#399.14

Motor Unit Recruitment During Tetanic Electrical Stimulation

Olle Lagerquist* and David F. Collins
Human Neurophysiology Laboratory, Faculty of Physical Education and Recreation, University of Alberta, Edmonton, Alberta, Canada

Introduction

Functional electrical stimulation (FES) is used to generate movement in persons unable to volitionally generate muscle contractions, as well as to combat disuse muscle atrophy.

Typical FES stimulation uses pulse widths of 100-400 µs and frequencies of 20 Hz. The resultant muscle contractions are believed to be due to the direct stimulation of large diameter motor axons, resulting in contractions that do not recruit the slow twitch muscle fibers and therefore fatigue rapidly.

Previous experiments have shown that high frequency, wide pulse width tetanic electrical stimulation can cause muscle forces "extra" to those due to the recruitment of motor axons alone (see Figure 1). These "extra" contractions are believed to be triggered by large Ia afferent synaptic input to α-motor neurons, triggering a central recruitment of motor neurons (1,2).

If this novel method of delivering FES can trigger central mechanisms residing in the human spinal cord, it may be possible to recruit the low threshold motor neurons. This method may make FES contractions more fatigue resistant and help to reduce muscle atrophy.

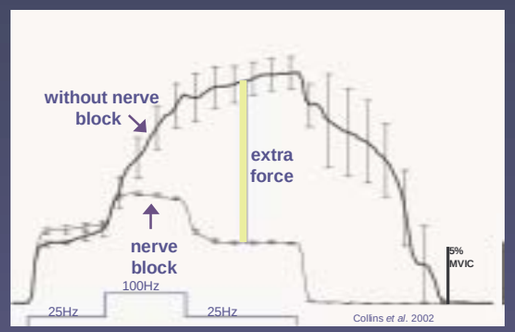

Figure 1. Plantar flexion force traces evoked by high frequency, wide pulse width electrical stimulation with and without a proximal nerve block in a single subject.

Purpose

To evaluate what type of motor units are recruited during wide pulse width tetanic stimulation of the soleus muscle in neurologically intact humans.

Hypothesis

Motor units recruited through central mechanisms during tetanic stimulation will be lower threshold and more fatigue resistant than those recruited through peripheral mechanisms.

Methods

- Obtained maximal isometric voluntary contractions (MVIC) during plantar flexion.
- Motor units were recorded using intramuscular fine wires.
- Performed voluntary ramp contractions up to ~25% MVIC.
- Stimulated the tibial nerve at motor threshold with 20/100/20 Hz bursts, 2s/2s/3s respectively, and a 1-ms pulse width throughout.

Preliminary Results

Thus far, all motor units recorded during high frequency tetanic stimulation of the soleus have occurred between 30-35 ms latencies (six motor units from five subjects), indicative of synaptic recruitment of α-motor neurons via the H-reflex pathway. Four of these same motor units have been identified during voluntary contractions, recruited below 10% of a maximal voluntary isometric contraction.

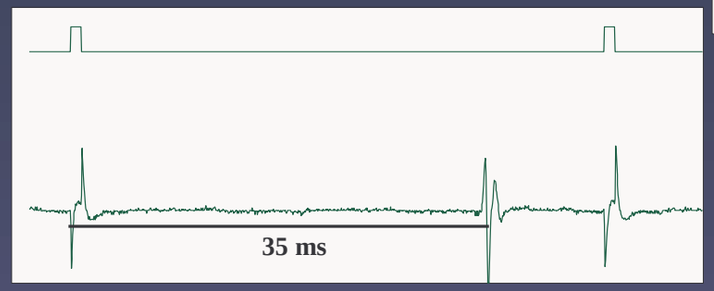

Figure 2. Single motor unit trace from soleus during 20 Hz stimulation.

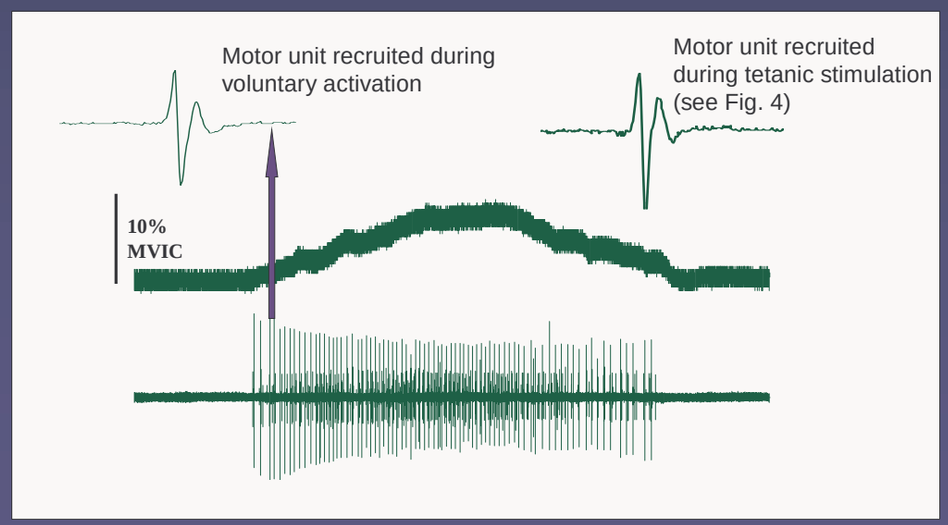

Figure 3. Single motor unit trace from soleus during a voluntary contraction.

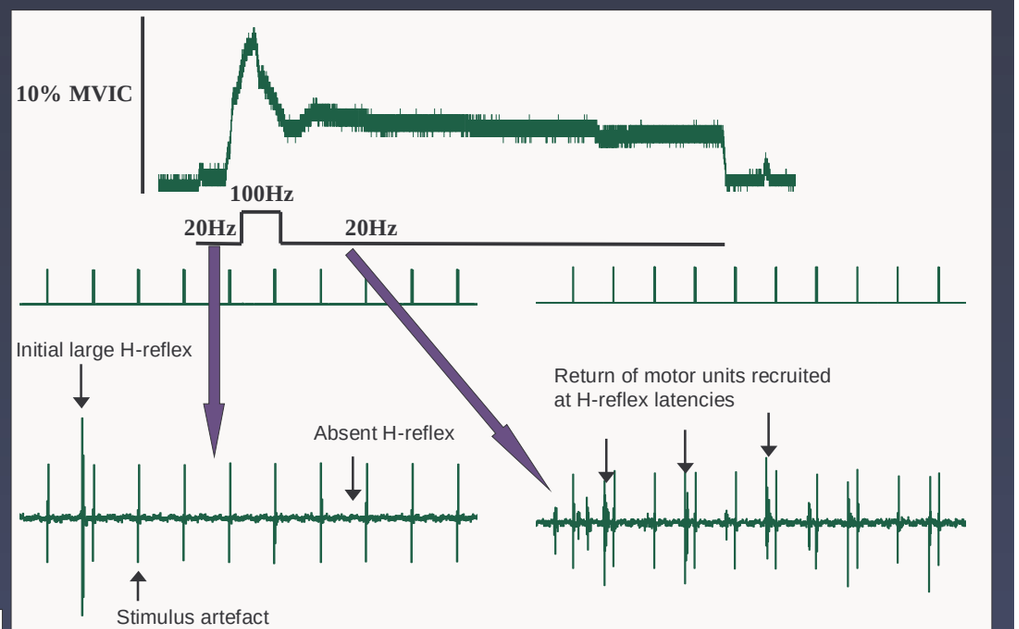

Figure 4. Soleus motor unit recordings during wide pulse width electrical stimulation of the tibial nerve.

Conclusion

Previous findings suggested that the H-reflex is abolished during high frequency stimulation (3). Our preliminary results suggest that human motor units *can* be centrally recruited during 20 Hz tetanic electrical nerve stimulation via the H-reflex pathway. These data suggest that recruited units are the low-threshold, fatigue-resistant fibers. Activating these muscle fibers should decrease the rapid onset of fatigue commonly seen with functional electrical stimulation and may provide a way to improve current FES protocols for the prevention of muscle wasting after a spinal cord injury.

References

1. Collins DF, Burke D, and Gandevia SC (2001). *J Neurosci* Jun1;21(11):p4059-65.
2. Collins DF, Burke D and Gandevia SC (2002). *J Physiol* Jan 1;538(Pt 1):p289-301.
3. Lang AH and Vallbo AB (1967). *Exp Neurol* Aug;18(4):383-91.

Acknowledgements

The authors would like to thank Alex Ley and Zoltan Kenwell for their outstanding technical support