ACTIVATION OF MUSCLE SPINDLE AFFERENTS INCREASES FORCE FLUCTUATIONS IN THE KNEE EXTENSOR MUSCLES

Eric T. Coellen, Lindsay S. Cuaresma, Karlie A. Intelkofer, and Brian L. Tracy (Faculty Sponsor)
Department of Health and Exercise Science, Colorado State University, Fort Collins, CO.

INTRODUCTION

- The neural mechanisms that underlie the fluctuations in muscle force during isometric contractions are not well characterized.
- Specifically, the contribution of afferent feedback from stretch receptors to the fluctuations is not well established.
- Muscle spindles can be excited with a vibratory stimulus of the tendon. Afferent projections from muscle spindles exert an excitatory effect on alpha motor neurons to the same muscle.
- Tendon vibration may therefore alter the output of a pool of motor neurons acutely and affect the fluctuations in force.
- The effect of chronic vibration on motor output variability is different depending on the muscle group (Yoshitake 2004, Shinohara 2004).
- **The purpose of this project was to examine the effect of acute tendon vibration on fluctuations in force during contractions of the knee extensor muscles in young healthy subjects**

METHODS

Subjects

- Young, healthy adults (N= 12; 26 ± 13 yrs).

Experimental apparatus

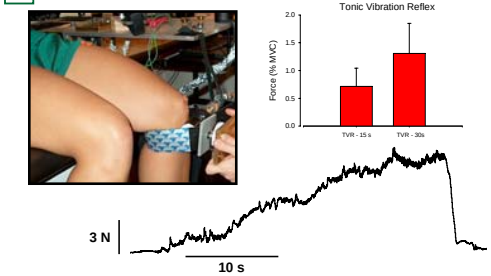
- Experimental chair with pelvis and thigh straps. Load cell oriented to measure force perpendicular to shank.
- Subject position: Sitting, knee angle ~ 90 deg.
- Tendon vibrator: High-speed engraving tool with off-center spinning weight provided an oscillatory force (110 Hz) and 1 mm displacement when applied to the tendon. A constant pressure of 10 N to the tendon was maintained (Figure 1).
- Motor unit action potentials were recorded in four subjects using bipolar fine-wire (50 µm) electrodes inserted into the rectus femoris muscle with a sterile hypodermic needle.

Measurements

- Maximal force during a maximal voluntary contraction (MVC).
- Force fluctuations during constant-force trials with (VIB) and without (NOVIB) vibration at target forces of 2.5, 30, and 65% MVC
- Low frequency changes in force (< 0.5 Hz) were removed (detrended) with a filtering function *post hoc*.
- Coefficient of variation (CV, (SD/mean force) x 100) of force during constant-force contractions.
- Force elicited during tonic vibration reflex (TVR) at 15 and 30 s.
- Individual motor unit action potentials were discriminated using a spike recognition algorithm. Discharge rate (Hz) and variability of discharge rate (CV) were determined.

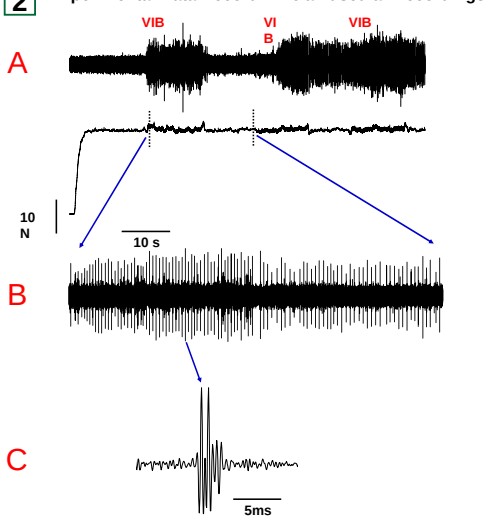
RESULTS

1 **Experimental Setup**



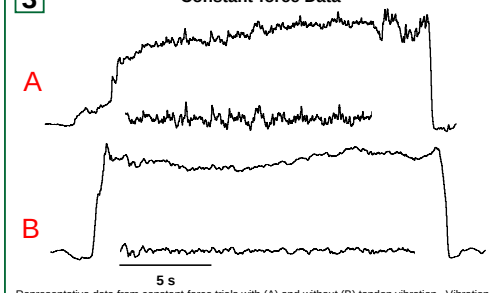
Vibration was applied to the patellar tendon with a constant force of 10 N. Tendon vibration during rest elicited a tonic vibration reflex (TVR) from the knee extensor muscles.

2 **Experimental Data Record – Intramuscular Recordings**



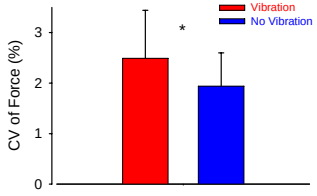
(A) Force-matching task with periods of vibration, (B) a train of action potentials from the same motor unit, and (C) a single motor unit action potential.

3 **Constant-force Data**



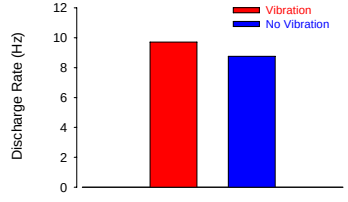
Representative data from constant-force trials with (A) and without (B) tendon vibration. Vibration artifact in the force signal was removed *post hoc* with a digital filter (low pass at 30 Hz). Detrended force is inset below original.

4 **Fluctuations in Force were Greater During Vibration**



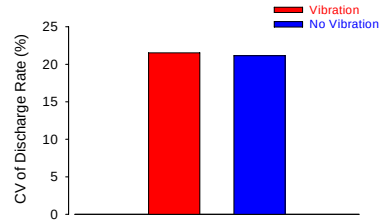
Coefficient of variation (CV) of detrended force (SD/mean force) during vibration and no vibration constant-force trials. * P = 0.016

5 **Motor Unit Discharge Rate Increased during Vibratory Stimulus**



Motor unit discharge rate during constant-force isometric contractions. Data is shown for 15 periods of vibration or no vibration from 2 young subjects.

6 **Vibration Did Not Alter the Variability of Motor Unit Discharge Rate**



Coefficient of variation (CV) of motor unit discharge rate during constant-force isometric contractions. Data is shown for 15 periods of vibration or no vibration from 2 young subjects.

CONCLUSIONS

- Vibration of the patellar tendon provided an acute excitatory stimulus to the motor unit pool for the knee extensors:
  - Vibration elicited a tonic vibration reflex.
  - Vibration increased the discharge rate of motor units.
- Tendon vibration alters the output of the motor neuron pool such that fluctuations in force are increased:
  - This effect occurs independent of visuomotor correction of the force.
  - Preliminary evidence suggests that the variability of motor unit discharge rate does not contribute to the increased fluctuations.
- A change in the gain of the stretch reflex loop can accentuate force fluctuations.

REFERENCES

1. Yoshitake et al. J Appl Physiol 97: 2090-2097, 2004.
2. Shinohara et al. Society for Neuroscience Proceedings 188.8, 2004.

ACKNOWLEDGEMENTS

Many thanks to Devin Dinenno, Bjørn Jørgensen, and Seth Welsh for their assistance with this project. Supported by Research Career Award NIH AG19171 (B. Tracy) and McNair Scholars program funds (E. Coellen).