflexes were least variable, and largest, when longer phase durations were used.

Response variability can be decreased, and reflex amplitude increased, using long phase durations, and mono phasic or biphasic waveforms.*

Reducing response variability may facilitate the collection and interpretation of clinical tests and experimental data.

Figure 1A. Electrical stimulation over a mixed peripheral nerve recruits both motor and sensory axons.

Figure 3. Participant position in the Biodex dynamometer and locations of the stimulating and recording electrodes.

Results

Monophasic pulses: four phase durations

Single subject

Two phase durations and three waveforms: Group data

Figure 6. Mean data for the group for monophasic pulses. Panels A and B show the amplitudes of M-waves and H-reflexes, respectively. Panels C and D show the variability, measured as the coefficient of variation (COV), for M-waves and H-reflexes, respectively. (error bars = 1 SD)

Figure 7. Mean data for the group when using 2 phase durations and three waveforms. Panels A and B show the amplitudes of M-waves and H-reflexes, respectively. Panels C and D show the variability, measured as the coefficient of variation (COV), for M-waves and H-reflexes, respectively. (error bars = 1 SD)

Conclusions

Alternating stimulus phase duration (H-reflexes), and waveform (M-waves), influenced the recruitment of axons in the human tibial nerve. M-waves were most variable when using kilohertz frequency waveforms. H-reflexes were least variable, and largest, when longer phase durations were used.

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