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Research Article

Effect of Break Time on the Upper Extremity Musculoskeletal Disorder Development among Intensive Computer Users in Malaysia

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Abstract

Upper extremity musculoskeletal disorder (MSD) has become a common problem among office workers in Malaysia. Studies have shown that an appropriate work-rest schedule can reduce fatigue and MSDs among office workers. In Malaysia, there has been an increase in the occurrence of MSDs, especially in work that require intensive computer use. Operators who used computers continuously for more than 4 hours a day have shown to develop CTDs. Studies on the effect of break time on the performance of office workers in Malaysia are still lacking. As such this study was aimed to evaluate effect of work rest schedule on the discomfort, performance and muscular load levels of computer users in Malaysia. The effect of break time starting with no break, one minute and 30 seconds break interval were carried out on the 15 subjects. EMG was measured for each task given. Performance which was calculated by multiplying speed and accuracy (WPM) showed 30 seconds break was 13.5% higher than 1 minute break and 20.14% higher than schedule with no break. EMG analyses showed 30 seconds have lowest mean AEMG which was 0.035 for flexor carpi ulnaris and 0.0331 for radialis muscles. It also recorded least discomfort scale for upper extremity muscles compared to the other two schedules. This study showed that more frequent microbreaks can improve performance of office workers and reduce MSD problem from occurring.

Keywords: MSD, EMG, Microbreaks, Intensive Typing, Work Rest Schedules

1.0 Introduction

Cumulative Trauma Disorders (CTD) is used to describe repetitive strain injuries of musculoskeletal and nervous system (Ahmad, 2006). Generally, sedentary working people such as office workers whose job are mainly focused on computers and typing activity are highly exposed to the risk of CTDs such as carpal tunnel syndrome, tendonitis and low back disorders. One of the major factors that contribute to the development of CTD is repetitive task using certain parts of the body for prolonged period without sufficient interval break. The number of reported cases of office workers experiencing work related musculoskeletal disorder increases annually in Malaysia. One third of the total cases was attributed to computer related work since 61.4% of the workforce in Malaysia are highly dependent on computers, according to the report from the National Institute of Occupational Safety and Health (Niosh), Malaysia.

Work intensity and time spent on computer activities have increased rapidly following the advancement of technology and the need to complete jobs at a faster rate. This situation has led to an unhealthy working condition which slowly and progressively develops musculoskeletal Disorder (MSD) (Rojects, 2013; Gonzalez et al., 2016). Besides afflicting health and well-being of the workers, long hours of continuous computer-mediated work can also affect occupational performance and increase compensation rate to cover the medical cost. In addition, musculoskeletal disorder of the upper extremity body parts is costly to treat.

Studies by Sheahan et al. (2016); Rempel et al. (2007) has investigated that periodic rest breaks can minimize self-report discomfort at the upper limb muscles by as much as 35% while sustaining or even improving work productivity and speed. According to Silva (2014); Pillastrini, (2010), both overall body discomfort and productivity can be improved by practicing scheduled rest breaks at 15- min intervals over the duration of six-week intervention. Findings of Rempel has been supported by Chowdhury et al. (2013) that 15-min interval break was very effective for reducing physical discomfort at the shoulder, neck, back and upper arm and at the same time improve workers` productivity, accuracy and speed during prolonged seating. As for 5-min rest break for every 30 minutes work during seated work was more beneficial to reduce blurred vision, eyestrain and physical discomfort on various body regions.

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Therefore, the purpose of this study is to examine the effect of three different rest break schedules on muscle fatigue and work productivity, engaged in prolonged seated work. It is hypothesized that office workers with frequent and shorter break time shows better tying performance with less muscle fatigue.

2.0 Materials and methods

2.1 Electromyography

Electromyography (EMG) method was used in this study to determine an appropriate work rest schedule (Simoneau, et al., 2013). This experiment was conducted in the Bioscience Faculty of UPM involving UPM students as participants. This study has been approved by University Ethics Committee for Involving Human (JKEUPM). Six females (mean weight =50.2±5kg, mean height= 1.5± 0.2m) and nine males (mean weight, 60.53±28kg, mean height= 1.67±0.12m); were recruited from the university population. Participant was excluded from the study if diagnosed with chronic wrist pain such as carpal tunnel syndrome or other neuromuscular disorders. In addition, participants were asked to avoid from any vigorous activities or core exercises 24h prior to the participation in the experiment. Participants were also requested to understand and sign up an informed consent form before beginning the experiment. Participants` skin was prepared over the dominant forearm muscles such as flexor carpi ulnaris and flexor carpi radialis. Biopotential electrodes were placed on the muscles after validated through palpation and signal response to muscle contraction (Onyebeke et. al., 2014). A ground electrode was placed on dry earth strap around the wrist. EMG electrodes (Delsys PowerLab 15T (LTS) were attached to the skin on the particular spot using pre-gelled adhesives (Gerard et. al., 2002).

2.2 Protocol

Participants were invited for three different sessions on the same day to complete three working schedules. Participants were given a printed 3 page document at each session to type in the word file. Prior to the typing, the participants were reminded to not to delete or backspace any spelling mistakes and must type at normal speed as it will influence the productivity and speed calculation during analysis. A microbreak time software which was saved in the desktop initially will remind the participants to pause and take a break at an appropriate intervals. Table2.1 shows three separate work rest schedules provided to participants.

Table 2.1 Work Rest schedules

Schedules	**1**	**2**	**3**
Work rest period	No rest	1 minute break at every 15 minutes interval	30 seconds break at every 10 minutes interval

2.3 Data analysis for EMG

The myoelectric signals received from the muscle contraction was digitalized and inserted into a computer where it will be filtered, processed and analyzed by LabChart software through the method of artificial neural networks to indicate the muscle fatigue level from continuous typing for three schedules. Then a measured p-test and t-test applied to each of the schedules to show the difference in the mean frequency produced by the FCU and FCR muscles. Schedule 1 (without break) was set as a controlled experiment to compare with schedule 2 and schedule 3.

Another analysis which was carried in the experiment was measuring typing performance in terms of speed and accuracy. The typing speed of each participants was measured based on the keystroke per minute or word per minute (WPM). Typing speed also compared among three different sessions to find the significant relationship with the application of break time. Accuracy was measured for each participant at the end of their session based on the equation as below (Sheahan, Diesbourg, & Fischer, 2016):

$$\text{Accuracy} = \frac{(\textit{Number of correct words})}{\textit{Total words}}$$

At the end of each schedule, respondents were given a questionnaire to evaluate the discomfort level scores. Three different classes were used to organize the discomfort scores such as minimum, average and high. Minimum class comprised of scores from 1-5; average class used score 5 and high class used score number 6 to 10.

3.0 Results and discussion

3.1 Results of EMG study

The results presented here were quantitative in nature. Muscular fatigue experienced during prolonged typing activity was tested using electromyogram (EMG). The overall performance of the typing skill was measured from the product of speed and accuracy (word per minute/WPM) and discomfort levels experienced from each schedules were collected from questionnaire.

3.2 Comparison of muscle activity level among schedule 1, schedule 2 and schedule 3

The mean EMG signals produced by flexor carpi ulnaris and flexor carpi radialis muscles which were responsible for the wrist abduction (ulnar deviation) and wrist adduction (radial deviation) postures during typing was recorded. The readings were taken three times at separate time for each respondents as shown in the table 2.1. The EMG signal was recorded using Delsys power lab. An average EMG (AEMG) values were calculated for analysis. Table 3.1, 3.2 and 3.3 presents average EMG values for all the 15 respondents.

Table 3.1 Comparison between EMG value related to the flexor carpi ulnaris and carpi radialis muscles Activity of the respondents for schedule 1 (controlled study) and schedule 2

Parameters	**Electromyography reading**			
	Schedule 1 (Controlled Study)	Schedule 2	t-value	p-value
Mean AEMG-1 (mV)	0.0414±0.02	0.0379± 0.018	5.859	0.942**
Mean AEMG-2 (mV)	0.0435±0.018	0.0363±0.008	4.780	0.603*

**Correlation is significant at the 0.01 level (2-tailed). *Correlation is significant at the 0.05 level (2-tailed)

Table 3.2 Comparison between EMG value related to the flexor carpi ulnaris and carpi radialis muscles activity of the respondents for schedule 1 (controlled study) and schedule 3

Parameters	**Electromyography reading**			
	Schedule 1 (Controlled Study)	Schedule 3	t-value	p-value
Mean AEMG-1 (mV)	0.0414±0.02	0.0350±0.012	7.498	0.930**
Mean AEMG-2 (mV)	0.0435±0.018	0.0331±0.011	5.543	0.253

**Correlation is significant at the 0.01 level (2-tailed)

Table 3.3 Comparison between EMG values related to the flexor carpi ulnaris and carpi radialis muscles activity of the respondents for schedule 2 and schedule 3

Parameters	**Electromyography reading**			
	Schedule 2	Schedule 3	t-value	p-value
Mean AEMG-1 (mV)	0.0379± 0.018	0.0350±0.012	4.358	0.928**
Mean AEMG-2 (mV)	0.0363±0.008	0.0331±0.011	4.375	0.747**

**Correlation is significant at the 0.01 level (2-tailed)

Based on the table 3.1, 3.2 and 3.3, schedule 1 showed higher mean AEMG compared to schedule 2 and 3 which is 0.0414±0.02 for muscle 1 and 0.0435±0.018 for muscle 2. Schedule 3 showed the lowest mean AEMG that is 0.0350±0.012 for muscle 1 and 0.0331±0.011 for muscle 2. This shows that schedule 3 which practiced 30 seconds break at every 10 minutes can reduce the muscle load and help to reduce MSD problems.

The amplitude of the EMG signal ranges from -0.1 to 0.1mV (peak-to peak). The parameter used to measure the amplitude of three different schedules was mean frequency value. The comparison in terms of mean frequency measured during the schedule 1 (no break), schedule 2 and 3 (with break) protocols were presented in Figure 3.2.

The graph in Figure 3.2 showed that mean frequency of the EMG was initially at the same position at 1.5th minute of typing which was between the ranges of (0.03 to 0.035mV). The mean EMG frequency increased continuously for all the three schedules gradually over time for the 30 minutes of typing duration. However the increment for schedule 1 was slightly higher than schedule 2 and 3 throughout the typing period. From 25.5th minutes of typing, EMG mean frequency for schedule 1 started to rise more rapidly until it reached 0.05mV at 30th minute. Similarly mean frequency for schedule 2 started to rise from 27th minute and reached 0.049mV at 30th minute. However in schedule 3, the mean frequency increased slightly from 0.036mV at (22.5th min) to 0.04mV at (25.5th min) and remains at 0.04mV until 30th minutes of typing. This showed that increment of muscle load in terms of mean frequency (mV) was less in schedule 3 compared to schedule 1 and 2 due to more frequent rest breaks.

Over a sustained postural contraction, activation and deactivation of different postural muscles within FCU and FCR occurred. Microbreaks induced changes in the mean frequency due to changes in muscle activation where the motor units become less inactive after a break. According to McLean (2001), postural shifts caused reduction of intramuscular pressure, hence promoting the clearance of byproducts such as inorganic phosphate and potassium ions of the muscles. This work induces recovery from fatigue in the affected motor units. Hence implementing more frequent microbreaks can demonstrate less muscle fatigue during sustained typing activity. Balci (2004) concluded that, short and frequent breaks prevent musculoskeletal discomfort from exceeding the ‘quite-a-bit’ threshold for 99% of the VDT populations.

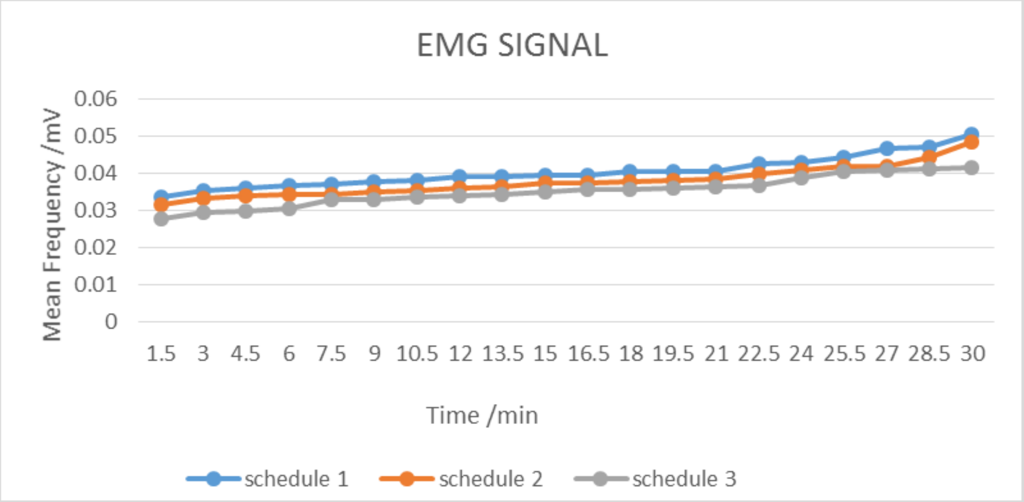

Figure 3.2 The comparison in terms of mean frequency measured during the schedule 1 (no break), schedule 2 and 3 which are (with break)

Due to the experimental design, other factors which might have caused the changes in EMG signals and productivity measures which cannot be avoided. As an example some participants have picked up phones or adjusted their chair. During these occasion, some moments would have dragged for the respondents to get back to their script which they have left and slow down their writing. At the end of each schedules, they were advised to perform some simple stretching activities.

3.3 Comparison in the typing speed and accuracy among the three respective schedules of all the 15 respondents

The overall performance of the respondents was measured by multiplying speed (WPM) and accuracy from their typed script and compared between schedule 1, 2 and 3. The average typing speed which was measured for each respondents at the beginning of the experiments was 24 ± 11 wpm (range 21-30 wpm). Table 3.4, 3.5 and 3.5 showed the comparison between the typing speed and accuracy of the respondents for schedule 1 (controlled study) schedule 2 and schedule 3.

Table 3.4, 3.5 and 3.6 showed the mean values of speed and accuracy for each schedules and correlational analysis among schedule 1, 2 and 3. Typing speed and accuracy in schedule 3 showed higher mean values compared to schedule 1 and 2. The typing speed and accuracy was the lowest in schedule 1 followed by schedule 2 which considered the performance was poor. As for the correlational analysis, schedules between 1 and 3 showed the higher positive significant values which was 0.993 for speed and 0.846 for accuracy which indicate that workers typing performance have increased significantly in schedule 3 compared to schedule 1.

Table 3.4 Comparison between typing speed and accuracy of the respondents for schedule 1 (controlled study) and schedule 2

Parameters	**Performance measures**		
	Schedule 1 (Controlled Study)	Schedule 2	p-value
Speed (WPM)	21.88 ± 5.30	23.20 ± 4.80	0.987**
Accuracy	0.92 ± 0.017	0.94 ± 0.019	0.778**

**Correlation is significant at the 0.01 level (2-tailed)

Table 3.5 Comparison between typing speed and accuracy of the respondents for schedule 1 (controlled study) and schedule 3

Parameters	**Performance Measures**		
	Schedule 1 (Controlled Study)	Schedule 3	p-value
Speed (WPM)	21.88 ± 5.30	25.68 ± 4.95	0.993**
Accuracy	0.92 ± 0.017	0.95 ± 0.016	0.846**

**Correlation is significant at the 0.01 level (2-tailed)

Table 3.6 Comparison between typing speed and accuracy of the respondents for schedule 2 and schedule 3

Parameters	Performance Measures		
	Schedule 2	Schedule 3	p-value
Speed (WPM)	23.20 ± 4.80	25.68 ± 4.95	0.876**
Accuracy	0.94 ± 0.019	0.95 ± 0.016	0. 841**

**Correlation is significant at the 0.01 level (2-tailed)

Figure 3.3 shows the overall performance which was the product between speed and accuracy for all the three schedules. Based on the Figure 3.3, the overall performance of typing task with schedule 3 was 13.5% higher than schedule 2 and 20.14% higher than schedule 1. This result was consistent with the findings by (Toosi et al., 2011) who stated that more frequent microbreaks can improve typing performance due to the sufficient recovery time. (Balci & Aghazadeh, 2004) reported that operators` productivity can benefit from short and frequent rest breaks. The poor performance level in the schedule 1 might be due to the muscle fatigue or loss of focus which slow down the typing speed and make more typing errors. The result of this experiment revealed that more frequent microbreaks can improve overall performance of typing activity.

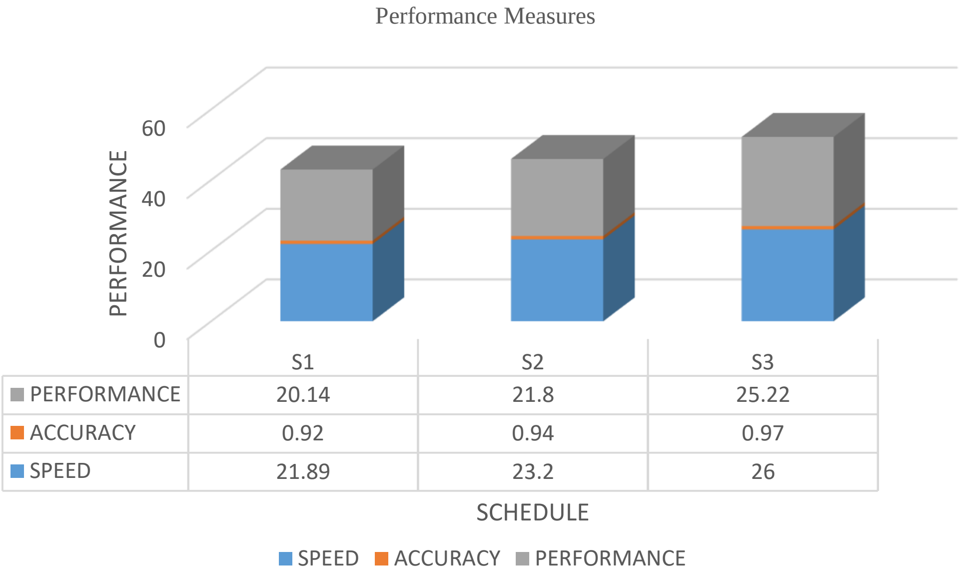

Figure 3.3 Overall performance
The overall performance of the respondents for each schedules

3.4 *Comparison of muscle discomfort level among schedule 1, schedule 2 and schedule 3*

At the end of each schedules, respondents were given a questionnaire to evaluate the discomfort level scores. Three different classes were used to organize the discomfort scores such as minimum, average and high. Minimum class comprised of scores from 1-5; average class used score 5 and high class used score number 6 to 10. Respondents were asked to record the discomfort level for the upper extremity parts such as shoulder, forearm, upper arm, elbow fingers and wrist. The discomfort scores were shown in the Figures 3.4, 3.5 and 3.6.

Figures 3.4, 3.5 and 3.6 displays the discomfort questionnaire scores which were completed at the end of each schedules. Schedule 1 recorded greater number of high scores especially on the shoulder (87%) and upper arm regions (53.33%) followed by other parts such as forearm, elbow, fingers and wrist (33.33%). Higher minimum discomfort was recorded on the elbow, fingers and wrist which were (53%). Average discomfort was recorded by 13.33% of respondents on upper arm, fingers and wrist. In schedule 2 more respondents recorded minimum discomfort percentage such as on forearm and elbow (80%); upper arm, fingers and wrist (66.66%). High discomfort percentage was recorded on shoulder which was 46.7% followed by upper arm and wrist (20%). Average discomfort was recorded on fingers (20%); shoulder, wrist, upper arm and elbow was 13.33 percentage and forearm 6.66%. In schedule 3, most of the respondents recorded minimal discomfort where 93% on finger; 87% on elbow and wrist; 80%, 78.6% and 53% on forearm, upper arm and shoulder part respectively. Average discomfort on shoulder, forearm, upper arm by 13.33% while elbow, fingers and wrist 6.66%. However 33.33 percentage of respondents still recorded high discomfort shoulder region; 6.66% on forearm, elbow and wrist.

This study showed that work rest schedules made a significant difference in the amount of upper extremity discomfort. The schedule 1 which was with no break showed the highest percentage on the high discomfort scores. In schedule 2, high discomfort scores had become less and scores for average and minimal discomfort has increased. As for the schedule 3, higher percentage was for minimal and average discomfort for most of the body parts except shoulder. This results conclude that short and frequent breaks can prevent musculoskeletal discomfort on most of the body parts. Rana Balci (2004) have showed that 30/5 schedule have decreased musculoskeletal fatigue among VDT workers in his study.

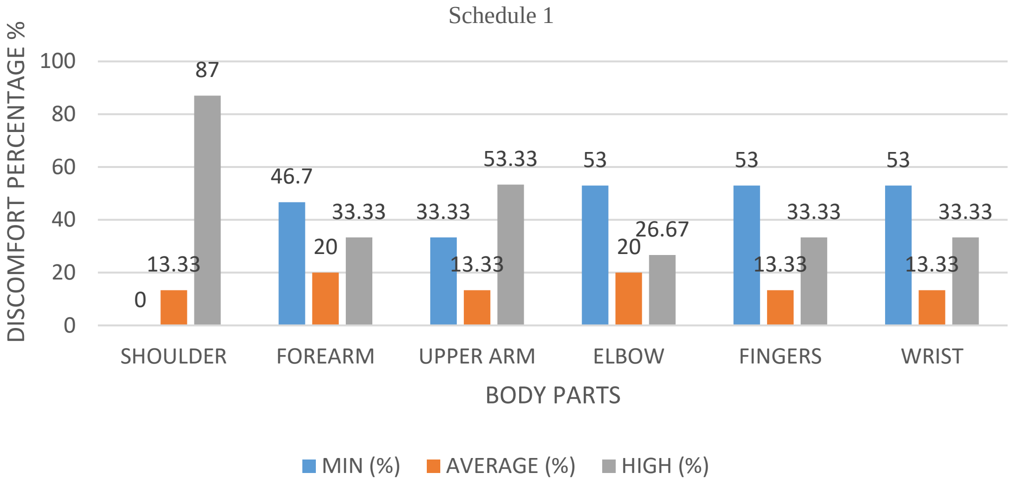

Figure 3.4: Discomfort scores for schedule 1

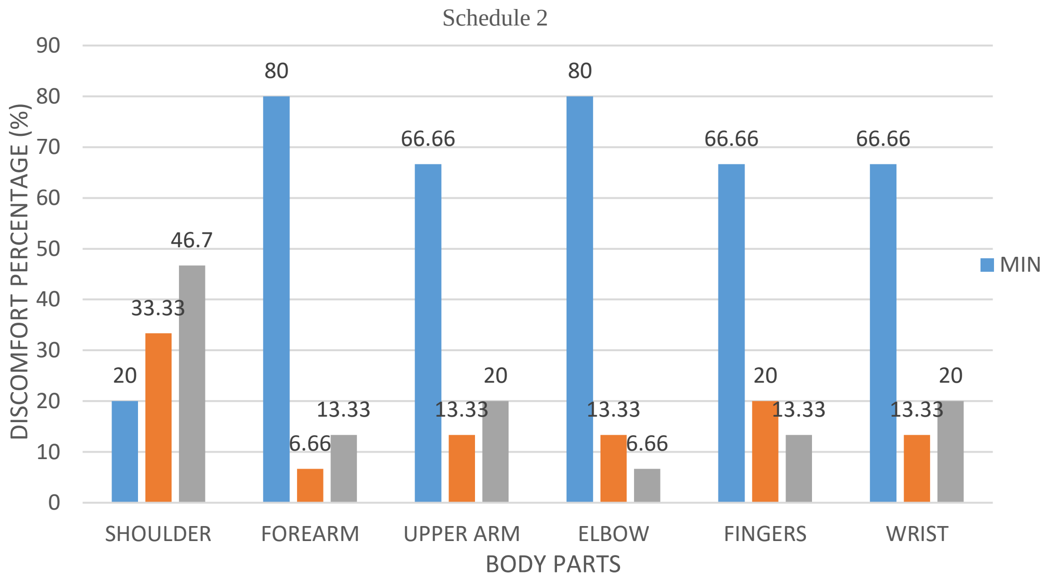

Figure 3.5: Discomfort scores for schedule 2

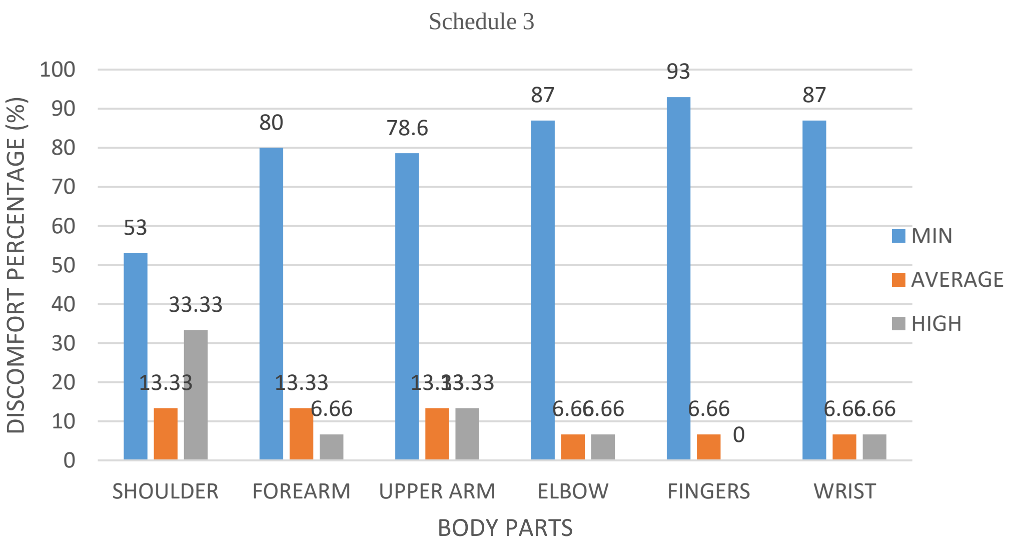

Figure 3.6: Discomfort scores for schedule 3

4.0 Conclusion

The major contribution of this research was to show the beneficial effect of practicing regularly scheduled microbreaks on improving the performance of typing and reducing discomfort ratings at the upper limb body parts of the subjects. Analysis on the questionnaire survey which was conducted on the office workers clearly showed that lack of rest breaks and continuous typing work was the significant factor that contribute to the development of MSD. In addition, experiment on the myoelectric signals produced during prominent typing activity via EMG proves that implementation of microbreaks does not deteriorate the work performance in1 terms of accuracy and speed of subjects. Finally, EMG experiment performed through Delsys powerlab also provide evidence that prolonged typing activities will generate muscle fatigue by measuring myoelectric signals of flexor carpi ulnaris and radialis. Average frequency does not increase much especially after the implementation of microbreaks. This is because motor units may have changed their firing statistics after the break. This indicates that break time allows for a periodic recovery of motor units. Further research can be done on the effect on break time among intensive computer gamers by measuring their muscle fatigue level using EMG.

5.0 Declaration

The authors declare no conflicts of interest in this work.

6.0 Acknowledgements

The authors would like to thank the Human Ethics Committee of UPM (JKEUPM) for giving approval to conduct electromyogram (EMG) experiment on UPM bioscience students. The authors also thankful to the department of engineering for giving grant with the vot number 9485300 and department of bioscience of UPM for providing facilities and equipment to complete this research. Additionally, we express our sincere gratitude to all the participant who took part in the data collection.

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