INTRODUCTION

In the search for mechanisms and risk factors for occupational injuries to the upper extremity, many facets of the work task have been evaluated. High repetition and high force, especially in combination are known risk factors for the development of disorders [1]. Traditionally, measures have been averaged or summed over the entire shift or task. More recently, it has been suggested that injury or pain may be associated with the cycle to cycle variability of a task [2]. The purpose of this study was to re-examine the effect of force and repetition on muscle activity during a pushing task with and without grip, on a cycle by cycle basis.

METHODS AND PROCEDURES

Ten male and 10 female participants performed a series of bimanual horizontal pushing tasks with and without simultaneous gripping. The set-up included two parallel tracks with a grip dynamometer on the right side and a post on the left (Fig. 1). Handle position was monitored using linear potentiometers. A combination of three force levels (1 kg, 2 kg, and 4 kg on each side), three frequencies (4/min, 8/min, and 16/min) and two grip conditions (30% maximum grip and self-selected) were performed in 120 s trials [3].

EMG was collected from 8 muscles: posterior deltoid, anterior deltoid (AD), biceps brachii, triceps brachii, extensor digitorum, extensor carpi radialis, flexor digitorum superficialis and flexor carpi radialis. Grip force, displacement and EMG were sampled at 2048 Hz. Raw EMG was linear enveloped at 3 Hz. For each muscle, EMG was normalized to maximum voluntary exertion (MVE) and averaged (AEMG).

For each full trial, cycle, and cycle component (Fig. 2), push distance, time, AEMG, and muscular rest were calculated. Variability was examined using the standard deviations (SD) of each component and the coefficient of variation (COV = SD/mean) for time and AEMG. In addition, the AEMG work/rest ratio was calculated.

RESULTS and DISCUSSION

Although each cycle was initiated with a metronome, considerable variability was found in the cycle components. Variability (using SD) in work time was lowest in the high frequency condition (16/min) with and without grip. Gripping intensified this effect and resulted in lower work SD in the high load condition. Rest and cycle time variability had no relationship to frequency or force. The COV adjusts the SD for the duration of each
phase and indicated a similar relationship for work time but, for most conditions, indicated very small COV during rest, especially at 4 and 8 cycles/min.

In terms of AEMG, the anterior deltoid responded to the force required reaching about 25% MVE with the highest load but was invariant to frequency during the work phase (push + return) (Figure 3 - top). The same pattern of activity was seen with the grip. During the rest periods (non-work), the mean AEMG was less than 4.5% but was dependent on both force level and frequency (Figure 3, middle). The increase in activity with frequency and load may reflect anticipation of the next cycle or an inability to achieve rest between pushes.

It has been suggested that EMG variability, defined as RMS EMG (work) divided by RMS EMG (rest), is an important variable with respect to pain, experience and development of work-related disorders [2]. Plotting this cycle to cycle ratio reveals a perspective novel to either work or rest alone (Figure 3 - bottom). Thus the work/rest ratio has a shape that reflects a relationship inverse to the rest activity but relatively independent of the work activity. This pattern was not evident when the entire trial was analyzed as a whole [3]. By examining the activity in this manner, it can be seen that the work phase is invariant to frequency but the rest activity, and the task overall, is dependent on both load and frequency.

Simultaneous gripping and pushing are common in the workplace and detailed examination of the muscular response to loading and frequency parameters will provide further insights to potential injury mechanisms. Examining tasks on a cycle to cycle basis, particularly with respect to variability of EMG, time, and kinematics, holds promise for elucidating the nature of disorder development in the upper extremity.

REFERENCES

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