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Digit kinematics during typing with standard and ergonomic keyboard configurations

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Abstract

This study compared the differences between digit joint angles, velocities and accelerations during two typing tasks: one on a standard keyboard configuration and one on an ergonomic keyboard configuration. A marker-based motion analysis system was used to capture digit movements during typing and digit joint angles, angular velocities, and angular accelerations were calculated. Results showed significant differences between the ergonomic and standard keyboard configurations for digit angles, angular velocity, and angular acceleration, particularly for the left metacarpophalangeal joints. Most notably, the ergonomic configuration tended to reduce the angular velocity and acceleration for metacarpophalangeal and proximal interphalangeal flexion/extension and increase these variables for metacarpophalangeal abduction/adduction. The participants showed no significant differences in typing speed and error rate between the two keyboards. This research supports other research, which suggests that an ergonomic configuration can alter keyboard kinematics, but suggests that researchers should evaluate not only the wrist kinematics, but the digit kinematics as well.

Relevance to industry

This research provides information of interest to people who are considering acquiring an alternative keyboard in the workplace.

Keywords: Musculoskeletal disorders of the upper extremity (MSD-UE); Range of motion; Acceleration; Velocity; Motion analysis

1. Introduction

The incidence of musculoskeletal disorders of the upper extremity (MSD-UE) in computer users has not been specifically estimated, although it is considered to be one of the leading disorders in this population (National Research Council and the Institute of Medicine, 2001). Risk factors for MSD-UE in computer users include awkward postures (Carter and Banister, 1994) and wrist angular velocity and acceleration (Marras and Schoenmarklin, 1993). The assumption that a standard keyboard positions the wrists in postures that put the worker at risk for MSD-UE has lead to the development of "ergonomic" keyboards that are configured to provide engineering controls for the risky postures associated with MSD-UE. These keyboards are designed to reduce ulnar deviation, pronation, and extension of the wrists. The studies on the effects of ergonomic keyboard design on positioning the wrists have generally reported success in reducing non-neutral wrist postures during keyboarding (Baker and Cidboy, 2006; Marklin et al., 1999; Smith et al., 1998; Zecevic et al., 2000).

Although little is known about what constitutes "risky" motions and actions for the hands and digits during keying it is possible to extrapolate some possible risk factors from present hypotheses about the effect of biomechanical forces on the tendons of the wrist and hand, and from research on hand motions for other tasks. Awkward postures of the wrists and digits can increase the forces acting on the tendons and tendon sheaths, and these increased forces

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may be associated with the development of MSD-UE (Goldstein et al., 1987; Pascarelli and Kella, 1993; Tanzer, 1999; Volz et al., 1980). In addition, higher levels of angular velocity and acceleration of the digit joints may be risk factors associated with digit movement. While there have been numerous studies examining the biomechanics of typing for body postures, head postures, arm postures, and wrist postures, there have been only three studies (Baker et al., 2007; Sommerich et al., 1998, 1996) that have looked at the postures and actions of hands and digits during standard keyboard use. No studies have examined the effect of an ergonomic keyboard configuration on these postures.

Hand displacement, defined as the overall translational movements of the hand during computer keyboarding also is potentially a risk factor for MSD-UE. Previous studies (Baker et al., 2007), as well as clinical observations, have suggested that computer keyboard users either continually move their hands to position the digits for keystrike or keep their hands still and reach out with the digits to strike the keys. Keyboard users who reach with their digits rather than move their wrist/forearms may increase non-neutral posture, such as wrist extension, ulnar deviation, and pronation which are believed to be important risk factors for MSD-UE (Goldstein et al., 1987; Marklin et al., 1999; Rempel et al., 1992, 1997; Schuind et al., 1990; Sommerich et al., 1998; Tanzer, 1999; Werner et al., 1997).

This study compared the kinematics of the digits during typing on a standard keyboard configuration and an ergonomic keyboard configuration to determine if an ergonomic keyboard configuration reduced the digit postures and motions that are hypothesized to be risk factors for MSD-UE. The following two hypotheses were examined: (1) Participants using the ergonomic configuration would demonstrate significantly more neutral joint angles, slower joint angle velocities and reduced joint angle accelerations at the metacarpophalangeal (MCP) joint (flexion/extension and abduction/adduction) and proximal interphalangeal (PIP) joint (flexion/extension) compared to using the standard configuration; (2) Participants using the ergonomic configuration would demonstrate greater hand displacements compared to using the standard keyboard.

In addition, this study examined the effect of keyboard configuration on productivity measurements (i.e. typing speed and error rates), and also described the keyboard users responses to using an ergonomic keyboard.

2. Methods

This study was approved by the University of Pittsburgh Institutional Review Board. Informed consent was obtained from all participants.

2.1. Participants

Nineteen experienced typists were recruited from the University of Pittsburgh and signed an informed consent document. Experienced typists were defined as individuals who had experience as a data entry person, transcriptionist, or other job that required computer use. The participants were 68% female and 100% right handed. The participant demographics as well as hand anthropometrics are supplied in Table 1.

Table 1
Participant demographics

	Mean (sd)	Range	
		Min	Max
Age (years)	26.6 (9.9)	20	54
Comp. use (h/day)	7.2 (6.9)	2	10
Time using keyboard (%)	62.5 (25.0)	25	100
Time using mouse (%)	39.7 (25.1)	0	75
R grip strength (kg)	34.7 (9.8)	19.7	61.1
L grip strength (kg)	31.4 (9.7)	20.4	60.6
R tip pinch (kg)	4.27 (1.5)	1.4	6.4
L tip pinch (kg)	3.71 (1.3)	1.8	5.9
R wrist circum (cm)	15.3 (3.0)	5.2	20.0
L wrist circum (cm)	15.5 (3.0)	5.3	19.7
R hand circum (inc. 1st digit) (cm)	22.9 (1.5)	20.9	25.5
L hand circum (inc. 1st digit) (cm)	22.6 (1.6)	19.0	25.0
R hand length (cm)	18.5 (0.9)	16.4	20.0
L hand length (cm)	18.6 (1.0)	17.0	20.0
Participant BMI	24.8 (6.6)	18.6	42.0
	%		
Female	68		
Race—white	90		
R hand dominant	100		

R = right; L = left.

2.2. Equipment set-up

2.2.1. Computer set-up equipment

Kinematics data were collected using a VICON™[1] motion measurement system (VICON 612 system with 5 M2 cameras) positioned around a computer workstation. The hand and digit movements were derived from tracking 42 passive markers (4 mm diameter) positioned on the dorsal surface of both hands. The VICON™ motion capture set-up and marker set used are shown in Figs. 1 and 2 and are described in more detail by Baker et al. (2007).

The computer workstation chair was adjusted to the specifications of each participant, with the desk height kept constant to maintain the relative positions of the VICON™ cameras. A wrist rest and/or footrest was provided as requested. All keyboarding was completed on a GoldTouch™ keyboard.[2] For the "standard" trial the keyboard was positioned in a "standard" (i.e. flat and unangled) configuration. For the ergonomic configuration the

[1]Vicon Motion Systems Inc, Lake Forest, CA, USA—http://www.vicon.com/jsp/index.jsp

[2]Goldtouch Technologies Inc., Goldtouch US Corporate Headquarters, Irvine, CA, USA http://www.goldtouchtechnologies.co.uk/contact/index.html