Method for measuring the contribution of the vastus lateralis to cycling in incremental tests to fatigue in women

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Introduction

The purpose of this study is to determine whether or not there is a significant increase in the muscle activity of the vastus lateralis at different stages of a resistance ramp test to fatigue during cycling. The vastus lateralis is the quadriceps muscle on the lateral side of the leg. Basically, this study is figuring out if this muscle is more active at a higher power, or higher resistance, during cycling.

An increase in muscle activity due to increased motor unit recruitment has been found in ramp tests to fatigue during exercise (Camic C L et al 2010). Furthermore, it has been found that larger muscles, such as the vastus lateralis, are more dominant in the production of force during cycling (Wakeling J M and Horn T 2009). However, past studies have primarily used male subjects.

This study focuses on female subjects and uses physiological data to determine different stages of fatigue. Physiological data comes from ventilatory data and blood lactate data. Ventilatory data is collected through the system seen below (Figure 1). Surface electromyographic data (sEMG) is collected from surface electrodes on the skin, seen in Figure 2. These physiological determinants of fatigue are then compared with sEMG data to study muscle activation and, specifically, the contribution of the vastus lateralis to cycling with an increase in power during the ramp tests.

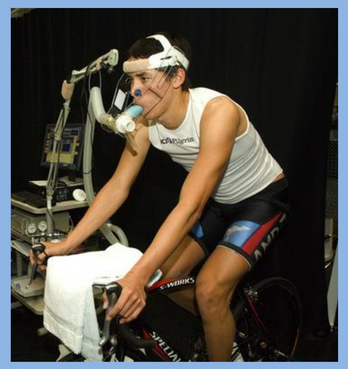

Figure 1- This system is used to collect ventilatory data to examine physiological determinants of fatigue to compare with lactate data.

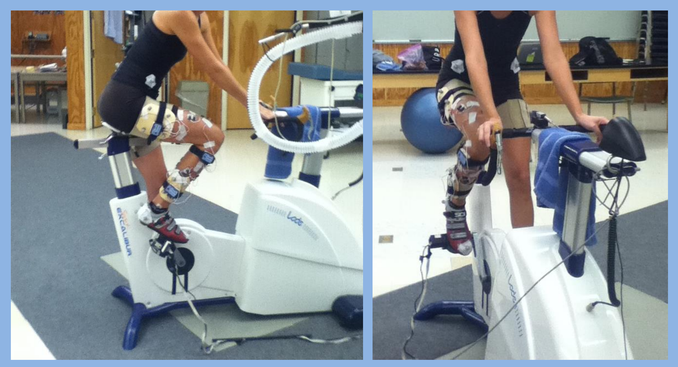

Figure 2- Surface electrodes are attached to transmitters that wirelessly record muscle activity throughout the test on a cycling ergometer.

Methods/Materials

Female subjects ages 18 to 45 with racing experience are chosen to participate in this study. Using a cycling ergometer, the resistance is increased in step-wise stages until the subject is no longer able to sustain the required power to turn over the pedals at a preselected rate (fatigue). Lactate levels are obtained at the end of each interval while ventilatory and electromyographic data are collected.

Blood lactate levels are used to establish physiological thresholds that are then compared to ventilatory data for validation. Lactate levels are also plotted versus VO_2. This graph shows the physiological changes related to the development of fatigue (Figure 3).

Muscle activity of the vastus lateralis is quantified using the electromyographic data from surface electrodes. Raw data from each stage is band pass filtered, rectified and normalized using an ensemble average for each stage. The ensemble average represents the average waveform of all of the pedal strokes. The peaks of the ensemble averages are used for comparison between stages, with the highest peak value for the entire test being used for normalization for each stage (Figure 4).

Muscle activity is compared at different stages based on these physiological thresholds. The three stages that are chosen for comparison are “no fatigue” where lactate levels have little to no change, “lactate threshold” where lactate levels increase by at least 1.5mmol/L, and “fatigue” at the highest lactate level before failure. SPSS is used to provide comparative statistics between stages using $p<0.05$ to determine a significant increase in muscle activity between stages.

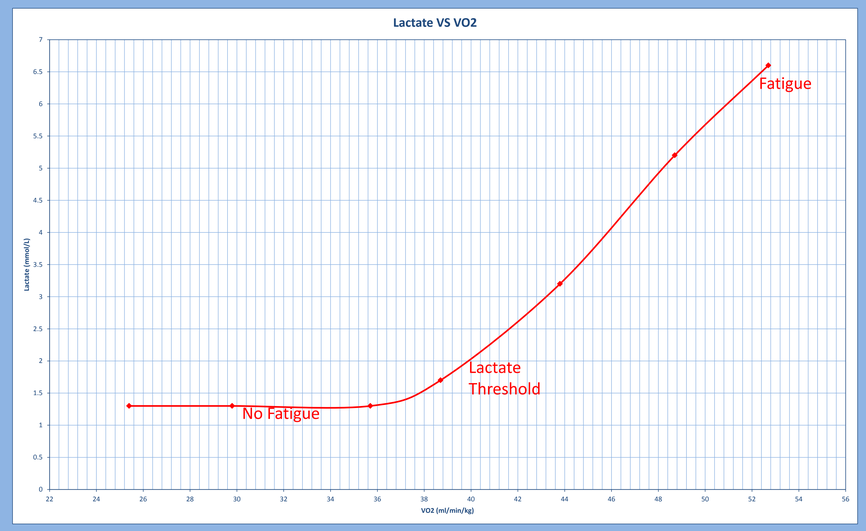

Figure 3- Data from this graph of lactate versus VO_2 is used to help determine the different stages of fatigue that we compare when looking at muscle activity data.

Results

So far, only three subjects have been tested, with one test producing insufficient data for the first two stages. However, results thus far are consistent between subjects in some aspects. There have been significant increases in the muscle activity of the vastus lateralis between stages where there is no fatigue and stages immediate following lactate threshold.

There have also been significant increases in muscle activity between stages where there is no fatigue and the last stages of fatigue. However, there have been no significant increases in muscle activity between stages passing or right past lactate threshold and the last stages of fatigue.

Figure 4- Raw data from the vastus lateralis is collected. It is then rectified to include all muscle activity as positive in the rest of our processing. Event markers are placed at the peaks of each pulse to identify a consistent place to measure from for normalization procedures. The data is then normalized into a graph that represents the average of the pulses, and the peak value is used for comparison between stages.

Conclusions

Though results thus far have shown some patterns, more subjects need to be tested to determine if these significant increases in the muscle activity of the vastus lateralis between different stages is consistent within our population. We predict that we will continue to see the same patterns we have seen in this preliminary testing. If this is the case, then there is a correlation between passing lactate threshold and a significant increase in the normalized muscle activity of the vastus lateralis.

References

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