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 voluntary 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.

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 na-
ture 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 re-
duced in the High condition for humeral ro-
tation and elevation angles and all 3 wrist
angles (p < 0.033). There was a significant
subject x condition interaction for all com-
parisons, indicating that each subject re-
sponded 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 sub-
ject variations reflect the numerous func-
tional solutions that exist, even a highly con-
trolled 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 gen-
eralize results from *localized* muscle fatigue
studies to *globally* fatiguing tasks.

**REFERENCES**

Cote, J. et al. (2005) *Clin Biomech* **20**: 581-
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