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The Effect of Keyboard Height on the Muscle Activity of the Upper Trapezius Muscle

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Abstract

This study is designed to reduce worker fatigue, improve efficiency and provide a functional working environment based on previous studies that pain occurs in the shoulder area, especially the upper trapezius muscle, when the keyboard height is not appropriate. In this study, the height of the keyboard is four, the height of the elbow and desk is the same height, the height of the desk is 3cm lower than the elbow, the height of the desk is 6cm high, and the height is 9cm high. When working on the keyboard, the wrist and forerunner were organized into four groups of 10 people so that the height was different for each group. When the height of the keyboard is given in various ways compared to the height of the elbow of the subject, it is verified whether there is a difference in the RMS (Root Mean Square) of the upper trapezius muscle. The results of this study showed that the muscle activity of the upper trapezius muscle cap was significant only in the left and right keyboard height -4cm, 0cm, +4cm, +8cm group, but the difference in muscle activity was not significant in the rest group. The first study will require a study of the control of the factors affecting the tension of the subjects, the measurement of muscle activity against various muscles, and whether the length of the shoulder and fingertips of the subject affect muscle activity according to the keyboard type.

Keywords: *Upper trapezius, VDT Syndrome, Keyboard Height, Electromyogram*

1. Introduction

In this age of information in the 21st century, working with the computer and using the Internet have become an essential part of our life, and automated devices and video display terminals (VDTs) for computers have been also popularized, which has improved job performance and productivity [1]. These trends, however, have significantly increased 'computer-related diseases' or 'VDT syndrome' that are caused by excessive repetitions or use of power, improper and uncomfortable postures, lack of relaxation, excessive vibration applied to the hands and arms, improper working environments (working posture, working intensity, workstation, working space), etc. [2~4].

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VDT syndrome entails shoulder-arm-neck syndrome, musculoskeletal system disorders, eye fatigue and feelings of irritation, skin symptoms, psychoneural symptoms, etc. [5], and it was reported that long working hours at the computer, in particular, cause pain on the upper trapezius muscle [6]. As health issues in the musculoskeletal system of those working with VDTs have emerged as a new social problem, these musculoskeletal system disorders have spread to other types of occupation in advanced countries such as the United States and countries in North Europe, topping the list of occupational diseases. In Korea, the number of those with musculoskeletal system disorders has sharply increased recently, and in particular their share out of occupational diseases has gradually increased from 12.6% to 40.8% [7].

One of the most widely used input devices in today's VDT environments is a keyboard, and Yang et al. [8] pointed out that elements that affect muscle strain on the neck and shoulders when working with a keyboard include the inclination angle of the spine and the lumbar vertebrae, and the posture of the neck bone and the upper arms, the location and design of a keyboard, working skills and intermission [9]. Out of them, the relationship between the posture of the spine, lumbar vertebrae and neck bone and muscle strain has been already identified [10], but the relationship between keyboard height and muscle strain has not been known much. Kim [11], An et al. [12] and Karlqvist et al. [13] reported that the proper height of a desk to reduce strain on the trapezius muscle is determined by keyboard design, and that wrist pads are essential when using a keyboard. Yoo et al. [14] reported that the higher the inclination angle of the neck bone (standard: 80°) and the trunk (standard: 80°), the lower muscle strain.

In addition, when a keyboard on a workstation is located excessively higher than chair height, the supination of the upper arms increases. This increases strain on the trapezius muscle, and raises the shoulders, which makes people easily fatigued. On the other hand, when a workstation is too low, the trunk tends to incline forward, which increases back pain. For this reason, it is important to maintain a proper workstation height, but it is difficult to recommend a uniform height due to different body measurements of workers. In general, it is recommended to maintain chair and workstation height at the level that can maintain the extension of the upper arms at less than 25˚, the supination at 15-20˚, and the angle of the elbows at less than 90˚ [15].

The trapezius muscle fixes the shoulder bone that forms the shoulder joint, and elevates the shoulders. As the trapezius muscle is situated right below the skin, it is easy to apply the surface electromyogram, measure muscle strain on the neck and shoulders, and most of the pain that people with VDT syndrome experience is from the trapezius muscle [16].

Based on the results of earlier studies that the improper height of a keyboard causes pain on the shoulder, particularly the upper trapezius muscle, this study aimed to design a working environment that can reduce workers' fatigue and improve efficiency and functions. To do so, changes in the muscle activity of the upper trapezius muscle were measured depending on the height of a keyboard in order to prevent diseases such as VDT syndrome and to suggest a proper working posture.

2. Research Methods

2.1 Research subjects

This study was conducted on 40 healthy college students in their 20s. Subjects were selected among those who can type 250~300 letters per minute on a keyboard and do not use a keyboard over 4 hours a day in order to exclude the effects of accumulated tension. Those who had medical history of cervical disc problems, and fractures in the shoulders, elbows, wrists and fingers were excluded from subjects.

2.2 Research tools

The muscle activity of subjects was measured using the surface electromyogram (MP 150WSW, BIOPAC

System Inc. CA, USA). Electrical activity in muscles was measured and analyzed using surface electrodes and was used in the assessment of the nervous and musculoskeletal system.

2.3 Experimental methods

A fixed chair (height: 50 cm) without arm rests and a 74.5 cm-high desk were used to ensure the legs of subjects and the chair can fit under the desk. The angle of a monitor was set at 0~30˚, and subjects were instructed to sit with their hips against the back of the chair and to straighten their back. The height of the desk was adjusted by adding a hand-made wooden board on a keyboard.

While subjects were sitting on the chair with their back straightened, the height of their elbows was measured. After adjusting their arms' position, the distance between the desk and chair was adjusted to ensure the flexion of the shoulder joints and the elbow joints was about 0˚ and 90˚ respectively. To eliminate any element that can affect the sensitivity of the filtering of subjects' electromyogram, any metal object was removed. Indoor fluorescent lights were turned off, and ambient noises were removed. Women with long hair were instructed to tie their hair and to wear underwear without any shoulder strap and a top. Men took off their top, and surface electrodes were attached on the upper trapezius muscle on both sides.

The areas to which surface electrodes were attached were cleansed with an alcohol tissue, and a small amount of an electrolyte gel was applied to the areas in order to reduce skin resistance. A surface electrode was attached between the 7^{th} cervical vertebrae and the middle part of the acromion process, and an ground electrode was attached to the styloid process of the foot bone.

In this study, four different keyboard heights were applied: 1) the height of the elbows and the desk was equal; 2) the height of the desk was 3 cm lower than that of the elbows; 3) the height of the desk was 6 cm higher; and 4) the height of desk was 9 cm higher. To ensure the wrists and the lower arms were not supported when subjects used a keyboard, subjects were divided into four groups (10 per group) and different keyboard heights were applied to individual groups. Subjects were instructed to type on a keyboard for 2 minutes, and to have a 2-minute break between experiments in order to eliminate any strain on the trapezius muscle.

2.4 Data processing and analysis methods

The data collected in this study were statistically analyzed using SPSS 18.0 ver. To verify the hypothesis, one-way ANOVA was conducted on the repetitively measured data. The significance level was set at α=.05 to verity their statistical significance.

3. Research Results

3.1 General characteristics of subjects

Subjects were randomly grouped as follows: 10 subjects into Group A (the height of a desk was 4 cm lower than the height of the elbows); 10 subjects into Group B (the height of the elbows and a desk was equal); 10 subjects into Group C (the height of a keyboard was 4 cm higher than that of the elbows); and 10 subjects into Group D (the height of a keyboard was 8 cm higher than that of the elbows). Each group was composed of 5 male students and 5 female students, and a total of 40 students participated in this experiment.

The average age of subjects was 25.0 years, and their average height and weight were 169.6 cm and 61.4 kg respectively. There was no significant difference in the average age, height and weight between groups (Table 1).

Table 1. General characteristics of subjects

	A	B	C	D	P
	M±SD	M±SD	M±SD	M±SD	
age	24.40±2.71	24.10±2.02	25.50±3.32	25.80±1.81	.30
height(cm)	169.10±8.50	169.50±6.32	170.40±11.40	169.70±8.57	.99
body weight (kg)	60.44±10.93	61.20±10.44	63.70±13.25	60.30±11.08	.90

A:-4cm group, B:0cm group, C:4cm group, D:8cm group P(.05

3.2 Comparison of the activity of the upper trapezius muscle depending on keyboard height

This study examined changes in the root mean square (RMS) of the upper trapezius muscle when different keyboard heights were applied based on the height of the elbows. Four different keyboard heights were applied: Group A (the height of a desk was 4 cm lower than the height of the elbows); Group B (the height of the elbows and a desk was equal); Group C (the height of a keyboard was 4 cm higher than that of the elbows); and Group D (the height of a keyboard was 8 cm higher than that of the elbows).

The RMS of the upper trapezius muscle was measured while subjects in each group were working with a keyboard on the desk. The measured RMS was converted into %RVC based on the value of Group B (the height of the elbows and the desk was equal). It was found that out of the four groups (keyboard height: –4cm, 0cm, +4cm, +8cm) the group of –4cm showed a statistically significant difference in the muscle activity of the left and right upper trapezius muscles only. The rest groups also showed a difference, but it was not statistically significant (Table 2).

Table 2. Comparison of muscle activity of upper trapezius muscle

Group	Trapezius		F	P
	Right	Left		
A	32592.9	25665.5	.97	.04*
B	32969.2	19468.7	1.07	.35
C	28468.5	24665.3	.89	.44
D	28579.9	27868.5	.34	.21

A:-4cm group, B:0cm group, C:4cm group, D:8cm group P(.05

4. Discussion

A study on changes in the surface electromyogram depending on the location of a mouse when subjects were working with a computer reported that the rear of the deltoid muscle, the trapezius muscle and the upper rhomboid muscle were mostly involved [17]. Those in their 20s and 30s tend to have more neck pain than those in other age groups, which was attributed to the fact that using a computer for long hours causes pain in the upper trapezius muscle of users [6] [18], and it was also reported that the wrists extended for a long time and the posture deviated towards the ulna caused carpal tunnel syndrome [19].

Song et al. [20] conducted a group examination on workers at the risk of shoulder-arm-neck disorders, and found that myofascial pain syndrome is the most frequently observed disease and that the upper trapezius muscle was most easily involved. In particular, it was reported that the trapezius muscle is highly likely to be damaged by repetitively using the hands and arms when doing tasks that involve delicate skills or visual requirements.

The height of a workstation is also another factor, and in particular working at a high desk is known to cause several problems (Simonaeu et al. [21]; Kargar et al. [22]). In other words, when working at a high workstation, muscles around the shoulders and arms become easily fatigued, and work efficiency can be reduced by up to 70 %. It was also reported that working at a low-rise desk causes pain in the back and neck, resulting in fatigue [23~24].

This study aimed to examine changes in strain on the trapezius muscle while working with a keyboard depending on the height of a workstation. Under the hypothesis that a long-lasting strain on the trapezius muscle causes localized ischemia and tonic cervical syndrome, a proper height of a worktable when working with a keyboard was recommended to reduce strain on the trapezius muscle. First, the distance between the desk and chair was adjusted to ensure the flexion of the shoulder joints and the elbow joints was about 0˚ and 90˚ respectively.

In this study, it was found that out of the four groups (keyboard height: –4 cm, 0 cm, +4 cm, +8 cm) the group of –4 cm showed a statistically significant difference in the muscle activity of the left and right upper trapezius muscles only. The rest groups also showed a difference, but it was not statistically significant. The results did not coincide with the results that the group of –3 cm (An et al. [12]) and the group of +5 cm (Kim [11]) showed a low level of muscle activity. Meanwhile, Karlqvist et al. [13] reported similar results that those who chose to use a mouse on a desk of which height was less than 3 cm lower than the height of the elbows showed a low muscle activity in the trapezius and deltoid muscles compared to those who used a desk of which height was 3-9 cm higher. Bendix [25] reported that when the flexion of the elbow joints was 90˚, and the height of the home key was equal or lower than that of the elbows, the relative activity of the trapezius muscle was low.

For VDU (visual display unit) tasks that involve visual requirements, it is recommended to use a relatively high-rise keyboard and pads under the lower arms and wrists, and for typing tasks, it is recommended to adjust the height of the elbows, but the necessity for the use of pads under the lower arms and wrists is uncertain [26]. It is also reported that biofeedback or voluntary efforts can reduce strain on the upper trapezius muscle without affecting strain on other muscles in the arms and hands. In addition, when performing the same tasks, it is possible to reduce energy consumption and improve the efficiency of work by reducing less muscles and muscle activity [22].

In conclusion, the proper height of a keyboard to reduce strain on the trapezius muscle is equal to the height of the elbows or 4 cm lower than the height of a workstation, which makes office workers do their work with a keyboard more comfortably [27]. In order to suggest a suitable keyboard height, it will be necessary to conduct studies on the height (4-8 cm) of a workstation in addition to the height of the elbows. Although the level of discomfort that user feel on their shoulders and neck is affected by the intensity and frequency of repetitive tasks, it is still necessary to conduct studies on the ergonomic assessment of improper VDT workstations.

The recommended keyboard height is expected to be utilized as a prevention method to reduce the morbidity rate of musculoskeletal diseases that VDT users experience. At the same time, it is needed to examine changes in the self-reported strain after conducting an experiment, and differences in strain between males and females, and to conduct studies on other musculoskeletal diseases associated with computer work such as turtle neck syndrome and carpal tunnel syndrome by controlling various work environments (monitor, keyboard, mouse, chair, desk), postures and exercises (stretching, ROM, massage) and comparing differences before and after conducting experiments in order to examine the effects of the variables on the diseases.

There are some limitations in this study. Since participants had to type on a keyboard in an unfamiliar space, they seemed to be uncomfortable with typing on a keyboard, and they started to be conscious of equipment and show unnatural postures. In addition, since other muscles were not measured, it was difficult to identify their impact, and the effects of the length between the two shoulders, and the length of fingertips on muscle activity depending on the type of keyboards was not also considered.

5. Conclusions

With the aim of examining the effects of the height of a keyboard on the muscle activity of the upper trapezius muscle, this study was conducted on a total of 40 subjects, and they were divided into four groups (10 subjects for each group): Group A (the height of a keyboard was 4 cm lower); Group B (the height of a keyboard and the elbows was equal); Group C (the height of a keyboard was 4 cm higher); and Group D (the height of a keyboard was 8 cm higher). Their muscle activity of the upper trapezius muscle was measured and it was found that out of the four groups (keyboard height: –4 cm, 0 cm, +4 cm, +8 cm) the group of –4 cm showed a statistically significant difference in the muscle activity of the left and right upper trapezius muscles only. The rest groups also showed a difference, but it was not statistically significant.

In follow-up studies, it will be necessary to control elements that affect strain, to measure the muscle activity of other muscles, and to examine the effects of the length between the two shoulders and the length of fingertips on muscle activity depending on the type of keyboards. By doing so, it will be possible to recommend a suitable keyboard for individuals and to generalize the results of this study.

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