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# The friction force mouse-pad and the forearm muscles efforts (preliminary results)

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# The friction force mouse-pad and the forearm muscles efforts (preliminary results)

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## SUMMARY

The objective of the article is to evaluate the impact of the friction force mouse-pad in the contraction level of the forearm muscles *M. extensor carpi ulnaris*, *M. extensor digitorum* and *M. extensor carpi radialis longus*. A standard protocol of mouse movements was performed involving horizontal, vertical and diagonal mouse displacements drag-and-drop type. The operators were instructed to execute the protocol with their normal working speed. The movements protocol were performed by each subject (n=17) with three selected pairs mouse-pad, classified as low, medium and high friction force pairs. The mean time to execute the protocol with each mouse was ~138s. Mean values of ~13%MVE and ~17%MVE were found in the *M. extensor carpi ulnaris* and in the *M. extensor digitorum* respectively when performing the movements' protocol. A 8.1% increase in %MVE was observed in the *M. extensor digitorum* and a 9.4% increase in %MVE was observed in the *M. extensor carpi ulnaris* when the high friction force pair was operated, relatively to the low friction force pair ($p<0.05$). The main preliminary conclusions of this study is that operating a high friction force mouse-pad may increase the risk to symptoms or disorders in the wrist due to an increase in the forearm muscles contraction levels, particularly during work with drawing applications.

**Key words**: *Computer mouse, forearm muscles, EMG, drag-and-drop, friction force mouse-pad*

## INTRODUCTION

The adoption of the graphical user interfaces pointing devices as computer mice, are present in every office environment. In most applications the use of the mouse accounts for almost 60% of total time, with a maximum level of usage of 65–70% in drawing applications. Mice are the most frequently used devices among the VDT users both in term of number of users and in terms of daily time spent in using it [1]. While data entry work is primarily performed with a keyboard, computer mice are used intensively for CAD work and in Scandinavia much focus has been directed towards the possible harmful effects of mouse use [2].

Currently, it is uncertain what the exposures to the various mouse-related risk factors are and how the exposures vary between persons, occupations, computer systems and software applications [3]. There is still a lack of knowledge as to the extent to which the use of different input devices influences the activation of the different muscles in the upper limbs [4]. However, there are indications that upper extremities musculoskeletal disorders are related to computer work.

The number of studies that have considered the impact of mouse use on musculoskeletal health is limited. Most of these studies only include experiments with small numbers and short-term effects, such as discomfort and muscle activity [5]. In some studies, mouse use is indicated as a risk factor in computer work [6][2].

Carpal tunnel pressure was measured in 14 healthy individuals while they performed tasks using three different computer mice [7]. A recommendation was made to minimize wrist extension, minimize prolonged dragging tasks and frequently perform other tasks with the mousing hand.

One of the objectives of a study developed by Blatter and Bongers [8] was to examine the association between work-related upper limb disorders (WRULDs) and duration of computer and particularly mouse use. Working with a computer during more than 6 h/day was associated with WRULDs in all body regions.

A epidemiological literature was reviewed to evaluate the evidence supporting a causal relationship between computer work and musculoskeletal symptoms and disorders (MSDs) of the hand, wrist, forearm, and elbow [9]. The study concluded that there is consistent evidence of a positive relationship across numerous prospective and cross-sectional studies with increased risk most pronounced beyond 20 hours/week of computer use or with increasing years of computer work.

Finger force exposures associated with computer mouse use was measured by Johnson et al [3]. According to the authors, it is uncertain whether musculoskeletal disorders can result from these low forces levels.

Any article involving the measurement of forearm efforts associated to the friction forces mouse-pad was found in the literature.

## MATERIALS AND METHODS

### The evaluation of the static friction force mouse-pad

The static friction force mouse-pad was measured in 39 different pairs mouse-mouse pad in effective use in the workplaces. A mechanical device was used to measure the force applied to the mouse, parallel to the pad surface, which initializes the displacement of the mouse.

A 0.5 mm nylon wire was carefully attached to the mouse with a 10 mm Tesa film adhesive band. A small 2 g extruded polystyrene (XPS) basket (40x48x30 mm) was used to receive small lead weights of 8-20-40 g, which were carefully inserted into the basket, until the displacement of the mouse. The friction force was measured in two different directions: (1) the longitudinal force was measured with the nylon wire in the longitudinal direction of the mouse and (2) the transversal force was measured with the nylon wire in the transversal direction of the mouse.

## The mouse movements protocols

To analyze the impact of the different friction forces in the forearm muscles contraction, it was asked the subjects to execute a standard protocol of movements with the three selected pairs mouse-pad (low, medium and high friction force pairs mouse-pad). The protocol included three groups of movements: (1) vertical ascending and descendent movements (2) horizontal left-right and right-left movements and (3) diagonal ascending and descending movements. It was created three Microsoft Paint Version 5.1 files (to vertical, horizontal and diagonal movements) with 16 vertical lines, 16 horizontal lines and 16 diagonal lines. The operators were instructed to execute the protocol with their normal working speed. The mean and range times to execute a group of three protocols with each mouse was 137.9 s (81-214; n=17).

## The subjects

Seventeen volunteer engineering students participated in the study (Table 1). All the subjects were familiar with mice utilization.

Table 1
Mean (SD) and range of age, anthropometrics, and muscular strength for the subjects (n=17)

| Demographic data | Mean (SD) | Range |
|---|---|---|
| Female subjects (n) | 10 | ----- |
| Age (years) | 22.5 (2.6) | 19.0-28.0 |
| Height (cm) | 172.1 (9.6) | 156.0-190.0 |
| Weight (kg) | 67.6 (17.3) | 48.0-110.0 |
| Handgrip strength – Right hand (kg) | 38.6 (18.9) | 19.3-103.3 |
| Pinchgrip strench – Right hand (kg) | 5.2 (1.3) | 3.0-7.9 |

## Electromyography

Surface EMG was recorded using disposable bipolar electrodes with a sensor area of 15 $mm^2$, with a skin contact size of 30 x 22, placed with a 22 mm center-to-center distance (Ag/AgCl sensor, Ambu Blue Sensor N, Ambu A/S, Ballerup, Denmark). Data was measured in the right forearm, in the *M. extensor digitorum* (ED), *M. extensor carpi ulnaris* (ECU) and *M. extensor carpi radialis longus* (ECRL).

The maximum isometric tests were performed with the participants seated in a chair with adjustable height, the forearm resting at wrist and olecranon level in two soft expanded polystyrene (EPS) plates supported on a table, with a 90º flexed elbow and the hand palmar surface down, extended according to forearm direction. The subjects were instructed to maintain the hand horizontal, face down, extended and aligned with the forearm direction. Three groups of tests were executed: (1) each participant was encouraged to exert a maximum dorsal wrist extension against a Manual Muscle Tester (MMT), (2) each participant was than encouraged to exert a maximum dorsal wrist extension simultaneously with maximum radial wrist deviation against the MMT and finally (3), each participant was encouraged to exert a maximum dorsal wrist extension simultaneously with maximum ulnar wrist deviation against the MMT.

### The selected mice-pads

Three pairs mice-pads were selected to test the lower arm efforts during mouse operations. The criterion was to select pairs representative of low, medium and high friction force (Table 2).

**Table 2**
The characteristics of the selected mice-pads pairs

| **Mice-pads characteristics** | **Low friction force pair** | **Medium friction force pair** | **High friction force pair** |
|---|---|---|---|
| PS/2–USB Ball-optical | PS/2 – optical | PS/2 – optical | PS/2 - ball |
| [1] $F_{L0} – F_{T,0}$ (g) | 18 – 18 | 21 – 21 | 42 – 28 |
| [2] $F_{L,100} – F_{T,100}$ (g) | 34 – 34 | 54 – 54 | 79 – 77 |
| [3] $F_{L,150} – F_{T,150}$ (g) | 54 – 45 | 57 – 57 | 97 - 85 |
| [4] $F_{L,200} – F_{T,200}$ (g) | 63 – 51 | 86 – 65 | 115 – 107 |
| Buttons | 2 button | 2 button | 2 button |
| Scroll wheel | 1 scroll wheel | 1 scroll wheel | 1 scroll wheel |
| Manufacturing year | 2007 | 2002 | 2001 |
| Weight (g) | 65 | 69 | 90 |
| Height–length–width-button width | 38-121-57-62 mm | 37-116-59-59 mm | 30-110-70-50 mm |
| Contact surface mouse-pad | 4 eliptical areas<br>Axles 14/4 mm | 4 eliptical areas<br>Axles 14/6 mm | 4 circular areas<br>Diameter 6 mm |

[1] Friction force with the mouse subjected to his own weight, in the longitudinal and transversal mouse directions
[2] Friction force with the mouse subjected with a compression force of 100 g, in the longitudinal and transversal mouse directions
[3] Friction force with the mouse subjected with a compression force of 150 g, in the longitudinal and transversal mouse directions
[4] Friction force with the mouse subjected with a compression force of 200 g, in the longitudinal and transversal mouse directions

## RESULTS AND DISCUSSION

The EMG signal was normalized to the maximum contraction level in each muscle (MVE), in order to evaluate the contraction levels during mouse operations. The following protocols were selected to normalize MVE signal in each muscle:

- *M. extensor digitorum*: MVE signal was measured during hand dorsal extension
- *M. extensor carpi ulnaris*: MVE signal was measured during hand dorsal extension simultaneously with ulnar deviation
- *M. extensor carpi radialis longus*: MVE signal was measured during hand dorsal extension simultaneously with radial deviation

The contraction levels in the different muscles during mouse operations are represented in Table 3. The values in the table include MEAN-P10-P90 %MVE values obtained from data combining horizontal, vertical and diagonal mouse movements' protocol.

**Table 3**
The mean and P10 contraction levels (%MVE) in the different muscles during operations with the 3 selected mice-pads pairs – composition of horizontal, vertical and diagonal movements protocols (n=17 subjects)

| **Mice-pads characteristics** | **Low friction force pair (%MVE)** | **Medium friction force pair (%MVE)** | **High friction force pair (%MVE)** |
|---|---|---|---|
| P10 (range; SD) (%MVE) | | | |
| *M. extensor digitorum* | 8.6 (3-14; 3.4) | 8.7 (3-13; 3.3) | 8.6 (4-13; 3.5) |
| *M. extensor carpi ulnaris* | 10.6 (4-18; 4.0) | 11.0 (5-21; 4.3) | 10.4 (5-21; 4.3) |
| *M. extensor carpi radialis longus* | 7.6 (3-18; 4.0) | 7.9 (3-18; 3.8) | 7.5 (3-17; 3.8) |
| Mean (range; SD) (%MVE) | | | |
| *M. extensor digitorum* | [1] 12.3 (6-19; 4.7) | 12.1 (6-20; 4.4) | [1] 13.3 (6-25; 5.4) |
| *M. extensor carpi ulnaris* | [2] 15.9 (7-29; 5.7) | 17.6 (10-33; 5.8) | [2] 17.4 (9-31; 6.3) |
| *M. extensor carpi radialis longus* | 9.1 (3-20; 4.4) | 9.5 (4-21; 4.4) | 9.3 (4-19; 3.9) |

[1,2,3,4,5] Significant differences ($p<0.05$) between %MVE values resulting from operations in pairs mouse-pad with different friction forces.

[6,7] Significant differences ($p<0.001$) between %MVE values resulting from operations in pairs mouse-pad with different friction forces.

Non-parametric Wilcoxon Mann-Whitney test for two samples (SPSS – version 13 *for Windows*)

Non significant differences (p>0.05) were found in P10 %MVE values to each muscle, when the three mice – low, medium and high friction force – are operated. *Extensor carpi ulnaris* was the muscle with the highest P10 values (4-21%MVE, n=17). This muscle also revealed the highest mean values (7-33%MVE, n=17).

Significant differences were found in the mean %MVE values of *M. extensor digitorum* and *M. extensor carpi ulnaris* when the low and high friction mouse-pad pairs were operated. A 8.1% increase (from 12.3 to 13.3%MVE) was observed in the *M. extensor digitorum* and a 9.4% increase (from 15.9 to 17.4%MVE) was observed in the *M. extensor carpi ulnaris* when the high friction force pair was operated, relatively to the low friction force (p<0.05).

Non significant differences in %MVE values were found when the low-medium and when the medium-high friction forces pairs were operated (p>0.05).

## CONCLUSIONS

A standard protocol of mouse movements was performed involving horizontal, vertical and diagonal mouse displacements. The protocol involved active displacement of the mouse in the pad, similar to the movements performed during drawing applications.

The movements protocol were performed with three selected pairs mouse-pad, classified as low, medium and high friction force pairs. The three selected pairs were selected from a sampling of 39 pairs actually in use in office workplaces.

Mean values of ~13%MVE and ~17%MVE was found in the *M. extensor carpi ulnaris* and in the *M. extensor digitorum* respectively when performing the movements' protocol (~138 s).

A 8.1% increase in %MVE values was observed in the *M. extensor digitorum* and a 9.4% increase in %MVE was observed in the *M. extensor carpi ulnaris* when the high friction force pair was operated, relatively to the low friction force pair (p<0.05).

The main preliminary conclusions of this study is that operating a high friction force mouse-pad may increase the risk to symptoms or disorders in the wrist due to an increase in the forearm muscles contraction levels, particularly in operations involving intensive mouse displacements (drag-and-drop gestures)

In this sense, when selecting a computer mouse to work with drawing applications like CAD work, particular attention must be paid to the characteristics of the mouse contact surface with the pad as well as with the characteristics of the pad surface, both in terms of the static and sliding coefficient of friction.

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