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Original Article

Effect of postural angle on back muscle activities in aging female workers performing computer tasks

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Abstract. [Purpose] This study investigated the effects of postural angle on back muscle activity during a computer task in aging women. [Subjects] Seventeen women ≥50 years old participated. [Methods] The participants were instructed to perform computer-related tasks for 20 minutes on a workstation that simulated typical office working conditions. Back posture was measured from the measured trunk and pelvic angles. Electromyography activities were recorded simultaneously from the cervical erector spinae, longissimus, and multifidus muscles. [Results] The lowest mean percentages of maximum voluntary contraction for the cervical erector spinae and longissimus muscles were obtained when the upper trunk and pelvic angles were between 0° to −5° from the sagittal plane. The back muscle activities increased as the upper trunk and pelvic angles exceeded 0°. Statistical analysis showed significant correlations between upper trunk angle and cervical erector spinae and longissimus muscle activities. Similarly, pelvic angle was significantly correlated with cervical erector spinae and multifidus muscle activities. [Conclusion] A neutral back posture minimizes muscle activities in aging women performing computer tasks.
Key words: Postural angle, Muscle activity, Aging

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INTRODUCTION

The aging-related deterioration of an individual's physique including posture and muscle strength may influence work performance and productivity[1)]. Hence, the involvement of the aging population in economic development is a vital issue, considering that the retirement age in Malaysia was raised from 58 to 60 years in 2011[2)]. In 2013, there were more than 1,111,600 employees aged 50 years and above in Malaysia[3)]. In addition, the widespread use of computers at work makes tasks physically and cognitively less demanding, which encourages aging workers to remain working[4)]. Nowadays, various office tasks such as retrieving files, collecting mail, and attending meetings can be performed by using a computer without moving from one's workstation. Microsoft recently found that the average worker spends seven hours per day in front of a computer[5)]. Most previous studies related to computer tasks only involved young computer users[6, 7)]. Accordingly, it is imperative to investigate the behavior of aging workers performing computer tasks, because computer tasks constitute an increasing part of sedentary work in industrialized countries. Repetitive computer tasks such as typing and using a mouse as well as the adoption of poor posture at work lead to symptoms of the neck, thoracic spine, and low back[8)]. A thorough understanding of human limitations forms the basis of ergonomics interventions, which can correct awkward postures and reduce problems exacerbated by stress and fatigue, which affect the performance of aging workers.

Determining the ideal levels of back muscle activation during low-load tasks such as sitting is challenging and remains controversial. Back muscle activation is proposed to vary according to the context and complexity of the task being performed[9)]. Dealing specifically with seated trunk muscle activation, Dankaerts et al.[10)] found that low back pain is associated with both increased and decreased trunk muscle activation. Thus, there may be situations in which reduced and increased muscle activation is desirable.

To date, no studies have specifically investigated the back posture of the aging population at work. Therefore, this study examined the effect of postural angle on back muscle activities in aging female workers performing seated computer tasks.

SUBJECTS AND METHODS

A total of 17 women (mean ± SD age: 55 ± 3.22 years, range: 50–61 years) 50–61 years old were recruited to participate in the study. The participants were staff from various departments within the university, whose work duties mainly involve sitting in front of a computer for more than 4 hours per day. Each participant was given a standard information sheet at the beginning of the session, and informed consent was obtained prior to participation. This study was approved

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by the Medical Ethics Committee of the University of Malaya.

The participants were required to perform 20 minutes of standardized computer tasks. In the first task, participants typed the text of a document for 10 minutes, which only involved interaction with the keyboard. Next, an exercise involving the use of mouse and keyboard, such as selecting and dragging items on the computer screen with the mouse, was performed for 10 minutes. These tasks are similar to the standardized tasks implemented by Delisle et al.[11] and Dumas et al[12]. The participants spent an average 20% of the experimental task using the mouse, while the remaining time was spent working with the keyboard. These proportions are close to those reported previously for regular computer work[13].

Back postural angles were measured from the upper trunk and pelvis. Inline 2D inclinometers (Noraxon USA, Inc.) were attached at the T2 level and sacrum by surgical tape to record movements in the sagittal plane[14]; the inclinometer sensors are 3.05 × 3.05 × 3.05 cm and weigh 45.5 g. Bony landmarks were identified manually. Back postural angles were measured as reference body postures and during the experimental tasks. Reference body postures were recorded over 45 seconds both before and after work. The average of the recorded angles was determined and used for calibration as well as a reference for recording occupational seated back posture. Back postural angles were recorded continuously during the experimental task. The participants sat on an office chair adjusted to their preferences and comfort. The back postural angles of each participant during the computer tasks were analyzed in terms of the mean angle deviation from the sagittal plane; a positive value indicates upper trunk flexion and forward pelvic rotation, whereas a negative value indicates upper trunk extension and backward pelvic rotation. An example of a positive upper trunk and pelvic angle is shown in Fig. 1.

Electromyography (EMG) and a sensor system (Noraxon USA, Inc.) were used to record the activities of the low back muscles including the cervical erector spinae (CES), longissimus, and multifidus muscles. This study focused on these muscles, because low back injuries and chronic back pain due to problems with the erector spinae and multifidus muscles are frequently reported. To detect muscle activity, Ag/Ag Cl/solid adhesive pre-gelled disposable surface electrodes were attached to the skin of the participants. The transmitter sent real-time EMG and inclinometer signals wirelessly to a desktop PC. Time, rate, and other acquisition parameters were recorded using Myo Research XP software. Muscle activity measurements were recorded during back extension and experimental tasks. Back extension was performed in the prone lying position as described previously by Konrad to determine the maximum voluntary contraction (MVC) of the back muscles[15].

The raw EMG data were sampled during test contraction at a sampling rate of 1,600 Hz and band-pass filtered at 20–800 Hz in parallel to the postural angle recordings. Electrocardiography spikes due to EMG artefacts were filtered without affecting the actual EMG amplitude or power spectrum. The most reliable method for analyzing EMG is monitoring the changes in root mean square (RMS) amplitude; therefore, the RMS values of the EMG data were analyzed in this study. The data were normalized with respect to the highest MVC value derived from the previous MVC test and expressed as the percentage of maximum voluntary contraction (%MVC). The normalized EMG RMS (%MVC) obtained during the experimental tasks were analyzed and used to represent muscle activity.

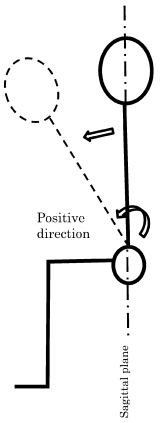

Fig. 1. Positive direction of postural angle

The data were initially tested for normality using the Shapiro-Wilk test. Spearman's ρ correlation was used to determine the correlations between postural angle and muscle activities. One-way ANOVA was performed to identify whether there were significant differences in muscle activities between different ranges of postural angle. The level of statistical significance was set at $p < 0.05$.

RESULTS

The mean upper trunk angles of the participants during upper trunk flexion and extension while performing computer tasks ranged from 0.26° to 7.75° and −2.12° to −5.81°, respectively. Spearman's ρ analysis revealed significant correlations between the upper trunk angle, and CES and longissimus muscle activity, indicating these muscles were affected by the upper trunk angle of the participants when performing the computer tasks (Table 1).

The lowest mean %MVC values for the CES and longissimus muscles were produced when the upper trunk angle deviated between 0° and −5° from the sagittal plane. The highest mean %MVC for all muscles was obtained when the upper trunk angle exceeded 0°. The activities of the CES, longissimus, and multifidus muscles with respect to the range of upper trunk angle are shown in Table 2. ANOVA indicated there were significant differences in CES ($F_{(2, 49)} = 39.75$, $p < 0.05$) and longissimus ($F_{(2,49)} = 28.568$, $p < 0.05$) muscle activity among the three conditions; ($\theta < -5°$, $0° \leq \theta \leq -5°$ and $\theta > 0°$).

The mean pelvic angles of the participants during forward and backward rotation while performing computer tasks ranged from 0.77° to 13.9°and −0.11° to −12.3°, respectively. Pelvic angle was significantly correlated with CES and multifidus muscle activities (Table 3).

The lowest mean %MVC value for the CES and longis-

Table 1. Correlations between upper trunk angle and muscle activity

		Upper trunk angle
Spearman's ρ, Correlation coefficient	Cervical erector spinae	0.498**
	Longissimus	0.420**
	Multifidus	-

**p < 0.01 (two-tailed)

Table 2. Mean %MVC with respect to different ranges of upper trunk angle

% MVC	Upper trunk angle, θ		
	θ < −5°	−5° ≤ θ ≤ 0°	θ > 0°
Cervical erector spinae*	11.86	8.88	23.82
Longissimus*	8.60	4.06	10.56
Multifidus	4.89	8.50	11.54

MVC: maximum voluntary contraction. *p < 0.05.

Table 3. Correlations between pelvic angle and muscle activity

		Pelvic angle
Spearman's ρ, Correlation coefficient	Cervical erector spinae	0.428**
	Longissimus	-
	Multifidus	0.324**

**p < 0.01 (two-tailed).

Table 4. Mean %MVC with respect to different ranges of pelvic angle

% MVC	Pelvic angle, θ		
	θ < −5°	−5° ≤ θ ≤ 0°	θ > 0°
Cervical erector spinae*	19.14	0.56	21.4
Longissimus	8.55	7.17	11.42
Multifidus*	4.6	11.42	10.14

MVC: maximum voluntary contraction. *p < 0.05

simus muscles occurred when the pelvic angle deviated between 0° and −5° from the sagittal plane. Meanwhile, the lowest mean %MVC value for the multifidus muscle was obtained when the pelvic angle was less than −5°. Finally, the highest mean %MVC value for all muscles occurred when the pelvic angle exceeded 0°. CES, longissimus, and multifidus muscle activities with respect to the range of pelvic angle are shown in Table 4. ANOVA also indicated there were significant differences in CES ($F_{(2,49)}$ = 44.212, p < 0.05) and multifidus ($F_{(2,49)}$ = 15.195, p < 0.05) muscle activities among the three conditions; (θ < −5°, 0°≤ θ ≤ −5° and θ > 0°).

DISCUSSION

The results indicate the neutral upper trunk posture, in which the angle deviates between 0° and −5°, minimizes CES and longissimus muscle activation. This posture allows the subject to maximize balance and optimize the proportions of their body mass and framework based on their physical limitations while performing computer tasks. Low muscle activity indicates less energy is required to maintain this posture, because the muscles are at their ideal length in a neutral position. Hence, the muscles can generate more force with less effort. The inert joints and ligaments provide minimum passive resistance to motion when the spinal segments are in the neutral zone, which minimizes back stability when the subject adopts this position. The neutral posture is associated with elastic equilibrium, in which the least elastic stress and lowest joint load are produced[16], which is reflected by the low levels of muscle activity. The neutral upper trunk position can be considered the ideal posture because it encourages proper alignment of the body's segments such that the least amount of energy is required to maintain a desired position. The results of the present study indicate the upper trunk angle is significantly correlated with CES and longissimus muscle activities, indicating upper trunk posture influences the activities of the back muscles.

The participants showed the lowest activity in the multifidus muscle when they sat in an upper trunk extension posture. In this position, the upper trunk posture inclines backward with an angle less than −5°. The upper trunk extension posture adopted by the participants while performing computer tasks is attributed to the backrest feature of the office chair. Andersson[17] shows that an increased backrest inclination angle and the use of a lumbar support reduce muscle activity, because the backrest takes some of the weight off the upper body and reduces the pressure on the discs and muscles when the subject leans against it. This posture also minimizes spinal disc movements and decreases strain on the low back region. The findings of several studies indicate the upper trunk extension or reclined posture is the optimum position for back health[18].

The forward pelvic rotation demonstrated by the participants during seated computer tasks produced the highest activity in the CES and longissimus muscles. Furthermore, the pelvic angle was significantly correlated with CES muscle activity, indicating CES muscle activity is affected by pelvic rotation. It is generally accepted that when the lower back experiences excessive forward pelvic rotation, the same will be observed in the neck region. Hsiao and Cho (2012) also report that older adults experience greater neck flexion than younger people when using a computer[19]. In an attempt to keep the eyes correctly aligned for clear vision, the chin will be pushed forward, creating a forward head position. Therefore, this observation corroborates the results of previous studies showing that forward pelvic rotation causes neck pain. This is because the spine connects the CES to the sacrum, which fits between the two hip bones that connect the spine to the pelvis; therefore, the pelvis is interrelated with the CES muscles and significantly impacts balance while sitting.

Longissimus muscle activity increased during forward pelvic rotation, indicating this muscle is activated to achieve and maintain this position. Forward pelvic rotation was preferred by the participants as it provides pelvic stability, which is necessary for dynamic spinal movements. In addi-

tion, this posture provides upper-arm stability when the participants performed computer tasks. Dunk et al.[20] suggest most flexion occurs at the S1 joint in a sitting position, which is primarily driven by pelvic rotation via the hips. However, individuals with low back and hip disorders are less able to move their lumbopelvic region[21]. Age may influence the increment of muscle activity. Laursen and Jensen[22] report muscle activity is significantly higher in older adults than young people and highlight the existence of physiological differences between young and older computer users.

The neutral pelvic posture is attained when the pelvis is balanced between two exaggerated forward and backward rotations, in which the angle deviates between 0° and −5° from the sagittal plane. The present results show that the neutral pelvic posture adopted by the participants yielded the lowest activity of the CES and longissimus muscles. Neutral pelvic alignment helps balance the spine by removing most of the pressure on the spine and back muscles. In addition, the neutral pelvic posture reduces back pain. Furthermore, this posture results in increased multifidus muscle activity. In the present study, pelvic angle was significantly correlated with multifidus muscle activity, indicating multifidus muscle activity is influenced by pelvic angle. Increased activity of the low back muscles during the neutral pelvic posture is required to maintain an erect posture. Posture determines the levels of passive tissue stress as well as the sharing of these stresses among supporting tissues. Scannell and McGill[16] found passive tissue stress was lowest when the subjects were either standing or sitting upright, because the spine curves and moves closer to its elastic equilibrium. There are two basic trunk movement patterns in the vertical direction, which can be observed when an individual moves from a slouched position to an upright trunk position. The first movement is driven by hip flexion, which results in a predominantly lumbar motion, while the second movement occurs predominantly at the thoracic lumbar junction, which emphasizes extension in this region of the spine[23].

The present results revealed that the backward pelvic rotation posture adopted by the participants reduces multifidus muscle activity. Furthermore, the pelvic angle was significantly correlated with multifidus muscle activity, indicating multifidus muscle activity is affected by changes in pelvic angle. The active use of the backrest by the participants contributed to backward pelvic rotation. One of the main reasons why the pelvis adopts this position is tight hamstring muscles, which prevent the pelvis from rotating rotation. However, the reduction in multifidus muscle activity with backward pelvic rotation is indicative of slouching; this position is akin to the flexion-relaxation phenomenon as studied by controlled upright and slumped sitting[23].

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