PHASIC MUSCLE ACTIVITY OF THE LOWER EXTREMITY AT DIFFERENT POWERS AND PEDALING CADENCES IN CYCLE ERGOMETRY

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INTRODUCTION

The performance of the human body depends on its muscle activity. Muscles move the body segments through their range of motion by creating moments at the joints. Both the intensity and the duration of muscle contraction determine the kinematics of the body as well as its strength capabilities. If a change in condition requires a change in performance, then muscle activity should change as well. A good understanding of muscle activity and its response to change can aid in strength training, performance evaluation, and rehabilitation.

The effect of cadence and either power or work load are frequently evaluated for many aspects of cycling including muscle activity. Although a few studies evaluated phasic muscle activity for a single condition (Ericson, Nisell, Arborelius, & Ekholm, 1985; Gregor, Cavanagh, & LaFortune, 1985), the majority studied the integrated EMG (Ericson, Nisell, Arborelius, & Ekholm, 1985; Goto, Toyoshima, & Hoshikawa, 1975).

This study evaluated the phasic muscle activity of the lower extremity in cycle ergometry at three power levels and three cadence levels.

METHODS

Three adult, male, experienced, recreational riders volunteered for the study. To eliminate the possible effect of fatiguing on the EMG data, the subjects were instructed to avoid strenuous physical activity on the test day.

Four surface electrodes monitored the muscle activity of the gluteus maximus (major hip extensor), rectus femoris (knee extensor & hip flexor), vastus lateralis (knee extensor), and biceps femoris (hip extensor and knee flexor) muscles. EMG data was collected for five seconds at a sampling rate of 1000 Hz.

The Lode Excaliber Sport bicycle ergometer set power output levels at 300W, 600W and 900W (±1W). A cadence meter displayed the subjects' pedaling speed. Toe clip pedals minimized movement between shoe and pedal. The saddle and handlebar height and fore/aft position were adjusted for each subject.

A single 60 Hz video camera videotaped lower extremity motion in the sagittal plane. A fixed point was defined on the ergometer frame, and joint markers were placed on the subjects' right side.

Each subject performed the nine trials in an arbitrary order. Video and EMG data collection began when the subject reached the target cadence. The data were synchronized by a simple LED circuit that generated a step function with the EMG data while the switching of the LED light was videotaped.

The raw EMG data was converted to a full-wave rectification. A 100 millisecond moving window average generated the envelope for determination of the start and stop of muscle activity when a 0.2 mV threshold was exceeded.

The video data was converted to a rigid-segment five-link system by digitization, transformation (direct linear), and smoothing (6 Hz digital filter). The coordinate system for crank position was positive clock-wise motion with 0°/360° at top dead center (TDC) of each crank revolution. For each trial condition, the data for each subject was averaged and then all subjects were averaged. Averages were also calculated for each level of both power and cadence.

RESULTS AND DISCUSSION

The rectus femoris muscle showed changes with cadence (Table 1). As cadence increased, the onset of rectus femoris activity shifted earlier in the crank cycle. The end of activity also shifted later in the crank cycle when cadence increased from 60 to 80 rpm but remained stable with the increase to 100 rpm. These changes increased the duration of rectus femoris activity from 210° to 260° to 280° at increasing cadences. Power output had no effect on the duration of rectus femoris activity; however the activity shifted slightly. As a knee extensor, this muscle may tend to fire earlier in anticipation of earlier extension needed at higher cadences. Its smaller belly size relative to the other muscles in the quadriceps group may indicate why it is less effective with increasing power.

The vastus lateralis muscle also changed with cadence (Table 2). When cadence increased from 60 to 80 rpm, the onset of muscle activity shifted earlier in the crank cycle, but then remained stable with the change to 100 rpm. The end of activity showed smaller changes but without pattern. The end result was an increase in the duration of vastus lateralis activity from 226" to 254° to 268° at increasing cadences. Relative to power output, the duration of vastus lateralis activity was about 10" higher at only the 450W trial condition. As a powerful quadriceps muscle, the vastus lateralis showed a longer duration at the highest power and lowest cadence. This trial condition was the most challenging of the nine and may have been the cause of an increase in phasic muscle activity.

Table 1.
Rectus Femoris Phasic Muscle Activity for all Nine Trial Conditions (°).

		Power			
		150W	300W	450W	mean
60 rpm	start	281	248	287	272
	stop	129	111	125	122
	duration	209	223	198	210
80 rpm	start	272	226	219	239
	stop	170	113	133	139
	duration	258	247	274	260
100 rpm	start	215	214	228	219
	stop	143	132	143	139
	duration	288	278	276	280
mean	start	256	229	244	
	stop	148	119	134	
	duration	252	249	249	

Table 2.
Vastus Lateralis Phasic Muscle Activity for all Nine Trial Conditions (°).

		Power			
		150 W	300 W	450 W	mean
60 rpm	start	350	331	306	329
	stop	201	220	166	195
	duration	210	249	220	226
80 rpm	start	291	289	282	287
	stop	182	169	194	182
	duration	250	241	272	254
100 rpm	start	289	290	281	287
	stop	199	184	201	195
	duration	270	254	280	268
mean	start	310	303	290	
	stop	194	191	187	
	duration	244	248	257	

The EMG data of the gluteus maximus had a small magnitude. When further complicated by signal noise, start and stop positions were difficult to determine accurately. Surface electrodes probably could not adequately receive a strong signal over the center of the muscle belly due to the interference of adipose tissue.

The biceps femoris muscle had an asymmetrical raw EMG signal pattern. When fully rectified, the start and stop points overlapped for each peak. Due to the two-joint nature of this muscle, it probably plays a very active role in both knee flexion and hip extension. In many cases, the muscle was active during the entire cycle.

CONCLUSIONS

The results from the rectus femoris and vastus lateralis indicated that the duration of phasic muscle activity increased with cadence. The effect of power was not as conclusive. Based on the results, it is suggested that cyclists train at higher cadences rather than at higher power in order to increase muscle activity during a greater portion of the crank cycle.

This study was limited by its sample size, the subject's fitness level and the number of muscles evaluated.

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