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Original Article

The Effect of Using Dual Screen Computer Panel to the Neck-Shoulder Muscle Activity among Group of Students

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Abstract

Background: Workstation design has shift from using single monitor screen to dual monitor screens, which may impose some impacts towards the muscles activity. This study aimed to determine the effect of using dual monitor screen computer to the neck-shoulder muscle activity among computer user.

Method: This experimental study was conducted in 2015 among 28 healthy students in University Malaysia Perlis. The muscle activity of sternocleidomastoid and trapezius were recorded using surface electromyography (sEMG) as the participants perform two types of computer task: (1) proofreading task for 10 minutes (2) typing task for 20 minutes in setting; single and dual monitor screens.

Results: There was a significant reduction in the median frequency of the left trapezius muscle (t=-2.515, P=0.018). Sternocleidomastoid muscle activity for both sides also showed a significant reduction in the median frequency where right SCM (t=-2.579, P=0.016) and left SCM (t=-2.345, P=0.027). When compared between both setup of screen display, it is showed that dual screen gave a lower trend of muscle activity compared to single screen.

Conclusions: Using dual screen may results in increasing the movement frequency and reducing the static strain in the neck-shoulder muscle area.

Keywords: Dual monitor screen, Neck-shoulder muscles, Surface electromyography

Introduction

In the era of urbanization and modern technology, the use of dual screens has become a common practice in the office setting. Even though this dual screen setting is common, few studies had been done regarding the effects of this setting to the neck-shoulder muscle activity. With the use of multiple monitor systems, and the potential for future growth, it is important to understand the impact of multiple monitors on muscle activity.

As concerned, the workstation which use dual screen computer may possibly positioned the two screens at somewhat angle. Therefore, simultaneously with past research the positioning of the screens computer at angled position was associated with the increase of trapezius muscle activity (1). High trapezius muscle activity is an indicator of the increased load on shoulder and neck areas and high level of muscle activity may indicate the increased of risk for getting MSDs (2, 3). A standard workplace design recommended positioning the centre of computer screen at 14º below horizontal eye level (4). Past research on display screen display only focusing on the single screen setting.

Computer users often performed prolonged seated tasks and viewing of single screen setting may lead to a static head-neck posture and sustained muscle activity which also increase the chances of having musculoskeletal pain and loading (4, 5). Awkward and static postures tend to reduce blood flow to the muscles thus reducing the flow of nutrients and removal of wastes, which can lead to pain and muscle fatigue. Static postures can lead to elevated heart rate and leads to joints and tendons problems (6).

Using dual screen was associated with a significant reduction in the median amplitude of the right trapezius muscle activity (5). This finding demonstrate that the use of dual screens have the benefits to the users in reducing the muscle activities which reflect the less load on the shoulder and neck area.

Therefore, this study was designed to determine the effect of using dual monitor screen computer to the neck-shoulder muscle activity among computer user. One way to detect muscle activity and muscle fatigue is by using surface electromyography (sEMG). This device allows the objective quantification of the energy of muscle. Researcher can study the muscle energy at rest and changing continuously over the course of movement and posture (7). Whilst root mean square (RMS) and power spectrum median frequency of the EMG were considered when conducting EMG (8). This method is safe, easy, and non-invasive and widely used in research and medical purposes (9).

Methods

Subjects

Subjects were recruited from University Malaysia Perlis (UniMAP) which consist of 5 males and 23 females thru random sampling method in 2015. Only individuals who had aged from 20-30 yr old and have no history of a significant back, neck and shoulder injury were considered as potential subjects. The subjects also must have had a regular pattern of computer usage for at least 2 yr with at least 2 hours of duration daily. All subjects were asked to complete a general questionnaire to obtain data on socio-demographic and also Northwick Park neck pain questionnaire to assess their current neck pain condition. Those subject with score >6 were excluded from this study.

This study was approved by University Putra Malaysia Human Ethical Committee.

Workstation Design

The experiment was conducted in a controlled room with a standardize workstation. A desktop computer with 15” LCD display was used in the single screen setup while two screens with the same specification with 15º angle were used in dual screen setup. The workstation was located in a room that controlled from all types of glare. The respondents were asked to perform the task, which are reading and correcting task, and typing task. The task was conducted in a controlled room, which have the temperature of 26 ºC with adequate lighting. The subjects were asked to sit and adjust themselves to a comfortable posture with 90º knee flexion angle and arms relaxed. The table height, the chair height can be adjusted, moved and large enough to allow the respondents to adjust it according to their comfort (10). The room humidity was kept around 50-60% and room noise level will be maintained at 55dB (A) or less.

Surface Electromyography Protocol

Data for surface electromyography were recorded using ADInstrument Powerlab with a sampling frequency of 1000Hz and bandwidth of 10-500Hz. The muscles tested were upper trapezius (UT) and sternocleidomastiod (SCM) where these two muscles involved in the rotation and as the indicator of the increased load on shoulder and neck areas. High level of muscle activities also is an indicative of higher muscle effort in performing a task, and if this is sustained for a long period, there may be greater muscle loading which may lead to fatigue and overstrain in the muscle (11, 12). The neck and shoulder region of the subjects were cleaned using 70% alcohol swap and the hair was shaved if necessary. The electrode placement on the skin was placed by following the standard protocol for sEMG. For SCM muscle, the electrode was placed was on skin surface fixed at the midpoint of the SCM, 4cm from the mastoid process, along the muscle fibers (bilaterally). For UT muscle, the electrode is placed at half the distance between the acromion line and C7, along the muscle fibers (bilaterally). A ground electrode was placed on the spinous process of C7. Before starting the experiments, subject was required to perform 3 trials of maximum activity voluntary contraction (MAVC) of the UT and SCM muscle for the normalization of sEMG signals. The subject must be standing, usual and comfortable posture, without shoes or socks, men without shirt or women dressing a top, looking to the horizon, with the upper limbs along the body (relaxed) without see the computer screen to avoid the visual feedback and commitment evaluation. The MAVC maintained for 5 seconds, of the cervical flexion–rotation toward the right shoulder (manually resisted) for the increased the activation of sternocleidomastoid muscle (MAVC of the right side SCM). MAVC maintained for 5 seconds, of the cervical flexion–rotation toward the left shoulder (manually resisted) for the increased activation of SCM (MAVC of the left side SCM). MAVC maintained for 5 seconds, of elevation of both shoulders simultaneously (manually resisted) for the increased activation of upper fibers of right side and left side of trapezius muscle (MAVC of the right side UTFR and MAVC of the UTFL). The MAVC must be performed with intervals of 10s between MAVC. After completion, a rest time for 5 minutes to start the next step. The sampling locations are illustrated in Fig. 1.

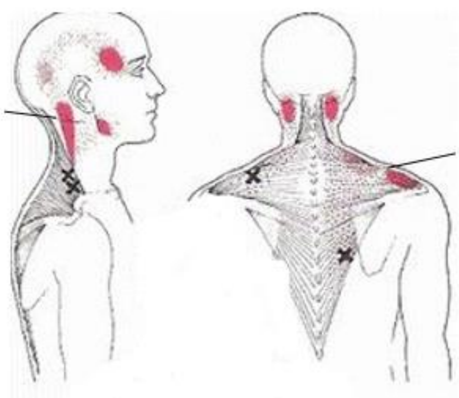

Fig. 1: Location of the placement of electrode

Experimental Tasks

All subjects were asked to performed computer tasks, which are proofreading tasks for 10 min, and involves in highlighting text and correcting spelling mistakes. They also were asked to perform typing tasks for 20 min. In the single screen setup, the subjects performed both tasks on single screen only while in dual screen setup, the subjects had to perform the tasks using both screens. In order to minimize bias, the texts used in this experiment were randomized and changed for each subjects. The duration for one complete task for one setup is about one hour. Throughout the experiment, the surface electromyography was attached to the subject's muscles and the readings were recorded.

Procedure

The subjects participated in two experimental sessions, which include preparatory information, electrode placement, maximal activity voluntary contraction, and 1 hour of experimental tasks.

Session 1: The subjects were informed of the requirements of the experiment, asked to read carefully, and signed the consent form. The subjects were asked to seat in the task chair and to keep both feet on the floor while using only the neck and shoulder muscles to exert maximum force. The subjects were asked to pushing forward their head with resistance against the forehead, which will generate maximum activity of sternocleidomastoid muscle. For the trapezius muscle, two maximum contractions were performed. The first method requires the subjects to abduct their arm against resistance while their arm was in 90º abducted posture. The second method, shoulder elevation was gained by having the subjects to pull up on two dumbbells on which the subject is standing (13). After the maximal activity voluntary contraction, the subjects will conduct the experimental tasks using the single screen setup first. The subject was positioned in the workstation and asked to perform 1 hour of proofreading and typing task.

Session 2: The experimental tasks were performed using dual screen setup. The subjects again were provided with consent form for review and signed. All the activities in Session 1 were then repeated.

Data Analysis

Raw EMG data were evaluated using MatLab software and the sEMG data were normalized to maximal EMG (MEMG) which being recorded during 3 trials of MAVC, and expressed as percentages of MEMG (%MEMG). This study used the result on the analysis of 10^{th}% and 50^{th}% percentile of % MEMG of the four muscles. The 10^{th}% and 50^{th}% is the indicator for static and median frequency of muscles activity respectively and literature has been reported widely using this protocol. The variables were compared between the single screen and dual screen setup using t-test in SPSS Version 22.

Results

Subjects Background

The respondents were recruited from the age of 20-30 yr old. The mean of the experimental group were 23 (2.4) where majority of the respondents were Malay (80%) and they were currently pursuing Bachelor degree (90%). The mean for height and weight of the respondents were 1.66 m (±6.4 m) and 61 kg (10.3kg) respectively. The subjects had mean BMI of 18 m^2/kg (±2.6 m^2/kg).

Determination and Comparison of Muscle Activities of Trapezius and Sternocleidomastoid Muscle

The result of the statistical analysis on the muscle activity are summarize in Table 1. The 10^{th}% tile of maximal EMG for the upper trapezius muscle (UT) showed a consistent trend for slightly high activity in the dual screen setup as compared to the single screen setup. The groups mean value for 10^{th}% tile of MEMG for the right UT recorded 3.47±2.63 for single screen setup and 1.23±0.08 for dual screen setup. The left UT showed 3.16±2.523 for single screen and 2.74±2.29 for dual screen.

Table 1: Mean ± SD, and *P*-values of maximal EMG at 10^{th}% and 50^{th}% tile of upper trapezius muscle and sternocleidomastoid muscle

Muscle	Screen setup	Mean ± SD (10^{th} % tile MEMG)	Mean±SD (50^{th}%tile MEMG)	t-value, (*P*-value) for 50^{th}% tile
RUT	Single	3.47±2.63	14.85±15.49	t=-1.494 , *P*= .145
	Dual	1.23±0.08	10.3±5	
LUT	Single	3.16±2.523	16.9±17.89	t=-2.515 , *P*=.018[a]
	Dual	2.74±2.29	8.16±4.042	
RSCM	Single	2.49±2.33	15.4±11.43	t=-2.579 , *P*=0.016[a]
	Dual	2.8±2.562	8.89±4.67	
LSCM	Single	2.17±2.1	13.18±6.87	t=-2.345 , *P*=.027[a]
	Dual	2.02±2.01	9.24±4.67	

[a] *P* significant at<.05

At sternocleidomastoid muscle, the value of 10^{th}% tile of MEMG of right and left SCM showed a very similar activity in single screen. The right SCM for single screen recorded 2.47±2.33 and 2.8±2.562 for dual screen. The left SCM showed 2.17±2.1 for single screen setup and while for dual screen setup was 2.02±2.01 of the group mean value. When the 10^{th}% tile of MEMG of UT and SCM were compared between single screen and dual screen setup using paired *t*-test, the results showed no significantly differences between both setup.

The 50^{th}% tile of maximal EMG for the upper trapezius muscle showed 14.85±15.49 of recorded group mean for single screen and 10.3±5 for dual screen. The left UT recorded 16.9±17.89 for single screen and 8.16±4.042 for dual screen. At sternocleidomastoid muscle, the right SCM showed 15.4±11.43 for single screen setup and 8.89±4.496 for dual screen. The left SCM recorded 13.18±6.87 for single screen and 9.24±4.67 for dual screen setup.

When the 50^{th}% tile of MEMG of upper trapezius (UT) and sternocleidomastoid muscle (SCM) were compared between single screen and dual screen setup using paired *t*-test, the results showed that 50^{th}% tile of MEMG of left trapezius muscle was significantly higher in the single screen setup than dual screen setup with t=-2.515 , P= 0.018. For sternocleidomastoid muscle, both right and left muscles shows a higher significant value for 50^{th}% tile of MEMG when compared for both screen conditions. Right SCM muscle give reading of t=-2.579, P=0.016 while left SCM muscle recorded t=-2.345, P=0.027.

Figure 1 shows the trend of EMG over time for Upper Trapezius muscle and Fig. 2 shows the trend over time for sternocleidomastoid muscle.

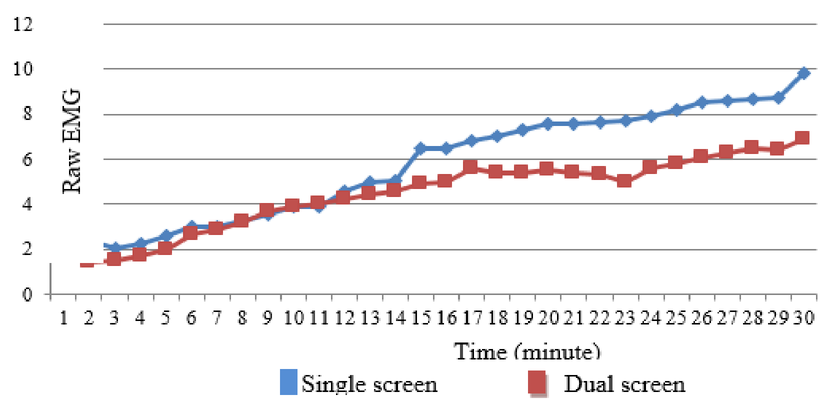

Fig. 1: The EMG trend over time for Upper Trapezius muscle

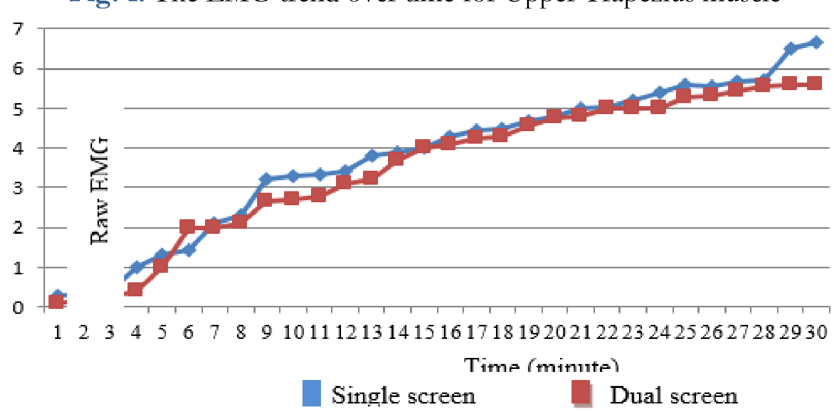

Fig. 2: The EMG trend over time for Sternocleidomastoid muscle

Discussion

The results of this study showed that none of this screen showed any significant differences at 10^{th}% tile of MEMG. The mean value of right sternocleidomastoid muscle (RSCM) muscle activities were similarly the same in both setup. This is due to the clicking and typing tasks that might affect the muscle activity. The prolonged typing tasks could consistently increase the muscle activity and this is clearly shown by the symptomatic office worker compared to asymptomatic pain free office worker (14). Further study on this issue also should be conducted on the office workers at their workplace especially for those who have chronic symptoms of MSDs in the extent for better results.

This study needs longer time to detect fatigue in the muscle. Muscle fatigue occurs due to the tiny leaks of calcium inside the muscle. One of the functions of the calcium is to help control the muscle contraction. This research found that after extended highly-intensity exercise, small channels in the muscle cells begin to leak calcium, which leads to weakened muscle contractions. This leaked calcium also stimulates an enzyme that attacks muscle fibers and will lead to fatigue. In conclusion, the seating duration of performing computer tasks of 90 minutes unable to detect significant muscle fatigue (15).

Analysis for 50^{th}% tile of MEMG showed that there is a significant difference in the 50^{th}% tile of MEMG in the trapezius and sternocleidomastoid muscle which consistent with the results from past research. Higher trend of trapezius muscle activity is associated with single screen viewing (5). In this study, it showed that maximum electromyography (MEMG) was associated by the changes of screen computer. Several studies have shown that changes in EMG amplitude can be caused by several factors including an increase in the force production of the muscle, postural changes or muscle fatigue (16).

For the trapezius muscle, the significant difference in the median frequency was due to the shoulder movement. The subject has to elevate their shoulder to manipulate the cursor keys during the typing task for 20-minutes. The other factor that may increase the trapezius muscle activities in the single screen setup may be due to the frequent changing of the windows during the typing task. The sternocleidomastoid muscle also showed a significant difference when compared with both screens setup. This was due to the adjustment of the neck components for the comfortable position of the head and neck. Therefore, increased forces were necessary to compensate the postural changes. It can be caused by attention-related activation of muscles without biomechanical needs (17).

Conclusion

Left upper trapezius muscle (LUT) showed the highest mean value with a significant difference in the muscle activities which due to the frequent changes of the windows during the typing task in the single screen setup and thus increasing the muscle load on the neck area. For sternocleidomastoid muscle, analysis showed significant difference in the muscle activities which due to the neck protracted or tilts forward to enhance the viewing quality. Therefore, these findings suggest that dual screen computer setup showed less muscle activities, which reduce the static load and increase the movement frequency in the neck and shoulder regions. The trend of muscle activities also showed that using dual screen have a reduced muscle activities compared to single screen setup.

Ethical considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

Acknowledgement

The authors declare that there is no conflict of interest.

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