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Effect of Sustained Typing Work on Changes in Scapular Position, Pressure Pain Sensitivity and Upper Trapezius Activity

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Abstract: Effect of Sustained Typing Work on Changes in Scapular Position, Pressure Pain Sensitivity and Upper Trapezius Activity: Se-Yeon PARK, *et al*. Department of Physical Therapy, The Graduate School, Inje University, Republic of Korea—Objective: The aim of this study was to investigate the effects of sustained computer keyboard typing on the human musculoskeletal system by assessing the pressure-pain threshold (PPT), scapular position and activation of the upper trapezius. **Methods:** Vertical and horizontal positional changes of the scapular were measured with a palpation meter before and after keyboard work, and the PPT was measured using a pressure algometer. Activation of the upper trapezius during 20 minutes of computer keyboard work was measured by electromyography, and four consecutive 5-minute segments were analyzed. **Results:** The vertical distance from the seventh cervical process to the acromion, and the horizontal distance from the inferior angle to the same level of the spinal process were significantly increased after keyboard typing work compared with before keyboard typing work (p<0.05). The average value of the upper trapezius activity increased with increased time at the keyboard. The percent reference voluntary contraction of phase 1 (from start to 5 minutes) was lower than those of phase 2 (from 5 to 10 minutes), and phase 3 (from 10 to 15 minutes) (p<0.05). **Conclusions:** We observed that sustained computer work changed the scapular position in the stretched upper trapezius. To prevent musculoskeletal problems in the shoulder region, posture reeducation during computer work should be considered in terms not only of neck and trunk posture, but also of scapular position.
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Key words: Computer work, Habitual posture, Pressure-pain threshold, Scapular alignment, Visual display terminal

Since the development of the modern knowledge-based industrial economy, an increasing number of sedentary workers spend their daily work time in front of computers[1]. Therefore, the prevalence of work-related musculoskeletal disorders (WRMSDs) has increased due to prolonged sitting postures and sustained computer work in an ergonomic environment[2, 3]. As a risk factor for WRMSD-related sedentary work, prolonged poor posture such as a forward head position and protracted shoulders could contribute to the prevalence of neck and shoulder pain[2, 4, 5]. Although a clear association between posture and pain is difficult to ascertain, a forward head posture positions the head more anteriorly from the line of gravity in the sitting position, which enhances the compressive load in the cervical articulation and leads to a creep response in soft tissue[6, 7]. With regard to the muscular system, the levator scapular and upper trapezius are easily activated in the forward head posture. When this altered activation is combined with weakness of the cervical flexor and lower trapezius and tightness of the pectoralis, this imbalanced musculature, the so-called “upper-crossed syndrome”, might contribute to dysfunction of the cervicothoracic and glenohumeral joints[7, 8]. Hyperalgesia and discomfort occur frequently in seated workers[9]. Strøm *et al.* suggested that the disturbance of vasodilatation in the upper trapezius region could decrease the pressure-pain threshold associated with computer work[9, 10]. This changed blood flux does not return to resting values even after work[10]. Hägg (1991) suggested that a degenerative process of type-1a muscle fibers is caused by fiber overuse, which induces pain in the upper trapezius region. This hypothesis, named the Cinderella hypothesis, explains pain as being caused by a long period of low motor unit recruitment of the upper trapezius[11].

Although the upper trapezius acts as a major deter-

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minant of scapular position and movement, there is a lack of investigations of scapular position-related pain induced by computer work. Recent findings have suggested that postural correction focusing on scapular alignment is an effective way to reduce neck and shoulder pain[12, 13]. Wegner *et al*. (2010) suggested that a postural correction strategy for scapular position was helpful in patients with neck pain for restoring muscular activation during work at the computer[12]. However, to our knowledge, no study has investigated the influence of prolonged computer work on scapular position with upper trapezius activation.

If sustained computer work induced altered activation of the upper trapezius, there could be abnormal alignment of the shoulder girdle, such as elevated scapulas and clavicles, or protracted shoulder. The purpose of the present study was to reveal the effect of prolonged computer work on scapular position and muscular activation in the upper trapezius.

Methods

Subjects

This study was performed with 14 men, aged 21 to 30 years (24.36 ± 2.02, mean ± SD), whose mean height and weight were 174.86 ± 4.11 cm and 68.57 ± 6.27 kg respectively. The subjects used computers an average of 3.5 ± 1.91 hours per day for Internet searching and work. The demographic characteristics of the subjects are shown in Table 1. University students who used a computer at least 4 hours per day in the seated posture were included in this study. Subjects with a history of upper or lower extremity injuries or diseases that could affect computer work were excluded from this study. Informed consent was acquired from these subjects prior to the execution of the study, as required by the Inje University Faculty of Health Science Human Ethics Committee.

Measuring instruments

Surface electromyography (EMG) data were obtained using a BIOPAC system (MP150 acquisition system unit, Acqknowledge™ software and surface EMG electrodes). EMG signals were amplified and band-pass filtered through 20 to 450 Hz, and an additional band stop was set at 60 Hz. A thousand hertz of sampled data was calculated as the root mean square with a window length at 0.25. One surface channel was used, and electrodes were placed on the right side of the upper trapezius (UT) at the upper crest of the shoulder half way between the seventh cervical (C7) spinous process and acromion. The ground electrode was located at the contralateral side of the acromion. All locations and procedures for attaching electrodes were as described previously[14].

Table 1. Averaged subject's demographic data

	Value
Age	24.35 (2.02)
Height (cm)	174.86 (4.10)
Weight (kg)	68.57 (6.27)
BMI	22.41 (1.79)
Work hours	3.5 (1.91)

Standard deviations are in parentheses.

A palpation meter (PALM; Performance Attainment Associates, St. Paul, MN, USA) was used to measure the distance and inclination between two bony landmarks of the body. The PALM consisted of an inclinometer and two caliper arms (Fig. 1), and the inclinometer had a semicircular arc that moved within the range 0–30° in either direction from the midline at 1° intervals. The PALM was used as a special body–tool interface to combine the advantages of palpation with the objectivity and reliability of caliper and inclinometer measurements. In a previous study; the scapular measurement reliability of the PALM was investigated by measuring the distance from the inferior angle to the thoracic spine and the acromion depression[15]. The same method was used in the present study, the horizontal distance between and the vertical depression of the acromion was used to identify the scapular position. The acromial depression (AD) was determined using the PALM calculator, which combines the values of the distance and inclination between the acromion and the C7 spinous process. The horizontal distance (HD) from the inferior angle to the spinal process was defined as follows: one arm of the caliper was fixed at an inferior angle of the scapular, and the other arm was positioned at the spinal process when the inclinometer indicated 0° (Fig. 2).

An analogical algometer (Wagner, FDK 20) was used to investigate the pressure-pain threshold (PPT) before and after computer work. The PPT describes the amount of pressure needed for the first sensation of pain. Each subject was asked to say "stop" when his sensation changed from pressure to pain[16]. The PPT was measured 2 cm lateral to the location of the upper trapezius EMG attachment site.

Procedure

Prior to performing computer work, the scapular positions and PPTs of the subjects were measured in the upright standing position by using the PALM and algometer, respectively. Each subject was asked to stand facing straight ahead in a relaxed posture. Any further attempt at posture correction was excluded because the normal posture differs from person to

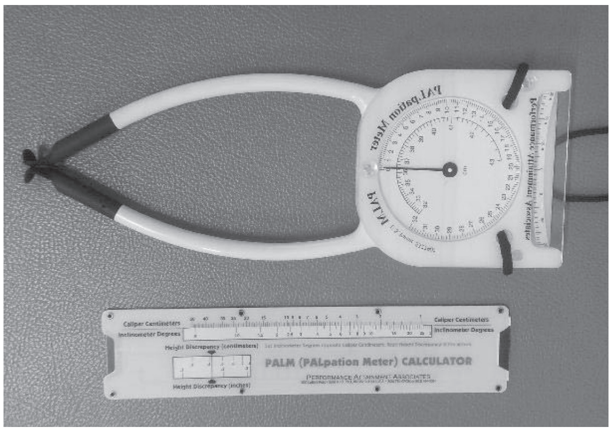

Fig. 1. Features of the palpation meter (PALM).

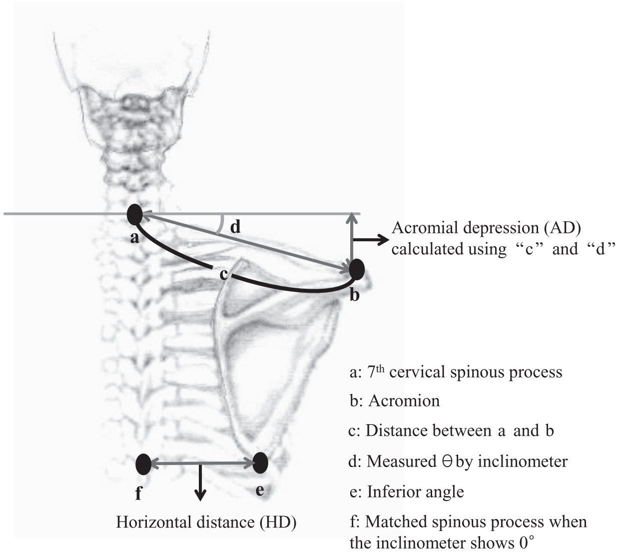

Fig. 2. Diagram illustrating the acromial distance (AD) and horizontal distance (HD).

person, and intentional posture correction might disturb the measurement of the natural scapular position. The same procedure was performed after subjects had completed their computer work.

As a normalizing procedure for EMG activity of the UT, the reference voluntary isometric contraction (RVIC) data were investigated after attaching electrodes to each subject's skin, which had been shaved and cleaned with alcohol. To collect RVIC data, subjects were asked to wear a 7-lb sandbag on each forearm, and to raise their arms in the scaption plane (almost 35° anterior to the frontal plane) until the shoulder was flexed at a 90° angle. Subjects maintained this posture for 3 seconds, and the mean value of two trials for muscle activity was recorded as the RVIC.

All subjects performed computer typing work for half an hour using the same computer workstation, in which the monitor was reclined 20° and the top of the display was set at eye level. An adjustable-height chair with a backrest was used as the initial sitting posture to position the hips, and the knees were flexed 90°. A 3-minute adjustment period was provided, during which subjects were instructed to select a workstation configuration that was most comfortable for them. During the experimental period, all subjects performed 20-minute of copy-typing work using a typing practice software program.

Data reduction and statistical analysis

The obtained electromyography data were averaged in 5-minute intervals; thus, four phases of EMG data were expressed as a %RVIC value against normalized data. The SPSS statistical package (version 18.0; SPSS, Chicago, IL, USA) was used to analyze significant differences in the %RVIC of the UT, the scapular position, and the PPT. Repeated measures one-way ANOVA was used for analysis of each phase of mean %RVIC values, and paired *t*-tests were performed to identify differences in scapular position (AD and HD) and PPT caused by the computer work. For analyzing specific differences in %RVIC between phases, Bonferroni correction with post hoc analysis was used for pairwise comparisons. Statistical significance was set at a value of $p<0.05$.

Results

Scapular position and pressure-pain threshold before and after computer work

Measurement of the AD and HD of the scapular position was significantly higher after computer work compared with before computer work. The vertical distance from C7 to the acromion was 7.08 ± 1.49 initially, and 7.83 ± 1.29 after computer work. The horizontal distance from the inferior angle to the horizontal level of the spinal process was 8.82 ± 2.09 initially and 9.18 ± 1.93 after computer work. The PPT value was 8.39 ± 3.33 after computer work, which was significantly lower than the initial value of 10.15 ± 3.57 (Table 2).

EMG of the upper trapezius

Muscular activation of the upper trapezius was represented as %RVIC within four phases. The %RVIC of phase 1 (from start to 5 minutes) was lower than those of phase 2 (from 5 to 10 minutes), and phase 3 (from 10 to 15 minutes), and there were significant differences between phases ($p<0.05$). There were no significant differences between phase 4 (from 15 to 20 minutes) and the other phases (Table 3).

Discussion

We investigated the differences in upper trapezius activity between time phases, and compared the changes in scapular position and pain sensitization after computer work. The PPT was significantly reduced after computer work. Although this study investigated short periods of typing work, our pain-sensitization results were similar to those of previous studies[9, 10].

There are two possible explanations with respect to our EMG and scapular position results. First, sustained activation of the upper trapezius might reduce the PPT. The mean %RVIC in the upper trapezius showed gradual increases with time. In previous studies, repetitive finger movements activated the post-neck region, upper trapezius muscles and forearm muscle using a motor unit recruitment pattern that showed a lack of variation[17, 18]. Although the EMG data of the last phase did not differ significantly from that of the initial phase, sustained activation of this specific muscular region could promote muscular damage, even with a low level of muscular recruitment[11]. Either degenerative changes or fatigue of the muscle fiber could increase pain sensitivity in response to pressure stress[19, 20].

Secondly, changes in the scapular position might have influenced the pain sensitivity in our study. After 20 minutes of computer work, the vertical distance of C7 to the acromion and the horizontal distance from the inferior scapular angle to the parallel level of the spinous process increased compared with the initial measurements. Measurement of the horizontal distance to determine the scapular position was initially suggested by Kibler[21]. Although our results showed significant increases in the horizontal distance after computer work, this difference was not clinically significant (difference >1 cm). However, changes in the scapular position occurred in the vertical distance as well as in the horizontal distance. Increased vertical distance suggests depression of the acromioclavicular joints, which is associated with scapular depression or downward rotation[22]. The scapular position data suggested that the muscular length of the upper trapezius was overstretched. When the PPT of the upper trapezius was investigated in subjects with scapular depression, the overstretched upper trapezius showed increased pain sensitivity compared with controls[23].

Both mechanisms could explain the reduction in PPT, however, the EMG data and the scapular position were inconsistent. The upper trapezius has been generally recognized as a scapular elevator as well as an upward rotator[24]. In this notion, the vertical distance from C7 to the acromion should be reduced, however, our results indicated increased vertical distance. Although we were unable to evaluate an individual's response to pain and physiological musculature changes, activation of the upper trapezius might be sustained to maintain posture against gravity and

Table 2. Comparison of the mean values of scapular position (AD, HD) and pressure-pain threshold before and after computer work

	Mean ± SD (cm, kg)		p
	Before computer work	After computer work	
Acromial depression (C7-acromion)	7.08 ± 1.49	7.83 ± 1.29	0.000*
Horizontal distance (Thoracic spine -inferior angle)	8.82 ± 2.09	9.18 ± 1.93	0.011*
Pressure-pain threshold	10.15 ± 3.57	8.39 ± 3.33	0.015*

*p<0.05.

Table 3. Percent reference voluntary isometric contraction value (RVIC) of the upper trapezius (UT) within four phases

	Mean ± SD (%RVIC)				
	Phase 1	Phase 2	Phase 3	Phase 4	p- value
	(Start–5 min)	(5 min–10 min)	(10 min–15 min)	(15 min–20 min)	
UT	18.95 ± 12.34	23.66 ± 15.47	24.67 ± 18.19	27.44 ± 22.01	0.00*

* Significant difference between conditions.

provide stability against distal repetitive movement[5, 18]. In computer work, recruitment of the motor unit of the upper trapezius might not induce movement of the neck or scapula, but may be a response to the tension requirement of the proximal joint.

In terms of the passive length-tension relationship, production of muscular tension can be accomplished by adopting a lengthening position above the resting length[25]. Similarly, a habitual flexed-relaxed trunk posture can be easily adopted for posture maintenance with a low muscular requirement. This posture is maintained with passive structure tension rather than active muscular effort[26, 27]. Although the average EMG value increased with time, 7 of 14 participants in our study showed decreased upper trapezius activation in the last phase compared with the second and third phases of computer work, and there were no significant differences in activation between the last phase and the other phases.

Kinematic changes in the cervical and lumbar area have been investigated previously in sophisticated studies using subjects involved in computer work[4, 26, 27]. This is to our knowledge the first study to investigate the influence of sustained computer work on the scapular position with muscular activation of the upper trapezius. However, this study had some limitations. First, the scapular position was defined as the vertical and horizontal distances from the spine to the scapular before and after computer work. To be more comprehensive, a 3-dimensional motion analysis device would be necessary for analysis of scapular position during computer work. Secondly, in future studies, a longer period of computer work should be used to evaluate intrinsic changes in muscle fiber or pain-related fatigue. Thirdly, all procedures were performed on asymptomatic participants; therefore, future studies should include participants with shoulder pain due to computer work.

Conclusions

We showed that sustained computer work changed the scapular position to an overstretched upper trapezius. Clinically, posture reeducation during computer work should be considered in terms not only of neck and trunk posture, but also of scapular position, to prevent musculoskeletal problems in the shoulder region.

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