Is the decrease in maximal voluntary contraction following tibialis anterior tendon vibration accompanied by a disruption in excitation contraction coupling?

L.M. Cornish, V.M. Feige, A.D. Guenter, C.L. Kliewer, E.A. Mellis

Supervisor: S.J. Garland, Ph.D.

Introduction

- Individuals utilizing equipment with vibratory elements demonstrate increased musculoskeletal and neurovascular impairments related to reduced strength and muscle fatigue (1).
- However, the reduced MVC may also be due to the disruption in E-C coupling (2).
- E-C coupling is ascertained in human subjects during functional activities (10 Hz) whereas maximal exercise (50 Hz) increases calcium in muscle beyond typical functional activation levels accounting for decreased E-C coupling (3).

Objective

- The purpose of this study was to investigate the extent to which E-C coupling plays a role in force attenuation following vibration.

Methods

- Subjects: 9 female and 1 male, age 33 (10.6)
- Individuals sat in a Biodex chair with 90° of hip and knee flexion.

Figure 1: Equipment set-up. The dominant foot and leg were immobilized while ankle dorsiflexion was measured.

- Stimulating electrodes were placed on the common peroneal nerve (CPN) just distal to the fibular head. For stimulation trials (7 singlet pulses, doublet, 10 Hz and 50 Hz), a dorsiflexion twitch was evoked via constant voltage stimulator.
- E-C coupling was determined by evaluating the ratio of 10 Hz to 50 Hz peak torque.
- For vibration trials, a vibrator was secured to the distal musculotendious junction of the tibialis anterior muscle.

Methods

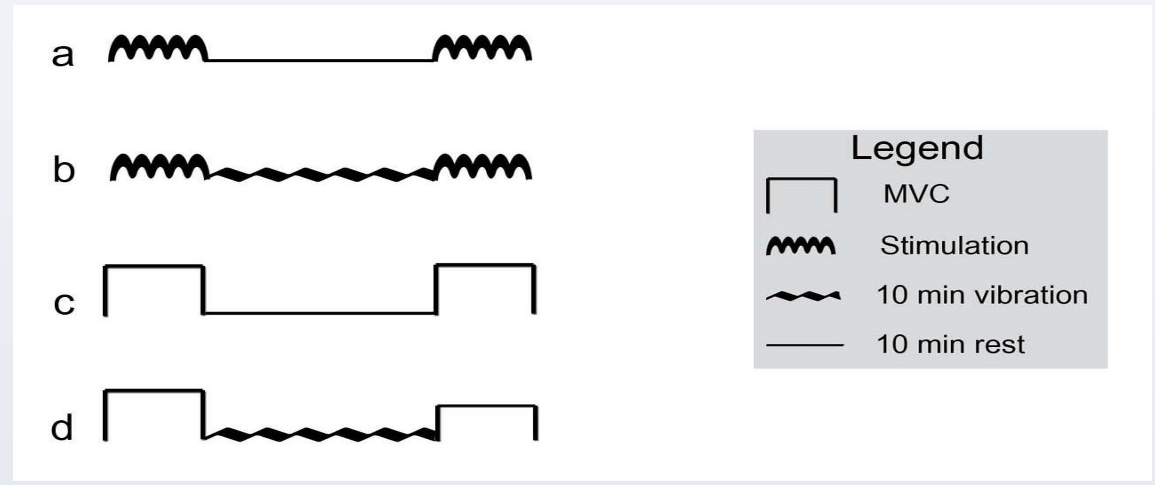

Figure 2: Subjects were exposed to a combination of 4 conditions that included 10 minutes of vibration or no vibration bracketed by MVC or electrical stimulation (ABCD, CDAB, ACBD, BDAC, ADBC).

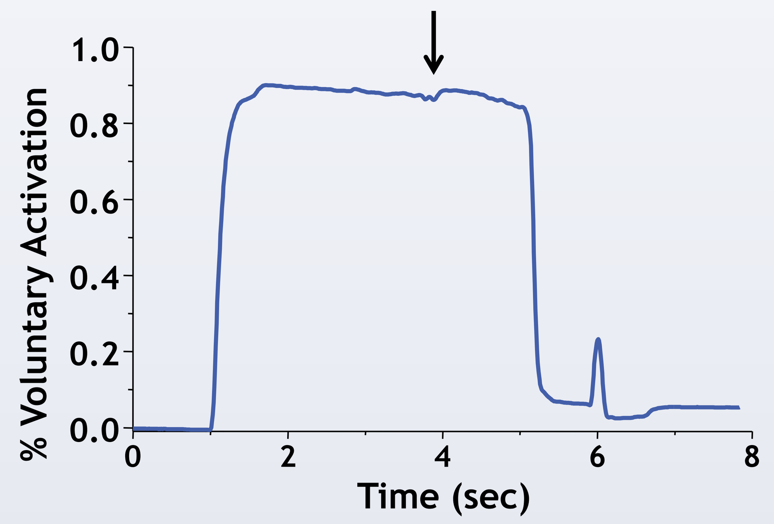

Figure 3: Torque trace during MVC. Black arrow denotes timing of interpolated twitch used to assess % voluntary activation. Interpolated twitch was elicited with doublet stimulation during and after MVC.

Results

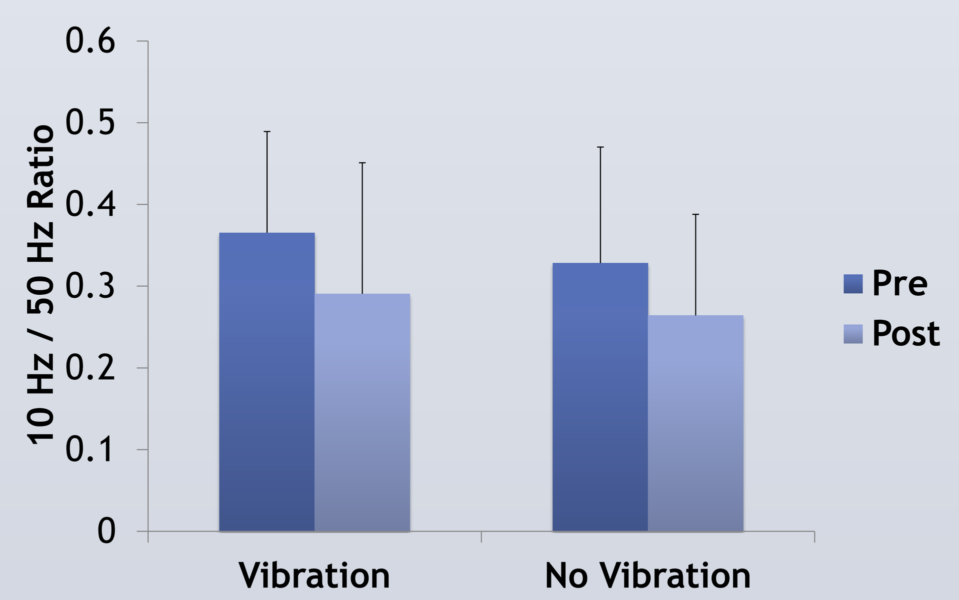

Figure 4: 10 Hz / 50 Hz ratio for peak torque. A significant decrease (p=0.007) following vibration and no vibration was observed; however, no significant difference was found across conditions.

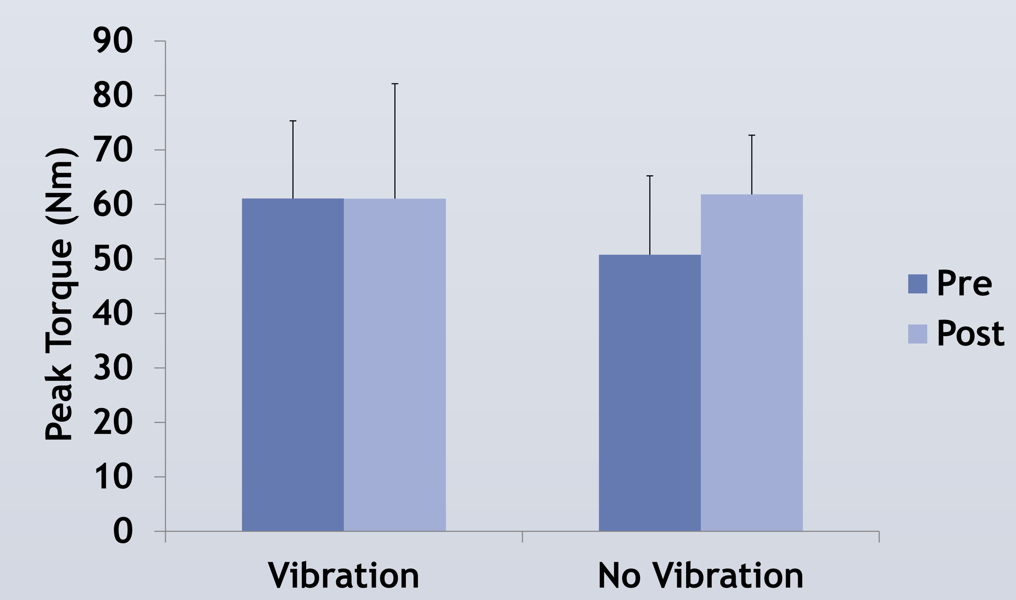

Figure 5: Peak torque during MVCs. No significant difference was found across the conditions.

	Vibration		No Vibration	
	Pre	Post	Pre	Post
Singlet				
Peak Torque (Nm)	2.4 ± 1.0	5.2 ± 10.8	2.3 ± 1.1	2.0 ± 0.9
Time to Peak Torque (ms)	110 ± 15.9	113 ± 13.4†	106 ± 10.5	109 ± 10.9†
Doublet				
Peak Torque (Nm)	8.9 ± 2.8	8.7 ± 3.3	8.4 ± 1.9	7.9 ± 1.8
Time to Peak Torque (ms)	113 ± 41.2	117 ± 43.6‡	123 ± 12.6	126 ± 10.8‡
10 Hz				
Peak Torque (Nm)	8.4 ± 3.8	6.7 ± 3.1*	7.4 ± 3.1	6.5 ± 2.9*
50 Hz				
Peak Torque (Nm)	27.2 ± 11.5	25.5 ± 9.3	24.0 ± 7.1	25.2 ± 5.7
Time to Peak Torque (ms)	205 ± 38.1	217 ± 16.4	210 ± 21.4	218 ± 11.8

Table 1: There was a significant drop in peak torque generated for pre to post comparisons for 10Hz stimulation. For the singlet stimulation, time to peak torque (mean ± SD) was significantly different between pre and post measurements in both conditions. For doublet stimulations, time to peak torque exhibited a trend towards difference in pre and post measurements.

*p<0.001, †p=0.007, ‡p=0.07

Results

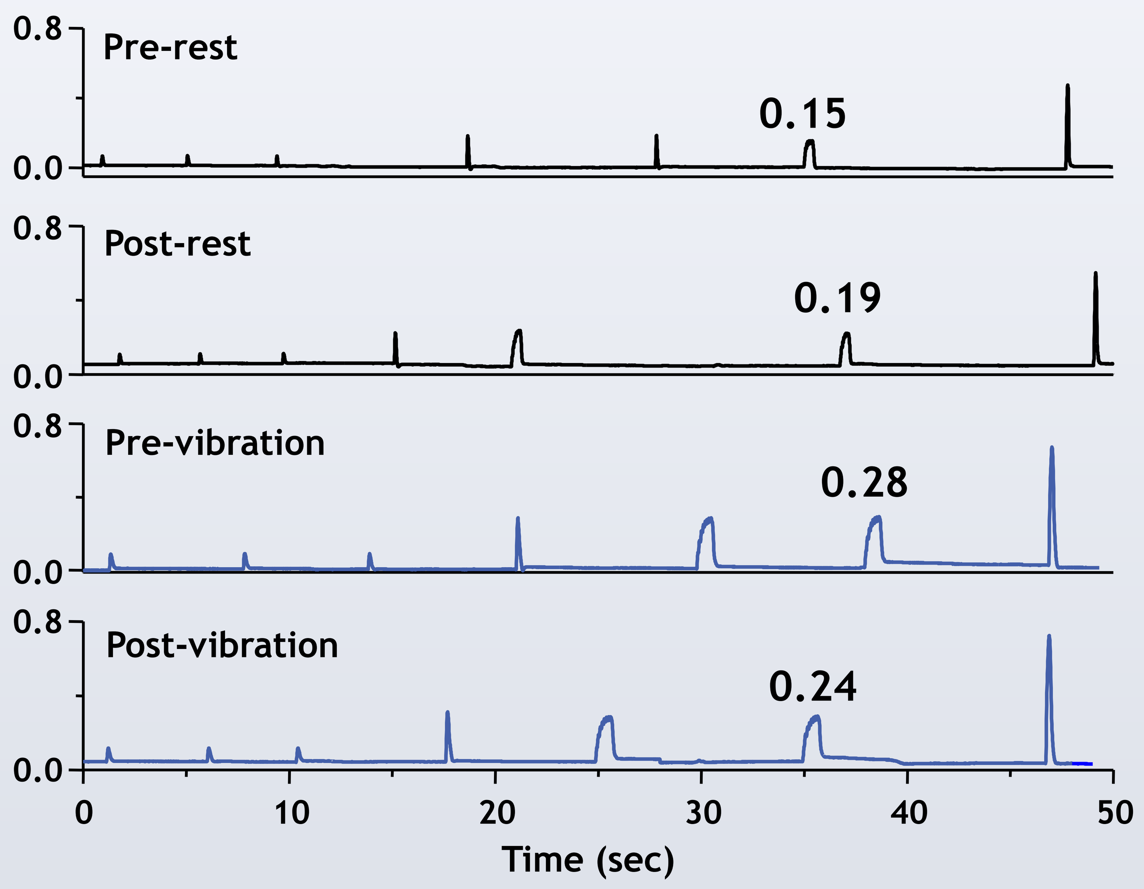

Figure 6: Real data figures displaying the following stimulations: 3 single twitches, doublet, 2 10 Hz and 50 Hz. Absolute values of torque labeled in figure demonstrate the decrease in torque during the vibration condition.

Conclusion

- Impairment in torque production by low frequency stimulation at 10 Hz suggests that the capacity to produce torque is compromised both during periods of immobilization and vibration.
- E-C coupling, as indicated by the 10 Hz/50 Hz torque ratio, may not be affected by vibration.
- Vibration was not found to attenuate MVC force production.

References

(1) Worksafe BC (2011).

(2) Shinohara, M. (2005a). Medicine and Science in Sports and Exercise, 37(12), 2120-2125.

(3) Cheng, A. J., & Rice, C. L. (2005). Journal of Applied Physiology. 99(4), 1446-1452.