Cycling and Electromyography – Thomas Young

The purpose of this project was to examine the patterns of muscle activation during stationary cycling on the following lower extremity muscles: Biceps femoris (BF), Medial head of Gastrocnemius (GA), Rectus femoris (RF), Tibialis Anterior (TA). A secondary purpose was to become familiar with functional muscle tests and examine the power phase of cycling.

The equipment used for this project was the following: one force platform (1200 Hz, BP600600, OR6-7, AMTI), 4 devices of 16-channel wireless EMG system (Delsys, USA), 3D motion analysis system (240 Hz, VICON), lode cycle ergometer (with 3 tracking markers), and a pair of instrumented pedals (with 4 tracking markers each). EMG devices were placed on the muscle bellies on the following location: BF, GA, RF, TA. Functional tests were used to obtain reference EMG signal to normalize EMG during cycling. The functional tests were the following: air squat, single leg hamstring curl, calf raise, and heel curl. Reflective markers were placed on the trunk, pelvis, thigh, leg, and foot on both sides. Specifically, anatomical markers were placed on each side of the body on the following bony locations: acromial process, greater trochanter, lateral epicondyle, medial epicondyle, lateral malleolus, medial malleolus, 1st metatarsal, 5th metatarsal, and 2nd toe. Tracking markers in groups of 4 were placed on the back of the pelvis (posterior pelvic cluster), one on each thigh (4 in cluster), one on each shank (4 in cluster), and one on each posterior heel (posterior lateral heel cluster). Once a static trial was collected and reflective markers labeled, anatomical markers were removed, and dynamic trials began. Data collection occurred only with one participant from the graduate school. The participant was instructed to cycle at a work rate of 80W, 120W, and 160W at a cadence of 80 revolutions per minute. Condition 1 was called 80W, condition 2 was called 120W, and condition 3 was called 160W. The participant was instructed to keep a cadence of 80 rpm for one minute while data was collected for only the last 10 seconds of the minute. One trial was performed for each condition. The lab was cleaned after data collection and data processing was completed with Visual3D (C-Motion, Inc.) in the biomechanics computer lab.

3) Table 1: Range of Motion for each condition in degrees read as average ± standard deviation

Table 1: ROM

	80W	120W	160W
Ankle	5.87 ± 1.36	9.60 ± 2.17	11.60 ± 3.13
Knee	69.22 ± 0.90	69.99 ± 0.78	67.98 ± 1.14
Hip	-51.35 ± 0.52	-49.62 ± 0.36	-50.72 ± 0.65

Table 2: IEMG / RMS activation values for each condition read as average ± standard deviation

Table 2: EMG

		80W	120W	160W
BF	IEMG	0.82 ± 0.16	0.95 ± 0.15	1.34 ± 0.18
	RMS	2.62 ± 0.54	3.01 ± 0.54	4.09 ± 0.61
GA	IEMG	3.79 ± 1.13	2.66 ± 0.38	2.93 ± 0.44
	RMS	13.24 ± 3.70	8.72 ± 1.37	9.38 ± 1.87
RF	IEMG	2.19 ± 0.27	3.85 ± 0.65	5.00 ± 0.69
	RMS	7.50 ± 0.88	12.44 ± 2.47	16.57 ± 2.61
TA	IEMG	1.73 ± 0.48	2.53 ± 0.56	2.72 ± 0.72
	RMS	6.80 ± 1.98	10.06 ± 2.39	10.79 ± 3.03

As a preface, only the power phase was analyzed in post data collection for each condition. The first metric above (Table 1) is the range of motion for the following three joint centers: ankle, knee, and hip. The ankle experienced a larger range of motion in condition 2 compared to condition 1. The ankle also experienced a higher ROM for condition 3 compared to condition The following trend is as the wattage increases the higher the ROM is for the ankle average and ankle standard deviation. This is expected as the ankle plantarflexes more as the workrate increases. The knee and hip experienced relatively similar ROM across all three trials for both average and standard deviation. The only slightly different number was for the knee as it experienced a decrease by two degrees in average but increased in standard deviation from condition 2 to condition 3. The knee did experience a higher peak from 120W to 160W, but looks like the ankle compensated for this correction.

For the EMG activation relating to Table 2, four muscles were looked at during the power phase. The power phase can be defined as the first half of the cycle action from 0 degrees to 180 degrees with 0 being at the top of the cycle when the foot is parallel with the floor. The first muscle was biceps femoris (BF) and the trend for both imaging electromyography (IEMG) and root mean square (RMS) increased as wattage increased. This is expected as this long muscle is located in the posterior thigh and is responsible for movement at both the hip and knees. As wattage increases in each condition so will the activation and recruitment of muscle fibers pushing down on the pedal. The medial head of gastrocnemius (GA) was the second muscle looked at and was the only muscle that did not experience a trend. From condition 1 to condition 2, both average and standard deviations went down for both the IEMG and RMS metrics. In contrast, the GA muscle activation went up in both average and standard deviation from condition 2 to condition 3 in both IEMG and RMS. The GA is a contributor to plantar flexing while also contributing to knee flexion. Both of these actions are experience in the power phase of cycling as they contribute to pushing down on the pedal. The rectus femoris (RF) saw an increase in muscle activation for both IEMG and RMS across all conditions. This is expected as this muscle contributes to hip flexion and knee extension. The tibialis anterior (TA) was the last muscle looked at and saw a significant increase from condition 1 to condition 2 while experiencing a slight increase from condition 2 to condition 3 for both metrics IEMG and RMS. The function of the TA is to dorsiflex the foot which primarily happens in the recovery phase, but can be seen at the start of the power phase from the TA graph.

For EMG activation relating to the graphs created in Visual3D, the graphs can be read by first looking at the title for each muscle while wattage is in the parenthesis. The x-axis signifies time as a percent of the cycle phase with the power phase as 0-50% and the recovery phase as 50-100%. The y-axis signifies EMG activation in mV. For BF and RF, there is a peak around the 25% mark of the cycle phase indicating this muscle is activated primary doing the middle of the power phase. This peak increases as wattage increases and is around the 25% mark of the cycle phase in each condition. For GA, there are several peaks in each condition, but the highest one is the first one across all conditions and can be seen in the middle between the 25% and 50% mark of the cycle phase. Again, this is in the power phase and this muscle is used to help plantarflex the ankle. For TA, there are two peaks with the highest peak being the second peak. This can be seen between the 75-100% portion of the crank phase which can be denotated as the recovery phase. This makes sense as this muscle's action is to dorsiflex the ankle which in experienced cyclers would exhibit a higher value with their foot pushing up on the foot straps.