Myoelectric Activity of Wrist Flexors and Extensors at Different Computer Mouse Platform Slopes

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ABSTRACT

The purpose of this study was to investigate the effect of using three different computer mouse platform slopes on the myoelectric activity of the wrist extensors and flexors. The three computer mouse platform slopes tested were; a horizontal slope with a forearm support, and two downward tilted slopes of 10º and 20º. Thirty male students participated in this study. Each student conducted a 'point and click' computer mouse task for 30 minutes at each of the three computer mouse platform slopes. Wrist extensors' and flexors' surface EMG data were collected and normalized in relation to the EMG activity recorded at the horizontal slope without using the forearm support. Results revealed that computer mouse use at the 10º downward tilted slope was associated with the least myoelectric activities of the specified muscles. Consequently, it was concluded that computer mouse use at a 10º downward tilted computer mouse platform slope is much more preferable than its use at any of the other three slopes. Thus, using the computer mouse at this slope can be beneficial in reducing the computer related musculoskeletal disorders.
Keywords: *Computer Mouse Platform Slope, Electromyography, Wrist Muscles, Computer Mouse Use.*

INTRODUCTION

A substantial shift in personal computer operation has occurred in the past two decades with the introduction of computer software packages that make primary or even exclusive use of electromechanical pointing devices such as the computer mouse and trackball[4]. It has been estimated that 30-60% of computer user’s time involves the use of these devices[6].

As the use of personal computer became more integrated into many workplaces, an alarming increase has occurred in reports of computer related upper extremity musculoskeletal pain. Much research work suggested that intensive computer mouse users are at increased risk for carpal tunnel syndrome and other upper extremity musculoskeletal disorders[6]. One of the factors that might account for the increased incidence of carpal tunnel syndrome and other musculoskeletal disorders among computer mouse users is the sustained static muscle loading. Maintenance of static postures leads to muscle imbalance with some muscles being overused and others underused. The overused group undergoes hypertrophy whereas the underused one becomes weakened due to lack of use. Static loading on the overused muscles produces reduced peripheral circulation and myalgia. In addition, maintaining abnormal or prolonged static postures can also increase pressure around peripheral nerves or stretch them, causing increased tension within the nerve, which results in chronic nerve compression[5,7].

A controversy still exists about which wrist position is associated with the maximum muscular tension. Ferguson et.al[3] reported that when the hand is in a wrist-neutral position, the muscles of the forearm could work at maximum efficiency and generate maximum contractile force. On the other hand, Rose[11], and Mogk and Keir[8] stated that sustained wrist extension causes elevated muscle activity of wrist and finger extensors. Maintaining these positions at which there is high muscular tension is hazardous as it causes the development of several musculoskeletal disorders including lateral epicondylitis (inflammation of the common extensor origin). So, it is important to avoid static wrist positions that are associated with increased muscle load[5].

From the above findings it appears that appropriate design for computer workstations is needed to provide certain degrees of comfort for the wrist to minimize pain and discomfort of the hand. Therefore, the aim of this study is to design a prototype computer mouse platform with variable slopes that enable different wrist positions and examine its effect on the handling of the mouse. The four computer mouse platforms to be tested are two horizontal slopes (once in the presence of a forearm support and another in its absence) and two downward tilted slopes of 10° and 20° (in the presence of a forearm support). The aim of this study is to examine the effect of the four mouse platforms on the myoelectric activity of the wrist extensors and flexors.

METHOD

Subjects

A group of thirty male university students participated in this study on a voluntary basis. Their average age was 19.6 (± 1.3) years. Their average height was 177.3 (± 6.1) cm. Their average weight was 77 (± 13.2) Kg. They were familiar with computer mouse use and they were free of any musculoskeletal disorders.

Instrumentation

1- An office chair (Fig. 1): An office chair of an adjustable height was used to ensure an optimum sitting posture for the subject. It has two forearm supports; one of which was removed and replaced with a portable forearm support. The portable forearm support was specifically designed to include two rounded pads. One pad was firm and fixed to the chair with a height adjustable stand while the other was a little bit soft, swiveling on the fixed pad to allow a free movement of the student’s elbow and forearm in all directions without imposing a frictional force between the student’s elbow and the forearm support. The backrest was tilted 100° backwards. A stabilizing belt was used to stabilize the participant's trunk against the chair backrest to ensure that each subject will be recorded in the same posture.

Fig. (1): The office chair with a portable forearm support.

2- A personal computer with a 17 inches monitor placed over a desk of a fixed height (71.5 cm) and a standard mouse was used by the students to perform the mouse task.

3- A specifically designed computer mouse platform of adjustable height and slope (Fig. 2) was used. It is rectangular in shape with 25cm length and 20.5 cm width. Its height was adjusted to a height similar to that of the seated student's elbow height measured from the ground. Three different slopes were tested, a horizontal slope (0°), two downward tilted slopes (10° and 20°). The horizontal slope was tested twice, with and without the use of a forearm support.

Fig. (2): The computer mouse platform.

4- An EMG apparatus: A BIOPAC system was used with a MP100 data acquisition unit and CMRR of 110 dB. Two channels were used to record changes in the patterns of EMG signals of the right wrist extensors and flexors. Acknowledge 3.7 software was used for data analysis of the raw EMG signals. Silver-Silver Chloride (Ag-AgCl) disposable surface electrodes were used to record the EMG activity from the specified muscles.

PROCEDURE

As a preparation for the recording of the EMG activity of the specified muscles, the EMG apparatus was set at a gain of 10,000 with a sampling frequency of 500 Hz and the acquisition time was set for 15 seconds for each trial. Student’s skin at the sites of recording and ground electrodes were prepared, shaved and cleaned by alcohol to decrease skin impedance. Surface disposable Ag/AgCl electrodes were placed midway between the motor points and the tendenious origins of both the wrist extensors and flexors. Ground electrodes were placed on the left upper arm.

The chair height was adjusted such that the top of the seatpan was leveled with the student's upper border of the patella. The height of the seatpan was recorded to be considered for each student in each session.

The student's trunk was supported and stabilized against the backrest using a stabilizing belt. The student monitor distance was kept at an armlength from the center of the monitor's screen for each student. The forearm support was adjusted to the seated student elbow height with both shoulders leveled. The height of the mouse platform was adjusted to a height similar to that of the forearm support such that the student's forearm was oriented horizontally in a forward reaching position. These heights were to be considered at each of the four tested sessions.

After electrode placement, the EMG signals from the recorded muscles were monitored on the screen for adjusting the EMG apparatus. The myoelectric activity of the wrist extensors and flexors were recorded for 15 seconds while performing the computer mouse task at the horizontal slope without using forearm support. The myoelectric activity was recorded again at the end of a 30-minute computer mouse task at the specified conditions (horizontal slope with using forearm support, slope 10 and slope 20 degrees) (Fig.3).

Fig. (3): The subject while performing the task at a zero slope mouse platform. The EMG activity is recorded from the wrist flexors and extensors.

Kinetic data including the myoelectric activity of the right wrist extensors and flexors were collected and analyzed, using the MP100 system (Acquisition software version 3.7). For each muscle and at each trial, the signals were full wave rectified and integrated to measure the EMG amplitude in Volt. The recorded EMG from the specified muscles was normalized in reference to the EMG recorded at the position in absence of forearm support. Each student underwent three sessions with a different computer mouse platform slope at each session. The three tested slopes were a horizontal slope, in the presence of a forearm support, and a downward tilted slope, once of 10° and another of 20°. The order of the three computer mouse platform slopes was randomized among the three sessions for each student.

RESULTS

1- Myoelectric activity of wrist extensors

The results of the study showed that the mean value of the normalized EMG activity was 78.8%, 79.9 % and 128.6 % during mouse use at the horizontal mouse platform in the presence of a forearm support (Horizontal new design HND), the 10˚ downward tilted slope (SL 10) and the 20˚ downward tilted slope (SL 20) respectively. Statistical analysis using one-way ANOVA test showed that there was a significant difference ($p<0.05$) among the three tested computer mouse platform slopes (CMPSs) for the mean percentage of normalized EMG activity of the wrist extensors. Meanwhile, paired comparison using Duncan's multiple comparison test was used to compare between each pair. Table (1) and figure (4) summarize the mean percentage values of normalized EMG activity.

Table (1): Descriptive statistics and one-way ANOVA of the mean percentage of normalized EMG activity of the wrist extensors at the four mouse platform slopes.

CMPSs	HND	Sl 10	Sl 20
X±SD	78.8 ± 13.2	79.9 ± 11.8	128.6 ± 16
	ANOVA		
	F value = 3.84	p value = 0.01	
HND vs Sl 10	0.9		
HND vs Sl 20	0.004		
Sl 10 vs Sl 20	0.005		

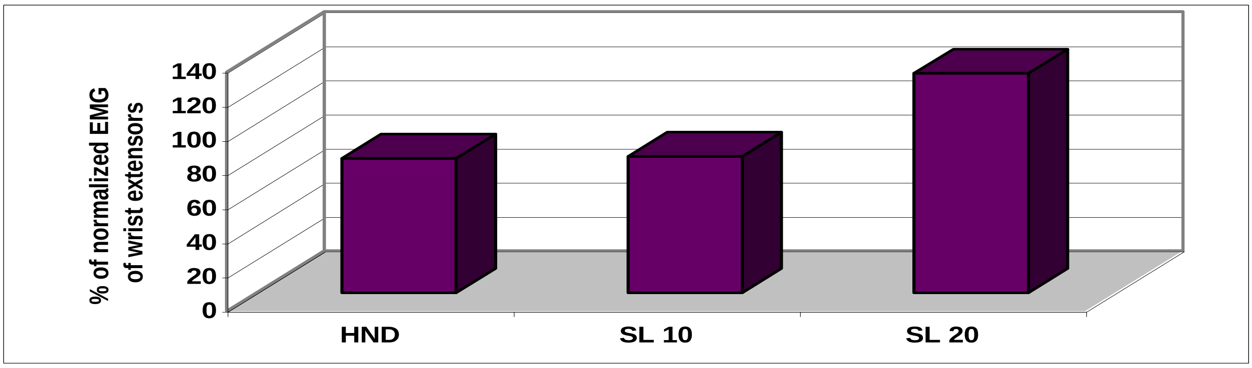

Fig. (4): Mean values of the percentage of normalized EMG activity of the wrist extensors at the three mouse platform slopes.

2- Myoelectric activity of wrist flexors

The results of the study showed that the mean value of the percentage of normalized EMG activity of the wrist flexors was 114.6, 84.2 and 128.6 after 30 min of mouse use using the horizontal platform in the presence of a forearm support, the 10˚ downward tilted slope and the 20˚ downward tilted slope respectively.

Statistical analysis using one-way ANOVA revealed that there was no significant difference among the three tested mouse platform slopes for the mean percentage of normalized EMG activity of the wrist flexors. Also, paired comparison using Duncan's multiple comparison test was conducted to compare between each pair (table2). The mean percentage values of normalized EMG activity of the wrist flexors during computer mouse use are shown in figure (5).

Table(2): Descriptive statistics and one-way ANOVA of the mean percentage of normalized EMG activity of the wrist extensors at the three mouse platform slopes.

CMPSs	HND	Sl 10	Sl 20
X±SD	114.6 ± 9.2	84.2 ± 10	128.2 ± 18
	ANOVA		
	F value =1	p value = 0.4	
HND vs Sl 10	0.3		
HND vs Sl 20	0.6		
Sl 10 vs Sl 20	0.1		

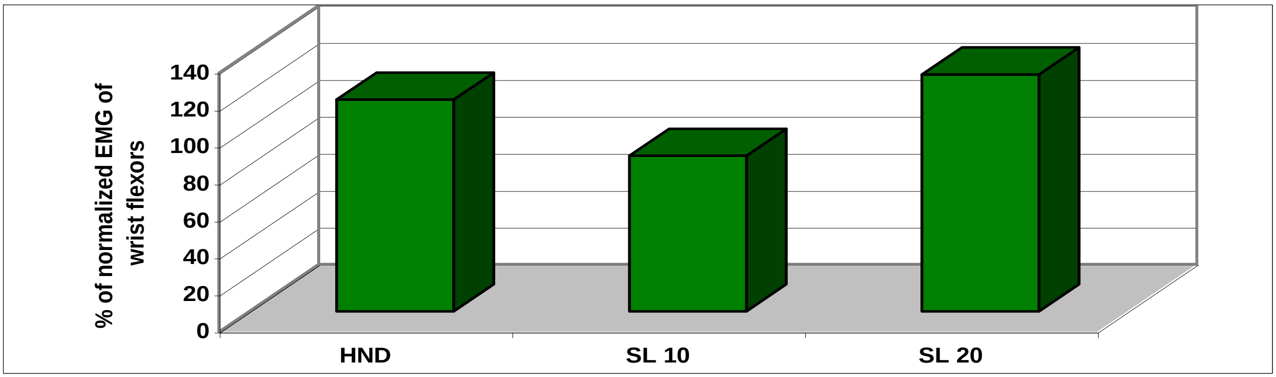

Fig. (5): Mean values of the percentage of normalized EMG activity of the wrist flexors at the three mouse platform slopes.

DISCUSSION

This study investigated the effect of grasping and using the computer mouse at three different computer mouse platform slopes on the myoelectric activity of the wrist extensors and flexors. The three tested platform slopes were horizontal slope with forearm support, and two anteriorly downward tilted slopes of 10° and 20°

Statistical analysis of the data obtained from 30 university students revealed that there was a significant difference between the 20° downward tilted mouse platform and either of the 10° downward tilted slope and the horizontal one in the presence of a forearm support, with the highest mean percentage of normalized EMG attained at the 20° downward tilted slope. As the wrist moved in a downward direction from an extended wrist position to a flexed one, moving from the horizontal slope to the 20° downward tilted slope passing by the 10° downward tilted one, an increase in the percentage of normalized EMG activity occurred. This might be attributed to the lengthened position of the wrist extensors, particularly the extensor digitorum communis producing a high tension (based on the length-tension relationship). This lengthened position of the wrist extensors during wrist flexion creates a passive extensor torque at the fingers, which further reduces effective grip force[8,9]. Moreover, the increased moment arm of the wrist flexors associated with wrist flexion is responsible for the high wrist flexion torque that even reaches its maximum at flexion. In addition, the effect of the gravity and the hand weight increase the flexion torque. As a consequence, a high extension torque produced by the wrist extensors counteracts this high flexion torque[1,10].

The increased activity of the wrist extensors associated with increasing wrist flexion could be supported by the findings of Mogk and Keir[8]. They studied the effects of wrist and forearm postures on forearm muscle loading during gripping. Ten healthy individuals performed five relative handgrip effects (5%, 50%, 70% and 100% of maximum, and 50 N) for combinations of three wrist postures (flexed, neutral and extended) and three forearm postures (pronated, neutral and supinated). Results revealed that both the extensor carpi radialis and extensor digitorum communis had higher activity in flexion than in extension from 50%

to 100% of $Grip_{max.}$ This relationship was also true when comparing activity in flexed wrist with that in a neutral one at 50% and 70% $Grip_{max.}$

Simoneau et.al.,[12] suggested that a slight decrease in percentage of maximum isometric voluntary contraction (MIVC) of the extensor carpi ulnaris muscle was noted as the keyboard slope moved from an upward tilt of 7.5° to a downward tilt of 15°. This is not surprising, as this study had not examined the effect of a downward tilt slope of more than 15°. A slope of such degree might have produced a more flexed wrist posture, which might have been accompanied by an increased EMG activity in wrist extensors as reported in this study.

Regarding the least mean percentage of normalized EMG activity of the wrist extensors, results showed that this was recorded during computer mouse use at the horizontal platform in the presence of a forearm support and the 10° downward tilted platform. Meanwhile, using Duncan's multiple comparison test, it was revealed that there was no significant difference between these two slopes for the mean percentage of normalized EMG activity of the wrist extensors ($P>0.05$). The absence of any significant difference between both slopes might be attributed to the absence of familiarity with the tested slopes, attributed to the design of the study. The participants were familiar with computer mouse use at the horizontal slope in the presence of a forearm support, however, they were unfamiliar with its use at the 10° downward tilted slope. A significant difference might have been found between both slopes if the participants were familiar with both slopes, as has been found by Dowler et.al.,[2]. They studied the effect of neutral posture on the myoelectric activity of the wrist extensors and upper trapezius muscles using surface EMG. Two similar positions were tested with different keyboard placement. The keyboard was once placed on the desktop, which was adjusted such that the participant's elbow form an angle of 90° with his hand rested on the desktop. Another time, the keyboard was rested on a 15° downward tilted keyboard tray with the elbow kept at 90° and the hand rested on the keyboard tray. A pre-test and post-test design was used to measure the muscle tension during typing, in control and experimental groups after 30 days. Results revealed that the myoelectric activity of the upper trapezius and wrist extensors was significantly lower when the keyboard was used at the 15° downward tilted keyboard tray as compared with that recorded when the keyboard was placed on the desktop ($P<0.001$). The decrease in the myoelectric activity of the wrist extensors with neutral wrist postures might be attributed to the decreased extensors torque needed to counterbalance the effect of the gravity, the hand weight and the flexors torque. This is as compared with the increased extensors torque needed to counterbalance the increased effect of gravity and flexors torque present during wrist extension.

Regarding wrist flexors in this study, the statistical results revealed that there was no statistically significant difference among the three CMPSs for the percentage of normalized EMG of the wrist flexors. However, it was obvious that computer mouse use at the 20° downward tilted slope was associated with the highest mean percentage of normalized EMG in wrist flexors for the three tested slopes. This might be due to the decrease in the grip force associated with wrist flexion, which consequently might need a more motor control in order to be able to manipulate the computer mouse and prevent it from slipping, thus increasing the flexors' activity.

The increased myoelectric activity of the wrist flexors with downward tilted platforms has also been reported by Simoneau et.al.,[12]. They tested the effects of a downward sloped keyboard on wrist position and forearm electromyography. Their results revealed that there was an increase of 1% to 1.5% MIVC in the muscle activity of the flexor carpi ulnaris muscle as the keyboard was sloped downward from an angle of 7.5° upwards to 15° downwards. A similar finding was reported by Mogk and Keir[8] who reported that the flexed wrist reduced the maximum grip force by 40%-50% while the EMG amplitude of the wrist flexors remained elevated. They added that even with reduced grip force, the flexors often had higher activation with flexion than in other wrist postures, except in the 70% and 100% Grip $_{max}$ trials.

Regarding the least mean percentage of normalized EMG of the wrist flexors, statistical results showed that this was found during computer mouse use at the 10° downward tilted slope. This might be attributed to the decreased muscle length with a consequent decrease in muscle tension associated with mouse use at this slope. This is as compared with the increased muscle length and subsequent muscle tension that was found during computer mouse use at the horizontal slopes (either in the presence or absence of the forearm support) where the wrist joint was extended more than that at the 10° downward tilted slope. In addition, computer mouse use at the 10° downward tilted slope wasn't associated with the increased motor control required to manipulate the computer mouse, precipitated by the fear of mouse slippage. This is as compared with the increased motor control needed to manipulate the computer mouse at 20° downward tilted slope.

As results of this study revealed, the lowest mean percentage of normalized EMG activity of the wrist extensors was found during computer mouse use at the horizontal mouse platform, used in the presence of a forearm support and the 10° downward tilted mouse platform. However, there was no significant difference between both slopes for the mean percentage of normalized EMG activity of the wrist extensors. Considering the myoelectric activity of the wrist flexors, there was no significant difference among the three tested computer mouse platform slopes for the percentage of normalized EMG activity of this muscle group. However, computer mouse use at the 10° downward tilted slope was associated with the least mean percentage of normalized EMG activity of the wrist flexors. This level of myoelectric activity of the wrist flexors might be beneficial especially if the computer mouse is to be used for a prolonged period of time. Thus, based on the myoelectric activity of the wrist extensors and flexors, it might be concluded that computer mouse use at the 10° downward tilted computer mouse platform slope is associated with the least myoelectric activity of both the wrist extensors and flexors.

Conclusion

The results of this study indicated that computer mouse use at a downward tilted computer mouse platform slope of 10° demanded a minimal myoelectric activity from the wrist extensors and flexors. On the other hand, when the computer mouse was used at the horizontal slope with a forearm support and also at a downward tilted slope of 20°, the results showed higher myoelectric activity at the wrist muscles. Therefore, from the results obtained it could be concluded that when using a computer mouse, it is favorable to be supported on a downward tilted platform of 10°. Such position could decrease the computer-related musculoskeletal disorders especially wrist extensors and flexors tenosynovitis and lateral epicondylitis.

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الملخص العربى

النشاط العضلى الكهربى للعضلات الباسطة والقابضة لمفصل الرسغ مع اختلاف ميل قاعدة فأرة الكمبيوتر

الغرض من هذه الدراسة هو اختبار تأثير استخدام ثلاثة زوايا ميل مختلفة لقاعدة فأرة الكمبيوتر على النشاط العضلى الكهربى للعضلات الباسطة والقابضة لمفصل الرسغ . الثلاثة زوايا المختبرة هى 1- زاوية أفقية باستخدام ساند للساعد، 2- زاوية ميل 10 درجات للأمام ولأسفل، و3- زاوية ميل 20 درجات للأمام ولأسفل. وقد شارك ثلاثون من الطلبة الذكور فى هذه الدراسة، وقد قام كل طالب بالاشارة والنقر بفأرة الكمبيوتر لمدة ثلاثين دقيقة فى كل زاوية ميل، وقد تم تجميع بيانات عن النشاط الكهربى للعضلات الباسطة والقابضة لمفصل الرسغ وذلك قبل وبعد أداء المهمة المطلوبة من الطالب. وقد أوضحت النتائج أن استخدام فأرة الكمبيوتر عند زاوية ميل 10 درجات لأسفل كانت مصحوبة بأقل نشاط عضلى للعضلات السابقة الذكر وبالتالى فان استخدام فأرة الكمبيوتر عند زاوية ميل 10 درجات لأسفل وللأمام هى أفضل الزوايا لتقليل اضطرابات الجهاز العضلى الحركى .