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A Comparison of Muscular Activity Involved in the Use of Two Different Types of Computer Mouse

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Two types of computer input devices, a conventional mouse and a roller bar one, were studied in terms of muscular activitiy in m. trapezius dexter, m. deltoideus anterior dexter and m. extensor digitorum dexter, and comfort rating. Fifteen university students and employees participated in this study. The order of the devices was random. While a task was performed, electromyography (EMG) data were recorded for each test. Muscular activity was found to be significantly lower for the roller bar mouse than for the conventional one. Comfort rating indicated there was a significant difference in moving a cursor with the conventional mouse compared to the roller bar one. It is concluded that a roller bar mouse allowed the subjects to work closer to the body compared to the conventional one, thus the former can be recommended as a general means of reducing upper extremity musculoskeletal disorders.

muscular activity EMG computer mouse

1. INTRODUCTION

Computers are common in the workplace and at home; ~25% of computer users have reported using the computer for more than 50% of their working day [1]. A computer mouse is associated with most software applications requiring movement of a screen cursor [2]. It appears that computer users spend two thirds of their computer work hours using a mouse [3]. The computer mouse has become an important input device that has created new problems in today's workplace [4]. There have been research reports that intensive computer mouse users are at increased risk for carpal tunnel syndrome and other upper extremity musculoskeletal disorders [3, 5, 6]. However, the number of studies that have examined the impact of mouse use, in contrast to the use of a keyboard, on musculoskeletal health is limited. Postures adopted while using a mouse are shoulder abduction, forward flexion of shoulder and external rotation [7, 8, 9]. The abduction of the arm has been shown as a risk factor for musculoskeletal disorders of the neck and shoulder [2]. Mouse users have reported adopting postures of extension, pronation and ulnar deviation of the wrist [3, 8, 10]. Fogleman and Brogmus [4] reviewed workers' compensation claims and found that although mouse-related claims constituted a small proportion of all claims, the problem was growing and required research. People are now required to use the computer mouse as an input device for a large proportion of their workday. Johnson, Hewes, Dropkin, et al. [11] analyzed 10 people performing word processing, spreadsheet/

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database and graphics/drawing applications and found that mouse usage constituted 31, 42 and 65% of each task respectively. Karlqvist, Hagberg and Selin [3] examined postures associated with mouse use versus keyboard-only use. Although postural differences were noted, large variances and a brief testing period were deemed responsible for the lack of statistical significance. They concluded that strenuous (i.e., greatly deviated from neutral) wrist and shoulder postures were maintained for a greater percentage of time while a mouse rather than a keyboard was used. Sustained elevated carpal tunnel pressure has been proposed as a causative factor in carpal tunnel syndrome [12]. Carpal tunnel pressure is elevated in patients with carpal tunnel syndrome as well as in healthy individuals when the wrist is deviated from neutral [13].

To reduce the musculoskeletal problem associated with using a conventional computer mouse, a newly designed mouse with a roller bar has been introduced in the market. The roller bar mouse is a computer input device consisting of a roller bar for cursor navigation and a set of buttons above the roller bar for clicking functions. Its design places mouse cursor control just below the spacebar of any rectangular keyboard. The function of the roller bar is to move the cursor horizontally, vertically or diagonally while allowing the mouse users to keep their forearm close to their body.

Very little research has been done on the effect of a roller bar mouse on upper extremities. Therefore, the aim of this paper was to study whether there were any differences in muscular load and comfort rating during a click-and-drag task with a conventional mouse compared to a roller bar one.

2. METHODOLOGY

2.1. Subjects

Fifteen students and employees (7 male and 8 female) from a university in Sweden participated in the study; six months of working experience with computers was set as a prerequisite. The average age of the subjects was 30.67 years (range: 22–26); the average computer experience was 8.67 years (range: 1–16). All subjects reported experience with the use of a conventional mouse with their right hand; none reported experience using a roller bar mouse.

2.2. Computer input devices

The computer input devices used in this experiment were a conventional mouse and a roller bar mouse. The former consists of two buttons (Figure 1); the buttons of the latter are positioned above the roller bar (Figure 2).

Figure 1. Conventional mouse.

Figure 2. Roller bar mouse.

2.3. Task

The subjects were asked to perform with their right hand simple point-and-click and click-and-drag tasks representative of actions typically performed with input devices [14, 15]. The approximate duration of the task was one minute [16]. The point-and-click task required the participant to select target icons in designated areas, selecting the target each time with a button-down action and releasing. The click-and-drag task required the participant to hold the button down while moving the icon between designated areas and releasing each target with a button-up action. Figure 3 shows a schematic representation of the two tasks. The point, click and drag tasks required the participant to move the cursor (+) as directed by the arrow. The horizontal distance from one icon to another (e.g., 1 and 2) was 28 cm, while the vertical distance from one icon to another (e.g., 1 and 3) was 10 cm. The tasks were performed for each input device.

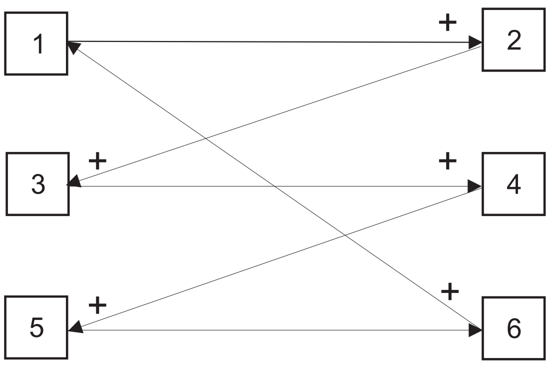

Figure 3. Pictorial representation of the movement in the given task when clicking, pointing and dragging.

2.4. Procedure

The subjects were seated ~60 cm from the screen and centred in front of the keyboard, with the centre being defined by the point between the H and J keys, 16 cm from the left edge of the keyboard and perpendicular to the midsagittal plane [16]. The conventional mouse was placed on the right side of the keyboard ~42 cm from the centre of the keyboard [16]. The roller bar mouse was placed just below the keyboard spacebar and the centrally positioned cursor and clicking buttons were also perpendicular to the midsagittal plane. The subjects were informed about the test and briefly interviewed about their experience with computers, software applications and input devices. A computer desk—with separately adjustable input devices and display support surfaces—and an ergonomic chair were used as the workstation. Each subject was asked to adjust the chair to a preferred comfortable position. The monitor and input device support surfaces were then adjusted to an ergonomically correct height that was appropriate for the height setting of the subject's chair.

Before the test began, the subjects used the input devices freely for familiarization. The tests were then initiated. The order in which the computer input devices were used was randomized and electromyography (EMG) data were recorded for each test. Digital telemetric ME300 EMG analysis system equipment (Mega Electronics Ltd, model 3000, Finland) was used for measuring muscular activity. The raw EMG signal was root mean square (RMS) detected at a time constant of 100 ms. EMG data were then transferred to a computer for editing in the ME300 EMG analysis software program version Mega Win 2.06. Muscle activity was studied for three muscles of the right side [14, 16]: m. trapezius dexter, m. deltoideus anterior dexter and m. extensor digitorum dexter.

Location of the muscles was identified on the basis of Cram, Kasman and Holtz [17], with subject motion and manual palpation as the final determinate for the placement of electrodes [18]. Surface electrodes (Blue Sensor, model NF-00-S; Ambu A/S, Denmark) were placed in pairs 10 mm apart on the skin overlying the muscles [19]. The skin was cleaned and shaved; alcohol was used to remove dirt, oil and dead skin. The electrodes were placed over the horizontal fibres of the middle trapezius, a quarter of the distance from the acromion to the 7th cervical vertebra (C7) [2]; the ground electrode was placed on C7 [16]. The electrodes for the anterior deltoid were placed over the belly of the muscle 6 mm apart [2]; the ground electrode was placed on the acromion [16]. For m. extensor digitorum dexter the surface electrode was placed one third of the distance between the lateral epicondyle and the lateral styloid process [20]. All electrodes were placed by the same person.

To set EMG baselines, the subjects relaxed for 30 s before registration with each input device and again after finishing the last test [20]. At the beginning of the recordings the subject performed standardized maximal contractions to obtain the maximal voluntary contraction (MVC). Electrical activity of all relevant muscles was done against manual resistance and performed by the same person every time [20]. MVC for m. trapezius dexter and m. deltoideus dexter was obtained with 90º shoulder abduction with the elbow flexed and forearm parallel to the floor; manual resistance was applied against abduction [21]. MVC for m. extensor digitorum dexter was obtained with the forearm at 90º and parallel to the floor, two fingers (index and middle) placed under the table and force exerted upwards against the table. The load on the table was ~100 kg. After MVC was obtained, there was a rest period of ~2 min before each test.

After the tasks, the subjects rated comfort for both input devices on a 1–5 scale (1—*most uncomfortable*, 5—*most comfortable*) for (a) moving the cursor, (b) strain in the hand/arm, and (c) strain in the shoulder.

2.5. Data analysis

Muscle activity was analysed and the percentage of MVC (%MVC) was obtained. All values were expressed as means and standard deviations. A paired *t* test was used to determine differences between %MVC for each muscle when the computer input devices were used. To test for normality the Kolmogorov-Smirnoff test was used. Probability values of $p < .05$ were accepted as statistically significant.

3. RESULTS

Table 1 shows the results of the analysis of muscle activity in %MVC. Using the *t* test muscle activity was found to be significantly different ($p < .05$).

The average %MVC for m. extensor digitorum dexter was found to be significantly different when a roller bar mouse was used compared to a conventional mouse. The mean value of %MVC for m. deltoideius dexter was 7.76% for the conventional mouse and 1.65% for the roller bar one; mean %MVC for m. trapezius was significantly different when a roller bar mouse was used compared to a conventional one.

Figure 4a shows that the conventional mouse was rated more comfortable ($M = 4.4$) for moving the cursor than the roller bar one ($M = 2.93$); the difference was significant ($p < .05$). The roller bar mouse was rated less strenuous ($M = 4.2$) for the hand/arm than the conventional one ($M = 3$); $p < .05$ (Figure 4b). The difference in comfort rating for strain in the shoulder was not significant for either the conventional mouse ($M = 3$) or the roller bar one ($M = 3.53$) (Figure 4c).

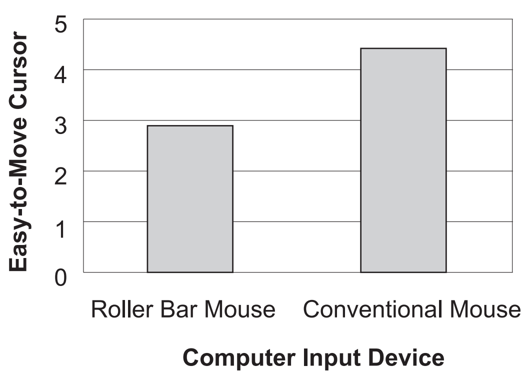

Figure 4a. Comfort rating for moving the cursor (*n* = 15).

TABLE 1. Mean %MVC (Maximal Voluntary Contraction) for a Conventional and a Roller Bar Mouse

	Conventional Mouse		Roller Bar Mouse		
Muscle	***M***	***SD***	***M***	***SD***	***P* value**
Extensor	10.65	3.86	9.69	3.43	.047*
Deltoid	7.76	5.02	1.65	1.10	.000*
Trapezius	12.50	13.33	7.93	6.95	.003*

Notes. *—significant at $p < .05$

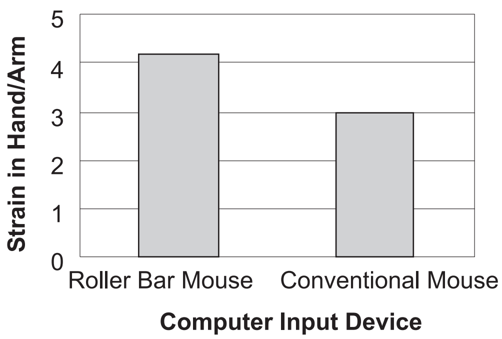

Figure 4b. Comfort rating for strain in the hand/arm (n = 15).

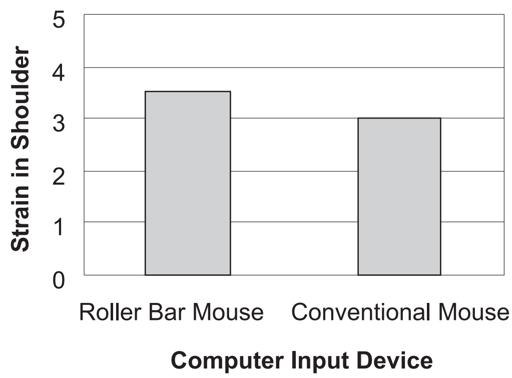

Figure 4c. Comfort rating for strain in the shoulder (n = 15).

4. DISCUSSION

This study determined the activity of muscles while a conventional and a roller bar mouse were used. It was found that there was less muscular activity while the roller bar mouse was used compared to the conventional mouse. The reason could be that the conventional mouse required the subjects to abduct and slightly rotate their arms to complete tasks. The roller bar mouse did not require abduction to complete tasks because its design permitted closer-to-the-body operation.

There was a statistically significant difference between the activity of the right extensor muscle while the conventional and the roller bar mouse were used; however, the mean for the conventional mouse (M = 10.65) was not much higher than that for the roller bar one (M = 9.69). The possible reason could be that while the conventional mouse was used, the wrist was not supported and was constantly extended, which caused a static load on the extensor muscles. When the roller bar mouse was used, the wrist was supported because its design incorporated arm and wrist support. Thus wrist posture was neutral and wrist extension was reduced [22].

There was also a statistically significant difference between the activity of the right deltoid and trapezius muscles while the conventional and the roller bar mouse were used. Possible reasons for this difference may be that the conventional mouse required abduction and rotation of the arm to perform the task, which caused a high static load on the right trapezius and deltoid muscles. As it has already been said, the roller bar mouse did not require abduction and ulnar deviation of the arm because of its design. Hedge and Shaw [23] showed that there was an increase in muscular activity when the angle of arm abduction during mouse operation increased. This implies that roller bar-type computer input devices, which permit the arm to be as close to the body as possible, would result in lower muscular activity, as demonstrated by this study. Muscular load and fatigue do not depend on body posture only, but also on the duration of a posture. There is strong evidence that awkward neck posture held for a prolonged time is a risk factor for the neck and shoulder region [24].

Though in this study the task lasted one minute, significant differences in muscular activity were found, which proved that there may be a relationship between the position of the pointing device and risk of upper extremity musculoskeletal pain. In a similar study Harvey and Peper [16] showed that a trackball positioned centrally caused lower muscular activity as compared to a conventional mouse during a one-minute task.

It was found that the conventional mouse was rated more comfortable in moving the cursor than the roller bar mouse. The reason could be that the subjects were used to the conventional mouse (range: 1–16 years) and found it difficult to move the cursor in a totally different manner. The subjects' extensive experience in the use of the conventional mouse could have contributed to the preference over the other input device. However, the roller bar mouse was found significantly better for strain in the hand/arm. One possible reason could be that when the conventional mouse was used, the arm was abducted and forward flexed, whereas when the roller bar mouse was used, the arm was not abducted and was close to the body. Golden and Vanderhoff [25] showed that after a roller bar mouse had been used for 2 weeks pain in the right hand pain was reduced by 16% and in the right forearm by 22%. No significant difference was found for strain in the shoulder, possibly because the subjects did not perceive any significant changes in the position of the shoulder when they used a roller bar mouse compared to a conventional one.

This study focused only on muscular activity and comfort rating when two types of mice were used; it was observed from photographs of subjects performing tasks that the supported wrist was neutral while using the roller bar mouse. There are several limitations to this study. First, the task was short (one minute). Second, the task was artificial although it was designed to mimic typical pointing tasks. Third, the roller bar mouse forced the position of the keyboard a little away from the body, which might have increased the load in upper extremities; however the roller bar mouse gave arm and wrist support, which could reduce muscular load. Fourth, the sample was relatively small.

5. CONCLUSIONS

Working with a roller bar mouse compared with a conventional one involved significantly lower muscular activity of m. trapezius dexter and m. deltoideus dexter. Muscular load for m. extensor digitorum dexter was relatively higher for both mice. This study concludes that although roller bar-type computer input devices require less muscular effort, their design may produce indirect unnecessary muscular tension such as shoulder flexion when the keyboard is used. However, it can also be concluded that a roller bar mouse can be recommended as a general means of reducing upper extremity musculoskeletal disorders in users of conventional mice.

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