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INVESTIGATION ON UPPER LIMB AND LOWER BACK MUSCLES ACTIVITIES DURING SEDENTARY WORK.

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ABSTRACT
The objective of this study is to investigate the upper limb and lower back muscles activities while performing a repetitive task in two different work area boundaries during sedentary work. Subjects consisted of 10 males (age mean = 27.7) and 10 females (age mean = 27.5) with no history of musculoskeletal injury or back problem at the time of participation. All of them are right hand dominance and performed same repetitive task in the near and in the far boundary work area in sedentary position. Surface electromyography (EMG) signals were recorded from the Right and Left Levator Scapulae, Right and Left Upper Trapezius, Right and Left Anterior Deltoid and Right and Left Erector Spinae. The results indicated that muscles activities increased significantly when performing work in the far boundary work area. The muscle activity in the far boundary work area is averagely 17% greater than in the near boundary work area. The most active muscle is the Erector Spinae. Females showed higher %MVC compared to males with average of 1.62 %MVC in near and 2.0 %MVC in far boundary work area. The result from independent sample t-test showed that the muscular activities are also affected by the gender differences.

Keywords: *Muscle Activity, Prolonged Sitting, Electromyography*

INTRODUCTION

Improvement in technologies had changed the way people do their jobs. Introduction of automation, robotics and microelectronic technologies into offices and manufacturing plants had led to the increment of office work, machine monitoring and operation work that is performed in a sitting position, for prolonged period of time. Even though sitting jobs require less muscular effort, but that does not exempt people from the injury risks usually associated with more physically demanding tasks. Injuries resulting from sedentary for long periods are a serious occupational health and safety problem. This problem will likely become more common in the future because the trend toward work in a sitting position is still increasing [3].

The majorities of workplace musculoskeletal injuries are related to repetitive muscle strain [8]. In most industrial workstations, workers usually perform manual tasks which involving repetitive arm motions, repetitive loading of muscle and soft tissues. The task done involving light exertion, but fatigue, pain and repetitive strain injuries in arm, shoulder and neck region are prevalent [10][12].The incidence of work-related musculoskeletal disorders is high in workers doing highly repetitive movements. Musculoskeletal disorders due to work related to upper limb disorders and work related back disorders are widely recognized for their adverse impact on worker productivity and health [1].

An optimal workstation is the workstation that support the needs of the worker and where worker operates in a conduce environment to the individual's abilities. The concept of normal and maximum boundary work area has been proposed to the workstation designers to decide on the placement of the workstation components that require manual handling [11]. Based on the boundary work area, all industrial workstation tools, controls, and other elements could be placed in a safe and reachable position. Ergonomics recommendation indicates that as the boundary work area exceeds the limit from near to far boundary work area, it would increase fatigue, pain and lower worker productivity. Workstation design from an ergonomics perspective can effectively enhance productivity through the interaction between the various system components [5].

Operationally gender has been considered as a confounding factor or modifying factor for work related musculoskeletal disorders in the ergonomics and epidemiological literature. According to Hagberg and Wegman (1987) [6], muscular pain in the neck and shoulder is frequent among females than males in both the general and

worker populations. It is not disputed that muscular fatigue is a risk factor for musculoskeletal injury however the disparity between gender with respect to muscular activity and fatigability is not well understood [2].

The absolute levels of muscular force production and fatigability between genders may be predisposition to a greater risk of injury when required to work in a fatigued state [2]. Thus, this study is to investigate the effects of upper limb and lower back muscles activity during prolonged sitting in two different boundaries work area in order to determine the most significant boundary work area for each gender. The result of this study could help engineer to plan compatible and conducive workstation for both genders to reduce fatigue and symptoms of work related musculoskeletal disorder.

MATERIALS AND METHODS

Subjects

Twenty healthy subjects, 10 female and 10 male were participated in this study. The subjects were between the ages of 22 and 37 to match the age range of the target working population. All subjects were right handed dominance and have no previous history of musculoskeletal injuries.

Table 1. Mean and standard deviation for the subjects

	Gender	N	Mean	Std. Deviation	Std. Error Mean
Age	female	10	27.50	5.811	1.838
	male	10	27.70	5.417	1.713

Tasks

The task involves a simple repetitive task where each subject has to group all the blocks and then assemble them accordingly. The tasks were performed in two boundary work area which is in near boundary and far boundary work area. EMG data was recorded throughout the experiment for 40 minutes with 20 minutes for each boundary work area. The chair used in the experiment has fixed height and no back rest.

Table 2. Distance for near and far boundary work area [7]

No.	Boundary Work Area	Distance of the Chair to the Edge of the Table
1	Near	Set to each subject's upper-arm length
2	Far	Set to 70% of the subject's total arm length

Apparatus

Electromyography (EMG) was used to measure upper limb and lower back muscle activities throughout the experiment.

Skin Preparation and Electrode Placement

The skin of each subject was thoroughly clean and prepared for the electrode placement. The surface electrodes were placed over the belly of the following muscles bilaterally [9] (Figure 1):-

1. Anterior deltoid, 2cm below and 1 cm medial to acromion (Hagberg 1981)
2. Trapezius pars descenders, 2cm lateral to half the distance between C7 and acromion (Hagg et al. 1987, Sommerich et al. 1998).
3. Levator scapulae, at base of neck (Schuldt et al. 1986)
4. Erector spinae, 3cm lateral to the spinae at level of L3 (Mirka and Marras 1993) (Figure 2).
5. The ground electrodes were placed on the participant's sacrum (S1) vertebrae.

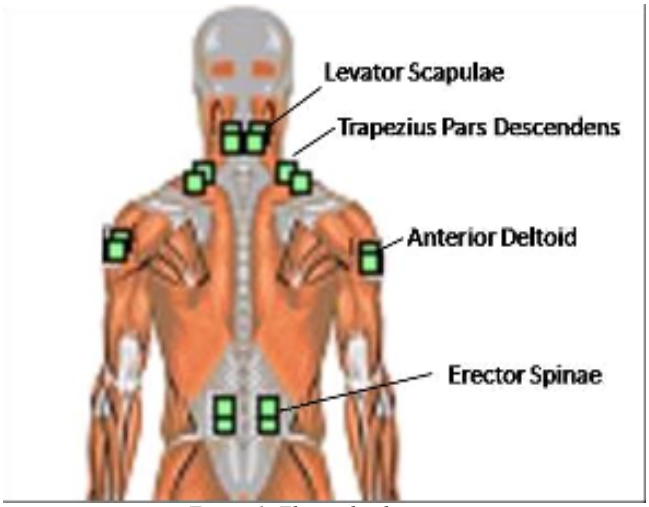

Figure 1. Electrode placement

Maximum Voluntary Contraction

A series of four types of exertion were performed to elicit the maximum muscle activity from each muscle. The exertion starts with pushing a static wall, fixing the arm near 90^o posture, abducting the arm in a 90^o posture with resistance from a strap placed proximal to the elbow (with the elbow angle also at 90^o), pulling up two inextensible straps (at 90^o elbow flexion) and lastly pulling a static load. All the exercises are performed using the exercise equipments in ergonomics laboratory

RESULTS AND DISCUSSION

This investigation was conducted with the objectives of evaluating the effect of upper limb and lower back muscles activity during prolonged sitting in two different boundaries work area to determine the most significant boundary work area for each gender. In order to investigate the upper limb and lower back muscles activity during sedentary work, a repetitive task have been designed in two boundaries work area. All subjects had to complete two repetitive tasks in near boundary work area and in far boundary work area. The EMG signal obtained from the tasks is expressed in terms of percent of MVC. The percent of MVC obtained from each subject muscles are compared and then analyzed with statistical analysis.

The result of %MVC for all muscles in near and far boundary work areas as shown in Figure 2 and 3 indicates that %MVC for all muscles increase with time. The most active muscle in this experiment is Left Erector Spinae, where the %MVC for this muscle is the highest among others. It might be due to Left Erector Spinae muscle is used actively in order to hold the body weight while performing the task during prolonged sitting. Left Anterior Deltoid muscle shows the lowest value of the %MVC. Low %MVC in the Left Anterior Deltoid might due to only simple repetitive task performed during the experimental task which did not involve lifting and only upper arm muscle is used.

All muscles showed higher %MVC in far boundary work area than in near boundary work area with average of 20% higher. This result was due to the longer distance between the chair and edge of the table set during performing the repetitive task. Thus, muscles more active in far boundary work area rather than near boundary work area.

The details comparison for all muscles in the near and far boundary work areas between female and male subjects are shown in the Figure 4 and 5 respectively. The overall results show that females have the highest %MVC value compared to male subjects. Based on these results, female subjects have high muscular activity and easily to feel fatigue rather than male subjects.

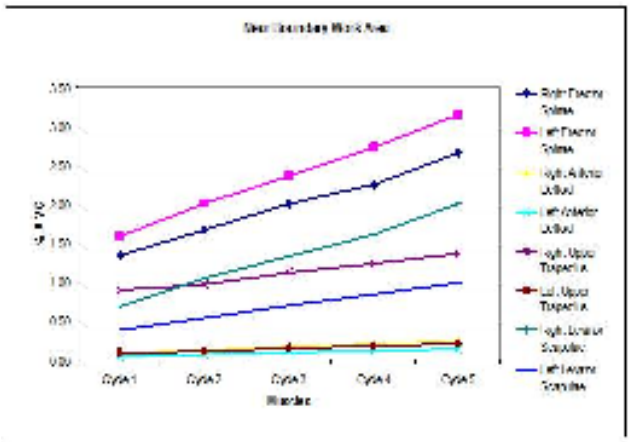

Figure 2. The change in %MVC for all muscles in near boundary

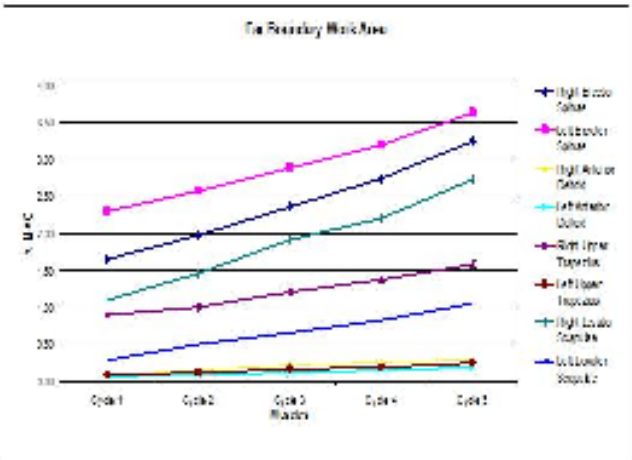

Figure 3. The change in %MVC for all muscles in far boundary.

Figure 4. Summary of %MVC for every muscle in near boundary

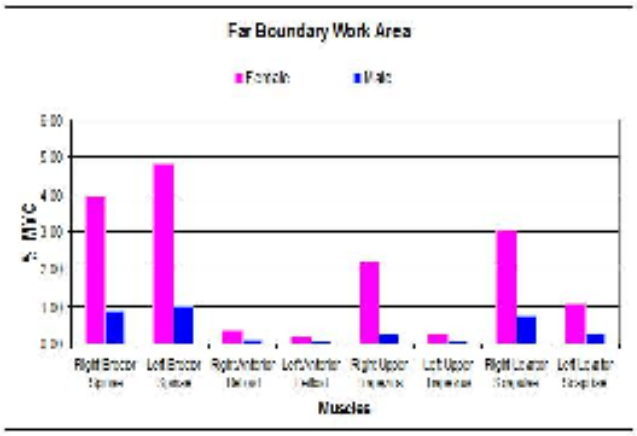

Figure 5. Summary of %MVC for every muscle in far boundary

The Independent Sample T-test result (Table 3) also shows there is significant difference ($p \leq 0.05$) in the %MVC of most muscles for both genders. In near boundary work area, the significant difference are obtained from the Right and Left Erector Spinae, Right Anterior Deltoid, Right Upper Trapezius and Right and Left Erector Spinae. However, in far boundary work area, all muscles show significant different between gender including Trapezius muscle [4]. These results will help in the determination of recommended boundary work area for each gender.

Table 3. p-value for Independent Sample T-Test

Muscle	*P value*	
	Near Boundary	Far Boundary
Right Erector Spinae	0.000	0.000
Left Erector Spinae	0.009	0.003
Right Anterior Deltoid	0.000	0.000
Left Anterior Deltoid	0.085	0.048
Right Upper Trapezius	0.006	0.016
Left Upper Trapezius	0.067	0.050
Right Levator Scapulae	0.004	0.001
Left Levator Scapulae	0.000	0.000

CONCLUSIONS

The value of %MVC in the near boundary work area is lower than in the far boundary work area with 17% different. Different genders show significant difference in the value of %MVC for most muscles including Trapezius muscle. Female shows higher muscular activity than male. Based on the overall result, working in near boundary work area is recommended for both genders since the %MVC is lower than in far boundary work area.

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