A Comparison of Muscle Fatigue Responses between Static and Quasi-Static Exertions

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Thesis Submitted in fulfilment of the requirements for the degree Master of Science Department of Human Kinetics and Ergonomics Rhodes University, 2015

ABSTRACT

Background: This study examined localized muscle fatigue responses from submaximal quasi-static work protocols and additionally how it compares to purely static work. The goal was to produce research that enhances the understanding of the demands on muscles during manual work to aid in preventing injuries stemming from localized muscle fatigue. Injury rates remain a problem in manual labour sectors, particularly for the lower back and shoulder regions for the manufacturing, service and construction sectors, and for knee and elbow flexors in the sports sector. Few studies have looked at quasi-static work and what the resulting fatigue characteristics are, especially when compared to purely static or purely dynamic work. This comparison is particularly important due to the fact that risk assessment tools that are currently utilized to assess risk in the working environment are based on fatigue studies that focus on purely static or purely dynamic work. This requires attention as many working situations are neither static nor dynamic, but rather quasi-static in nature, with aspects of both dynamic and static muscle components. The scope of this study only encompasses the comparison between purely static and quasi-static work.

Objectives: This study had two objectives, firstly, to determine what the fatigue characteristics of quasi-static work are and how it compares to fully static work. Secondly, to determine whether an underlying static component within an otherwise dynamic muscle force affects localized muscle fatigue compared to quasi-static work that has equal amounts of effort but with no underlying static component. Methods: Four experimental conditions were tested, each on four muscles, namely the medial deltoid, bicep brachii, bicep femoris and erector spinae muscles. To test the two objectives of this study, 16 volunteers performed a five minute fatigue protocol, that either entailed a fully static condition which involved: 1) producing a steady force at 25 percent of maximum voluntary force, 2) a quasi-static condition with fully dynamic muscle force that alternates the required force level between zero and 50 percent of maximum force, 3) a quasi-static condition with an underlying static component of five percent of maximum force, or 4) a quasi-static condition with a large underlying static component of 15 percent of maximum force. All the experimental conditions in this study had the same average workload of 25 percent of maximum voluntary force over time and thus total workload. The dependant variables of interest were ratings of perceived exertion, changes in muscle fibre recruitment (% of maximum EMG activity),
maximum force and center frequency from a spectral analysis of the surface electromyography. These were measured throughout the protocols at one minute intervals to determine how muscle fatigue progressed, and how the fatigue responses differed between conditions.

Results: The data from comparing fully static and quasi-static work showed that of the variables measured, the rating of perceived exertion (RPE) and maximum force data indicated that for bicep brachii and bicep femoris muscles, fully static work is more fatiguing than work that alternates between zero and 50 percent of maximum force. The results for the medial deltoid and erector spinae muscles were inconclusive. The findings regarding the comparison between quasi-static conditions with and without an underlying static component revealed that an underlying static component results in greater fatigue when compared to a quasi-static condition with no static component. The results may also suggest that a larger static component coupled with a smaller peak force results in less fatigue than a condition with a small underlying static component coupled with a higher peak force in some scenarios, provided total work is kept constant. All conditions had to have the same workload in order to be validly compared and thus the condition with a larger underlying static component had a lower peak force compared to the condition with no underlying static component or the condition with a small underlying static component.

Conclusions: This study presented evidence that quasi-static work does not induce fatigue when measured by RPE and drop in maximum force in the same way as static work. Additionally, the results indicate that a larger underlying static component does not necessarily fatigue a muscle faster if the overall workload is kept constant. However, the results do suggest that any underlying static component will increase the demand on a muscle when compared to a muscle exertion with no static component. When considering the available literature on how muscles fatigue during low level static contractions, the current understanding is that the larger the force during a static contraction, the faster the onset of fatigue and decrements in performance occur. The results of this study suggest that this same relationship cannot be applied to quasi-static work where an underlying static component is part of an otherwise dynamic muscle force. Thus total workload or peak force may play a larger role than the static muscle exertion in some scenarios.