A PRELIMINARY INVESTIGATION OF THE COMPARISON OF RIGHT-HANDED VERSUS LEFT-HANDED COMPUTER MOUSE USE

SANTOS BRENDA
École Polytechnique de Montréal, Département de Mathématiques et de Génie Industriel, Campus de l'Université de Montréal, C.P. 6079, Succursale Centre-Ville, Montréal, Québec, Canada, H3C 3A7 (santos.brenda@irsst.qc.ca)
DELISLE ALAIN
Institut de recherche Robert Sauvé en santé et en sécurité du travail, Montréal, Québec, Canada
IMBEAU DANIEL
École Polytechnique de Montréal, Montréal, Québec, Canada
MONTPETIT YVES
ErgoExcel Inc., Montréal, Québec, Canada

Abstract
This study compares upper-extremity postures during right-handed and left-handed computer mouse use. Thirty-one subjects from a large telecommunications company were tested in a laboratory setting. The subjects performed a series of tasks with various actions typical of computer mouse use. The group of tasks were performed randomly under three conditions: two with the right hand and one with the left. A tri-dimensional optoelectronic movement analysis system was used to collect kinematics data and to compute wrist, elbow and shoulder angles. Our results show that postural constraints may be reduced when the mouse is used with the left hand compared to the right hand.

Keywords: upper-extremity posture, computer mouse, left hand

UNE ÉTUDE PRÉLIMINAIRE SUR LA COMPARAISON DE LA MANIPULATION DE LA SOURIS D'ORDINATEUR AVEC LA MAIN DROITE ET LA MAIN GAUCHE

Résumé
Cette étude compare les postures des membres supérieurs lors de l'utilisation de la souris avec la main droite et la main gauche. Une évaluation a été réalisée en laboratoire avec trente et un employés d'une importante entreprise de télécommunications. Un système optoélectronique a été utilisé pour recueillir les données cinématiques tridimensionnelles sur les angles des poignets, des coudes et des épaules des sujets. Ces données ont été prises pour évaluer l'utilisation de la souris à gauche et à droite du clavier lors de l'exécution de tâches simulées prises au hasard dans trois conditions : deux à droite et une à gauche. Les résultats démontrent que l'utilisation de la souris du côté gauche pourrait réduire les contraintes posturales, par rapport à l'utilisation du côté droit.

Mots clés : posture du membre supérieur, souris d'ordinateur, main gauche

INTRODUCTION

The popularity of the graphical user interface has increased the use of pointing devices, particularly the computer mouse. Use of the computer mouse involves unilateral shoulder flexion, abduction and external rotation (4). As a consequence, the use of such devices may lead to musculoskeletal discomfort from prolonged exposure to awkward postures. It has been demonstrated (2) that the presence of a numeric keypad on most standard alphanumeric keyboards influences mouse position for the right-handed user by increasing the distance of the mouse from the body midline, resulting in shoulder abduction and flexion. It has been suggested (2) that an alternative strategy to reduce these postural constraints could be to use the mouse with the left hand.

Recently a large telephone company has implemented an ergonomics awareness program for its office employees. One recommendation of this program is for the employees to use the computer mouse with their left hand. The idea behind this recommendation is to eliminate hand travel over the numeric keypad. This would therefore reduce the amplitudes of motions required when moving from the keyboard to the computer mouse. This paper is aimed at investigating the comparison of upper-extremity postures of employees performing a number of actions, commonly performed during computer mouse work, with their right and left hands. Only results of data collected before the ergonomic awareness program for employees will be reported.

METHODS

Subjects

Thirty-one employees, who had not yet participated to the ergonomic awareness program, participated in the study. The 4 males and 27 females are aged between 31 and 53 years (mean of 41.3 $\pm$ 5.6 years). The subjects are right-hand dominant except one who is left-hand dominant and one who is ambidextrous. All subjects, except for one, usually use the mouse with the right hand. The subjects were informed of the purpose of the experiment and signed a consent form prior to the experiment.

Equipment

The experimental workstation which supported the computer monitor, mouse, and standard keyboard as well as the seat pan, backrest and armrests of the chair used was fully adjustable.

Kinematic data were collected using a tri-dimensional optoelectronic system (Optotrak, Northern Digital Inc, Waterloo, ON). This system tracked small infrared emitting diodes (IREDs) fixed on rigid bodies placed bi-laterally on the subjects' hands, forearms, arms, and shoulders. From the orientation of these rigid bodies, the positions of bony landmarks were determined, which served to build the local reference system of each segment. These local reference systems subsequently served to determine wrist, elbow and shoulder joint angles (3).

Procedure

When each subject reported to the laboratory for testing, the workstation was adjusted. The chair height was set so that the subject had both feet on the floor (or on a footrest) with a

knee angle at 90°. The table supporting the monitor was adjusted so that the top of the monitor was just below eye level. The table supporting the mouse and keyboard was also adjusted so that the home-row keys was approximately at elbow height. The subjects performed a series of tasks with various actions such as pointing and clicking, dragging, text-editing, and data entry. These tasks were performed randomly under three conditions: 1) right hand with left mouse button (**RL**) i.e., standard PC configuration; 2) right hand with right mouse button (**RR**); and 3) left hand with left mouse button (**LL**). Each subject was given the opportunity to become familiar with and practice the tasks before the IREDS were attached to their skin. Three trials of each condition were performed. After the third condition, Borg's (1) category rating scale was presented in a questionnaire to determine the subjects' perceived comfort and difficulty for each condition.

Initiation of the OPTOTRAK system and video data (of three views, see Figure 1) were accomplished when the subject selected an icon on their computer screen to start the trial. Data were collected for the duration of each trial (each lasting less than 10 minutes) at a sampling frequency of 25 Hz. Data were analyzed using in-house software. Postures assumed while using the mouse and while using the keyboard were analyzed separately. For the purposes of this paper, only postural data during mouse use will be reported.

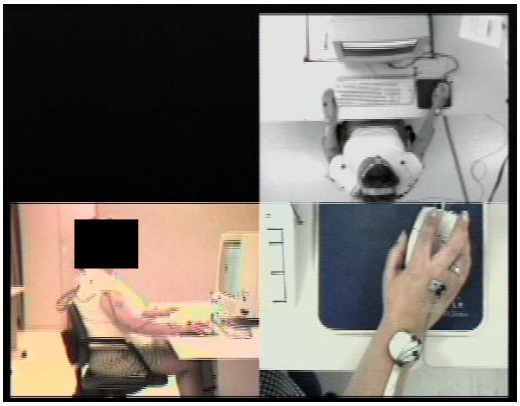

Figure 1a (condition RL)

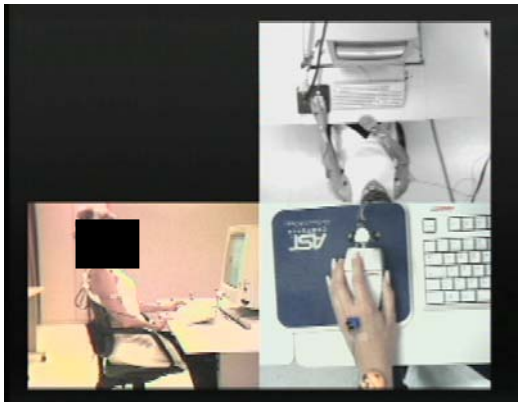

Figure 1b (LL)

Figure 1: Subjects (seen from three camera angles) performing tasks with the right hand (a) and left hand (b)

Statistical analysis

One-way analysis of variance (ANOVA) for repeated measures were performed to test for differences between conditions and trials. A 0.05 level of significance was used for rejection of the null hypotheses. When significant differences were found, *post-hoc* multiple comparisons (Bonferroni) were used.

The Friedman two-way analysis of variance by ranks was used to determine if the perception of the subjects' comfort and difficulty of using the mouse between the conditions differed.

RESULTS AND DISCUSSION

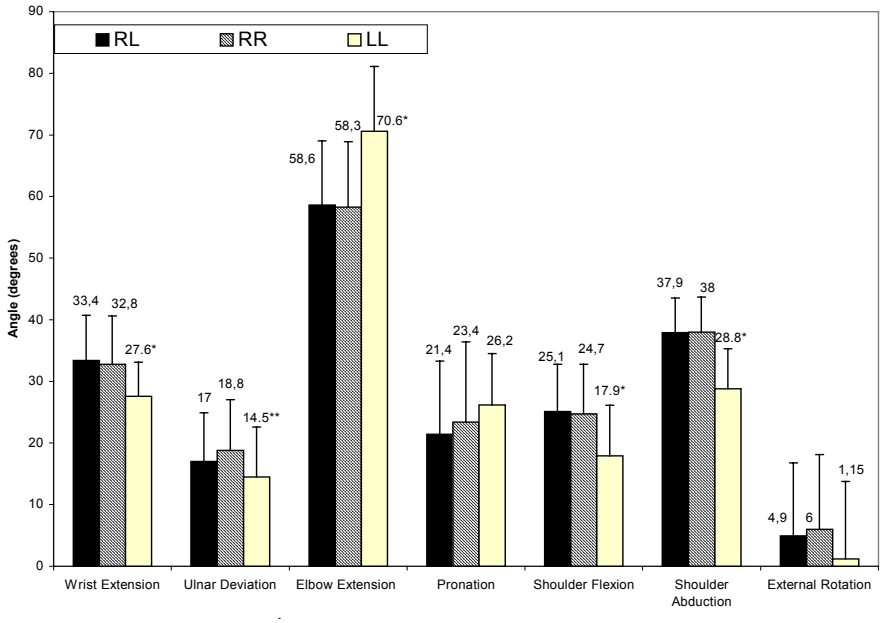

Figure 2: Average upper-extremity postures for all conditions

* Significantly different from conditions RL and RR ($p \leq 0.05$)
** Significantly different from condition RR ($p \leq 0.05$)

Generally, there was no effect of trial on posture. However, it appears that moving the mouse to the left side of the keyboard has positive effects. There was a reduction in shoulder flexion by approximately 7° and abduction by approximately 9°. Reduced shoulder external rotation was observed, though not significant. In shoulder flexion the subjects worked in the range of 9.8° to 24.2° with condition LL while for conditions RL and RR the ranges observed were from 18° to 31.6° and 17.4° to 31.3°, respectively. In abduction, the range of motion for condition LL was between 23.6° and 33.7°. On the right side, the ranges of motion were 31.9° to 42.2° (condition RL) and 31.7° to 42.2° (condition RR). Therefore, use of the mouse with the left hand would help decrease the maintenance of an awkward posture of the shoulder.

Furthermore, use of the mouse with the left hand reduced average wrist extension by approximately 5° and ulnar deviation by approximately 4°. Moreover, the minimum wrist extension was significantly less with condition LL compared to both right-hand conditions by approximately 9° (24.2°, 23.9° and 15° for conditions RL, RR and LL, respectively).

On average, elbow extension was greater on the left side compared to the right side. However, the range of motion in elbow flexion and extension was smaller. Unfamiliarity with using the mouse on the left side may account for this "stiffer" posture and may explain the "uncomfortable" rating on the Borg scales (see results below).

According to the Borg scales, the subjects perceived use of the mouse with condition LL as being more uncomfortable and more difficult ($p \leq 0.05$) than with conditions RL and RR. Condition LL was rated as being "very, very uncomfortable" by two subjects and "very difficult" by three subjects.

As expected, the time to complete the task was significantly faster with the right hand (RL and RR) than with the left hand condition (4.7 ± 0.9 min, 4.7 ± 0.8 min, 5.8 ± 0.9 min, respectively). Furthermore, it appeared that there was a learning effect of the tasks with the third trial, on average, being 34 seconds faster than the first. The three trials were significantly different between each other across all conditions.

CONCLUSIONS

Our results suggest that placing the mouse on the left side of the keyboard improves upper-extremity postures, primarily with regard to extension and ulnar deviation of the wrist, and flexion and abduction of the shoulder. A follow-up of these subjects is planned to determine if, after the ergonomics awareness program, use of the mouse with the left hand improves posture and performance. Though these preliminary results show the potential that left-handed mouse use may improve working posture, other parameters (e.g., muscle activity of the shoulder and neck muscles) and a long-term follow-up on symptoms should be investigated to monitor their contribution to musculoskeletal discomfort related to computer mouse use.

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