The Effect of Mental Processing on Upper limb Muscle during Repetitive Task Activity


Department of Engineering Design and Manufacturing
University of Malaya
Kuala Lumpur, 50603, Malaysia
Corresponding author’s e-mail: sitizawiahmd@um.edu.my

Abstract: The impact of various levels of mental processing and muscles activity on shoulder was monitored under five experimental tasks. Four female subjects between the ages of 20 to 25 were involved in the experiment. The aim of this study is to determine the relation between mental processing level and muscle activity during repetitive task. In this study, mental arithmetic task was designed to evaluate operator’s mental effort in two conditions: low load condition (adding two-digit number) and high load condition (adding three-digit number). Biceps muscle was chosen for the experiment because of its direct relation to the upper limb muscle activity. The results showed that concurrent mental processing and repetitive physical task demands may increase the biomechanical loading of the musculoskeletal system. It also showed that mental stress appeared when a time pressure coupled with mental workload that might affect task performance of worker.

Keywords: mental fatigue, muscle fatigue, repetitive task, mental processing task

1. INTRODUCTION

Mental fatigue may relate to inability to concentrate while working or having a poor memory of sequences while performing the repetitive task. The concept of mental fatigue early introduced by Grandjean (Grandjean and Kroemer, 1997) was clearly differentiated mental fatigue from physical fatigue. He defined that physical fatigue was concerned on the reduced muscular system performance while mental fatigue deals with much reduced mental performance and the sense of weariness.

An extensive study by Hagberg et al. (1995) explained that work-related musculoskeletal disorders (WMSDs) have become a major problem in several industrialized countries because the work cycles tend to be extremely short and repetitive, and the main work movements are performed by the same muscle groups over and over again. The main physical factors cited as risk factors for promoting upper limbs disorders are awkward positions, excessive force when performing occupational activities, highly repetitive movements and a lack of rest for a proper physiological recovery (Putz-Andersson, 1988). Modern work often requires rapid physical exertions along with different levels of mental processing (Davis, et al., 2002). While the effect of physical workplace factors on muscle loading has been widely documented, few studies have investigated the impact of interaction between mental activity and muscle loads. Therefore, there is a need to determine the relation between mental activity and muscle activity during task performance. The objective of this research is to examine the effect of mental tasks activity on upper limb muscle specifically biceps muscle using EMG during repetitive task.

2. METHODOLOGY

DATALAB 2000 software was used to collect the raw data. In this research, Electromyography (EMG) electrodes were placed on the bulk of the biceps branchii muscles of the subjects while performing the tasks. The biceps branchii muscle is the muscle that supporting the upper limb and hand activity (Roman-Liu, 2004). Subject’s personality type was evaluated by using Myers-Briggs Type Indicator (MBTI).

The primary apparatus used to measure muscle activity was EMG surface electrodes and fixtures used to perform Maximal Voluntary Contractions (MVCs). The subjects were required to push a heavy table which is stationary within 10 seconds before performing their task to get the MVCs. EMG data was measured throughout 3 job cycles. The deviation of each cycle was 30 seconds. Muscle activity was measured during five mental processing tasks. Each subject has to answer a questionnaire before performing their experimental task.
2.1 Experimental Task (Repetitive task)

The experiment was designed to simulate a lifting task in the distribution industry. The signals produced by the respective muscles were recorded using EMG in the ergonomics lab from four healthy subjects. Subjects required to lift few objects to the allocated boxes predetermined by mental task.

2.2 Mental Processing Task

Mental processing was consisted five different tasks which are:
   a. Turning clockwise and counterclockwise according to color
   b. Low mental load condition (adding two digit numbers before lifting)
   c. High mental load condition (adding three digit numbers before lifting)
   d. Mental arithmetic in slow condition (3 lifts/min)
   e. Mental arithmetic in fast condition (5 lifts/min)

2.3 Data Collection and Analysis

According to De Luca (1997), study in the time domain, Root-Mean-Square (RMS) was the most reliable parameters of EMG signals. So, in this study, all EMG signal parameter were calculated in RMS. The equation used is:

\[
RMS = \sqrt{\frac{\sum_{i=1}^{N} x_i^2}{N}}
\]  

(1)

\(X\) = EMG signals data in Volts.
\(N\) = Total number of samples data.

All subjects needed to complete five distribution tasks mentioned which required decision making (mental processing). They have to perform their tasks with their both hand in the standing posture. The results obtained from this experiment were:

1) Muscles activities measured by EMG equipment with the respect to time.
2) Personality evaluated by MBTI questionnaire.

3. RESULTS AND DISCUSSIONS

3.1 MVCs Results

![MVC of Biceps Muscle from Experiment 1 to 5 in Cycle 1](image)

Figure 1. Change of MVC Biceps

The ranged of the MVC was 8.7% to 11.5%. In task 1, the MVC was around 8.7% to 10.5% but advancing when performing task 2. From the graph shown above, MVC values were increasing significantly from task 3 to task 5. In this content, the biceps muscle strength changed when performing more complex mental processing task. For example, the MVC for subjects 4 increased 0.4%, from 10.1% to 10.5%.
3.2 Tasks Correlation

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<th>TASK2</th>
<th>TASK3</th>
<th>TASK4</th>
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<td>TASK5</td>
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<td>.430</td>
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*Correlation values are significant at the 0.05 level (P ≤ 0.05). The grey colored box indicate significant correlation.*

The results showed that task 1 is positively correlated with task 2, 3, 4, and 5 with the Pearson's correlation values 0.938, 0.643, 0.593, and 0.417 respectively. There is strong correlation exist between task 3 and task 4 with task 5. On the other hand, there is a weak correlation exist between task 1 and task 5. Task 5 was significantly different with task 1 because task 1 involved low load condition while task 5 involved mental processing level in fast condition.

**4. CONCLUSION**

It has been proven that different mental workload level will cause muscle to fatigue gradually when performing the repetitive lifting task. In addition, the slow and fast condition which defined as time pressure may lead to muscle fatigue. Ergonomics principle and design had to be added or considered in order to avoid discomfort and work-related muscular disorders.

**5. REFERENCES**


