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Notebook computer use with different monitor tilt angle: effects on posture, muscle activity and discomfort of neck pain users

Wen-Ko Chiou[a*], Wei-Ying Chou[a], Bi-Hui Chen[b]
[a] *Department of Industrial Design, Chang Gung University, Wen-Hwa 1st Road, Kwei-Shan Tao-Yuan, Taiwan, 333, R.O.C.*
[b] *Chihlee Institute of Technology, Sec. 1, Wunhua Rd., Banciao District, New Taipei City, Taiwan, 313, R.O.C*

Abstract. This study aimed to evaluate the posture, muscle activities, and self reported discomforts of neck pain notebook computer users on three monitor tilt conditions: 100°, 115°, and 130°. Six subjects were recruited in this study to completed typing tasks. Results showed subjects have a trend to show the forward head posture in the condition that monitor was set at 100°, and the significant less neck and shoulder discomfort were noted in the condition that monitor was set at 130°. These result suggested neck pain notebook user to set their monitor tilt angle at 130°.

Keywords: display angles, chronic neck pain, forward head posture

1. Introduction

As overall technology grows, more and more people choose a notebook computer rather than a desktop for all their computer needs. Notebook computers, however, owing to their features of compact form, integrated monitor, and small input devices can increase exposure to risk factors for neck pain [1-3].

The monitor tilt angle is the only one part that can adjust by user without extra additions. However, the research about the monitor tilt angle of notebook computer is relatively insufficient. Jonai et al. [4] reported less neck flexion, neck extensor muscle activity but with higher discomfort at the tilt angle of 100°, suggested the ergonomic problems attributable to notebook computers are distinct from the desktop computers.

In the other head, many studies reported altered motor control of the neck pain subjects, suggested the distinctions between the health and neck pain subjects [5-7]. Therefore, a specific suggestion of display tilt angle for the notebook computer users with neck pain, was needed to be investigated.

2. Methods

2.1. Subjects

Six subjects were recruited in this study (three male and three female, age range = 20-26 years). All subjects using computer at least 3 hours per day, and complaint about neck-shoulder pain for at least 3 of the past 12 months. An interview questionnaire modified from the Standard Nordic Questionnaire [8] was used to collect information about musculoskeletal symptoms. The anthropometric measurements of subjects were measured in accordance with ISO 7250-1: 2008. The mean anthropometric measures for the subjects were showed in Table 1. This study was approved by the Chang Gung Memorial Hospital Institutional Review Board.

[*] Corresponding author. Email: wkchiu@mail.cgu.edu.tw

Table 1
Subject data and mean (SD) anthropometric measures by gender.

	Male (n = 3)	Female (n = 3)
Age (year)	22.3 (3.2)	22.0 (1.7)
Computer use (hr/ week)	33.3 (15.3)	27.3 (11.0)
Height (cm)	173.7 (4.9)	157.0 (7.5)
Weight (kg)	63.0 (2.6)	49.6 (8.4)
Sitting Height (cm)	89.7 (4.2)	83.1 (3.0)
Shoulder Height (cm)	59.8 (3.8)	55.2 (2.5)
Elbow Height (cm)	21.3 (3.6)	19.7 (1.5)
Popliteal Height (cm)	44.2 (3.3)	41.2 (0.8)
Biacromial Width (cm)	39.3 (7.5)	31.7 (1.5)
Elbow-wrist Length (cm)	30.12 (2.4)	27.6 (0.4)
Hand Length (cm)	17.5 (1.3)	16.7 (0.3)
Hand Width (cm)	8.8 (0.3)	8.1 (0.2)

2.2. Procedure

This study designed three different setting of monitor tilt angle: 100°, 115°, and 130°. All subjects worked for 5 min in each condition followed by 5 min breaks. The orders of these conditions were randomly allocated. For all conditions subjects used a 13.3 inch notebook computer (Sony VGN-SR45T). The notebook computer was placed on an adjustable desk with the desk height selected to let elbow flexion approximate to 90°. A chair with adjustable height was used, and the height of seat was adjusted to the match popliteal height.

Before start typing, the subjects would be asked to sit upright. During typing, the subjects can adjust their posture until they feel the posture is suit for their. Lateral photographs were taken before and after each typing task. This study assessed the head flexion, neck flexion and cranio-cervical angle (Figure 1) through photographic analysis of visual markers placed on body landmarks (right outer canthus, right tragus, and C7). The camera was positioned on a tripod 80 cm from the floor and 250 cm from the subject, for minimize parallax error. At the beginning and the end of each typing task, the subjects are asked to rate their typing-related discomfort in neck-shoulder regions, using a 10 cm visual analogue scale. Muscle activity of right cervical erector spines (CES) and upper trapezius (UT) muscles was measured by surface EMG. Electrodes that placed over the right CES and UT muscles were in accord with pervious paper [9]. The signals were amplified by a preamplifier placed close to the electrodes and then sent to the data acquisition unit of the NeXus-10 System (Mind Media B.V., Netherlands) that amplified and sampled the EMG inputs at 2048 Hz. All the EMG signals were processed in BioTrace+ (Mind Media B.V., Netherlands) program with a band-pass filtered at 20–500 Hz. Then the signals were down-sampled to 10 Hz RMS (root-mean-square). The EMG amplitude was normalized to maximum voluntary contraction (MVC, see Table 2) [6].

2.3. Data analysis

Nonparametric 2-related Wilcoxon (SPSS 16.0 for Windows, 2008) was used to examine the difference of posture, discomfort scores and normalized EMG

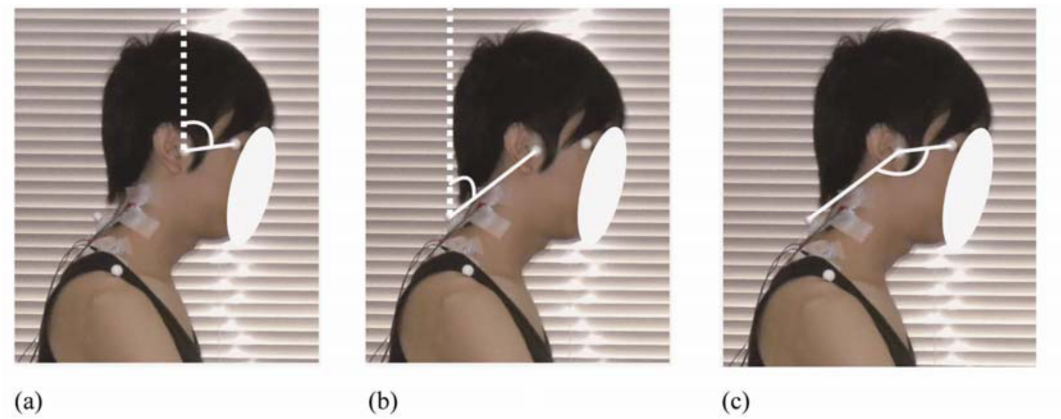

Fig. 1 Example of angle definitions: (a) head flexion, (b) neck flexion, (c) cranio-cervical angle

Table 2
Maximum voluntary contraction tested in normalization for CES and UT muscles.

Muscle	Starting position	Muscle action and application of load
Cervical erector spinae (CES)	Head in upright position	Neck extension- against resistant force at the post-erior occiput
Upper trapezius (UT)	Arm in 0° flexion and abduction Scapula at neutral elevation	Scapular elevation- against adjustable strap on the acromioclavicular joint

amplitudes within these conditions. The significance level was set at $p < 0.05$.

3. Results

The results of head flexion angle, neck flexion angle, and cranio-cervical angle were showed in Fig. 2. Before start typing, no significant different of posture was found among the three monitor tilt angles. The results of head flexion showed significant increased after typing, in the condition of monitor tilt 115° and 130°. The degree of neck flexion showed significant increased after typing in all conditions. In the condition of monitor tilt 100°, the results of cranio-cervical showed significant increased after typing. Compared the after typing posture of head flexion and neck flexion, there are no significant difference was found within these conditions. However, the cranio-cervical angle showed significant difference between the monitor tilt 100° and 130°, the lowest value was noted at the tilt angle of 130°

Table 3 showed the muscle activities and the ratings of discomfort in the different conditions of monitor tilt angle. The highest CES activity was found in the condition that the monitor tilt angle was set at 100°, and the highest UT activity was found in the condition that the monitor tilt angle was set at 130°. However, no significant different was found among these conditions. The highest cervical and shoulder discomfort was noted when the monitor tilt angle was set at 100 °. Subjects reported the tilt angle of 100° was significant discomfort than 130 °.

Table 3
Mean (SD) muscle activities of muscles and ratings of discomfort.

	100°	115°	130°	Nonparametric 2-related Wilcoxon
CES muscle activity (% MVC)	9.5 (2.5)	8.7 (5.5)	8.8 (4.5)	^{n}
UT muscle activity (% MVC)	5.8 (4.6)	3.8 (3.6)	7.0 (7.9)	^{n}
Cervical discomfort (cm)	1.7 (0.8)*	1.2 (1.3)	0.3 (0.5)*	* **p = 0.024**
Shoulder discomfort (cm)	1.3 (1.0)*	0.8 (0.8)	0.3 (0.5)*	* **p = 0.038**

^{n} No significant difference was found

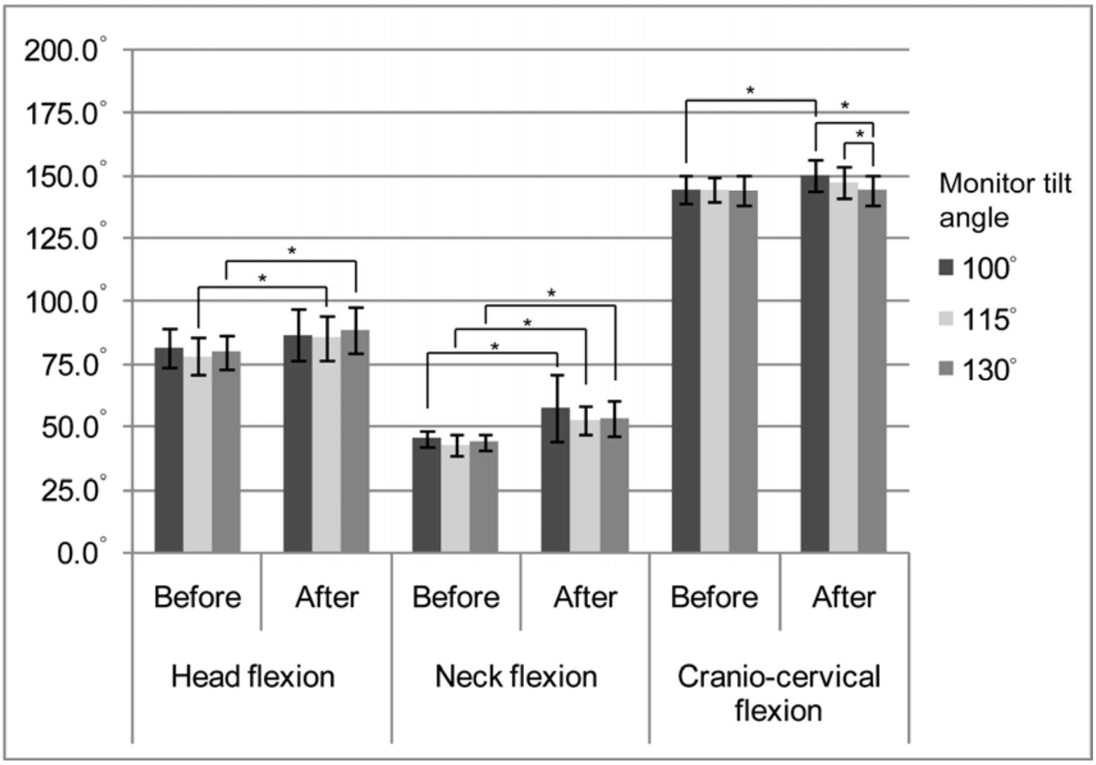

Fig. 2 Posture before and after typing, in the monitor tilt angle 100°, 115° and 130°.

4. Discussion

Many studies report the forward head posture, a combination of upper cervical extension and lower cervical flexion, is a major contribution factor to neck pain [5, 10, 11]. The head flexion angle reflects the posture of upper cervical spine segment and the neck flexion angle reflects the posture of lower cervical spine segment. Compare with before typing posture, all of conditions show significant increased of neck flexion after typing, and no significant difference is found among the three conditions. This suggests the subjects intend to hold their lower cervical spines in a more flexion posture when focusing on the computer monitor. However, the significant increase of head flexion are only found in the conditions of monitor set at 115° and 130°, means a more backward tilt monitor can play a role to help subjects to hold their upper cervical spines in more flexion, to avoid from the forward head posture.

The combined consequence of head flexion and neck flexion can observe form cranio-cervical angle. Since the relatively less head flexion and significant increased neck flexion, compare with before typing posture, subjects in the condition of monitor set at 100° report significant increased cranio-cervical angle after typing, this result also shows significant different with the condition that set the monitor at 130°. This means a more upright monitor has a trend to induce the forward head posture on neck pain subjects. The results probably because a more upright monitor makes subjects to show a more upright posture. However, since the reduced ability to maintain an upright sitting posture [12], the subjects finally fail to maintain their posture and show a forward head posture.

Compare with the condition that set monitor at 100°, this study report the subject's discomfort are significant lower in the condition that set monitor at 130°. It probably because a more tilt monitor led the subjects to increase their upper cervical flexion, this movement can offset the increased angle of neck flexion, and prevent their from forward head posture. The muscle activities of CES and UT reported no significant different among conditions, these results suggest the monitor tilt angle at 100°-130° probably provides no significant advantage or disadvantage to CES and UT.

In conclusion, results from this study show the neck pain subjects in different monitor tilt angle settings create different type of head-neck posture and different level of self reported discomfort. The significant less craio-cervical angle and self report discomfort was note in the condition that set the monitor tilt angle at 130°.

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