Recruitment of human motor units during low current electrical stimulation

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Introduction

- Continuous electrical stimulation of peripheral nerves can produce muscle contractions that develop over several seconds (Lang and Vallbo 1967, Collins et al. 2001) with a time course of motor unit recruitment that is too slow for a simple reflexive pathway (Lang and Vallbo, 1967).
- Persistent inward currents (PICs) in motor neurons can develop over several seconds and produce sustained firing in response to excitatory synaptic input.
- We propose that peripheral nerve stimulation activates sensory axons, providing excitation to spinal neurons and activating PICs.

Project hypotheses

- Motor units will fire asynchronously from the stimulation pulses, with firing sustained after stimulation ends.
- The electrically-evoked synaptic activation will recruit the same low threshold motor units as weak voluntary contractions.
- The time course of motor unit recruitment will be consistent with PIC activation.

Experimental Methods

- 9 subjects
- Surface tibial nerve stimulation
  - 1 ms pulses, 30 seconds at seven constant frequencies (10-100 Hz)
- Slow-rising voluntary contractions
- Measured variables:
  - Soleus EMG – surface electrodes
  - Soleus motor unit EMG – fine wire electrodes
  - Plantarflexion torque

Low current stimulation evokes asynchronous, sustained motor unit firing

- Single pulses do not activate motor units
- Recruitment latency will depend on stimulation frequency
- We activated the lowest threshold motor units, which may have a slower time course than other motor units
- Other factors including post-tetanic potentiation and changes in axonal properties could affect motor unit recruitment, contributing to the slow time course

The same motor units are recruited in stimulated and weak voluntary contractions

- Asynchronous, sustained motor unit firing would be expected if PICs are activated.
- Recruitment order is consistent with synaptic excitation.
- Recruitment time course is slower than expected.
- Higher stimulation frequencies recruit motor units with a shorter latency.

Summary

- Low current stimulation can produce asynchronous, sustained motor unit activity.
- Motor unit activity develops with a slow time course (~15 sec).
- Consistent with PICs?

A simple model fits the recruitment latency data

- Average time constant = 15.3 ± 10.4 seconds

References


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