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Effects of using a document holder when typing on head excursion and neck muscle activity among computer users with and without neck pain

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Purpose. The aim of this study was to examine the effects of using a document holder while typing on head excursion and neck muscle activity among computer users with and without neck pain. *Method*. An experimental study including 52 individuals with ($n = 26$) and without ($n = 26$) neck pain was conducted. Head excursion and neck muscle activity were measured using an accelerometer and surface electromyography, respectively. Two-way analysis of variance was conducted to examine the effects of using a document holder between computer users with and without neck pain. *Results*. The results demonstrated a decrease in head excursion ($p < 0.001$) and muscle activity of both the right and left upper trapezius and the left lower trapezius and right anterior deltoid ($p < 0.05$) with the use of a document holder. Computer users with neck pain had significantly ($p < 0.001$) higher right lower trapezius muscle activity compared to the group without neck pain. *Conclusion*. The results of the study supported the use of a document holder to assist in decreasing head excursion and neck muscle activity. The use of a document holder while typing may be beneficial in preventing repetitive strain injuries among computer users.

Keywords: Computer users; neck pain; muscle activity; head excursion; triaxial accelerometer; electromyography

1. Introduction

Computerization has become a necessity, not only in the workplace but also in many activities of daily life. In Malaysia, 60.3% of the 30.3 million population over the age of 25 years use a computer and this rate is increasing every year [1]. In fact, many people use computers daily for prolonged periods [2,3]. This extensive use of computers worldwide increases the risk of work-related neck disorders among computer users [4].

Work-related disorders are injuries or disorders in muscles, nerves, tendons, joints, cartilage and spinal discs brought about by exposure to risk factors in the work environment [5]. Such disorders have resulted in such occupational injuries as repetitive injuries, static load and awkward postures among people who work in offices for long hours [6]. In terms of computer use, work-related neck disorders are those caused by repetitive and/or sustained work at computers [7]. Previous research has shown a strong link between work-related neck disorders and increased use of computers [8–11].

Computer users have to hold their necks in a forward bent posture for prolonged periods when viewing a computer screen and documents [12]. In addition, the repetitive movements involved in typing contribute significantly to neck pain [13]. Previous studies have reported that people with neck pain have an imbalance of muscle workload in the neck and upper shoulder region and abnormal postures which lead to muscle tension [14]. Abnormal postures and an increase in muscle tension may precipitate the onset of muscle stiffness and increased pain in the neck and shoulders, which may affect productivity in the workplace [15,16]. Even if computer users take measures to prevent or reduce neck pain, they will still experience recurring episodes of neck pain because of poor workstation ergonomics and lack of information regarding correct posture.

People who work on computers are required to view documents which are usually placed on the left or the right of the keyboard, between the keyboard and the screen or behind the keyboard. When computer users view a computer screen and documents while typing, they have to maintain a neck posture in a forward bent position for an extended period of time [13]. If the document is placed to the side of the keyboard, there is a lot of lateral flexion and rotation. If the document is kept between the screen and the keyboard or behind the keyboard, neck flexion/extension movement is increased [17]. The increase of neck flexion movement brought about by prolonged activity has been related to greater neck extensor movements which lead to muscle fatigue and pain [18].

The document holder is a piece of office equipment which has been ergonomically designed to hold documents [17]. The benefits of using a document holder include maintaining the head and neck in a neutral position.

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Using a document holder reduces neck extensor load and increases comfort and efficiency as it reduces eye, neck and back repetitive movements, maintains normal spine curvature and reduces muscle strain [17,19,20]. However, previous studies have not examined the effects of using a document holder on the head excursion and upper quadrant muscles, increased use of which leads to the development of neck pain.

The aim of our study was to investigate the effect of a document holder on head excursion and neck muscle activity when computer users with and without neck pain performed such tasks as typing. It was hypothesized that, when computer users with neck pain used a document holder, head excursion and neck muscle activity would change.

2. Methods

2.1. Participants

A total of 52 participants (26 computer users with neck pain and 26 computer users without neck pain) aged between 24 and 40 years were recruited from banks and accounting firms. The participants met the following inclusion and exclusion criteria [17,21]. They worked at a computer for a minimum of 4 h/day. To be included in the 'without neck pain' category, participants should not have any pain on the day of testing and should not have had any discomfort in the neck and shoulders for 7 days prior to testing. If a participant had neck pain in the past 12 months, the said pain should have been resolved at least 3 months prior to the study. To be included in the 'with neck pain' category, a participant should have had pain in the neck and shoulder region which lasted longer than 1 month during the past year and had neck pain in the past 7 days and on the testing day itself. Participants with a history of cervical fracture or trauma, cervical surgery, idiopathic scoliosis, requiring bifocal or graduated glasses to use a computer and on medications (analgesic, muscle relaxant and neuroleptics) were excluded from the study. The study procedures were explained to the participants and written consent was obtained from the participants prior to the study.

2.2. Workstation

A computer workstation based on Malaysian Government Occupational Safety and Health Guidelines was set up [18]. The working desk was placed at a range of 600–750 mm from the participants. The screen was positioned in the centre with a range of not less than 400 mm and the upper edge of the screen at a height lower than the eye level of the participants. An adjustable height and good backrest chair was used. These arrangements, i.e., the position of the screen, the keyboard, document and document holder developed by the authors for this study (Ergopad), were replicated for all participants.

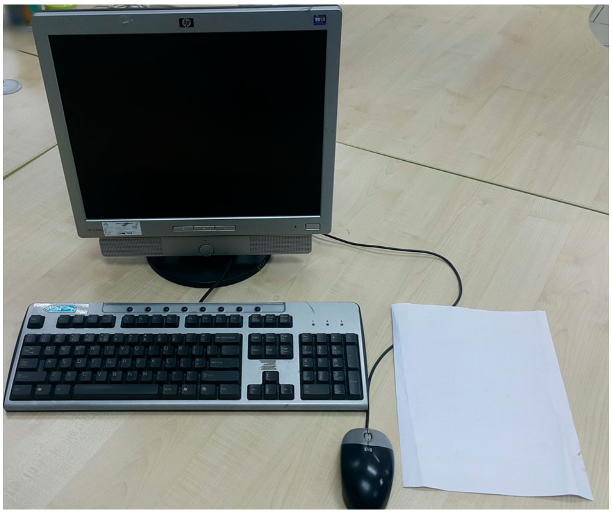

Figure 1. Document placed on a flat surface.
Note: The full colour version of this figure is available online.

Figure 2. Document placed on a document holder (Ergopad).
Note: The full colour version of this figure is available online.

The typing task protocol was adapted from an established protocol [17]. The participants were asked to type a short story using Microsoft Office Word version 2007. The participants were asked to type at their normal pace. Typing errors were ignored. This protocol was followed in order to induce the participants to type 'naturally', without requiring extra attention. During the study, one document was placed on a flat surface (Figure 1) while another was placed on a document holder (Ergopad) (Figure 2) on the right-hand side of the participants.

2.3. Measurements

2.3.1. Triaxial accelerometer

A triaxial accelerometer (AliveECG v2. 23, Australia) was used to measure head excursion (Figure 3). The device measures gravitational (g) data from the excursion with a sampling frequency of 20 Hz. The recorded data from

Figure 3. Triaxial accelerometer.
Note: The full colour version of this figure is available online.

the accelerometer were calculated at 75 samples/s and the output measurement was calibrated with gravity force.

An accelerometer using a tape and a headband to minimize the soft-tissue sensor movements was attached to the subject's forehead (Figure 4) as recommended in a previous study [19]. The position of the sensors was based on three axes (x, y, z); x axis (ax), the horizontal forward–backward position; y axis (ay), the horizontal medial–lateral direction; z axis (az), the vertical direction.

The raw data from the triaxial accelerometer were calculated accordingly for each accelerometer direction (ax, ay, az). The total acceleration of the head excursion was calculated as the square root of the sum of the squared accelerations for each direction as indicated in the following equation [22]:

$$\text{Total acceleration of head excursion} = \sqrt{ax^2 + ay^2 + az^2} = 1g,$$

where $ax = x$ axis; $ay = y$ axis; $az = z$ axis; $g =$ gravity.

2.3.2. *Surface electromyography*

Muscle activity of the neck and upper limbs was examined using surface electromyography (SEMG) (MYO420 EMG unit; Motion Lab Systems, USA). Muscle amplitude was recorded using eight-channel SEMG. Eight pairs of 10-mm-diameter Ag/AgCl electrodes were used to record muscle activity of the upper trapezius, lower trapezius, anterior deltoid and cervical extensor muscles on both the right and left sides.

Before placing the electrodes, the placement area was cleaned with abrasive gel and alcohol and was shaved

Figure 4. Accelerometer attached to the subject's forehead.
Note: The full colour version of this figure is available online.

Table 1. Electrode placement for each muscle based on the SENIAM guidelines [25].

Muscle	Placement
Cervical erector spinae	Lateral to the C5 spinous process
Upper trapezius	In the mid-point between the tip of the acromion process to the spinous processes of the C7 line
Lower trapezius	In two-thirds of the line between the trigonum spinae of the scapula to the spinous processes of the T8 line
Anterior deltoid	Distal and anterior from the tip of the acromion process with a distance of one finger width

Note: EMG = electromyography; SENIAM = surface EMG for non-invasive assessment of muscles.

if necessary to reduce the skin impedance [23,24]. The electrodes were placed parallel on the muscles based on the recommendations for surface EMG for non-invasive assessment of muscles (SENIAM) [25] (Table 1).

2.4. ***Procedure to determine head excursion using the triaxial accelerometer and neck muscle activities using SEMG***

The movements of the participants' heads and their neck muscle activity, typing while viewing documents placed on a flat surface and in a document holder, were registered continuously and transferred to a computer for analysis. To obtain accurate readings, participants were asked to work at their normal pace [22]. Measurements of head excursion and neck muscle activity were taken with the document placed on a flat surface and in a document holder. Participants were required to type continuously for 5 min with a 10-min break between the different placements of the documents [17]. Measurements for both document placements were taken at the same time of the day. The raw data for head excursion were collected and transferred to be analysed using Microsoft Office Excel version 2007.

The SEMG data signals were normalized and processed with a high-pass filter at 10 Hz and a low-pass filter at 500 Hz, amplified (gain, 1000) and sampled at 2000 Hz. The final data from SEMG were processed using Myon ProEMG Version 3 and expressed in terms of root mean square (RMS). A single researcher assessed all of the participants.

3. Data analysis

Data were analysed using SPSS version 21.0. The α level was set at 0.05. Descriptive statistics were used to compute the mean and standard deviation of the head excursion and neck muscle activity variables. Two-way analysis of variance (ANOVA) (with and without neck pain × with and without document holder [Ergopad]) was conducted to examine the effects and interaction of using the document holder (Ergopad) between computer users with and without neck pain.

4. Results

Fifty-two participants, 26 individuals with neck pain (mean age 28.23 ± 4.01 years) and 26 individuals without neck pain (mean age 27.77 ± 2.82 years), participated in this study. Table 2 presents the demographic details of the computer users with and without neck pain. There were 18 and 14 females without and with neck pain, respectively. All of the participants were right handed. Most of the participants without neck pain ($n = 21$) and with neck pain ($n = 19$) used a computer for 4–8 h/day. A document holder was not previously used by 22 participants without neck pain and 18 with neck pain. Two-way repeated-measure ANOVA (with and without neck pain × with and without Ergopad) was conducted to examine the effects and interaction of using a document holder (Ergopad) between participants with and without neck pain. The Shapiro–Wilk test indicated that normality was not violated and Mauchly's test showed that the assumptions of sphericity were not violated for repeated-measure tests.

The results demonstrated that with the use of the document holder (Ergopad) there was a significant decrease in head excursion ($p < 0.001$) and muscle activity of the right upper trapezius ($p < 0.05$), left upper trapezius ($p < 0.05$), left lower trapezius ($p < 0.05$) and right anterior deltoid ($p < 0.05$). Computer users with neck pain had significantly ($p < 0.001$) higher right lower trapezius muscle activity compared to the group without neck pain. However, there were no differences in muscle activity in the other muscles between participants with and without neck pain.

Table 2. Sociodemographic characteristics of participants without and with neck pain.

Characteristic	Individuals without neck pain ($N = 26$), n (%)	Individuals with neck pain ($N = 26$), n (%)
Age (years)		
<30	20 (76.9)	22 (84.6)
30–39	6 (23.1)	4 (15.4)
Gender		
Male	8 (30.8)	12 (46.2)
Female	18 (69.2)	14 (53.8)
Hand dominance		
Right	100 (26.0)	26 (100)
Physical activity		
<4 times/month	8 (30.8)	8 (30.8)
1 time/week	11 (42.3)	9 (34.6)
3 times/week	7 (26.9)	9 (34.6)
Computer use (h/day)		
4–8	21 (80.8)	19 (73.1)
>8	5 (19.2)	7 (26.9)
Preferred computer screen		
Right	3 (11.5)	4 (15.4)
Centre	23 (88.5)	22 (80.8)
Usage of document holder		
Yes	4 (15.4)	8 (30.8)
No	22 (84.6)	18 (69.2)

5. Discussion

In our study, there was no statistically significant difference in head excursion among computer users with and without neck pain. However, the mean and standard deviation showed lower head excursion between both groups when a document holder was used. Similar results were presented in a previous study which reported changes in mean and standard deviation (which at 8% were not statistically significant) between both groups [20]. The probable reason for these results was that computer users with neck pain may have adopted forward head excursion as a fixed posture, with neuromuscular adaptation [20]. It should be noted that a change of merely 5° in head flexion angle can have considerable consequence on neck extensor moments as the neck muscles must increase the forces required to support the weight of the head [27–29].

Our study showed that when a document holder was used there were significant reductions in head excursion and neck muscle activity. The use of a document holder decreased neck flexion motions and brought about neck rotation. As neck pain has been positively correlated to neck flexion and no association has been found between neck pain and neck rotation [18], we deduced that decreasing neck flexion can assist in the reduction of neck pain problems among computer users.

Postures which have been observed among computer users are increased head tilt, neck flexion and neck extensor movements [20,30]. Continuous static loading on the cervical spine in these postures can eventually lead to neck and shoulder pain [31]. However, reduced head excursion in flexion can increase comfort levels among computer uses when they are viewing and typing. As a result, computer users will experience reduced tension in the postural muscles and compressive forces in the cervical spine.

Our study demonstrated no statistical difference in muscle activity among computer users with and without neck pain. Previous studies using EMG to compare muscle activity among individuals with and without neck pain have shown similar results [32,33,26]. In addition, only a weak association was noted between neck muscle activity and sedentary work such as office work [26,28]. However, it is noteworthy in our current study that lower neck muscle activity was found in the group with neck pain (as compared to the group without neck pain). This finding is supported by another study where individuals with muscle disorders decreased their workloads or the length of their working hours to reduce muscle activity and avoid pain [29].

Both the right and left cervical extensor muscles showed lower muscle activity when a document holder was used in our study. However, usage of the document holder had no significant effect on muscle activity. A possible reason could be that we only monitored muscle activity for a short period of time (5 min). Cervical extensor muscles categorized as part of the ‘local muscle system’ of the cervical spine are anatomically designed to control posture during extension movements of the head and neck [30]. Sustained neck flexion when a computer user is typing increases muscle activity, which leads to fatigue [17,19,30]. Eventually, prolonged fatigue and increased stress on the cervical structures expose computer users to work-related neck disorders [21,27,31,36].

Most occupational ergonomic studies have examined the upper trapezius muscle as a muscle at risk in people working at computers [17,20,34]. Based on our current study, the right and left upper trapezius muscles showed lower muscle activity with the use of a document holder, compared to flat surface document placement. The results also showed significant effects with the use of a document holder among computer users with and without neck pain. Previous studies have shown that the placement of the screen and document at lower angles directly increases upper trapezius muscle activity (measured using EMG) [19,24,31]. The use of a document holder beside a screen will probably reduce the load on the upper trapezius muscles of asymptomatic computer users [17,35].

On the other hand, by functioning as static scapular stabilizers, the lower trapezius balances the spine and shoulder regions [20]. In our current study, there was a significant effect with lower muscle activity on the right and left lower trapezius muscles when a document holder was used by computer users with and without neck pain. Typically, when individuals view documents and type on a computer continuously for a sustained period, they adopt a posture of excessive scapular protraction. This posture stresses the lower trapezius muscles as extra load is required to maintain the posture. It is important to refrain from placing extra load on the lower trapezius in order to maintain the scapula in retraction [35,37]. We deduced that with the use of a document holder, in our study, the scapula was maintained in a retracted position, thus lowering muscle activity in the lower trapezius.

The anterior deltoids are known to be the main agonist muscles in the upper arm and the dynamic mover of the shoulder region for forward flexion in the arm [32,38]. In our study, only the right anterior deltoid showed significant effect with the use of a document holder. There was no significant effect on the left anterior deltoid. This may be due to the fact that all of the participants in our study were right hand dominant. The document and document holder were also placed on the right side to standardize the study procedure. In a previous study, higher anterior deltoid muscle activity was related to increased shoulder flexion and increased shoulder discomfort in individuals performing computing-related tasks [33].

The limitation in our study was the short duration of the typing task (5 min) used to measure both head excursion and neck muscle activity. The same shorter duration has also been used in a previous study [17]. The short duration of the task was mainly to avoid increasing the muscle load among participants with neck pain [38]. Another possible limitation has to do with the selection of participants for our study. To have good control, when a study compares people with symptoms to people without symptoms we require a ratio of 2:1 (with symptoms:without symptoms). This could be a reason for our results not showing a significant difference between the two groups.

6. Conclusion

In summary, using a document holder such as the Ergopad may reduce neck and shoulder muscle work load and neck excursion. It is hoped that the document holder will be used as an aid to manage and even prevent neck and shoulder disorders among computer users. Other approaches, measures and strategies which reduce neck and shoulder pain are also important in the development of healthier workplaces.

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Disclosure statement

No potential conflict of interest was reported by the authors.

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