Evaluation of Upper Extremity Computer Mouse-Related Musculoskeletal Disorders

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ABSTRACT

An investigation of the effect of using the computer mouse on selected shoulder and back muscles activity was conducted using electromyography (EMG). The possibility of existence of some levels of musculoskeletal dysfunction even in the absence of any subjective complaint was also examined. Twenty patients and twenty normal volunteers (control group), all are computer mouse users, were included in the study. The EMG activity of the tested muscles showed a significant increase in both groups compared with the non-dominant side muscles of the control group at resting position. The EMG activity of the tested muscles of the patients group was significantly higher than the control group dominant side. No correlation was found between the level of muscle tension and subjective perceived tension. The results proved that the use of computer mouse placed beside a wide keyboard is the cause of musculoskeletal dysfunction, which also exist in mouse users without any subjective complaint.

Key words: *Computer mouse, Musculoskeletal dysfunction, Electromyography, Subjective awareness, Ergonomics.*

INTRODUCTION

Although computers are powerful tools that can enhance the creative capabilities of man, they also possess in no less measure the potential for causing a minor to a major musculoskeletal disorder. Reports of upper limb disorders related to computer use are increasing[4,8,16,17]. People who use a mouse start reporting pain and discomfort in their shoulders and arms [20]. The mouse is usually positioned to the side of the keyboard, the side of the hand preference. Early keyboards were narrow and the mouse was close to the user. As the keyboards are being made wider to facilitate data entry, the mouse is moved farther away. The new raised ergonomic keyboards are even wider [22,23]. Accordingly, the mouse users must extend their arms about thirty centimeters from their legs, and hold them out at an angle. Today, computer users tend to use the mouse at least 30% of the time for word processing, to about 80% or more when they do graphic work or play games[9,14,18].

An electromyographic (EMG) apparatus was used in order to test the amount of activity in the muscles of the upper arm and shoulder girdle. The purpose of this study was to use EMG as an objective method for evaluating the effect of mouse position on muscle tension levels of some upper arm, shoulder girdle, and back muscles during the use of computer mouse; and to investigate the possibility that, some levels of dysfunction can also exist even in the absence of any subjective complaints.

MATERIALS AND METHODS

Subjects:

Twenty patients with upper arm and shoulder pain (13 females and 7 males) 21 to 52 years old (mean age 31.85 years, ± 9.27 years) voluntarily participated in the study. A group of normal volunteers (11 females and 9 males) 20 to 50 years old (mean age 32.40 years, ± 8.80 years) served as a control group. In order to be included in the study subjects had to 1) be using computer mouse for at least one year, and 2) have no history of upper arm or shoulder pain in the dominant side. All subjects were right handed, and they all gave their written consent to participate in the study.

Instrumentation:

i) Cyborg J33 EMG unit (Cyborg Corp., 342 Westeren Ave, Boston, MA 02135).
ii) A pre gelled adhesive silver-silver chloride electrodes (Cyborg Corp.) 1 cm in diameter.
iii) A 70% ethyl alcohol.
iv) Universal goniometer.
v) An IBM compatible computer with an extended IBM 101-key keyboard model M, a 48x20 cm mouse pad, and a standard two-button curved Microsoft model Inport mouse (Microsoft Corp., one Microsoft way, Redmond, WA 98052-6399)
vi) A local wooden computer desk, and desk hydraulic adjustable height and tilt chair.

Procedure:

Subjects were seated and positioned at a computer desk with a keyboard and mouse pad. The surfaces of the keyboard and mouse pad were marked for consistent placement. The subjects were centered in front of the keyboard at the point between the H and J keys. The mouse and mouse pad were placed immediately to the right side of the keyboard. Chair height and distance to the keyboard was adjusted using the goniometer to allow a 110 degrees bend at the elbow with the forearm parallel to the floor, and a 110 degrees bend at the knee with the feet flat on the floor[1,11].

Skin surface was prepared using pads saturated with 70% ethyl alcohol. The active electrodes of the EMG were placed 3 cm apart for the following muscles according to Basmajian and Blumentein, 1980[2].

i) Posterior deltoid: active electrodes were placed 2 cm below the angle of the acromion and parallel to the muscle fibers; the ground electrode was placed on the acromion.
ii) Upper trapezius: the active electrodes were placed halfway on line between C7 and the angle of the acromion; the ground electrode was placed on C7.
iii) Lower trapezius and rhomboids: the active electrodes were placed lateral to the vertebra and medial to the inferior angle of the scapula between T5 and T7; the ground electrode was placed on the inferior angle of the scapula.

Following electrode placement and signal calibration, the time base was set to 4c/sec, and sweep to 25 ms/division. Each channel frequency was set to 10 KC/s, and sensitivity to 2000 μv/division. The subject was asked to look straight ahead at the monitor and rest his hand in his lap, then he was asked to draw circles using the mouse for one minute. The subject was also asked to rate his awareness of muscle tension in the tested muscle groups on a scale of 1-5, 5 for the highest muscle tension and 1 for the least muscle tension perceived. The procedure was repeated 3 times in the same sequence for each subject. The means of the three readings were used for analysis.

For the control group the electrodes were then repositioned to the same muscles of the

opposite upper limb (non-dominant) and three recordings during the resting position (hands in lap) were taken. The mean of the three readings was used for analysis.

RESULTS

The effect of arm position on EMG signal level of activity means for the three tested muscles were compared, at rest and at mouse use position, using independent t test. The middle 30 seconds of each 1-min trial was used for analysis to avoid any signal movement artifact at the beginning and end of the trial. The differences were considered significant at $P \leq 0.05$.

Comparison of raw EMG signal means at rest showed a significantly higher level of activity in the three tested muscles in the patients group compared to the control group dominant side; and in the control group dominant side compared with control group non dominant side (table 1,2, and figure 1).

Table (1): Comparison of the EMG signal level in the three tested muscles at rest in both patients and control groups dominant side.

Muscle	Patients dominant		Normals dominant		t-test	
	Mean	SD	Mean	SD	t	P
Post deltoid	7.30	0.69	5.25	0.48	12.07	0.0000*
Upper trapezius	18.81	1.47	10.12	2.55	13.84	0.0000*
Lower trapezius rhomboids	16.42	3.23	11.44	2.28	7.20	0.0000*

* $P < 0.05$

Table (2): Comparison of the EMG signal level in the three tested muscles at rest in control group dominant and non dominant sides.

Muscle	Control non dominant		Control dominant		t-test	
	Mean	SD	Mean	SD	t	P
Post deltoid	3.50	0.37	5.25	0.48	14.36	0.0000*
Upper trapezius	6.99	1.30	10.12	2.55	4.77	0.0001*
Lower trapezius rhomboids	7.80	1.23	11.44	2.28	6.68	0.0000*

* $P < 0.05$

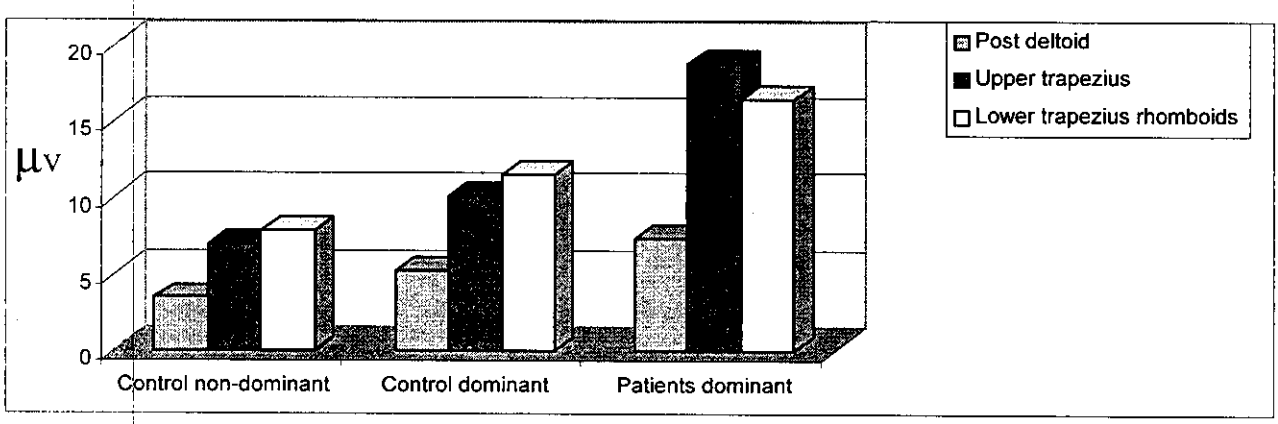

Fig. (1): Comparison of three muscle groups at rest in both sides of control group and dominant side of patients group.

Comparison of raw EMG signal means during mouse use showed elevated, but not, significant difference in the level of activity of the posterior deltoid muscle between the patients group and the control group dominant side. The upper trapezius, and lower trapezius and rhomboid muscles EMG signal means were significantly higher in the patients group (table 3, and figure 2).

Table (3): Comparison of the EMG signal level in the three tested muscles at mouse use position in patients and control groups dominant side.

Muscle	Patients dominant		Control dominant		t-test	
	Mean	SD	Mean	SD	t	P
Post deltoid	15.02	3.48	14.80	3.97	0.18	0.8588
Upper trapezius	40.50	8.25	38.11	4.50	1.11	0.2783*
Lower trapezius rhomboids	28.01	6.49	24.95	2.98	1.84	0.0800*

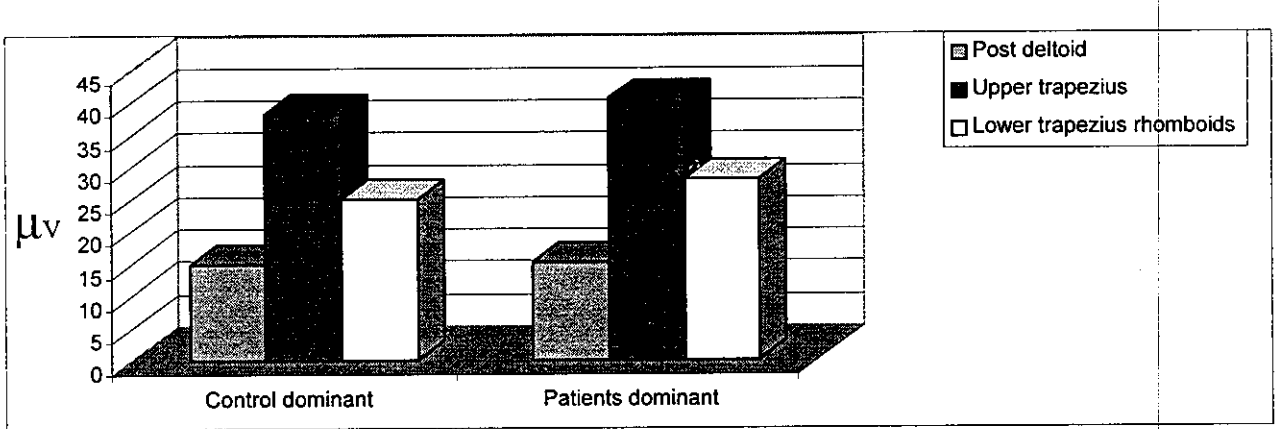

Fig. (2): Comparison of three muscle groups at mouse use position in control and patients groups dominant side.

Subjective awareness of muscle tension levels showed no significant correlation between measures of subjective awareness and corresponding muscle groups. Pierson product moment correlation was used, $P > 0.05$.

There were no observed gaps during mouse use, in which the EMG signal level was equal to the resting EMG signal level of the three muscles, at resting position in both groups.

DISCUSSION

All subjects in this study were computer users and all of them were using the computer mouse placed to the side of an extended keyboard. The computer mouse is present in every office to be used with recently developed graphical user interface[5,8]. A little has been published on the nature and magnitude of upper extremity musculoskeletal disorders associated with computer mouse use. A lot of work on the musculoskeletal problems associated specifically with computer mouse use is needed[14]. The investigation of current epidemiologic and ergonomic research demonstrates consistent relationships between certain computer-related factors and musculoskeletal disorders[10,15].

Extended use of the mouse placed to the side of an extended keyboard leads to

significant increase in muscle tension in the shoulder, back, and arm. More importantly this elevated muscle tension occurs without awareness or microbreaks. The lack of awareness of the developing muscle tension could lead, in addition to pain and discomfort, to injuries of the musculoskeletal components of the neck, back, and upper limb[6,13,22].

The results of this study showed that the activity in the posterior deltoid, upper trapezius, and lower trapezius and rhomboids were higher than normal in the patients affected side and in the control group dominant side during rest. These higher values of the control group dominant side indicated that they had muscle tension, and they are at risk of developing musculoskeletal disorders.

The sharp elevated activity of the tested muscles during mouse use position in both groups indicated that these muscles motor behavior was abnormal, and showed that additional motor units were progressively recruited to compensate for the loss in contractility due to impairment of the fatigued units[3,19,21].

The absence of correlation between subjective awareness and muscle tension levels proved the possibility of existence of some levels of musculoskeletal dysfunctions even in the absence of any subjective complaints.

The results of the study also indicated the important role of electromyographic evaluation of patients with computer-related disorders, and normal computer users at risk of developing computer-related musculoskeletal disorders. The results also clarified the need for better and safer equipment design and techniques of use[12], developing training programs to improve subjective awareness of muscle tension, and developing techniques to help the operator to release the tension when developed.

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الملخص العربي

تقييم الخلل الوظيفي العضلي الهيكلي للطرف العلوي المرتبط باستخدام مؤشر الكمبيوتر (الفأرة)

يهدف هذا البحث لدراسة تأثير استخدام مؤشر الكمبيوتر (الفأرة) الموضوعة بجانب لوحة المفاتيح العريضة على النشاط العضلي لعضلات أعلى الذراع والكتف والظهر . وقد استخدم جهاز تخطيط العضلات الكهربائي لدراسة النشاط العضلي لمجموعتين ، عشرون من المرضى وعشرون من الأصحاء كلهم من مستخدمي الكمبيوتر والمؤشر . وقد أجري الاختبار في وضع الراحة وعند استخدام المؤشر . وقد أظهرت نتائج البحث وجود فروق معنوية في زيادة النشاط العضلي للمجموعتين مقارنة بالجانب الغير سائد لمجموعة الأصحاء في وضع الراحة . كذلك أثبتت النتائج وجود فروق معنوية في زيادة النشاط العضلي لمجموعة المرضى مقارنة بمجموعة الأصحاء في وضع استخدام المؤشر . لم تظهر النتائج وجود ارتباط معنوي بين درجة النشاط العضلي والإحساس بهذا النشاط الزائد لدى المجموعتان . مما تقدم ثبت تأثير استخدام مؤشر الكمبيوتر الموضوع بجانب لوحة المفاتيح العريضة في إحداث الشد العضلي الزائد لدى المستخدمين من الذين يشكون من أعراض والأم بأعلى الذراع والكتف والظهر ، وكذلك المستخدمين الذين لا يشكون من أي أعراض .