Summer 2018

Quantifying Passive Joint Stiffness at the Elbow Following EIMD of the Elbow Flexors

Angus Lamont

Quantifying Passive Joint Stiffness at the Elbow Following EIMD of the Elbow Flexors

Angus Lamont and Dr. Gary McCall
University of Puget Sound

University of Puget Sound | Exercise Science

Introduction

Exercise-Induced Muscle Damage (EIMD) refers to the physiological responses to physical exertion that disrupt normal muscle function. While EIMD can occur following various types of exercise, it is most prominent following high-force eccentric muscle actions, in which the muscle lengthens under active tension. Symptoms of EIMD include reduced strength, inflammatory responses, delayed-onset muscle soreness (DOMS), and muscle/joint stiffness. While each of these EIMD responses has been investigated before, many studies describe muscle/joint stiffness either qualitatively or by measuring static joint positions. **The purpose of this project was to quantify joint stiffness at the elbow during passive isokinetic movement throughout the full range of motion after EIMD of the elbow flexors.**

Methods

Seven subjects without a recent history of strength training participated in the study (age(years) = 28.14±10.16, height(cm) = 170.49±13.55, weight(kg) = 76.73±32.83). After a familiarization day, subjects completed five testing sessions over the course of one week. A Cybex isokinetic dynamometer was used to measure maximal torque of elbow flexors (15°/s) and passive joint stiffness during elbow flexion and extension (5 & 15° /s). On the initial test day (indicated by *), 50 maximal eccentric efforts were performed during elbow extension (60°/s) of the non-dominant arm to cause EIMD.

Sample Testing Schedule						
S	M	T	W	Th	F	S
	X*	X	X	X		
	X					

Measurements taken on days marked with an “X”:

- **Limb Circumference (cm)** – measured at the elbow and the muscle belly of the elbow flexors.
- **Relaxed Elbow Angle (degrees)** –measured with the arm hanging relaxed at the subject’s side.
- **Perceived Soreness** – arm discomfort rated on a visual analog scale.
- **Passive Elbow Joint Stiffness (Nm)** – torque recorded while the elbow was moved passively through its full range of motion at 5°/s and 15°/s.
- **Isokinetic Maximum Strength (Nm)** – torque measured during maximal voluntary concentric contractions of the elbow flexors at 15°/s.

A 2-factor (arm x day) ANOVA was used to compare the means and interactions for each dependent variable, with α<0.5 as significant.

Results

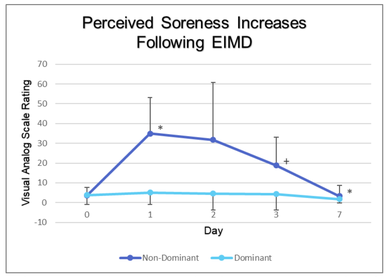

Figure 1. Rating of perceived soreness on a visual analog scale. ANOVA effects for arm (p=0.008), day (p=0.004), and arm*day (p=0.005).
* p<0.05 arm*day from prior test day
+p<0.10 arm*day from prior test day

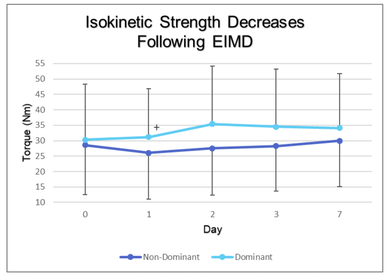

Figure 2. Torque (Nm) during maximum elbow flexion at 15°/s. ANOVA effects for arm (p=0.013), day (p=0.062), and arm*day (p=0.026).
+p<0.10 arm*day from prior test day

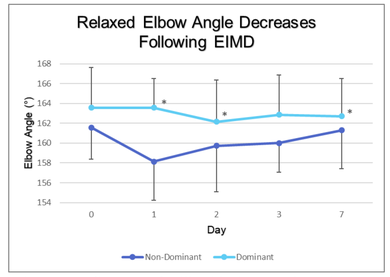

Figure 3. Elbow angle (°) with the arm hanging relaxed at the side. ANOVA effects for arm (p=0.027), day (p=0.048), and arm*day (p=0.001).
* p<0.05 arm*day from prior test day

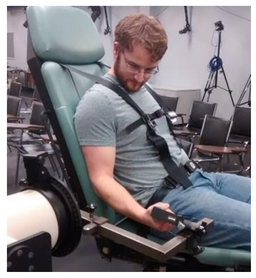

Figure 4. Isokinetic dynamometer positioning.

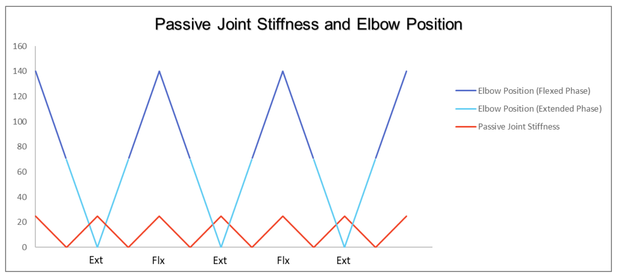

Figure 5. Typical pattern of elbow joint torque during a passive stiffness test. The extended movement phase is depicted in light blue and the flexed phase in dark blue. Joint stiffness is the torque curve depicted in red.

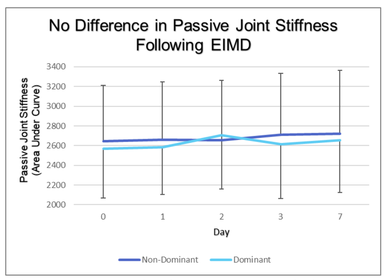

Figure 6. Area under the torque curve during elbow extended phase at 15°/s. ANOVA effects for arm (p=0.692), day (p=0.139), and arm*day (p=0.308).

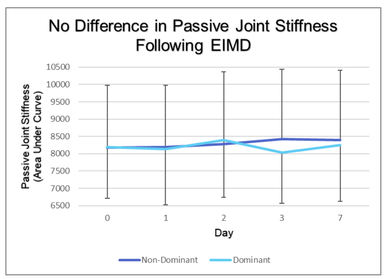

Figure 7. Area under the torque curve during elbow extended phase at 5°/s. ANOVA effects for arm (p=0.816), day (p=0.375), and arm*day (p=0.380).

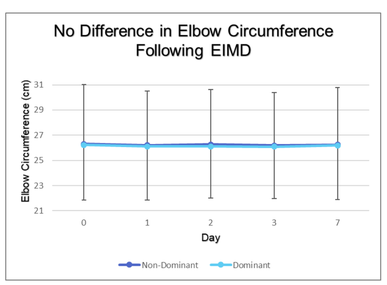

Figure 8. Circumference (cm) at the elbow. ANOVA effects for arm (p=0.550), day (p=0.583), and arm*day (p=0.974).

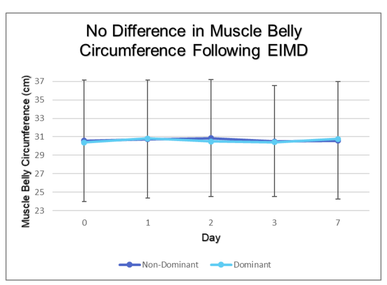

Figure 9. Circumference (cm) at the muscle belly of the elbow flexors. ANOVA effects for arm (p=0.662), day (p=0.632), and arm*day (p=0.500).

Summary

- The eccentric exercise produced EIMD in the non-dominant arm as indicated by an increase in perceived soreness, a decrease in isokinetic strength, and a decrease in relaxed elbow angle.
- Despite EIMD in the non-dominant arm, there was no difference in passive joint stiffness during the extended phase at either 5°/s or 15°/s.
- There was no difference in limb circumference at the elbow or the muscle belly following EIMD.
- The lack of increase in passive joint stiffness after EIMD may be due to a small sample size, and more subjects will be tested to improve statistical power.
- Analysis of the effects of EIMD on passive joint stiffness during the flexion phase is ongoing.

Literature

1. Chleboun GS, Howell JN, Conatser RR, Giesey JJ. Relationship between muscle swelling and stiffness after eccentric exercise. Med Sci Sports Exerc. 1998;30(4):529–35.
2. Cleak MJ, Eston RG. Muscle soreness, swelling, stiffness and strength loss after intense eccentric exercise. Br J Sports Med. 1992 Dec 1;26(4):267–72.
3. Clarkson PM, Hubal MJ. Exercise-induced muscle damage in humans. Am J Phys Med Rehabil. 2002 Nov;81(11 Suppl):S52-69.
4. Proske U, Morgan DL. Muscle damage from eccentric exercise: mechanism, mechanical signs, adaptation and clinical applications. J Physiol. 2001;537(2):333–45.
5. Proske U, Allen TJ. Damage to skeletal muscle from eccentric exercise. Exerc Sport Sci Rev. 2005;33(2):98–104.

Acknowledgements

I would like to thank Dr. Gary McCall for his guidance and help throughout the study, the Exercise Science Department for their resources and equipment, and the Washington NASA Space Grant Consortium and the University Enrichment Committee for funding the study.