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Evaluation of Muscle Activities on Different Type of Exercises During Prolonged Sitting

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Abstract: Electromyography (EMG) signal is an analysis of electrical signals generated during muscular contractions that have been used to measure and record electrical muscle activity usually applied for medical tests. In this research EMG signal is used to; (1) evaluate muscle activations on different gender during prolonged sitting task; (2) investigate the influence of various types of exercise during prolonged sitting on muscle activation and (3) proposed the best exercise that can help to prevent low back discomfort. Twenty subjects (10 males and 10 females) were recruited from undergraduate engineering student's education background in UniMAP with age ranging between 20 to 24 years old. The subject must be asymptomatic back pain, normal BMI and right-handed. . Three different types of sitting, one hour per sitting were done by each subject in order to reach the goals of this study. First sitting (sitting without exercise) was conducted while second and third sitting (sitting with exercise) were done in order the investigate the effectiveness of the exercises. Two different types of exercise were performed in second and third sitting, both of exercises were chosen from Mc Kenzie's exercise. EEGOTM sport device were used to record the EMG signal from four types of muscles which are Erector Spinae, Latissimus Dorsi, Internal Oblique and External Oblique. By comparing the Root Mean Square (RMS) values from EMG signals muscle activation during prolonged sitting and the effectiveness of performing the exercises have been evaluated based on RMS values. As the results, muscle become deactivate during prolonged sitting. The best exercise to reduce back pain discomfort is exercise type 1 (Seated Lumbar Exercise) and it is recommended to perform this exercise regularly to reduce the risk of getting hazardous disease due to prolonged sitting.

Keywords: Prolonged sitting, muscle activity, exercises on prolonged sitting

1. Introduction

Working in prolonged sitting posture has been classified as one of the occupational risk factors which can results in injuries. Prolonged sitting is a commonly adopted posture during work which can cause harm towards human body and leads to body discomfort [1]. Work- related musculoskeletal disorder (WMSDs) is identified as one of the occupational hazard caused by work activities such as prolonged sitting. Sitting duration more than 30 minutes has been classified as sustained posture where particular position was held by the body over prolonged period [2]. Due to the increasing number of WMSDs cases, there are many approaches have been done in order to identify, assess and control the risk of getting this hazardous disorder. Ergonomics modification in the workplace is one of the plans to overcome this problem [3][4],

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yet this approach only focused on changing workstation or working style which may contribute extra expenses. The initiative which does not contribute any loss towards the company is by ensuring each of the employees to give attention to their health. The strength impact of doing exercise in reducing harmful effect towards human body has been discovered [5],[6]. However, there is still lack of evidence based on the previous study which proved the effectiveness of the exercise in term of muscle activation (EMG signal). Besides, which type of exercises are eligible for both genders especially during prolonged sitting also yet observed in past studies [7]. This is because, muscle activation between men and women may be not equal to each other. Thus, this research focussed on the incompetent information from previous study. Moreover, the exercise conducted from this research can be used for all especially for those who require sitting in long duration per day. In addition, this research can be evidence for the effectiveness of doing exercise to reduce low back discomfort thus it will help in preventing chronic back pain.

2. Experiment

2.1 Subject

Twenty subjects aged between 20 to 24 years old have participated in this study. All subjects are normal body mass index, right-handed dominant and without back pain history. This criterion of subject selection is compulsory to standardized subject's state.

2.2 Experimental Setup

The experiment starts with a briefing about the protocols of the experiment. All subjects were not allowed to do excessive movement such as bend, twist, flex and get up from the chair during one hour of sitting. After the explanation, EEGO Sport Device was set up and electrodes were attached to the desired muscle (Erector Spinae, Latissimus Dorsi, Internal Oblique and External Oblique) as shown in Fig. 1. The electrodes only attached at the right side of muscle since it is not much difference between both right and left side. The ground electrode will be placed at the bone (elbow). Table 1 shows the exact location for electrode placement. In order to assure the electrode were correctly attached to the muscle, subjects require to twist and bend their body and the signal is observed. This step is done before one hour of sitting. 15 minutes break was allocated between each task to prevent fatigue.

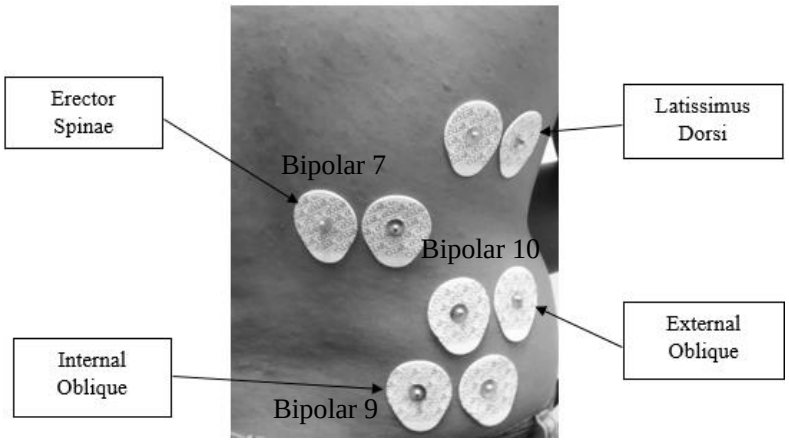

Fig. 1 - Electrode placements based on muscle that associate with back pain

Table 1 - Location of EMG electrodes

Bipolar Channel	Muscle	Placement
Bipolar 7	Erector Spinae (ES)	Largest muscle, roughly 4 cm from midline
Bipolar 8	Latissimus Dorsi (LD)	Muscle at the most lateral
Bipolar 9	Internal Oblique (IO)	Below external oblique electrode and just upper to inguinal ligament.
Bipolar 10	External Oblique (EO)	Roughly 15 cm from midline

2.3 Experimental Protocol

The amplifier will be directly connected to the tablet and bipolar channels. In this experiment, only four channels were used which are Bipolar 7, Bipolar 8, Bipolar 9 and Bipolar 10. The raw data of EMG signal in the tablet is filtered by using Notch filter and the frequency is between 3 Hz to 70 Hz to remove electrical noise, digitally bandpass 20 Hz to 450 Hz and the sampling rate is 1000 per second. The subjects were required to do sedentary work during one hour of sitting which are reading and writing. The exercises done for second and third sitting are based on McKenzie's exercise. The overall flow of this research has been summarized in Fig. 2.

Explanations of both exercises can be seen in Table 2 and Fig. 3. In the second sitting which is sitting with exercise type 1, the exercise done is Seated Lumbar. Meanwhile, for third sitting, exercise type 2 applied is a Standing Lumbar Extension. The raw data will be recorded three times for first sitting and four times for second, and third sitting. The data for first sitting (without exercise) was recorded one minute per duration which are the first one minute of sitting, one minute in the middle (after 30 minutes of sitting) and the last one minutes.

Table 2 - Mckenzie's Exercises [8][9]

Seated Lumbar Exercise (Exercise Type 1)	**Standing Lumbar Extension Exercise (Exercise Type 2)**
Subject sat in a good posture with hand resting on knee, then moved forward and bend down. While bend down subject exhale and inhale when rise back. The steps are repeated for 10 times.	Subject stand with him/her feet shoulder-width apart, hands are placed on small of the back. Spine is slowly bent backward as far as possible. The end position is hold for a few seconds and returned back to upright position. The exercise is repeated for 10 times.

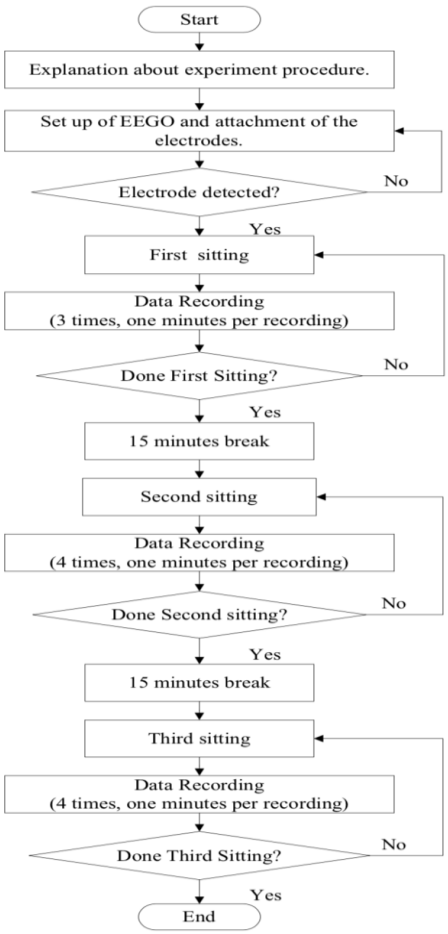

Fig. 2 - Flow of the research

Besides, for second and third sitting the data were recorded four times. The first recording starts at the first one minute of sitting. Since the exercise will be done after 30 minutes of sitting, the second and third recording were recorded for one minute before exercise and one minute after exercise. The recording will show is there any different in activation of muscle before and after doing the exercise. The fourth data recording will be recorded for one minute after one hour of sitting. After all data were collected, the data have directly transferred from the tablet through email to avoid losses of data.

a b

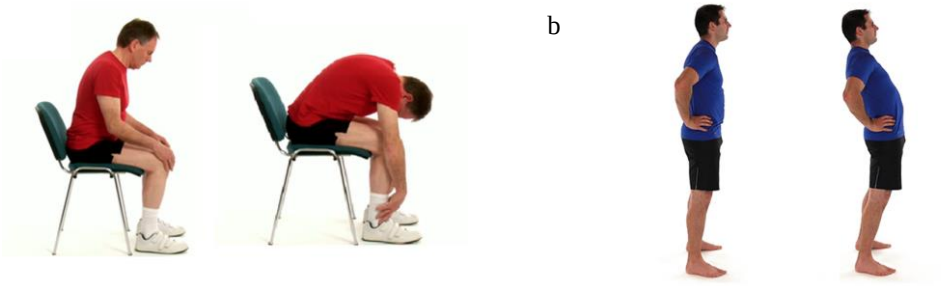

Fig. 3 - Two different exercises that been performed in this research, (a) seated lumbar exercise and (b) standing lumbar extension exercise

3. Data Analysis

3.1 Signal Processing

All collected data will be analysed by using matrix laboratory (MATLAB) software. MATLAB is used in analysing electromyography (EMG) data. In analysing process, only 10000 data will be used from 60000. 10000 recorded data will be directly segmented by using rectangular windows in MATLAB software. After the segmentation process, fourth order, high pass Butterworth filter (30Hz), has been used to eliminate heart rate contamination [10]. By integrating simple coding, data will be imported and the values of root mean square will be directly executed from the segmented data.

3.2 Statistical Analysis

SPSS software was used to perform quantitative analysis complete statistical package based on point and click interface. One-way analysis of variance (ANOVA) was conducted to compare RMS values of each muscle among groups (gender). Meanwhile, in evaluating muscle activation for one hour of sitting, paired t-test was performed. *P* values (significance values) obtained from these two tests were compared with 95% confident level.

4. Results and Discussion

4.1 Signal Processing

RMS values from first sitting were obtained to indicate muscle activity during one hour of sitting. The first sitting was done to evaluate muscle activities on different gender. In this first sitting, there was no exercise done by all subjects. Average RMS value for each recording was obtained from 10000 data. The average values of RMS from 1st recording (1 minute of sitting) and 3rd recording (after 1 hour of sitting) were compared to observe changes in muscle activation for four types of muscle during one hour sitting based on gender.

Fig. 4 illustrated the comparison between female and male subjects based on average values of RMS during one minute of sitting and after one hour of sitting for four different muscles. By comparing all RMS values, male subjects have highest RMS values for each muscle. After one hour of sitting, values of RMS for both genders were decreased. Erector Spinae indicate the maximum value of RMS for both genders, which are females, 5.02 and males, 5.80. Muscle with the lowest average values of RMS for female was Latissimus Dorsi. Meanwhile, for male, the lowest average values of RMS were shown in External Oblique muscle.

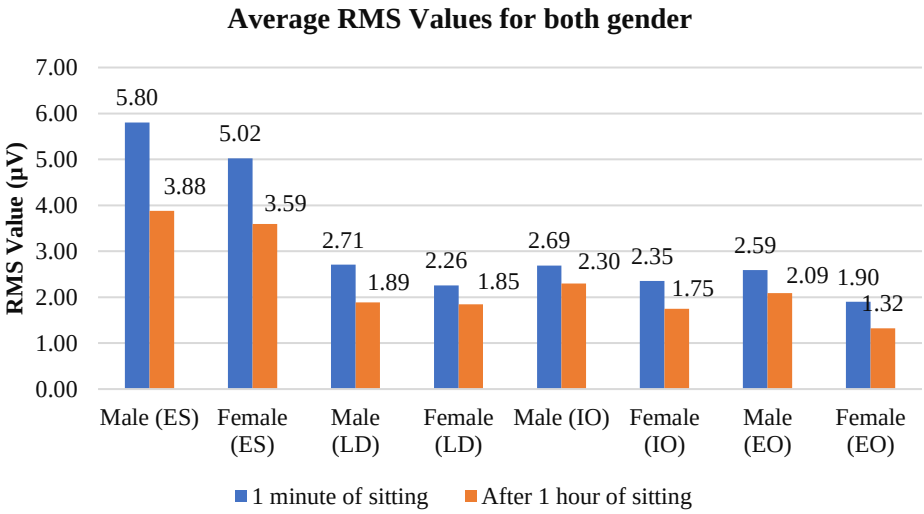

Fig. 4 - Bar graph for average values of RMS (µV)

One-way ANOVA was used to compare RMS values between genders for each type of muscle after one hour of sitting. In this test, gender has been divided into two groups which is Group 1 for male and Group 2 female. Table 3 shows that there is no significant difference in both genders during one hour of sitting since its significance values is more than 0.05.

Table 3 - One-Way ANOVA for both genders with different muscles

RMS Values		N	df	Sig. Values
1 hour (ES)	Between groups	10	1	0.868
	Within groups		8	
	Total		9	
1 hour (LD)	Between groups	10	1	0.957
	Within groups		8	
	Total		9	
1 hour (IO)	Between groups	10	1	0.379
	Within groups		8	
	Total		9	
1 hour (EO)	Between groups	10	1	0.130
	Within groups		8	
	Total		9	

4.2 Effectiveness of Doing Exercise

RMS values from second and third sitting were used to evaluate the effect of doing exercise during prolonged sitting. Both sitting involved with exercises that have been done after 30 minutes of sitting. Collected data were divided into 1000 from 10000 of data for each recording to get the average value of RMS. Average values of RMS from all recording were used to observe changes in muscle activation for four types of muscle based on gender.

Table 4 shows the RMS values for both genders. Erector Spinae was having the highest value of RMS for both genders. Muscle with the lowest value of RMS for both genders were similar which is Latissimus Dorsi. However, muscle activation between male and female were different before and after performing Seated Lumbar Exercise since male show the reduction of RMS values once doing the exercise. On the other hand, female show the increment of RMS values after performing the exercise.

Table 4 - Average values of RMS for both genders (2nd sitting) (µV)

Recording time	Male				Recording time	Female			
	Muscle					Muscle			
	Erector Spinae	Latissimus Dorsi	Internal Oblique	External Oblique		Erector Spinae	Latissimus Dorsi	Internal Oblique	External Oblique
1 minute of sitting	5.18	2.04	3.80	3.79	1 minute of sitting	4.51	1.91	2.84	2.17
30 minutes (Before Exercise)	5.04	2.21	3.41	3.46	30 minutes (Before Exercise)	4.05	1.89	2.16	2.48
30 Minutes (After Exercise)	5.11	2.51	3.50	3.55	30 Minutes (After Exercise)	4.75	2.85	2.39	2.21
1 hour of sitting	4.60	2.45	2.26	3.58	1 hour of sitting	5.49	1.90	3.13	3.85

While in Table 5, it shows that Erector Spinae was having the highest value of RMS for both genders. Muscle with the lowest value of RMS for both genders were similar which is Latissimus Dorsi. However, muscle activation between male and female were different before and after performing Standing Lumbar Extension Exercise. Males show the decrement of RMS values for all muscle except for Internal Oblique. Meanwhile for females, it is shown that RMS values were increased for all muscle except for External Oblique.

Table 5 - Average values of RMS for both genders (3rd sitting) (µV)

Recording time	Male				Recording time	Female			
	Muscle					Muscle			
	Erector Spinae	Latissimus Dorsi	Internal Oblique	External Oblique		Erector Spinae	Latissimus Dorsi	Internal Oblique	External Oblique
1 minute of sitting	5.60	2.71	2.45	3.45	1 minute of sitting	5.49	2.65	2.35	2.66
30 minutes (Before Exercise)	6.57	2.94	2.48	3.55	30 minutes (Before Exercise)	5.65	1.98	2.86	1.75
30 Minutes (After Exercise)	5.47	2.08	2.52	3.37	30 Minutes (After Exercise)	6.35	2.08	2.45	2.68
1 hour of sitting	6.34	1.73	3.17	2.04	1 hour of sitting	4.58	1.94	1.77	2.41

5. Conclusion

Sitting in one hour would reduce muscle activity and it is proven since values of RMS were decreased in both genders after one hour of sitting. Meanwhile, sitting with Seated Lumbar exercise (Type 1) shows the increasing values of RMS in female after performing the exercise. Due to the increment RMS values after performing Seated Lumbar exercise, muscle has been activated to improve the muscle activity that reduced by time during prolonged sitting. Thus, it is proved that Seated Lumbar exercise (Type 1) is the best exercise, which helps to prevent low back discomfort. As for future study, it is recommended that this type of research should focus on two groups which are with and without history of back pain to determine how muscle will react to the exercises. This is very important for the researcher to build a platform for further reference since previous studies do not show the detailed comparison on muscle activities between genders during prolonged sitting. Other type of exercises can also be implemented for further analysis of this study.

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