Research Paper: Evaluating Muscle Activity During Work With Trackball, Trackpad, Slanted, and Standard Mice

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Citation Labbafinejad Y, Eslami-Farsani M, Mohammadi S, Ghasemi MS, Reiszadeh M, Dehghan N. Evaluating Muscle Activity During Work With Trackball, Trackpad, Slanted, and Standard Mice. Iranian Rehabilitation Journal. 2019; 17(2):121-128. http://dx.doi.org/10.32598/irj.17.2.121

http://dx.doi.org/10.32598/irj.17.2.121

Article info:
Received: 01 Oct 2018
Accepted: 28 Jan 2019
Available Online: 01 June 2019

Keywords:
Electromyography, Ergonomics, Computer mouse, Input devices

ABSTRACT

Objectives: Mouse is one of the most important data entry devices for computers. Undesirable and prolonged postures during work with the computer mouse increase workload, muscle aches and upper extremity musculoskeletal disorders. The present study aimed to evaluate and compare muscle activity during the use of 4 types of mouse, including trackball, trackpad, slanted and standard by Electromyography (EMG).

Methods: This experimental study included 15 subjects (7 men and 8 women). The electrical activity of EDC, ECU, ECR, FDS, PQ, and FDL muscles was recorded by EMG while performing a standard task with each mouse. The order of using each mouse was randomized. The obtained results were analyzed by SPSS using the measures of central tendency, Friedman's test, and Independent Samples t-test.

Results: The results of assessing the electrical activity level of muscles suggested no statistically significant difference in the recorded EMG between FPL, FDS, and PQ muscles while working with the 4 mice. The electrical activity reduced in EDC, ECR, and FPL muscles with the use of slanted mouse, compared to that of other mice ($P<0.05$).

Discussion: There was no significant differences between the electrical activity of FDS, FPL, and PQ muscles during work with the studied mice. Furthermore, the activity of EDC, ECR, and FPL muscles reduced during work with a slanted mouse, compared to the other types. The habit of using a new mouse can affect the level of muscle activity; thus, the use of a slanted mouse may reduce the incidence of musculoskeletal disorders in the wrist and hand of users in the long run.

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Highlights

● The slanted mouse (slant angle=30° or 50°) may lead the future market in computer accessories and replace conventional mouse (slant angle=0°).

● A slanted mouse may reduce the incidence of musculoskeletal disorders in users' wrists and hands in the long run.

Plain Language Summary

A slanted mouse (slant angle=30° and 50°) is superior to an ordinary mouse based on EMG results. Furthermore, the electrical activity of the hand muscles reduces when working with the slanted mouse. The slanted mouse may lead the computer accessories market and replace the conventional mouse. Further practice of the users with the new ergonomic mouse may improve its functional parameters. Besides, the electrical activity of muscles decreases when working with this new mouse design. In the long term, it can reduce the incidence of musculoskeletal disorders in users' wrists and hands.

1. Introduction

Work-related musculoskeletal disorders are the most important problems in the health of workforce. These discomforts cause many working days lost, increase absenteeism from work, and impose annual economic costs [1, 2]. Electromyography (EMG) is a common method for investigating the relationship between an optimal mouse design and the risk of musculoskeletal disorders. This device measures action potentials produced by the muscles [3]. Most studies evaluating different mouse types have used EMG. This is because of its favorable predictive nature of the wrist position, posture, pressure on the body, and movements [4].

In these experiments, the standard task is repeated by the participants by considering some variables where a common variable is used for this purpose. EMG can measure the diagrams generated from the electrical activity of each individual muscle in the same task by different mice. When evaluating the mice, it is necessary to examine the electrical activity of the most involved muscles. Agarabi et al. evaluated the ECU, ED, PQ, FDS, FDI and SDI muscles [4].

Lee et al. examined the ECU, FDS, FDI, EDC, and ECR muscles [5]. Dennerlein et al. studied the ECU, ECR, FCU, FCR, anterior deltoid, and middle deltoid muscles, and the upper trapezius [6]. Hengel et al. examined the ECU, ED, FDI, and ECR muscles [7]. The ECR and ECU muscles in the wrist and the ED muscle in the fingers have most been evaluated while working with a mouse [8]. These muscles are at higher risk of musculoskeletal disorders when working with a mouse [5].

EMG signals are highly variable which can be due to the random nature of action potentials and functional differences in individuals. These differences are more frequent in comparing different people. The amount of fat or muscle in the hands causes changes in the physical activity curve of individuals. In addition, the difference in the forearm structure may also affect it.

To improve these differences, many studies have used Maximum Voluntary Contraction (MVC). Most of these studies have applied EMG to measure the wrist muscle strength in isometric tasks [9]. The EMG test is highly affected by noise. The common noise sources include electrodes and cable movements, potential electrode aggregation, and electromagnetic interference caused by alternating current [4]. To reduce the noise, dead skin cells must be removed, which reduces electrical resistance between the skin and the electrode. Many studies have recommended cotton and alcohol for cleaning the skin [10].

Considering the importance of the aforementioned literature, further research is required on the electrical activity of muscles while working with a computer mouse [3-5]. Therefore, the present study evaluated the performance and convenience of 4 different computer mice, using EMG.

2. Methods

The study participants

The present experimental study was conducted on 15 software design engineers, including 7 men and 8 women. All participants were right-handed. A standard task was designed and they were requested to complete it with each mouse for 5 minutes. The study participants aged 25 to 45 years. Prior to conducting the test, each study participant was requested to perform a standard task with each mouse for several times to reduce the effect of habit on the test.

Input devices

At this stage, 4 different mouse types, including trackball, trackpad, slanted and standard were examined (Figure 1). To eliminate the effect of habit on the desired task, the order of presenting the mice to each subject was randomly determined; this also prevented the effect of order and carryover effect.

The standard task

This task included clicking on 20 squares that were arranged in numbers in two rows of 10. For each mouse, this task was performed by each subject for 5 minutes to record EMG data [11].

The study muscles

This study examined 6 muscles, including Extensor Digitorum Communis (EDC), Extensor Carpi Ulnaris (ECU), Extensor Carpi Radialis (ECR), Flexor Digitorum Superficialis (FDS), Pronator Quadrates (PQ), and Flexor Pollicis Longus (FPL).

These muscles play a major role while working with a mouse [5]. At first, the mean activity level of each muscle was calculated; then, the electrical activity of each muscle was obtained as a percentage of the MVC. The quantitative data obtained from electrical activity was expressed as the percentage of MVC for each muscle. The use of each mouse was separately recorded for each sample and averaged in 15 samples. To control the confounding factors of the effect of habit on the desired task, the order of using the 4 mice was randomly considered for each participant. The electrical activity of muscles was recorded using the portable EMG (DataLOG, MWX8) and the related computer software (Biometrics Ltd ®, the UK) (Figure 2).

During the evaluation, a five-minute rest was given in the interval of each task with each mouse, to prevent the effect of fatigue. The conditions of the laboratory environment were the same for all participants. Each participant was requested to set their seat height to feel comfortable in a natural posture.

Data extraction and data processing

The EMG recordings were converted into quantitative data by Biometrics Analysis Software. SPSS was used to analyze and compare the data. The Friedman two-way Analysis of Variance (ANOVA) was used to compare the

Figure 1. Input devices

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Left to right: trackpad, slanted mouse, trackball mouse, and standard mouse

Figure 2. EMG of the user during the task with a trackball mouse

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electrical activity levels of the muscles when working with each mouse.

3. Results

The Mean±SD age and work experience with the computer of 15 participants were 28.4±4.61 and 11.2±2.1 years, respectively. Table 1 presents the demographic characteristics of the study participants. As per Table 2, the mean activity level of EDC, ECR, and FPL muscles for the slanted mouse were 11.02, 7.41, and 14.93, respectively; these were the lowest values, compared with the other mouse types. The activity level of ECU muscle during work with the standard mouse was the lowest (12.93). The lowest levels of activity for FDS and PQ muscles during work with trackball mouse were obtained as 3.52 and 3.36, respectively.

The electrical activity of muscles during operation with a slanted mouse in EDC, ECR, FDS, FPL, and PQ muscles was less than that of a standard mouse. According to the above table, the Friedman two-way ANOVA results revealed no significant differences in the EMG activity level between FPL, FDS, and PQ muscles when using the 4 mice. However, there was a significant difference between the obtained results for EDC, ECU, and ECR muscles.

4. Discussion

The Friedman two-way ANOVA results indicated no significant differences in the EMG assessments of FDS, FPL, and PQ muscles in respect of the 4 studied mice. This suggests that the studied mice are approximately similar in terms of the activity of these three muscles during usage. Therefore, the differences in the design of the studied mice had no effect on the electrical activity of these muscles. According to previous studies, these are the 3 main mus-

Table 1. The demographic characteristics of the study participants (n=15)

Variable	Mean±SD
Age, y	28.4±4.61
Height, cm	171.24±7.12
Weight, kg	70.23±10.13
Work experience with the computer, y	11.2±2.11
Daily working hours with the computer, h	5.42±1.26

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Table 2. Mean±SD scores of muscle electrical activity as a percentage of MVC during work with the 4 types of mouse (n=15)

Muscle	Mean±SD				P*
	Trackball Mouse	Trackpad Mouse	Slanted Mouse	Standard Mouse	
EDC	13.38±4.49	15.08±5.25	11.02±2.12	11.98±4.21	0.03
ECU	19.87±5.68	14.32±4.43	14.92±5.98	12.94±3.83	0.01
ECR	9.31±3.28	11.69±5.14	7.14±3.31	7.54±2.31	0.01
FDS	5.65±3.52	10.12±7.79	6.06±4.18	6.65±5.58	0.14
FPL	16.09±8.08	19.34±9.97	14.93±8.89	15.09±7.71	0.06
PQ	7.39±3.36	8.87±2.21	7.79±3.32	8.21±4.91	0.64

*One-way ANOVA

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cles involved in working with different types of computer mouse; thus, consistent with the previous studies [12-14], the achieved results supported this fact.

The electrical activity of FPL muscle was the lowest, which can be due to the improvement of hand posture while working with the slanted mouse [15-17]. According to Chen et al., who examined mice with different slopes, the proximity of hand posture to natural mode would reduce the electrical activity of hand muscles [18]. The wrist condition was normal in this study while working with the slanted mouse. Moreover, ulna and radius bones had a lower deviation, compared to using other mice, reducing the electrical activity of the muscles while working with the slanted mouse.

Muller et al. argued that the users' habit of working with new and alternative mice can significantly affect muscle load and muscle electrical activity. They concluded that 5 days of work with the new instrument revealed a significant difference in the electrical activity of muscles, as well as functional parameters such as speed and error [13, 19-21]. Therefore, the adaptation of users with the slanted mouse can further decrease the electrical activity level of muscles, compared with other mice.

We also compared the effects of slanted mouse and trackball mouse on EDC, ECU, ECR, and FPL muscles. It was determined that the electrical activity reduces in these muscles while working with the slanted mouse, which was superior to the trackball mouse. The form, shape, and holding position of a slanted mouse create the closest hand posture to the natural mode. Therefore, these factors have led to a decrease in the electrical activity of muscles, compared with a trackball mouse.

Comparing the effects of slanted mouse and trackpad mouse on EDC, FDS, ECR, and FPL muscles determined that the electrical activity decreases in these muscles when working with the slanted mouse. Lee et al. compared the newly designed trackpad, standard, and ergonomic mice. They concluded that the hand posture in using a trackpad mouse generated a greater distortion in the wrist, compared to the natural mode [12, 22, 23]. Therefore, the difference in the electrical activity level of EDC, ECR, FDS, and FPL muscles between the trackpad and slanted mice could be attributed to the differences in the posture and hand movements.

The EMG results suggested that a slanted mouse is superior to other mice. Furthermore, the electrical activity of these muscles is reduced when working with this mouse (except for ECU electrical activity that is the lowest with a standard mouse). The slanted mouse may lead the market, compared with other conventional mice.

Further accustom of the users with new ergonomic mice may improve the functional parameters [13]. In addition, the electrical activity of muscles decreases when working with new mice. In the long-term, it can reduce the incidence of musculoskeletal disorders in the wrists and hands of users.

5. Conclusion

The results of recording and analyzing EMG in the studied mice suggested that the activity level of EDC, ECR, and FPL muscles was lower, while using a slanted mouse, compared to other types. Being accustomed to a new slanted mouse may decrease the electrical activity of muscles while working with this ergonomic device. This can enhance the convenience of working with a mouse. It may also lead to the prevention of musculoskeletal disorders in the wrists and hands of users in the long run.

Ethical Considerations

Compliance with ethical guidelines

The Research Council of the Iran University of Medical Sciences in agreement with the Declaration of Helsinki approved all the study procedures prior to the onset of study.

Funding

This work was supported by Iran University of Medical Sciences (Grant No.: 95-01-123-2571).

Authors' contributions

Study concept and design: Yasser Labbafinejad, Naser Dehghan; Data collection: Mansour Eslami-Farsani; Interpretation of data: Saber Mohammadi, Mohamad Sadegh Ghasemi; Supervision: Mahnoush Reiszadeh; and Writing-review and editing: Naser Dehghan.

Conflict of interest

The authors declared no conflict of interest.

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