

EVIDENCE OF GENDER SPECIFIC MOTOR TEMPLATES TO RESIST A VALGUS PERTURBATION AT THE KNEE

Martha Cammarata^{1,2}, Tobey DeMott², and Yasin Dhaher^{1,2}

¹ Department of Biomedical Engineering, Northwestern University, Chicago, IL, USA

² Sensory Motor Performance Program, Rehabilitation Institute of Chicago, Chicago, IL, USA

E-mail: m-cammarata@northwestern.edu

INTRODUCTION

The incidence of anterior cruciate ligament (ACL) injuries in female athletes is up to six-fold higher than in their male counterparts (Agel et al. 2005). A prospective study implicated abnormal abduction loading at the knee during a jump landing as the primary predictor for ACL injury risk in female athletes (Hewett et al. 2005). Indeed, females tend to assume postures conducive to high abduction loading at the knee during sport maneuvers (Ford et al. 2005). This may suggest that the mechanisms of knee joint stability in this plane differ between genders.

While males have greater passive knee stiffness than females in the frontal plane (Bryant and Cooke 1988), it is not known if there exist differences in reflexively mediated muscle activation. Previous work has demonstrated that reflexive muscle activation can be elicited via a valgus perturbation at the knee in male subjects (Dhaher et al. 2003). These muscle contractions were shown to significantly increase knee joint valgus stiffness by 25% on average. (Dhaher et al. 2005). However, it remains to be seen if a valgus perturbation triggers a similar muscular response in female subjects. Accordingly, in this study, we sought to compare the properties of valgus induced muscle contractions between genders.

METHODS

Five males and nine females with no history of neurological or musculoskeletal disorders participated in the study. Female subjects were tested within 3 days of menses to

reduce the potential confounding factor of hormonal variations between subjects.

Subjects were seated in an experimental chair with the right knee fully extended. The right ankle was placed in a cast and connected to a servomotor via a rigid cantilever beam. Brackets were secured around the knee to prevent medial/lateral translation. To eliminate mechanical delay, the knee joint was pre-loaded in the abduction direction (3° or 4°). Then, abduction positional perturbations, ranging from 5° to 7° , were applied to the knee at a loading speed of $60^\circ/\text{s}$. At least 4 trials at each amplitude were performed on each subject. Surface electrodes recorded EMGs from quadriceps [rectus femoris (RF), vastus lateralis (VL), vastus medialis (VM)] and hamstring [semitendinosus (ST), and biceps femoris (BF)] muscles.

Data was filtered online with an 8th order low-pass Butterworth filter with a 220 Hz cutoff and sampled at 1000 Hz. EMG signals were then rectified and filtered again with the same digital filter at a 120 Hz cutoff. Valgus induced muscle activity was considered significant if the rectified EMG activity, averaged over 70ms and 500ms after the onset of movement (t_o , see Figure 1), was greater than the mean plus one standard deviation of the background EMG signal calculated between 10ms and 110ms prior to t_o . For each subject, the probability that a given perturbation would result in firing of a muscle was computed as the ratio of trials where a significant EMG response occurred to the total number of trials performed at that angular perturbation on the

same subject. The proportions were averaged for each muscle and gender and then compared between genders.

RESULTS AND DISCUSSION

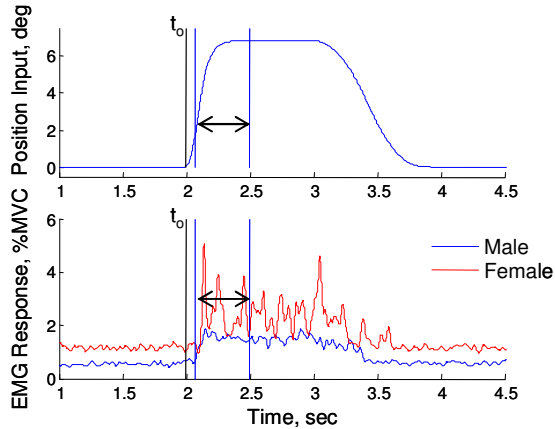


Figure 1. Seven degree position input signal (top) and resulting EMG activity in the ST muscle, normalized by MVC (bottom). The arrows specify the time window used to calculate perturbation induced EMG activity.

Reflex muscle activation in response to a valgus perturbation was observed much more frequently in males than females at all perturbation amplitudes (Table 1). In females the ST muscle displayed the largest probability of firing. For the 7° valgus perturbation reflex firing of ST was consistent across trials in 3 female subjects resulting in a firing probability of 0.36. The onset latency of the muscular responses averaged 102 +/- 22 ms for females and 94 +/- 19ms for males, which is less than the onset latency of a volitional triggered response (182 +/- 34ms).

Based on the firing probabilities, it appears that females rely more on hamstring muscles than quadriceps. Also, both genders showed a preferential firing of medial muscles (RF, VM, ST) over lateral muscles (VL, BF), which would be optimal to resist the lateral perturbation.

SUMMARY/CONCLUSIONS

Our preliminary results indicate that the probability that a valgus perturbation will elicit a neuromuscular response is much greater in males than females. While a larger sample size is warranted, these results may indicate that there exist gender differences in the motor control template used by the CNS to maintain joint stability in the frontal plane. It remains to be seen if such motor templates are modifiable via proprioceptive training paradigms designed specifically to reduce the prevalence of ACL injury in the female population.

REFERENCES

- Agel J et al. (2005), *Am J Sports Med*, **33**(4): 524-30.
 Bryant JT, Cooke DT. (1988), *J Orthop Res*, **6**(6):863-70.
 Dhaher YY et al. (2003), *J Biomech*, **36**(2): 199-209
 Dhaher YY et al. (2005), *J of Neurophysiology*, **93**(5):2698-709.
 Ford KR et al. (2005), *Med Sci Sports Exerc*, **37**(1):124-9.
 Hewett TE et al. (2005), *Am J. Sports Med*, **33**(4):492-501.

ACKNOWLEDGEMENTS

This work was supported by the National Institute of Health (1-R01-AR049837-01)

Table 1: Probability that a valgus perturbation will elicit a reflex response at each amplitude.

		Overall		RF		VL		VM		ST		BF	
		M	F	M	F	M	F	M	F	M	F	M	F
5	Mean	0.89	0.09	0.87	0.06	0.70	0.03	0.87	0.00	0.95	0.13	0.93	0.21
	SD	(0.25)	(0.19)	(0.30)	(0.17)	(0.48)	(0.08)	(0.18)	(0.00)	(0.10)	(0.22)	(0.15)	(0.31)
6	Mean	0.87	0.16	0.83	0.16	0.73	0.14	0.77	0.09	1.00	0.29	0.83	0.15
	SD	(0.24)	(0.22)	(0.33)	(0.26)	(0.33)	(0.19)	(0.28)	(0.20)	(0.21)	(0.28)	(0.33)	(0.24)
7	Mean	0.91	0.15	0.92	0.05	0.83	0.11	0.81	0.06	1.00	0.36	0.92	0.23
	SD	(0.23)	(0.27)	(0.17)	(0.10)	(0.33)	(0.25)	(0.38)	(0.11)	(0.13)	(0.41)	(0.17)	(0.31)