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Effects of forearm and palm supports on the upper extremity during computer mouse use

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ABSTRACT

The use of forearm and palm supports has been associated with lower neck and shoulder muscle activity as well as reduced musculoskeletal discomfort during keyboard use, however, few studies have investigated their effect during computer mouse use. Eight men and eight women completed several computer mousing tasks in six arm support conditions: Forearm Support, Flat Palm Support, Raised Palm Support, Forearm + Flat Palm Support, Forearm + Raised Palm Support, and No Support. Concurrently, an infrared three-dimensional motion analysis system measured postures, six-degree-of-freedom force-torque sensors measured applied forces & torques, and surface electromyography measured muscle activity. The use of forearm support compared to the no support condition was significantly associated with less shoulder muscle activity & torque, and the raised palm support was associated with less wrist extension. Forearm supports reduced shoulder flexion torque by 90% compared to no support. The use of either support also resulted in lower applied forces to the mouse pad. Participants reported less musculoskeletal discomfort when using a support. These results provide recommendations for office workstation setup and inform ergonomists of effective ways to reduce musculoskeletal exposures.

1. Introduction

Computer ownership and Internet use have increased substantially in the United States over the past decade (US Census Bureau, 2009) and it has been well documented that computer use is associated with the development of upper extremity musculoskeletal disorders (MSD) (Blatter and Bongers, 2002; Hernandez et al., 2003; Gerr et al., 2004). Approximately two-thirds of typical computer operation time is attributed to mouse use (Karlqvist et al., 1994), a proportion which can be much greater in some professions such as radiology (Goyal et al., 2009). Mouse use has been associated with high levels of static muscle activity and extreme postures (including shoulder abduction, wrist extension and ulnar deviation) (Karlqvist et al., 1994; Dennerlein and Johnson, 2006; Burgess-Limerick et al., 1999), which are risk factors for development of MSDs (Valachi and Valachi, 2003; Hales and Bernard, 1996). Consequently, evaluations of simple computer workstation interventions are needed in order to characterize biomechanical loads required for mousing tasks.

During mouse use, the upper extremity can be considered as a kinematic chain where a variety of factors affect the loads applied to joints and muscles. The use of workstation or chair arm supports can provide a mechanical ground to the arm kinematic chain and may change the biomechanical loads. A moderate level of evidence suggests that forearm supports can reduce the risk of developing neck and back musculoskeletal disorders (Conlon et al., 2008; Cook et al., 2004). The use of arm supports during keyboard use has been shown to reduce neck and shoulder muscle activity and reduce musculoskeletal discomfort in the neck, shoulders, wrist, and arms (Conlon et al., 2008; Aaras et al., 1997; Lintula et al., 2001; Delisle et al., 2006; Rempel et al., 2011). Forearm support use has been associated with a decrease in wrist extension and ulnar deviation (Cook et al., 2003; Lintula et al., 2001; Cook et al., 2004), though the use of wrist rests has been associated with increased carpal tunnel pressure and less postural variability (Cook et al., 2003).

Most previous research has been conducted for arm support use during keyboarding rather than mousing. Furthermore, to our knowledge, no studies have evaluated joint torques or grip forces during computer use in conjunction with the use of arm supports.

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Therefore, the objective of this study was to measure the biomechanical demands of the upper extremity while using forearm supports and palm supports during computer mouse use and examine the effects of these supports on biomechanical load and musculoskeletal discomfort. Specifically, we examined the effect of several arm support types on resulting biomechanical load, as measured by upper extremity forces, joint torques, posture, grip force, and muscle activity during computer mouse use.

We hypothesized that forearm supports and palm supports during computer mouse use will lower biomechanical load and result in reduced musculoskeletal discomfort compared to the no support condition. These results will provide insight on the effects of forearm and palm supports that can guide recommendations for office workstation setup and inform ergonomists of effective ways to reduce musculoskeletal loads on the upper extremity during mouse use.

2. Methods

A repeated measures laboratory experiment was performed in which participants completed a set of computer mousing tasks across six support conditions. Sixteen healthy right-handed participants (8 men, 8 women, 25.7 ± 3.1 yr) participated in this study. The mean anthropometric measurements for participants were typical of the average United States population (Table 1). The Harvard School of Public Health Office of Human Research Administration approved all protocols and informed consent forms.

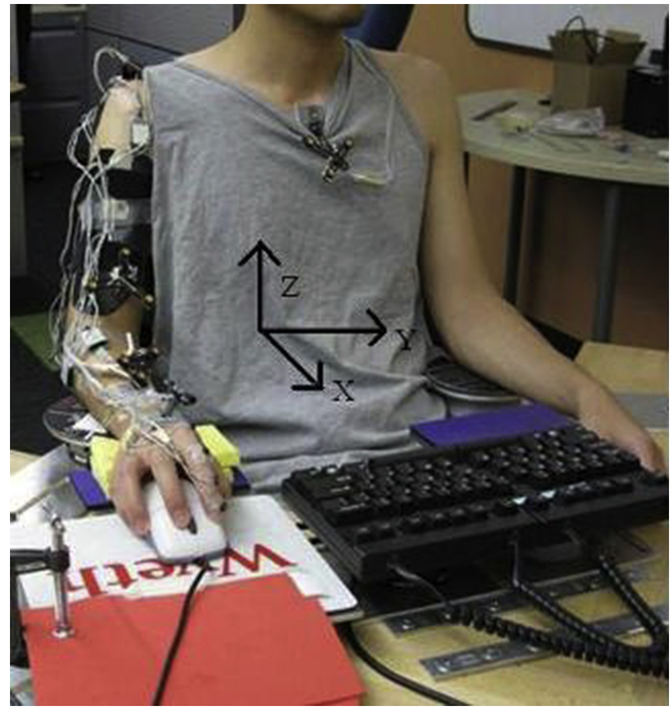

Fig. 1. Experimental Setup for the forearm and raised palm condition.

2.1. Experimental setup and support conditions

Participants sat in an armless chair at a workstation which consisted of a computer monitor, mouse and mouse pad (Fig. 1). The height of the chair and desk were adjusted so that the participant's feet were on the floor and the thighs were parallel with the floor, and all devices and support surfaces were at elbow height. The 20 × 24 cm mouse pad was fixed to the right of a keyboard (though the keyboard was not used in this study), with the center of the mouse pad approximately 30 cm to the right of the centerline of the workstation and monitor. The location of the participant's chair was adjusted so that the body's mid–sagittal plane was in line with the centerline of the workstation and as close to the table and comfortable as possible.

There were three support surfaces for the right arm that were positioned according to the participant's comfort: a forearm support, a flat palm support, and a raised palm support. The forearm support was a flat, 13 cm diameter circular support and was placed 18 cm from the front edge of the mouse pad, a distance which is approximately two thirds of the average American population forearm length from the wrist (Winter, 2005). This placement allowed for support of the forearm but not the elbow. When participants were using the forearm support, they rested their left arm on an identical left forearm support to maintain symmetry. The flat palm support was a 7.2 cm (length) × 15 cm (width) rectangular support placed in front of the mouse pad separated by only a slight space. For the raised palm support, 2.5 cm of soft foam was placed on top of the flat palm support. When using either of the palm supports, participants were asked to rest the scaphoid bone on the supports, rather than their wrist or distal forearms. The surface of the forearm support, palm support, and mouse pad were all the same material (fabric covered rubber material common to most mouse pads). Six total support conditions that were evaluated for each participant: Forearm Support, Flat Palm Support, Raised Palm Support, Forearm + Flat Palm Support, Forearm + Raised Palm Support, and No Support (Fig. 2). The order of the support conditions presented to participants was randomized.

Table 1
Mean (SD) anthropometric measures.

	Males ($N = 8$)	Females ($N = 8$)	All
Age (yrs)	26.9 (3.5)	24.5(2.0)	25.7 (3.1)
Height (cm)	176.5 (7.2)	166.9 (6.9)	67.6 (3.3)
Weight (kg)	83.9 (18.1)	62.5 (12.5)	73.2 (18.7)
Shoulder width (cm)	46.9 (4.5)	38.4 (3.0)	42.7 (5.8)
Shoulder to wrist (cm)	58.4 (3.1)	56.7 (3.3)	57.6 (3.2)
Hand length (cm)	18.9 (1.2)	17.8 (1.3)	18.4 (1.4)
Hand breadth (cm)	8.3 (0.4)	7.4 (0.6)	7.8 (0.7)

For each support condition, participants were asked to complete a nine-minute simulated computer mousing task. The task was designed to incorporate the static, dynamic, and passive interactions involved during computer mouse usage that involved a combination of clicking, dragging, pointing and clicking on icons, and reading onscreen text. For the first three minutes, participants played a game of Solitaire and thus had to move the cursor, by dragging and clicking playing cards, to various areas of the computer screen. For the next three minutes, participants completed a custom web browsing task in which they had to read a few lines of text and click on answers to simple multiple-choice questions regarding that text after viewing pictures or clicking and scrolling through web pages to find information. For the next three minutes, the participants read an online news passage and clicked "Yes" at the bottom of the screen when asked if they had finished reading. The order of these mousing tasks (Solitaire, Web Browsing, and then Reading) was fixed for all subjects.

2.2. Measurements

Posture, forces, and muscle activity applied to each support were recorded during each trial. An infrared three-dimensional (3D) motion analysis system (Optotrak Certus, Northern Digital, Ontario, Canada) measured upper extremity posture. Clusters of