REVERSING MOUSE BUTTONS REDUCES FINGER EXTENSOR MUSCLE STATIC LOAD

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This paper describes an evaluation of an alternative way to use an ordinary computer mouse. The function of the two mouse buttons were switched and the index finger operated the right button for normal clicking while the middle finger rested on the table directly to the right of the mouse. An electromyographic /EMG) evaluation of this alternative hand position in 29 subjects showed that the EMG activity in the extensor digitorum superficialis muscle was lower compared to a normal hand position both when the hand was resting on the mouse as well as during repeated clicking. All subjects showed a lower average EMG level during repeated clicking and 27 subjects reduced their activity when resting the hand on the mouse compared to a normal hand position on the mouse.

Keywords: EMG, forearm, computer work

1 Introduction

The use of computers in almost any human activity is constantly increasing in the industrialized world. According to Swedish statistics, 48 percent of the female population used a computer every day in 2003 while this figure had increased to 60 percent in 2006. Similar figures for men were 58 and 69 percent respectively (SCB, 2006).

In almost any modern computer interacting with its user, some kind of two dimensional graphical interface is applied, demanding a pointing input device, mostly a computer mouse. When you buy a personal computer, a conventional computer mouse is included as standard. Due to identified ergonomic problems related to these mice (see below) an increasing number of alternative solutions with other hand postures have been suggested and put on the market. However, the conventional mouse still is the dominating graphical input device in use. Karlqvist and co-workers found that 95% of a population using a computer at work used a conventional mouse (Karlqvist et al., 2002). Alternative solutions are considered mostly as a reactive measure when problems occur.

Computer work is associated with significant risks for musculoskeletal disorders (MSD) in the upper extremities (Punnett and Bergqvist, 1997; Village et al., 2005). Possible causing activities may be keyboard or mouse use. The latter has been identified causing adverse static loads (Jensen et al., 1998) and Dennerlein and Johnson (2006) have shown that mouse use causes higher loads on the upper extremity compared to keyboard use.

The widespread Windows operating system demands two mouse buttons for efficient use. The left button (operated by the index finger) is the most commonly used while the right (operated by the middle finger) is used more sporadic. The hand position, normally applied, is in this paper referred to as the normal position (NP) and is shown in figure 1. Lee et al. (2007) recently have reported that 48 percent of a graduate student population lifted their middle finger not to do an unintentional right click during mouse use. Own unpublished observations indicate that this behaviour is most pronounced when doing left clicks. This lifted finger involves a statically activated finger extensor muscle in the forearm which is considered as a risk factor for MSD (Sjøgaard et al., 2000).

Lee at al. (2006) have suggested alternative mouse designs to avoid this problem. In this paper a much simpler solution is suggested based on the available conventional mouse.

The Windows system can easily be reprogrammed to switch the functions of the two mouse buttons. This option is mainly intended for left-handed users. However, in this paper this option is used to create an alternative hand position (AP) on the mouse according to figure 2.

The aim of this paper is to assess and compare the electromyographic muscle activity (EMG) in the extensor digitorum superficialis muscle (EDS) at NP and AP, both with the hand resting on the mouse and during repetitive clicking.

2 Material and methods

2.1 Material

Twenty-nine voluntary test subjects (18 women, average age 51 years, range 17-64; 11 men, average age 42, range 16-64) were recruited. The inclusion criteria were: right handed man or woman within the age range 16 – 65 years of age with no signs of MSD in the forearm during the previous month using a conventional computer mouse. Some of the subjects had occasionally tried other input devices such as track ball, mouse trapper or vertical mouse. Twenty-seven used the computer daily 1-7 hours a day. Two of them used the computer only 1-4 times a month.

2.2 Hand positions on the mouse and mouse functions

Two hand positions on the mouse were compared. The first one was the normal hand position (NP, see figure 1) with the index finger on the left mouse button and the middle finger on the right button. The functionality of the mouse in this position was the standard one.

In the alternative position (AP, see figure 2) the hand was placed on the mouse with the index finger on the *right* mouse button and with the middle finger resting on the table directly to the right of the mouse. In this position, the function of the two buttons were switched in the Windows system. This implied that the subjects had normal functionality when they clicked with the index finger. When normal “right click” was needed (not assessed here) they had to move the index finger over to the left button.

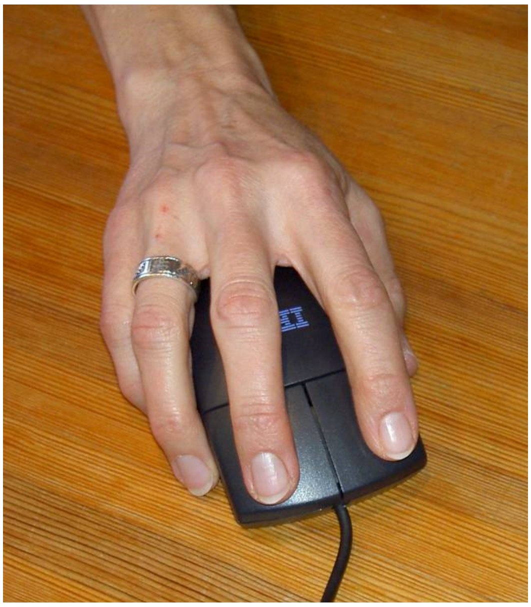

Figure 1. Normal position (NP)

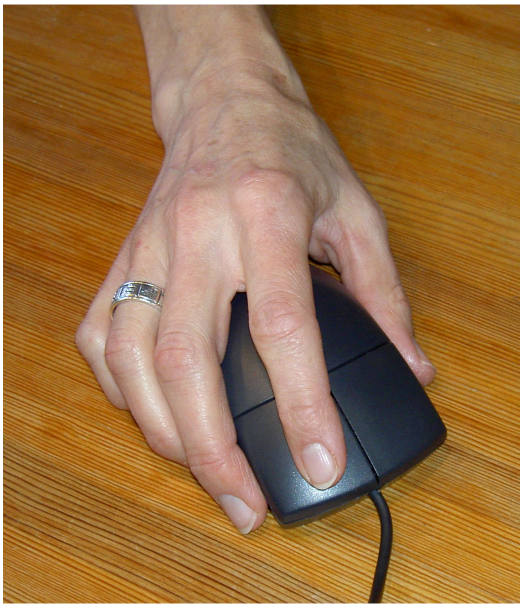

Figure 2. Alternative position (AP)

2.3 EMG recording and evaluation

Disposable EMG-electrodes were used to detect the activity of EDS. The muscle belly was located by palpation while the hand and forearm were resting on the table and the subject was instructed to extend the middle finger repeatedly. The electrodes were attached with 2 – 3 cm interspace along the muscle fibres where the muscle belly was most pronounced. A reference electrode was attached on olecranon. The electrodes where connected to a simple EMG amplifier and computerized recording and evaluation system (Biofeedback II and Tension software from Ergit AB, Göteborg).

All recordings for one subject were performed at the same occasion with preserved electrode attachments.

The Tension software was run on a laptop computer which stored the recorded EMG data on line as RMS-readings. The software calculated average EMG level for each measurement period. All recordings were calibrated in µV, raw EMG, and the basic evaluation of the two positions was based on individual differences in average EMG activity.

As a definition of relaxed muscle with the hand on the mouse, a reading up to 0,5 µV above the reading with relaxed hand on the table (denoted RMT below) was accepted. This relaxation threshold is denoted RMM. Hence RMM = RMT + 0,5.

2.4 Experimental conditions and protocol

The subjects sat at a table with optimal adjustment of table height and chair with the main part of the forearm resting on the table and the back resting against the back support of the chair.

The computer mouse used was a traditional IBM mouse with two buttons according to figures 1 and 2. When gripping the mouse the subject was instructed to do it without unintentionally activating the mouse buttons. At NP, the instructions were to grip the mouse in a normal way. At AP the subjects were shown how to place the hand and also informed about the changed functionality of the buttons. When doing repetitive clicking the subjects were instructed to click approximately once per second.

EMG was recorded at five different conditions, 20 s each time. Between each recording the subject had approximately one minute of rest. The conditions are stated in the order they were performed in table 1:

Table 1. Experimental conditions in the order they were performed

	Resulting average EMG parameter
1. Hand resting totally relaxed muscles on the table	RMT
2. Hand resting on the mouse in NP	RNP
3. Repetitive clicking with the index finger in NP	CNP
4. Hand resting on the mouse in AP	RAP
5. Repetitive clicking with the index finger in AP	CAP

2.5 Statistics

All differences were tested with a paired t-test. Level of significance was set to 0.05.

3 Results

3.1 Resting

The results from the resting conditions on the table (RMT) and in the two handpositions, NP and AP (RNP and RAP) are shown in table 2. The median reduction in activity from RNP to RAP is 70 percent. All subjects except two (27) showed a reduced activity. One subject showed a small increase (1,3 μV) and one subject remained unchanged.

Table 2. Medians (ranges in brackets) of the resting measurements (experimental conditions 1, 2 and 4) and individual differences between RNP and RAP

RMT μV	RNP μV	RAP μV	(RNP - RAP), μV	Reduction %
0,5 (0,1-3,1)	8,8 (0,2-46,0)	1,8 (0,2-34,0)	7,2* (- 1,3 – 45,8)	70 (-260 - +99)

* $p < 0.01$

At NP only three of the 29 subjects reached our definition of relaxation, i. e. a reading below RMM. At AP, 13 of the subjects met this criterion.

3.2 Clicking

The results from the repeated clicking measurements are shown in table 3. The median reduction in activity from CNP to CAP is 59 percent. All 29 subjects showed a reduced activity when changing from NP to AP during clicking.

Table 3. Medians (ranges in brackets) of the clicking measurements (experimental conditions 3 and 5) and individual differences between CNP and CAP

CNP µV	CAP µV	(CNP – CAP), µV	Reduction %
11,8 (2,5-63,0)	6,0 (0,8-24,0)	7.6* (1,4 – 61,8)	59 (19 - 98)

* p < 0,001

4 Discussion

The shown data convincingly demonstrates that AP implies a lower muscle activity in EDS both "at rest" with the hand on the mouse without activating any button and during repetitive clicking, compared to NP. When resting the hand on the mouse at NP a large majority of the subjects (n=26) obviously exert some muscle effort, most likely with the purpose not to unintentionally activate the mouse buttons. Only three subjects succeed to reach our definition of relaxation here. In AP, 13 subjects reached relaxation while the others (n=16) still exerted a certain muscle activity, however lower than at NP. Only one subject increased the activity when changing from NP to AP, however a small increase of 1,3 µV.

The lack of relaxation when resting the hand on the mouse is possibly a risk factor for forearm MSD, especially when considering the Cinderella hypothesis (Hägg, 1991) which postulates that a sustained static muscle activity at any low level is a risk factor.

The muscle activity exerted in EDS to avoid an unintentional click is dependent on the force demanded to activate a button. The forces needed to activate a button on the used IBM mouse were not measured but there is no reason to believe that this mouse is not representative for computer mice in general.

The relative reduction in EDS activity was of the same relative magnitude during repeated clicking and here all subjects reduced their activity. Own earlier observations indicated that the lifting of the middle finger was most pronounced during clicking. A moderate increase in muscle activity is seen when going from RNP to CNP. The increase when going from RAP to CAP is much larger indicating that there is a functional need to activate EDS during clicking even if the middle finger is resting at the side of the mouse.

This investigation has not addressed what in software manuals is referred to as "right clicks". At AP, this is somewhat more troublesome, demanding a transfer of the index finger to the left button. However, normally, "right clicks" are performed rather seldom and own practical experience indicates that this is no major problem.

The EMG measurements never were calibrated in terms of MVC or any other biomechanical reference. This implies that the present data give little information about the absolute load levels in terms of e. g. %MVC. However, with the limited scope to compare the two load situations, only comparing paired individual data obtained with the same electrode application, the applied approach is valid.

It might be argued that the experimental order between NP and AP should have been reversed for half the subjects to avoid a systematic order effect. However, it is hard to conceive that such an effect would have any major impact on the data.

Own practical experience of AP on patients indicates that it can relieve or even extinguish forearm pain related to mouse use.

In conclusion the described alternative hand position on the mouse offers a simple way to substantially reduce the load on EDS with no extra hardware. It is suggested that the new hand position is referred to as “the Tapper position”.

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