MOVEMENT HEIGHT AFFECTS KINEMATIC VARIABILITY DURING FATIGUE

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INTRODUCTION

Muscle fatigue may be an important intermediary to the development of repetitive stress injuries (RSIs). Changes in kinematics (Cote, 2005) or muscular coordination (Corcos, 2002) can occur with fatigue. These changes may reflect the person's inability to maintain a proper posture which in turn could lead to the development of a RSI. Most research has focused on fatiguing *specific* muscle groups, so little is known about the effect of *global* muscle fatigue on coordination and variability.

This study examined the mean and variability of the kinematic range of motion (ROM) and EMG median frequencies (MdPF) during a high and low height repetitive task similar to a sawing motion. We hypothesized that the mean values of ROM and MdPF would change significantly over the course of each trial, reflecting a shift away from the initially more optimal movement patterns. We also hypothesized that the cycle-to-cycle variability of ROM and MdPF would increase significantly over the course of each trial, possibly reflecting an increasing attempt to maintain performance.

METHODS

10 healthy right-handed (28 ± 2 years) subjects sat in an adjustable chair with seat belts to help them maintain a constant posture (Fig.1). They then pushed a weight back and forth along a low friction horizontal track in time with a metronome until volitional exhaustion. The weight was set to 15% of the subject's maximum pushing/pulling force. The height of the track was set to either sternum level (Low) or shoulder level (High). Each subject performed both tasks in random order on 2 different days. The 3-D movements of markers on the arm and trunk were recorded continuously at 60 Hz using VICON (Oxford Metrics, Oxford, UK). EMG were collected at 1080 Hz from 9 arm and trunk muscles.

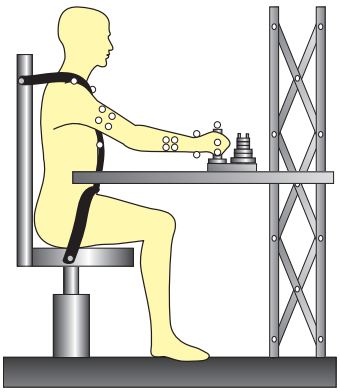

Figure 1. The experimental set-up.

Three rotational angles of the shoulder, elbow, and wrist were calculated using Euler angles. Dependent measures were calculated by splitting each time series into 10 bins. Mean values of MdPF and ROM were calculated for each bin and variability was measured as the standard deviation of each measure across that bin. A series of 3-factor (Subject x Condition x Bin) ANOVAs were used to identify differences over time (bins) and between conditions for each measure.

RESULTS AND DISCUSSION

The high height significantly reduced the time to failure ($p = 0.007$; Low: 24.1 ± 10.3

minutes; High: 12.1 ± 3.9 minutes). MdPFs decreased over time, indicating that both tasks significantly fatigued the arm and trunk muscles tested ($p < 0.001$ for 8 of 9 muscles). MdPF variability decreased in the triceps and anterior and posterior deltoid ($p < 0.011$) and increased in the Low condition for the triceps and middle deltoid ($p < 0.031$) (Fig. 1).

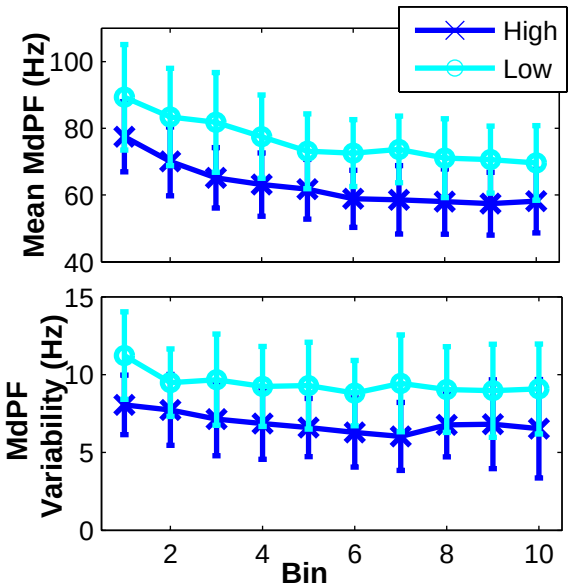

Figure 1. MdPF mean and variability of the anterior deltoid decreased significantly. Error bars are 1 standard deviation.

The ROM of the 3 shoulder angles and the wrist flexion angle were significantly lower in the High condition ($p < 0.001$; Fig 2). This was likely due to the constraining nature of the High task. Only the humeral plane angle ROM significantly decreased in across the task. Thus, subjects were largely able to maintain their ROM despite muscle fatigue. Variability was significantly reduced in the High condition for humeral rotation and elevation angles and all 3 wrist angles ($p < 0.033$). There was a significant subject x condition interaction for all comparisons, indicating that each subject responded differently to the change in height.

SUMMARY/CONCLUSIONS

The increase in height had a much stronger effect on mean ROM and ROM variability than did muscle fatigue. Large between subject variations reflect the numerous functional solutions that exist, even a highly controlled task. This large between subject variability agrees with previous work on EMG intensity patterns during a fatiguing cycling task (von Tscharner, 2002). Our results suggest that it may difficult to generalize results from *localized* muscle fatigue studies to *globally* fatiguing tasks.

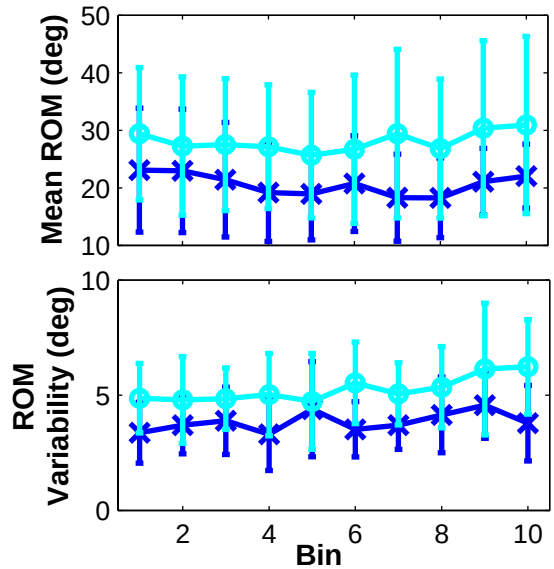

Figure 2. Humeral rotation ROM mean and variability were significantly lower for the high condition. There was no effect for bin. Error bars are 1 standard deviation.

REFERENCES

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von Tscharner, V. (2002) *J Elec Kinesiol* **12**: 479-492.

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