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Electromyography Analysis during Lifting Tasks: A Pilot Study

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ABSTRACT

Manual Material Handling (MMH) involves lifting, bending, and twisting motions of the torso. Poor lifting technique is often considered a major risk factor in low back injury associated with manual lifting tasks. Currently, there is little work on the effects of lifting on the Malaysian population. The MMH activities that was designed with the different lifting heights, frequency, weight of loads and the effect on of biceps and triceps muscle contraction of the subjects during the lifting tasks were studied. The parameters involved are weight of the loads lifted, height of the loads lifted and lifting frequency as the independent variables. Whereas the dependent variable is Electromyography (EMG) signal. The weight loads are varying from 10kg up to 24kg and the heights of the loads travels from the floor to 70cm and 130cm heights. The frequency of lifting is set to 1 lift and 6 lifts per minute. 14 healthy male and female subjects were recruited in this study. The questionnaires and consent form were used to identify the health condition of the subjects before performing the lifting tasks. The EMG activity was recorded and collected from biceps and triceps muscles using the Shimmer EMG system. This method is used in determining the maximum acceptable weight limit (MAWL) that can be lifted by the subjects in the lifting tasks. This research aims to design a lifting equation that suits for Malaysian people. Therefore, the effects of different manual lifting tasks on Malaysian physiological limits need to be identified.

Keywords: Electromyography, frequency, height, lifting tasks, load

INTRODUCTION

Manual material handling (MMH) involving acts such as lifting, lowering, bending, twisting, holding and others are the tasks

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and activities that involved in our daily life either in one time or frequent as part of regular works. Manual handling tasks occurs in many industries such as constructions, manufacturing, healthcare, hotels, agriculture, restaurant and other industries. In 1981, the National Institute for Occupational Safety and Health (NIOSH) recognised the growing problem of work related back injuries. This problem is contributing to tremendous health care costs, human suffering and lost productivity in company (Elfeituri & Taboun, 2002), (Waters, Anderson, Garg & Fine, 1993), (Rud, 2011), (Medina & Vina, 2012). The repetitive manual lifting of objects and materials will affect potential injuries to the workers involving the musculoskeletal problems (Potvin, 2012). Improper lifting techniques will cause back pain of the workers and also can lead the major loss to the company. Back pain is one of the factors of increasing the medical and compensation cost of the company (Shy, 2008). The performance of the workers such as productivity and quality will also be decreased. The two most prevalent musculoskeletal problems are low back pain and upper extremity cumulative trauma disorders (Marras, Leurgans, Fathallah, Ferguson & Allread, 1995). In MMH, the ergonomic risk factors such as awkward working posture, excessive load, and extreme temperature can also contribute to occupational injuries to workers (Kuorinka, Lortie, & Gautreau, 1994). Risk and back injury are exposed to the workers when they are doing the manual material handling of loads such as transporting and supporting the loads in an unfavourable ergonomic condition (Marras, Leurgans, Fathallah, Ferguson & Allread, 1995), (Kuorinka, Lortie, & Gautreau, 1994).

METHODOLOGY

The material and method were setup for this experiment including posture, variables, procedures and also the equipment used for this experiment.

Subject Selection

A total of 14 healthy subjects between the ages of 23 to 27 years, with no history of back pain were studied. The average height and weight of the subjects were 1.66m and 64.5 kg respectively. A questionnaires and consent form prior to the data collection was given to the subjects. The procedure for conducting the experiment was approved by the Ethics Committee.

Experimental Setup

There are several equipment's used to measure the parameters such as Shimmer EXG Development kit, adjustable table, loads, weight scale and lifting box. Shimmer EMG kit is used as main equipment to display and record the EMG signal of the subjects for each lifting tasks. EMG signal records the electrical activity that associated with muscle contraction and muscle response collected from biceps brachii and triceps brachii.

Lifting Variable. Two types of variable were measured in this experiment, which are the independent and dependent variable.
For independent variable, they are:

a) Weight Loads (L)
The loads are 10kg, 15kg, 20kg, 23kg and 24kg, placed at the centre of the lifting box.

b) Lifting Height (H)
The load will be lift started from the floor and increase at two different heights; 70cm and 130cm.

c) Lifting Frequency (F)
The number of lift; 1 lift per minute and 6 lifts per minute.

While for the dependent variable, EMG was used.
The fixed variables are squat lifting posture, distance of the subject to the table at 0.25m.

Lifting Posture. Squat lifting posture as in Figure 1 used during this lifting tasks. People mostly tend to use squat posture during lifting due to the less energy expenditure used.

Figure 1. Squat posture

Adjustable Table. The adjustable table as in Figure 3 can be adjusted to desired height for lifting tasks which are 70cm and 130cm.

Figure 2. Adjustable Table

Lifting Box and Loads. Lifting box used to carry the load. The box shown in Figure 4 has handles to reduce the grasp force and good coupling grasp. Various weights of loads (L) used in the experiment from 10 kg, 15kg, 20kg, 23kg, and 24kg.

Figure 3. Lifting box and loads

Lifting Procedures. The lifting procedures shown in Figure 5.

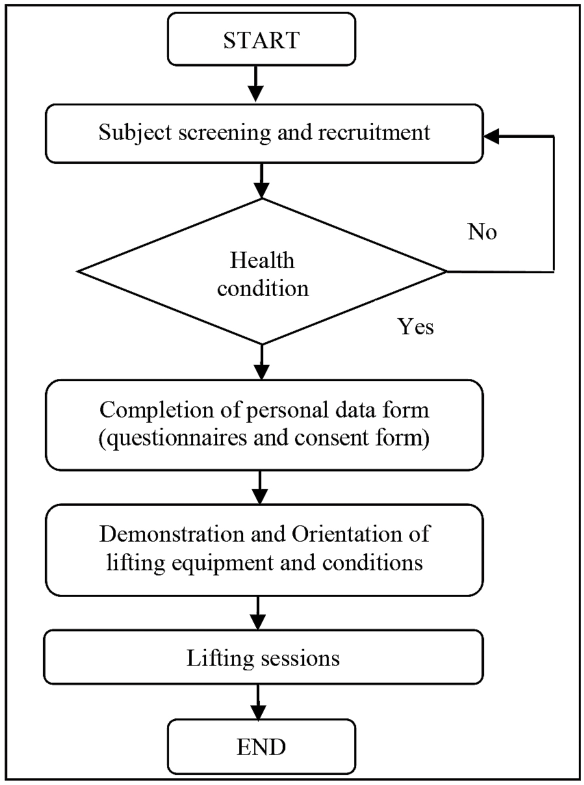

Figure 4. Flowchart of Lifting Procedures

Data Collection

The EMG signals were recorded during the lifting activities. EMG surface electrodes (Ag/AgCI, 10 mm diameter, 20mm inter-electrode distance) were placed near the centre of biceps brachii and triceps brachii muscle. The skin surface was prepared with alcohol prior to electrode attachment and the grounding electrode was placed on ulna bone since it has no effect of electrical biosignal as in Figure 5. The EMG signal shows the level of muscle contraction when the heights and loads of lifting task are varied

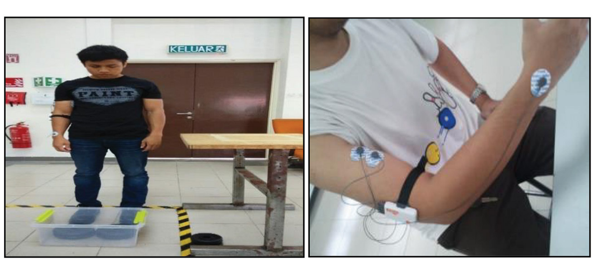

Figure 5. Shimmer EMG electrode placement and lifting setup

After placement of the electrodes, the subjects were asked to contract the muscle like bending the arm. The electrical activity can be seen on the monitor. The signal provides information about the muscle's ability to respond when the muscle nerves are stimulated. The more the muscle contract such as lift the heavier load, the electrical activity increases and a pattern can be seen. This electrical activity pattern can determine how the muscles respond during the lifting task while the loads of lifting were increased.

Lifting Session. Three lifting sessions involved in this experiment. Subjects will be screened by answering questionnaires and short briefing will be given on how to perform the tasks before each session started.

Subjects were given sufficient time to practice and familiarize with the task before actual data were recorded.

Table 1
Lifting Session

Lifting Parameters	**Lifting Session**		
	Session 1	**Session 2**	**Session 3**
Weight Loads	10 kg,15kg, 20kg, 23 kg and 24 kg		
Height	70cm	70cm	130cm
Frequency	1 lift / minute	6 lifts / minute	1 lift / minute 6 lifts / minute

The subjects required to do three major tasks of lifting which included the weight load varies from 10kg to 24kg as summarised in Table 1. The task performed by the subjects consisted of lifting the load from the floor to the desired height level of 70cm for the first and second tasks and increase to 130cm for the third tasks. The frequencies of lifting task were assigning to 1 lift per minute and 6 lifts per minute. During the lifting task, the subjects had the option to withdraw if they cannot proceed to the next stage of lifting tasks with heavier loads.

RESULTS AND DISCUSSION

The results of this study are to identify on how the muscle contraction during the lifting activities at each combination of height and loads together with different lifting frequency.

EMG Signal of Muscle Contraction

Figure 6 shows the relationship between mean of EMG signal and weight of subjects in Session 1. The EMG signal was inversely proportional to the weight of subjects. The force required to lift the load decreases as the weight of subject increases. Hence, the muscle contraction of bigger subjects was lower than the smaller subjects.

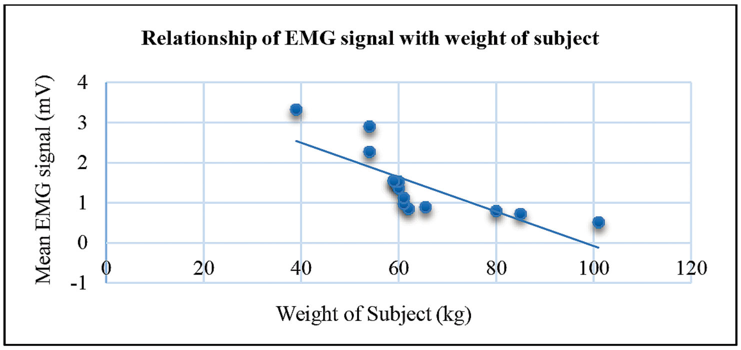

Figure 6. Relationship between EMG Signal and Weight of Subject

Figure 7 refers to Subject 1 with the height of 1.63m and weight of 80 kg in Session 1 lifting task at 70cm lifting height. The subject can lift the entire weight load from 10kg to 24kg. The amplitude of EMG signal increased constantly with the weight loads increased. In Figure 8 which represents the Subject 2 with height of 1.45 m and weight of 39 kg, it shows that the subject only can lift the loads of 10kg and 15kg. The EMG signals shows the subject needs a lot of energy from the biceps muscle to lift the heavy loads. The increasing of the EMG signal when the weight loads is increased associated with the energy that they use up to lift the loads.

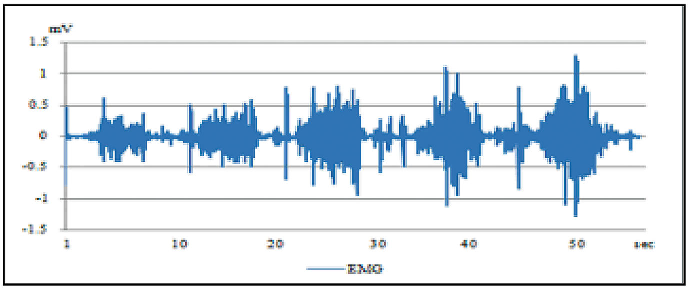

Figure 7. EMG signal of Subject 1 in Session 1

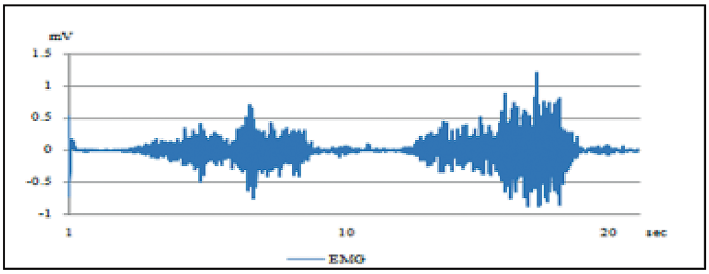

Figure 8. EMG signal Subject 2 in Session 1

Figure 9 and 10 represents the Session 2 for repetitive tasks when the loads were lift 6 lifts per minute of 10kg weight load. This result is based on the same subjects in Session 1. The different capability of different weight of subjects can be seen through the peak amplitude of the EMG signal produced. Figure 8 shows the peak amplitude of EMG signal for Subject 1 is less than 0.6mV. However, Subject 2 represented in Figure 9, the peak amplitude of EMG signals is nearly 1.0mV. The repetitive task of lifting frequencies also will influence the performance of muscle. This graph shows when the muscle contraction is increased, the biceps muscle consumes more energy and the higher the energy consumption, it will induce more fatigue to muscle of the subjects.

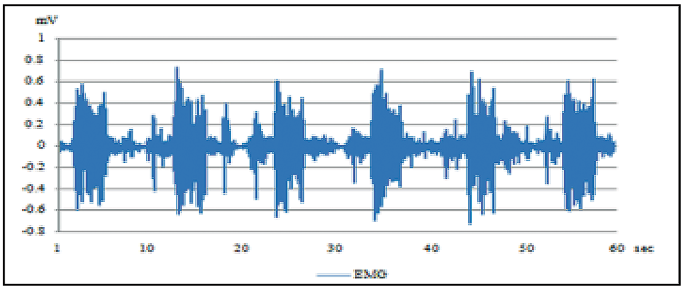

Figure 9. EMG signal Subject 1 in Session 2

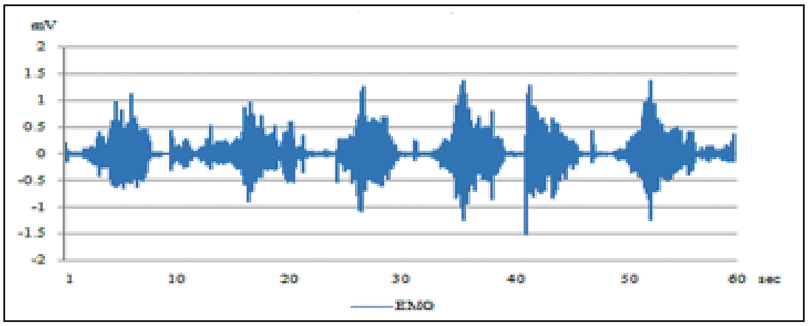

Figure 10. EMG signal Subject 2 in Session 2

Maximum Acceptable Weight Limit (MAWL)

Figure 11 shows the relationship between the weights of subject is directly proportional with the lifting weight loads. When the weight of subject is increased, the weight of loads increased. The bigger size of subjects able to lift the loads from 10kg to maximum of 24kg for 1 lift per minute task since they did not use much energy to lift the loads according to their size of body and strength. This load is within their ability without affecting any back pain problem.

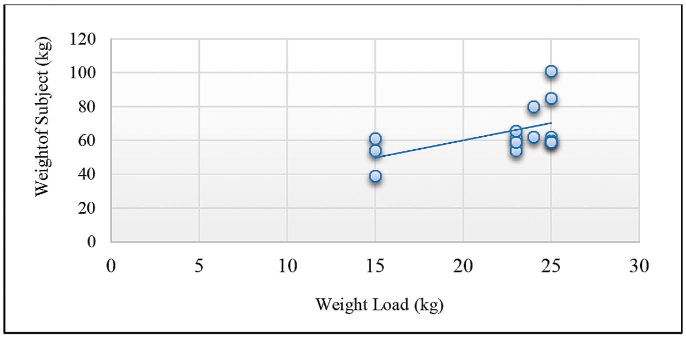

Figure 11. Weight of Subject and Maximum load in Session 1

Based on the Figure 12, it shows that the lifting frequency also effect the capability of the subjects to reach the maximum loads of lift since the number of subjects who can lift the maximum weight loads decrease in session of 6 lifts per minute. This is due to the force and energy are decreasing when the lifting frequency increases and the muscle become fatigued because of repetitive lifting task.

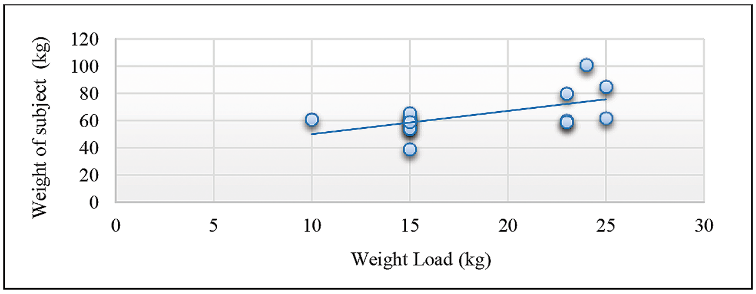

Figure 12. Weight of Subject and Maximum load in Session 2

CONCLUSION

Based on this preliminary experiment, the weight of the loads, height of lifting and lifting frequency could affect how the human body performs the lifting activities in terms of capability to lift the loads concerning of the weight of the subjects and energy used during the lifting tasks. The relationship between EMG signal was inversely proportional to the weight of subjects. The force required to lift the load decreases as the weight of subject increases. Since the smaller subjects need larger force to lift the load, they also required more energy to lift the load compared to the bigger subjects. Hence, the muscle contraction of EMG signal of smaller subjects will be higher than the bigger subjects. The increasing of lifting weight load and height have increased the contraction of EMG signal in the human muscle. The lifting frequencies also affect the muscle strength during the lifting tasks. Further analysis of this research is to define the recommended weight limit that suitable and safe for Malaysian people especially who work in industries to decrease the musculoskeletal disorder and injuries related to manual lifting task and also to increase the safety awareness in the workplace.

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