

## THE EMG/TORQUE RELATIONSHIP OF THE KNEE EXTENSORS DURING ACUTE FATIGUE

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### INTRODUCTION

Fatigue has been defined as a transient decrease of performance capacity of muscles during physical activity [1]. Response of knee musculature to acute fatigue may dictate adaptations to knee function during high impact activities, which may result in injury. One technique for assessing muscular adaptation to fatigue is to analyze the ratio of electromyographic magnitude (EMG) to torque production [2]. The purpose of this study was to determine the EMG/torque relationship of the vastus lateralis during acute fatigue.

### METHODS

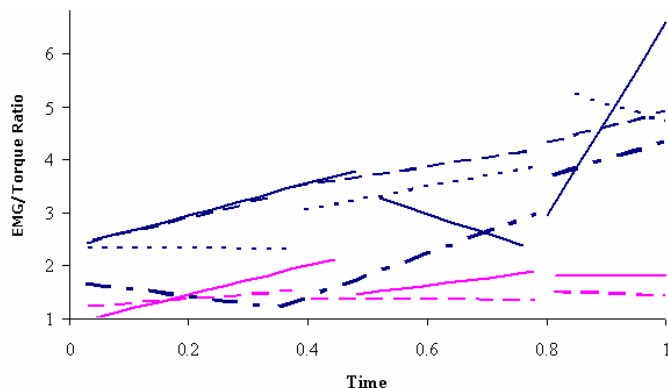
Six male subjects (mean age 24.3) participated in the study. All subjects signed an informed consent before participation. Subjects performed three isometric maximum voluntary (MVC) knee extension (KE) contractions at 45° before performing a fatigue protocol. The fatigue protocol consisted of subjects performing isokinetic KE contractions (concentric and eccentric) at 60°/s through their functional range of motion until acute fatigue was reached. Acute fatigue was defined as when the subject performed two consecutive contractions where the peak concentric torque was below 50% of MVC. All contractions were performed using the subjects' dominant leg.

Knee extensor torque during the isometric and isokinetic contractions was measured using a strain-gauge dynamometer (KIN-COM, Rehab World, Hixson, TN, USA). A passive bipolar surface EMG recording system (Myopac Jr., Run Technologies, Mission Viejo, CA, USA) was used to collect vastus lateralis (VL) activation magnitudes at a sampling frequency of 1000 Hz. EMG signals were bandwidth filtered (10-10,000Hz), full-wave rectified and smoothed with a 4<sup>th</sup> order Butterworth filter (low-pass cutoff = 5Hz) before analysis.

For analysis, torque production was normalized to body weight, processed EMG was normalized to maximal isometric activation and the ratio of EMG amplitude to torque production was calculated during each phase of the fatigue protocol. The change of torque produced during each phase was also determined.

### RESULTS AND DISCUSSION

It was determined that peak torque production during the fatigue protocol could be broken into three phases. The first phase ("initial") consisted of the first 12 to 15 cycles of the fatigue protocol where subjects maintained roughly 80 to 90%



**Figure 1:** EMG/torque ratio during the fatigue protocol. Time is listed as a proportion of the entire protocol.

of the torque produced during the isometric MVC. During the second phase ("decline") subjects' torque production dropped from 80% of MVC to below 50% in 12 to 15 repetitions and in the third and final phase ("fatigued"), declines in torque production leveled off and subjects maintained slightly less than 50% of MVC. The change of each subjects' torque production for each phase is shown in Table 1. Torque production during the initial phase increased slightly, in the decline phase there was a dramatic decrease and for the fatigued phase it leveled off with minimal declines.

Examination of the EMG/torque ratio indicates that responses to the fatigue protocol can be divided into two groups (Fig. 1). One group's EMG/torque ratio essentially doubled as a result of acute muscular fatigue, while a second group responded to fatigue without increasing their EMG/torque ratio. These results indicate that a group of subjects did not need to activate more fibers to sustain torque production of 50% MVC when fatigued. The other subjects needed to increase activation levels in an effort to maintain torque production during acute fatigue. Whether this signal increase resulted from increased recruitment or rate coding is undetermined.

### CONCLUSIONS

Further research is needed into the effects of acute muscular fatigue on the knee extensors. Future work will focus on whether the varied responses of the EMG/torque ratio to acute fatigue are due to group-specific training.

### REFERENCES

1. Asmussen E. *MSSE* **11**, 313-321, 1979.
2. Eguchi A. *Electro. Clin. Neuro.* **44**, 75-81, 2004.

**Table 1.** Change in torque production during each phase of the fatigue protocol (Nm/kg)

	Subj. 1	Subj. 2	Subj. 3	Subj. 4	Subj. 5	Subj. 6	Mean (SD)
<b>Initial</b>	-0.010	0.049	0.065	-0.024	0.110	0.030	0.037 (0.049)
<b>Decline</b>	-0.135	-0.181	-0.132	-0.101	-0.203	-0.136	-0.148 (0.037)
<b>Fatigued</b>	0.058	-0.059	0.018	-0.011	-0.012	-0.036	-0.007 (0.041)