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Designing a New Computer Mouse and Evaluating Some of Its Functional Parameters

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ABSTRACT

Background: This study aimed to design a new mouse and evaluate some of its functional parameters. The prototype of an ergonomic mouse was made according to design principles.

Methods: The study was conducted from 2011 to 2013 in the Department of Ergonomics in Shiraz University of Medical Science. Functional parameters including Movement Time (MT) and error rate of the new mouse were evaluated by 10 participants based on ISO 9241-9 standard.

Results: The application of design principles in the new mouse resulted in improving MT and error rate so that they could be comparable to those of a standard mouse. MT, in both the standard and the new mouse was 0.846 and 0.864 s, respectively. Error rate of the standard and the new mouse was reported as 13% and 19%, respectively. Statistical analysis showed no significant difference between the two mice from these perspectives.

Conclusions: Apparently, the studied functional parameters of the new mouse were similar to those of the standard one. The new mouse could be an appropriate substitution for the standard mouse without losing its positive characteristics.

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Introduction

Computer is the most popular device used by many people in the world. A computer mouse is one of the most applicable interfaces for data entry, browsing and navigation of web pages[1,2]. Intensive use of a mouse may cause musculoskeletal injuries in the upper extremities[3,4]. Furthermore, repetitive and prolonged postures as well as wrist deviation while working with a mouse may lead to musculoskeletal injuries in the upper extremities[5]. Mouse use more than 20 hours per week could cause hand/wrist musculoskeletal disorders and more than 30 hours per week may result in carpal tunnel syndrome (CTS)[6].

Although mouse manufacturers have attempted to design and produce ergonomic mouse, it seems that these mice put pressure on soft tissues of the hand/wrist region and also cause rotated posture of forearm bones (ulna and radius)[7]. In addition, it appears that enough attention has not been paid to psychological aspects, consumers' interests and needs in the design and production of these mice[7]. Thus, users are forced to endure pain while working with a mouse[8].This can cause increase in hand/wrist musculoskeletal disorders[9-11]. Although there are different types of ergonomic mice in the market, it seems that attention has been paid to new technologies and morphological characteristics, while their comfort, obligatory requirements, hand/wrist and arm postures and functional parameters have been neglected. Appropriate functional properties of a mouse (i.e., task completion time and error rate) put less musculoskeletal loads on muscles involved and therefore may lead to decreased risk of upper limb disorders among users[12,13]. Additionally, these parameters have been considered as useful indicators for computer input devises evaluation [14,15]. It is believed that a mouse with a better design and improved functional parameters may lead to a decrease in the rate of hand/wrist musculoskeletal injuries[15].

Given the above, the present study aimed to:

a. Designing a new mouse based on ergonomics principles.

b. Evaluating some of its functional parameters including TM and error rate as compared to a standard mouse.

Methods

This study was conducted from March 2011 to July 2013 in the Department of Ergonomics in Shiraz University of Medical Science. The study consisted of two phases:

Phase I: Designing and making a prototype mouse

After a thorough review of available mice in the market and their pitfalls, the idea of designing a new mouse with improved ergonomic characteristics and better functional parameters was formed. Improved wrist/hand posture, increased comfort, aesthetic aspects, minimized muscle involvement, better bottom layout and improved accuracy and speed were focused in design process. Design principles applied in making the prototype were as follows:

- Using index, thumb and middle fingers were considered for providing higher accuracy [16].
- When fingers are used to operate a mouse, accuracy and speed will increase. On the contrary, when forearm muscles are used, speed will decrease and more errors may occur [17].
- A pen shaped mouse can improve arm movements due to a better posture. This factor plays an important role in reducing the risk of hand/wrist musculoskeletal disorders [18].
- A mouse should be designed so that it can help an appropriate hand/wrist posture and minimize pronation [4].
- A mouse should be shaped so that the appropriate neutral posture of wrist can be obtained. This will reduce the risk of carpal tunnel syndrome[19,20].
- The shape of a mouse should fit the user's hand [21].
- Anthropometric data of the index finger's length, index finger and thumb's breadth should be applied as shown in Table 1 [22,23]. To accommodate a higher percent of the user population, the 95th percentile of dimensions were applied.

Table 1: Anthropometric dimensions used in mouse design (mm)[a]

Dimensions	Application in the prototype design	Mean	SD	95 Percentile
Index finger length (1)	Distance between finger fulcrum to the left click button	72	5	80
Index finger breadth (2)	Groove width to place middle and index finger	20	3	23
Thumb breadth (3)	Groove width to place thumb finger	22	2	26

[a] Taken from anthropometric database for hand dimensions of the 224 Iranian men [22]

Figure 1 shows a 3D schema of the new designed mouse with its bottom layout.

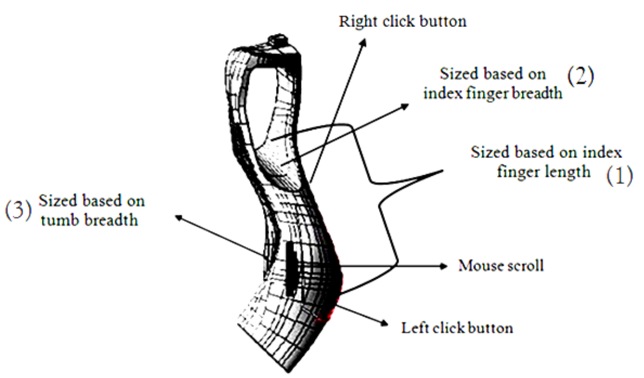

Figure 1: The 3D Schema of the new designed mouse prototype

In Figure 2, the prototype of the mouse used by an operator is presented. Finally, an electronic circuit was prepared and installed in the prototype.

Figure 2: Prototype of the new mouse which is in use by an operator

Phase II: Assessment of functional parameters

To evaluate MT and error rate, the new ergonomic mouse was compared with a standard one (Figure 3). Ten experienced VDT operators (6 males and 4 females), who signed an informed consent, participated as paid volunteers in this phase of the study. None of the participants had previously suffered from musculoskeletal injuries in the upper extremities. Participants performed a standard operation with each mouse. This operation was defined according to the ISO-9241-9 standard[6,10,11, 12]. By ISO 9241-9 standard, the performance of pointing devices (i.e., a mouse) from the viewpoint of the user's biomechanical capabilities and limitations, safety and comfort, and musculoskeletal injury can be evaluated [13,14]. Furthermore, it provides uniform testing procedures for evaluating computer pointing devices produced by different manufacturers [14].

Figure 3: The standard mouse used in the experiment for comparison

Using ISO 9241-9, movement time (MT) and error rate are measured in a standard task set by the software[14]. In the 10-minutetrial, the user needs to move the cursor and click on objects (targets) that appear on the screen. The size of each target and its distance from the home box change when it appears (Figure 4). During the trial, the user should click on the home point and then move the cursor and click on the target. This process is repeated periodically for 500 times. If the user cannot click on the target, it is considered as an error. In order to eliminate the learning effects and user's habit, each participant was asked to perform the test several times with each mouse before the onset of the trial process[14]. At the end of the 10-min process, the software calculated MT and error rate. It is to be noted that the software is validated [24] and is accessible to public free of charge.

Data analysis was done using SPSS16 software. The means of MT and error rate of the two mice were compared by independent *t*-test. A *P*-value of less than 0.05 was considered as significant.

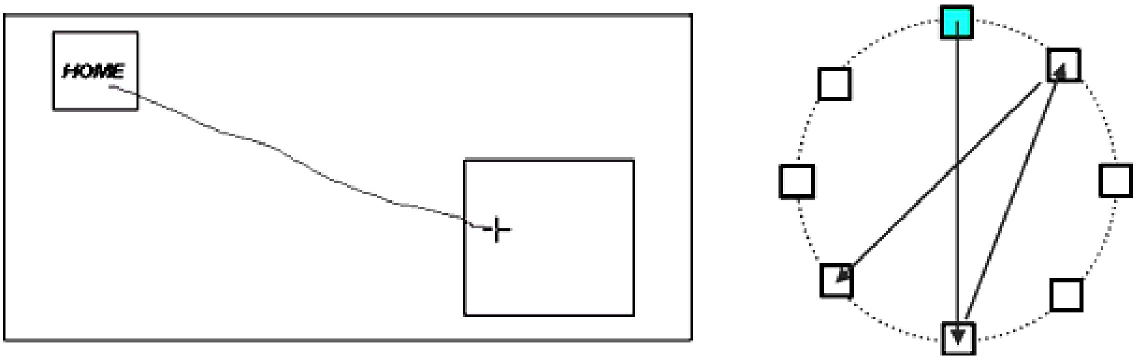

Figure 4: The image of task software environment of ISO 9241-9 standard

Results

Phase I: A new form of mouse was made based on the design principles mentioned previously. Appropriate anthropometric dimensions of Iranians' hands were used to determine the new mouse dimensions. The 95th percentile of index finger length of male was used to determine distance between the fulcrum of index finger and the left click button. Based on the results shown in Table 1, this dimension was 80 mm in the new mouse. The 95th percentile of men's thumb width (26 mm) was considered for the user to locate his/her thumb. Since the width of index and middle fingers were almost equal, the 95th percentile of male index finger was considered for location of the middle finger. This size was equal to 23 mm.

Phase II: The mean age and the mean years of VDT operation experience of the participants were 25.8±2.04 and 9.6±2.6 years, respectively. The mean MT for the standard and the new mouse were 0.846 and 0.864 seconds, respectively. The results also revealed that the error rate in the standard mouse was 13% while it was 19% in the new mouse (Table 2). As seen in Table 2, there was no significant difference between the means of MT and error rates of the two mice ($P>0.05$).

Table 2: Task time (Movement Time -MT) and error rate during the task (n=10)

Parameter	The Standard mouse	The new mouse	*P* value [a]
Task time (MT)(s)	0.846	0.864	0.649
Error rate (%)	13%	19%	0.132

[a] Independent *t*-test between the means of task time and error rate calculated for each mouse

Discussion

Using index finger for both holding and clicking the mouse might increase the error rate in the new designed mouse. This could be due to lack of familiarity of the participants with the new mouse. Habit and learning how to use a mouse would affect participants' speed and task time[18]. Straker et al. showed that after one week of working with the new mouse, functional parameters were significantly improved[25].

Although the standard mouse was to some extent better than our new mouse, but there was no significant difference between the functional parameters of the standard and the new mouse. Standard mouse has a better performance than any other new mice[18,26]. According to Capeners, thumb, index, and middle fingers form a prehensile tripod that could be used for precise activities[16]. This was considered in the design of the new mouse so that it could be held between flexed fingers (index and middle fingers) and the thumb. It was believed that this would improve the functional parameters of the new mouse and made them be similar to those of the standard one.

Observations have indicated that conventional mice have still a better place among graphists so that 95% prefer to use a conventional mouse[7]. This could be attributed to better functional parameters of standard mouse. In our design process, attempts were made to improve ergonomic as well as functional properties of the new mouse.

One limitation of our study was that for design purposes we used anthropometric data taken from the only database available for hand dimensions of Iranian men (n=224). Since this data bank may not be a good representative of Iranian men population, calculations for mouse dimensions cannot be generalized to all Iranian population. Besides, the 10 subjects participated in the tests might not be considered as the representative of all Iranian mouse users. Therefore, the results should be interpreted and applied with caution. Additionally, short term effects of design features on MT and error rate were assessed. To obtain more reliable results, longer trials (i.e., throughout a shift work) is required.

Conclusions

A new mouse with similar MT and error rate to the standard one was designed and introduced. The results showed that it could be an appropriate substitute for the standard mouse without losing its positive characteristics. It is expected that after using the new mouse for a while, its functional properties will gradually increase due to the power of practice.

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Conflict of interest statement

None declared.

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