Anthropology
ISSN: 2332-0915
Saied et al., Anthropol 2013, 2:1
DOI: 10.4172/2332-0915.1000117
Research Article
Open Access

For Prolonged Computer Users: Laptop Screen Position and Sitting Style cause more Cervical Musculoskeletal Dysfunction Compared to Desktop, Ergonomic Evaluation

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Abstract

Background: There is a recent trend to replace desktop with laptop computers. Laptops are portable, light weight and space saving, enabling the users to work anywhere and at anytime. But most laptops are designed with the screen joined to the keyboard, making it impossible to adjust separately in terms of screen height & distance, and keyboard height & distance. We proposed that computer type and user sitting style affect differently the craniocervical angle and the load over specific muscles in the back and neck.

Subjects and methods: Thirty volunteer computer workers were studied at the Basic Sciences Department, Faculty of Physiotherapy, Cairo University from November 2012 to April, 2013. They first assumed the desktop then laptop sitting styles each for 20 minutes. Electromyography was done for the semispinalis cervicis, capitis and upper trapezius muscles, and subject's posture was captured by an infrared camera.

Results: There was a statistically significant increase in the craniocervical angle in desktop than in laptop sitting styles at p = 0.0001. There was significant decrease in semispinalis cervicis and capitis activities for desktop than for laptop on both sides at p = 0.0002.

Conclusion: Contrary to laptop, sitting in front of desktop computer increases the craniocervical angle and lessens the muscular load on the semispinalis cervicis and capitis of both arms. Upper trapezius muscles are not affected.

Keywords: Craniocervical angle; Ergonomics; Electromyography; Computer screen height

Introduction

The tasks of using desktop and laptop computers are increasing everyday particularly in education, business, publishing, banking, and even entertainment. They also serve as useful tools for communications and for some home activities. Over the last few years, there is considerable debate about which one of the two types is more suitable for prolonged use, even though marketing shows a trend to replace desktop with laptops. The cause lies in the fact that laptops have the advantages of being portable, light weight and space saving, enabling the users to work anywhere and at anytime [1]. Most laptops are designed with the screen joined to the keyboard, making it impossible to adjust separately in terms of screen height & distance, and keyboard height & distance [2]. This leads to prolonged flexion at cervical spine with consequent higher activity in the cervical erector spinae and upper trapezius muscles, with a posture in which the trunk is slightly inclined backward [3]. This leads to a consequent forward head and trunk flexion adopted as a fixed postural habit. Recently concerned health professionals have begun to see the physical effects of these malpostures particularly in those spending long hours day after day using their computers [4]. This forward head posture (FHP) involves a combination of lower cervical flexion and upper cervical extension and has been linked to some musculoskeletal dysfunctions such as upper crossed syndrome [5]. The forward head posture reduces the average length of muscle fibers, which contributes to extensor torque at the atlanto-occipital joint, and it is possible that this shortening reduces the tension-generating capabilities of muscles. In clinical practice it is widely believed that a FHP and other ergonomic disadvantages linked to laptop PC contributes to the development of chronic neck and shoulder pain [1,6]. It is possible to evaluate and analyze the muscular work pattern at workstation by electromyography (EMG), and this helps to either prevent a problem or correct it, if included in a successful ergonomic program aiming to improve health users and enhance their productivity [7]. Selecting ergonomically designed tools and making sure that they are used correctly can help operators to reduce the incidence and severity of these impairments [8], and sometime encouraging workers to adopt more flexed neck to lessen unnecessary mechanical load [9].

Subjects and Methods

Thirty right handed non professional computer user volunteers (15 males and 15 females) were enrolled in this study, all assigned as a single group. The work was completed at the Basic Sciences Department, Faculty of Physiotherapy at Cairo University from November, 2012 through April, 2013. Volunteers' age ranged from 18 to 30 years and all have signed a written consent after taking the approval of the Faculty Ethical Committee. Exclusion criteria included: pregnancy, diabetes mellitus, pre-existing neck or upper limb disorders, any

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Received October 31, 2013; **Accepted** December 07, 2013; **Published** December 12, 2013

Citation: Saied GM, Kamel RM, Mahfouz MM (2013) For Prolonged Computer Users: Laptop Screen Position and Sitting Style cause more Cervical Musculoskeletal Dysfunction Compared to Desktop, Ergonomic Evaluation. Anthropol 2: 117. doi: 10.4172/2332-0915.1000117

Citation: Saied GM, Kamel RM, Mahfouz MM (2013) For Prolonged Computer Users: Laptop Screen Position and Sitting Style cause more Cervical Musculoskeletal Dysfunction Compared to Desktop, Ergonomic Evaluation. Anthropol 2: 117. doi: 10.4172/2332-0915.1000117

existing neurological or systemic illness, and those having impaired performance for any reason. At the beginning they assumed the first sitting style for twenty minutes, and after ten minutes rest they assumed the second sitting style for an equal time. The first sitting style was a desktop user's position where the chair and table height were adjusted to allow 90° elbow flexion with vertical upper arm and a horizontal forearm [10]. The screen inclined backwards by 20° and kept away from the user by ± 80 cm. The top of screen was adjusted 20° below eye level. Second sitting style was a laptop user's position, the operator is kept away from the computer by the same distance (± 80 cm) and his knees are at 90° flexion and calves hanging vertically. The screen adjusted to minimum glare. It was difficult to precisely adjust the craniocervical angle to be equal in both sitting styles, as minor alterations were mandatory to adjust the user for his best performance. The angle for desktop sitting style ranged from 156.2 to 159.7 degrees, while for laptop sitting style it was between 150.2 and 153.9 (Figure 1 and Table 1). Subjects were instructed to work continuously in a non-stop manner, avoiding moving their chair or computer table also avoiding looking to the recording camera.

Equipment

The study equipments included a camera system and an EMG unit. The desktop computers had a 14″ wide screen monitor while laptops were provided with 15.6″ ones. The Myomonitor is a dual mode portable EMG and physiological signal data acquisition system. The apparatus surface sensors were used for recording activities of semispinalis cervices and capitis and upper trapezius (UT) on both sides. For UT the sensor is placed at a lateral distance 25 mm from midpoint between acromion and C7, while for the other 2 muscles the sensors were placed at the posterior aspect of neck on the occipital bone on the area between the superior and inferior nuchal lines. The ground electrode was placed on the lateral epicondyle of the elbow (Figure 1).

At the end of fifteen minutes in each position the EMG triggered the motion capturing system to begin recording simultaneously for 5 seconds aiming at relating the muscular load to the postural change [11]. Angles' calculation is 3D angle: It was the real angle of the joint in all planes X, Y and Z without neglecting the rotations of the joint as in 2D angles. The craniocervical angle is the angle between the line from the tragus to the outer canthus of the eye and the line from the tragus to the C7 spinous process. Data were collected in three sheets: personal data sheet, motion analysis sheet, and EMG sheet and stored on a removable memory card. Paired samples t-test was used to evaluate the statistical difference between the two styles at p = 0.05. For the camera, the Qualisys ProReflex motion capture analysis system was used, where a Proreflex Motion Capture Unit (MCU) utilizing infrared light reflection by 3 silver-colored reflective markers by 3 cameras supported by an A wand–kit for calibration, and an ABC-530 serial interface adaptor (Figure 2). Markers were fixed over the outer canthus of the eye, the ear tragus and the 7th cervical spinous process. The cameras capture capability was 120 frames per second.

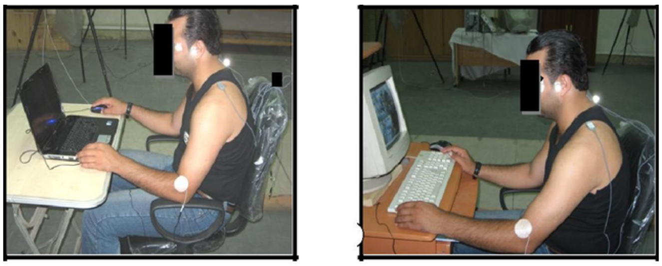

Figure 1: Laptop and desktop sitting styles with marker placement sites on: craniocervical angle, outer canthus of the eye, ear tragus and on C7 spinous processes.

SN	CCA D.top	CCA L.top	EMG Activities Desktop				EMG Activities Laptop			
			Rt. Semi	Lt. semi	Rt. U Trap	Lt. U Trap.	Rt. Semi	Lt. semi	Rt. U Trap	Lt. U Trap
1	158.4	151.8	12.2	11.5	10.1	9.5	13.5	12.9	10.1	9.5
2	157.5	152.7	12.5	11.8	10.2	9.3	13.9	12.8	10.4	9.2
3	159.4	150.9	12.9	12.1	9.9	9.8	14.2	13.5	10.5	10
4	158.1	151.8	13.1	12.2	9.5	8.3	14.5	13.9	9.5	8.9
5	158.6	151.9	12.6	12.1	9.4	9.1	14.8	13.6	9.9	8.9
6	157.4	152.9	13.2	12.8	9.8	9.2	15.5	14.1	9.7	8.5
7	156.9	151.8	12.5	11.9	9	8.2	13.7	13.1	10.3	9.6
8	156.6	153	11.1	11.5	10.2	9.7	13.9	13.1	10.1	9.2
9	156.2	151.5	12.9	11.8	10	9.5	13.3	13	9.8	9.1
10	157.5	152.5	12.8	12.1	9.2	8.5	13.9	12.9	9.9	9.2
11	158.3	152.6	12.2	11.5	9.5	8.9	13.5	12.9	9.6	8.9
12	156.5	151.6	11.5	10.5	10.1	9.8	14.9	13.5	10.5	9.7
13	158.6	152.6	13.2	12.4	10.2	9.9	14.7	13.1	10.4	9.9
14	157.3	151.9	13	12.5	9.7	9.5	14.6	13	9.3	8.9
15	157.9	152.7	11.9	10.9	9.6	9.1	15.1	14.2	9.5	8.4
16	159.7	150.6	12.7	13.6	10.4	10.6	15.6	13.7	10.3	10.6
17	156.2	153.9	10.9	11.6	10.5	9.8	14.3	14.8	10.6	9.5
18	158.4	154.2	13.3	12.4	9.8	8.2	14.7	15.8	10.4	9.2
19	158.8	152.7	12.7	11.7	10.4	10.5	13.7	15.3	9.4	8.4
20	157.2	152.6	12.1	12.2	10.3	8.9	13.2	14.7	9.6	8.2
21	159.5	151.3	11.8	11.5	9.3	9.3	14.7	14.3	9.1	9.5
22	155.8	154.3	12.9	12.8	9.7	10.5	15.8	14.8	10.3	10.7
23	159.6	152.7	12.5	11.9	9.2	9.5	14.7	13.2	10.2	9.2
24	159.2	152.3	11.7	10.2	9.1	8.6	15.8	15.9	9.8	8.6
25	156.4	150.2	13.2	13.2	10.3	9.1	13.6	14.8	9.9	8.1
26	158.8	151.6	11.4	13.9	9.5	8.3	13.8	14.7	10.2	9.8
27	157.2	151.2	12.7	12.5	10.2	9.7	15.8	15.1	10.5	9.2
28	157.9	153.7	12.6	11.2	10.7	8.4	15.4	14.8	10.2	10.6
29	158.7	151.8	11.9	12.7	9.2	9.6	14.6	13.6	9.3	9.6
30	**156.2**	**151.4**	**10.4**	**13.8**	**9.8**	**10.2**	**15.8**	**14.8**	**9.1**	**8.3**

Table 1: Results of Ergonometric Study.

Results

Half of the volunteers were females. Mean age in the full series was (24.36 ± 3.27) years, mean weight (71.3 ± 5.7) kg, mean height (167.33 ± 5.92) cm. The style of sitting in front of desktop had significantly increased the craniocervical 3D angle appreciably (157.82° ± 1.14). For laptop sitting style, the craniocervical 3D angle was found significantly decreased (152.22° ± 0.99) at p-value (0.0001) (Figure 3).

The muscular activities of the right semispinalis cervicis and capitis had been significantly decreased in the desktop sitting style (12.34 ± 0.74) mv compared to (14.51 ± 0.81) mv for laptop sitting style (p =0.0002). In the left side it was (13.99 ± 0.93) mv and for the right side (12.09 ± 0.87) mv. For the upper trapezius the results were no significant at p= 0.22 and 0.66 for the right and left sides respectively. (Table 2 and Figure 4) There were no differences between males and females regarding these data.

Discussion

For computer workers, display height and screen type are crucial

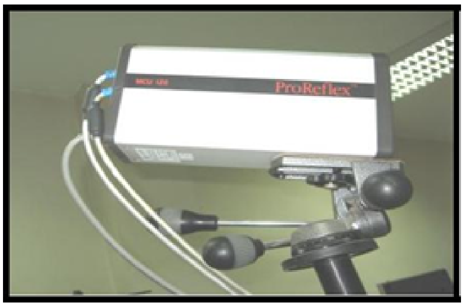

Figure 2: Pro-Reflex camera and its handel [en.souvr.com/product/201006/6595.html].

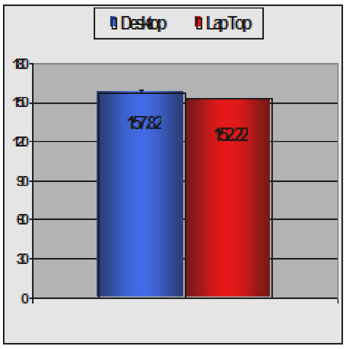

Figure 3: Mean and ±SD of the craniocervical angle.

CCA	Desktop	Laptop
Mean ± SD	157.82° ± 1.14	152.22° ± 0.99
Mean difference	5.6	
DF	29	
t-value	18.48	
p-value	0.0001	
S	S	

Table 2: Mean and ±SD, *t* and *p* values of Craniocervical angle.

factors for minimizing cumulative trauma disorders imposed over the musculoskeletal mass in the neck and upper limb [10]. Analysis of earlier statistical studies point to a decrease in the percentage of EMG activity of right compared to left semispinalis cervicis and capitis muscles with desktop than with laptop use. This decrease may be a feature of the usually adopted more erect position of the head and trunk which is more evident on the desktop position. This straight posture places the center of gravity of the head and neck close to their axes of rotation at cervical spine, thus decreasing the flexion thrust and reducing the demand on the neck extensor muscles to maintain the head and neck in equilibrium [12]. In addition, it has been reported earlier that the momentum arms of most of the neck extensors vary by <1 cm on changing head and neck posture [13]. For the semispinalis capitis and trapezius muscles this may increase by up to 2-3 cm from flexed to extended postures. This results in a less demand on the extensor muscles due to the inverse relationship between the momentum arm and the force exerted (momentum arm = momentum / force). On the other hand the myoelectric activity over the right upper trapezius showed a less difference between desktop and laptop sitting postures. It may be attributed to the need to increase the flexion angle between the head and neck in laptop than desktop workers. This accentuation

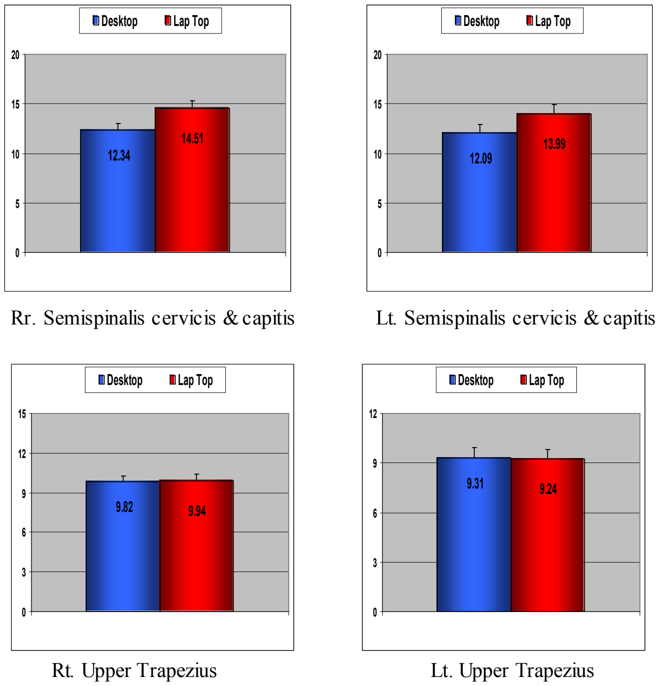

Figure 4: Mean and ± SD of the EMG activities of tested muscles.

moves the center of gravity further forward in front of the cervical spine increasing the momentum arm of the gravitational force. This may lead to a compensatory increased activity in the upper trapezius muscle to keep the head in a balanced position. The results of the present study go with those of Straker and his colleagues 4 years ago [10] who reached to the same conclusion by studying the muscle activity of the spine and upper limb of 36 young adults at different display heights. Surprisingly this was against the older viewpoint of Seghers and his team [14] who reported an appreciable difference in muscle activity between the right and left trapezius, and that the right trapezius was consistently more activated than the left at all screen heights. This odd result is probably related to the dominant hand control over the cursor keys during the experimental part of their study.

Conclusion

Contrary to laptop sitting style, sitting in front of desktop computer increases the craniocervical angle and lessens the muscular load on the semispinalis cervicis and capitis of both arms. The upper trapezius muscles are not affected. In general, it is recommended to work with desktop computers for prolonged users (>20 minutes) and also for younger children and school students. Individuals suffering from cervical or lumbar spondylosis may need medical consultation before. Left handed users may need separate study.

Acknowledgement

We thank all volunteers who participated in this trial. Appreciation is to Prof. Dr. Azza Moustafa, Faculty of Engineering for collaborative statistical revision, Dr Sahar Adel, Faculty of Physiotherapy and to Dr. Hala El-habashi, Faculty of Medicine for their active participation in the ergonomic testing.

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