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Kinematic and electromyographic differences between mouse and touchpad use on laptop computers

Carmela Conte [a], Alberto Ranavolo [a], Mariano Serrao [b,c], Alessio Silvetti [a], Giancarlo Orengo [d], Silvia Mari [e], Federico Forzano [a], Sergio Iavicoli [a], Francesco Draicchio [a,*]

[a] INAIL, Research Area, Department of Occupational Medicine, Via Fontana Candida 1, Monteporzio Catone, 00040 Rome, Italy
[b] Department of Medico-Surgical Sciences and Biotechnologies, University of Rome Sapienza, Polo Pontino, Via Faggiana 34, 40100 Latina, Italy
[c] Rehabilitation Centre Policlinico Italia, Piazza del Campidano 6, 00163 Rome, Italy
[d] Department of Electronics Engineering, Tor Vergata University, Via del Politecnico 1, 00139 Rome, Italy
[e] Fondazione Don Gnocchi, Milan, Piazzale Morandi 6, 20121 Milan, Italy

A R T I C L E I N F O

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A B S T R A C T

Background: Numerous studies have compared the postures and muscular activities induced by the various input devices available. To the authors' knowledge, no studies have yet compared upper body posture and movement, sEMG activity and muscle co-contractions induced by use of a mouse or of a touchpad.
Objective: The aim of this study was to compare posture, joint excursion and sEMG activity when using a laptop equipped with a mouse or a touchpad.
Methods: Trunk and upper arm posture, ranges of motion and muscle activities were measured in ten subjects during two standardized tasks.
Results: Mouse use induced larger shoulder abduction than touchpad use. On the other hand, when a touchpad was used, the upper arm joints were bound and fixed to a greater extent than during mouse use. Touchpad users are forced to maintain a more static posture. The upper arm electromyography results clearly indicate that touchpad use requires more stabilization than mouse use.
Conclusion: Motor tasks executed by means of the mouse allow a greater range of motions and reduce the biomechanical stress thanks to the greater postural mobility, even though the posture is less neutral. The results of our study tend to suggest that an external mouse should be preferred to the touchpad by frequent users of laptops.
Relevance to industry: This study is a suggestion for IT companies to give customers information of possible advantages using an external mouse. Furthermore our data highlight the importance of providing a mouse to all laptop users in order to reduce biomechanical risks.

1. Introduction

In recent decades, the use of laptops has continuously increased following the growing demand for work mobility and all the changes induced by the computer-related work environment. Laptops have even become the main work tool for workers who do not require PC mobility. As office workers are often seated at visual display terminals (VDTs) for more than 8 h a day, the spread of laptops has been accompanied by an increase in musculoskeletal problems due to postural fixity and non-neutral posture associated with their use (Straker et al., 1997; Sommerich et al., 2002; Sommerich, 2002). To convert user's actions in cursor movements on computer screen, laptops are usually equipped with an external basic mouse or built-in touchpad, and more rarely with a trackball incorporated in the keyboard. Among the non-keyboard input devices, which vary considerably in shape, size, mode and cursor velocity function, the external mouse is favored (Woods et al., 2003), probably because it provides better performances and has received higher subjective usability ratings than other devices (Baldus and Patterson, 2008). However, musculoskeletal pain and discomfort (e.g. stiffness and discomfort in the hands and wrist) have been reported in as many as 45% of mouse users (Atkinson et al., 2004). Biomechanical risk factors, associated with mouse use include non-neutral postures of the shoulder (abduction,

* Corresponding author. Tel.: +39 0694181373; fax: +39 0694181410.
E-mail addresses: f.draicchio@inail.it, francesco.draicchio@alice.it (F. Draicchio).

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external rotation and forward flexion) of the dominant arm (Houwink et al., 2009; Karlqvist et al., 1994; Oude Hengel et al., 2008). Furthermore, it has been demonstrated that the size of a computer mouse also has a marked biomechanical effect. Oude Hengel et al. (2008) showed that small notebook mice increase biomechanical stress. Moreover, shoulder muscle sEMG activity during mouse use sheds light on the influence of the mouse position (Cook and Kothiyal, 1998). The mouse lying on one side of the body, away from the midline, contributes greatly to musculoskeletal disorders by increasing shoulder muscle activity (Cook et al., 2000). Although studies in the literature show that mouse users are exposed to a considerable amount of stress, the EU directives (Direttiva 90/270/CEE may 29 1990: Legislative Decree 81/2008) implemented in Italy recommend the use of a mouse in case of frequent laptop use. In view of these findings, alternative input devices (e.g. touchpad) are often used to reduce biomechanical risks. Indeed, a touchpad embedded in the notebook's wrist rest leads to a more neutral posture, with the arm near the body midline (Cook and Kothiyal, 1998). However, it has been demonstrated that the touchpad may also induce discomfort in the neck and shoulder region (Kelaher et al., 2001) and that it may, possibly owing to the higher degree of accuracy needed for cursor movements (Akamatsu and MacKenzie, 2002), also result in greater postural fixity than an external mouse. To the authors' knowledge, no studies have yet compared upper body posture, movement, sEMG activity and muscle co-contractions induced by use of a mouse with those induced by the use of a touchpad. It was hypothesized that the use of the mouse reduces discomfort and non-neutral postural fixity if compared with the use of the touchpad. Therefore, the aim of this study was to compare trunk and upper arm posture, joint excursion and sEMG activity in subjects using a laptop equipped with a mouse or a touchpad. This comparison may help to determine which of these pointing devices should be recommended.

2. Methods

2.1. Subjects

Ten right-handed healthy subjects (five males and five females, aged 26–48 years) were selected from among a pool of computer users and randomly tested. All the participants were in good health. No subject reported a history of previous trunk or upper extremity injury, or the presence of a systemic or neurological disease. All the subjects were able to use both devices, i.e. the mouse and touchpad. Glasses or contact lens were not worn by any of the subjects. The subjects' demographic data are reported in Table 1. The research was approved by the local ethics committee and conformed to the Helsinki Declaration. All the subjects gave their informed written consent.

2.2. Instrumentation

2.2.1. Kinematic recordings

We used an optoelectronic motion analysis system (SMART-E System, BTS, Milan, Italy) (Ferrigno and Pedotti, 1985) consisting of

Table 1
Demographic data. Mean (±SD), min. and max. age and height of the subjects involved in the experiment.

Subjects demographic data				
Variables	Mean	SD	Min	Max
Age (years)	31.5	6.94	26	48
Height (cm)	170.6	6.89	160	180

Fig. 1. A representative picture of the position of the reflective markers and electrodes with video recording equipment.

eight infra-red ray cameras (operating at 120 fps) to detect the movements in three-dimensional space of nine markers covered with an aluminum powder reflecting material (6 mm diameter) placed over prominent bony landmarks according to a validated upper limb and trunk biomechanical model, as shown in Fig. 1 (Rab et al., 2002). The markers were attached using double-adhesive tape in such a way as to prevent them from falling out of place during the test. We also used an electronic goniometer consisting of a wearable resistive, one-direction flex sensor strip (Images SI, patent 5086785) to detect the abduction/adduction of the second finger of the hand with respect to the third. A commercial carbon-ink flex sensor was chosen because of its pliability, very high-bending sensitivity and the different lengths available to fit different finger joints. This sensor increases its resistance and, consequently, its output voltage as the degrees in bending increase (angular displacement), and includes a flexible substrate for attachment to the second and third fingers. The sensor was connected to an electric circuit for signal acquisition and conditioning to fit the response to the optoelectronic system with analog input specifications (voltage rage 0–5 V). Calibration was accomplished by recording sensor response to a set of known finger angles. The sensor was placed over a conventional goniometer and, by using an oscilloscope and a data acquisition toolbox (MATLAB™), the angles were associated with the output voltages to assess sensor linearity.

Synchronization with optoelectronic and electromyographic signals was also performed within the integrated system.

2.2.2. sEMG recordings

The sEMG signals were recorded with a sampling rate of 1000 Hz using a 16-bit acquisition board, and amplified using an 16-channel Wi-Fi transmission surface electromyograph