The Study of Work and Rest Arrangement on Muscle Fatigue Recovery for a Repetitive Task of Upper Limbs

Cheng-Lung Lee\textsuperscript{a}, Shih-Yi Lu\textsuperscript{b}, Peng-Cheng Sung\textsuperscript{a}, Chang-You Wu\textsuperscript{a}

\textsuperscript{a}Department of Industrial Engineering and Management, Chaoyang University of Technology, Taichung, Taiwan, ROC.; \textsuperscript{b}School of Occupational Therapy, Chung Shan Medical University, Taichung, Taiwan, ROC.

1. Introduction

Work-related musculoskeletal disorders (WMSDs) are one of the main focuses in the area of occupational disease prevention. Many preventive strategies of WMSDs including engineering control and administrative management were suggested in the literature. However, relatively few attentions were paid on work and rest arrangement issues during repetitive handling tasks of upper limbs. Most of these studies published were focused on the static (isometric) exertions (e.g., Kroemer and Grandjean, 1997; Sanders and McCormick, 1993; Rohmert, 1973; Milner, 1986; Rose et al., 1992; Bystrom and Fransson-Hall, 1994). Few studies were examined for dynamic tasks such as Shin and Kim, 2007, and Sbriccoli et al., 2007. Shin and Kim (2007) explored the trunk muscle fatigue during dynamic lifting and lowering as recovery time changes. Sbriccoli et al. (2007) also discussed low back disorders about the work to rest duration ratios exceeding unity situation. To prevent the WMSDs an experiment was conducted to explore the behavior of upper limbs during repetitive handling tasks with different work and rest arrangements in this study.

2. Method

2.1 Subjects

Twelve young male subjects were recruited as paid volunteers in this study. Their mean age was 24.3 years (SD 1.1 yr), mean body height 172.0 cm (SD 4.9 cm), and mean body weight 66.6 kg (SD 10.1 kg). All subjects were free of known musculoskeletal injuries and described themselves as right-handed. A written consent was obtained from the subjects after they were given a clear explanation of the objectives and procedures of the experiment.

2.2 Apparatus

Surface electromyography (sEMG) is often used to obtain myoelectrical signals from active muscles to determine local muscle fatigue. Four selected muscles of the right upper limb in the experiment were the middle deltoid, anterior deltoid, biceps brachii, triceps brachii. The raw sEMG signals were amplified with gain of 5000, lowpass filtered at 500 Hz, and digitized at a rate of 1000 Hz.

2.2 Experimental Design

The surface electromyographic measurement system environmental setting parameters were calibrated before the experiment. The anthropometric data were measured after the subject was given a clear explanation of the experiment objectives and procedures. Surface electrodes were then attached to four muscles of the upper limb. At the start of the experiment the maximum voluntary contraction (MVC) of each tested muscle was measured. The subject was instructed to be seated and remain in upright posture as the work surface was kept at the subject’ elbow height. The moving speed was 30 times/min. Four different rest periods (0.25, 0.5, 1, and 1.5 times of work time of 9 min) and 2 object loads handled (1 and 2 kg) formed 8 experimental conditions. Each subject had to complete 8 conditions in the experiment. The order of the 8 conditions was randomized. The Viewlog software developed was used to calculate %MVC of electromyographic signals to explore the upper limb muscle fatigue recovery.
3. Results

The sEMG results obtained from biceps brachii, middle deltoid, and anterior deltoid for the rest period of 0.25 times work time had the significantly different muscle fatigue recovery ($p < 0.05$) when compared with the other three rest periods (Table 1). More than 90% of the muscle recovery could be obtained for the rest period of 0.5 times work time. The sEMG results significantly affected the middle deltoid fatigue recovery when the object load changed.

Table 1. Duncan’s new multiple range test for mean %MVC in each experimental condition by tested muscle. Means with the same letter are not significantly different. ($\alpha = 0.05$).

<table>
<thead>
<tr>
<th>Tested muscle</th>
<th>R/W</th>
<th>Mean</th>
<th>Group</th>
<th>Tested muscle</th>
<th>R/W</th>
<th>Mean</th>
<th>Group</th>
<th>Tested muscle</th>
<th>R/W</th>
<th>Mean</th>
<th>Group</th>
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<tbody>
<tr>
<td>biceps brachii</td>
<td>0.25</td>
<td>0.8815</td>
<td>A</td>
<td>middle deltoid</td>
<td>0.25</td>
<td>0.8861</td>
<td>A</td>
<td>anterior deltoid</td>
<td>0.25</td>
<td>0.8409</td>
<td>A</td>
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<td></td>
<td>0.5</td>
<td>0.95</td>
<td>B</td>
<td>deltoid</td>
<td>0.5</td>
<td>0.9318</td>
<td>B</td>
<td>deltoid</td>
<td>0.5</td>
<td>0.8934</td>
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</tr>
<tr>
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<td></td>
<td>1.5</td>
<td>0.946</td>
<td>B</td>
<td></td>
<td>1.5</td>
<td>0.9359</td>
<td>B</td>
</tr>
</tbody>
</table>

R/W: ratio of the rest time to work time

4. Discussion

The study results found that the tested muscle fatigue increased when the handling loads increased and the rest period change might significantly affect the tested muscle recovery in this study. It was suggested that the rest period should be taken at 0.5 times of the working time and the recovery might reach between 87.3% and 98.6%. If the rest was allowed only with shorter time (0.25 times of work time), it was found more than 83.9% recovery could be reached.

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References


