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Effects of standing on typing task performance and upper limb discomfort, vascular and muscular indicators

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ABSTRACT

Standing is a popular alternative to traditionally seated computer work. However, no studies have described how standing impacts both upper body muscular and vascular outcomes during a computer typing task. Twenty healthy adults completed two 90-min simulated work sessions, seated or standing. Upper limb discomfort, electromyography (EMG) from eight upper body muscles, typing performance and neck/shoulder and forearm blood flow were collected. Results showed significantly less upper body discomfort and higher typing speed during standing. Lower Trapezius EMG amplitude was higher during standing, but this postural difference decreased with time (interaction effect), and its variability was 68% higher during standing compared to sitting. There were no effects on blood flow. Results suggest that standing computer work may engage shoulder girdle stabilizers while reducing discomfort and improving performance. Studies are needed to identify how standing affects more complex computer tasks over longer work bouts in symptomatic workers.

1. Introduction

Many studies have suggested that the sitting posture provokes musculoskeletal discomfort during computer work (Husemann et al., 2009; Fedorowich et al., 2015; Juul-Kristensen and Jensen, 2005). However, in recent years, standing computer work has become a popular alternative. A study suggested that the standing posture may promote cognitive performance through stimulation of the cardiovascular system, promoting greater awareness compared to sitting (Caldwell et al., 2003). Moreover, studies have found no detrimental effect of sit/stand alternations on computer work performance, although the sit/stand condition has shown increased physical and psychological well-being compared to sitting (Husemann et al., 2009; Ebara et al., 2008), suggesting some relevant benefits to workplace health.

Despite some potentially positive effects of the standing computer work posture, some studies comparing postural discomfort during computer tasks have shown higher overall comfort while sitting and greater fatigue and discomfort in standing after 20 min (Beers et al., 2008), 45 min (Lin et al., 2017) and after 90 min (Chester et al., 2002). Recently, another study on prolonged standing during computer work showed that multisite discomfort (lower limb, lower back and upper limb) increased after 120 min (Baker et al., 2018). Moreover, in a study focusing on the neck/shoulder region, discomfort was reported after 18 min in the seated posture but after 72 min while walking on a treadmill (Fedorowich et al., 2015). Furthermore, a six-week study with height adjustable tables found less upper body discomfort and musculoskeletal disorder (MSD) symptoms when participants could freely alternate table height (Hedge and Ray, 2004). These studies suggest benefits of other computer work postures, at least on subjective symptoms of discomfort.

Some recent studies have investigated the effects of standing work (in comparison to sitting) on upper trunk and limb tridimensional posture, electromyography (EMG) and discomfort, an approach that may help to explain mechanisms underlying discomfort in different working postures. Lin et al. (2017) showed that standing computer workstation reduced non-neutral shoulder posture and associated EMG but increased those of the wrist. However, Botter et al. (Botter et al. (2016) showed that the upper trapezius EMG amplitude was only marginally changed when computer work was accomplished in sitting, standing, and dynamic postures. High EMG amplitude during computer tasks may pose a risk for development of MSDs with increases over time (Kleine et al., 1999) or sustained activity levels thought to pose an injury risk (Westgaard et al., 2001), although there is little empirical evidence to support this (Strom et al., 2009b). Another motor pattern inferred from muscle activity signals is motor variability, defined as the variation of behavioral outcomes over repetitions or time (Latash et al., 2002). Research shows a lack of motor variability, in occupations requiring prolonged low-level muscle activity, as a risk factor for

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Table 1
Electrode locations and MVIC actions for each muscle.

Muscle	Electrode Location	MVIC Position	Movement and load application
Cervical erector spinae (CES)	10 mm right of C5 vertebrae	Prone laying	Neck extension against posterior resistance on head
Upper trapezius (UT)	Midpoint of C7 spinous process and acromion	Seated: arm at the side	Shoulder elevation against resistance
Anterior deltoid (AD)	Between lateral 1/3 of clavicle and deltoid tuberosity of the humerus	Seated: 45° arm flexion	Shoulder flexion against upper arm resistance
Wrist extensor (Wext)	2 finger widths distal to elbow, over muscle belly	Neutral wrist, pronated forearm, 90° elbow flexion	Wrist extension against dorsal resistance of hand
Middle trapezius (MT)	Midpoint of thoracic spine and scapula's medial side	90° shoulder flexion	Scapula adduction
Lower trapezius (LT)	Midpoint between T8 spinous process and scapula's inferior angle	90° shoulder flexion	Scapula depression against resistance under the upper arm
Lumbar erector spinae (LES)	Midpoint between T12 and S1, along lumbar spine over transversus process	Prone lying, arms at sides	Lumbar extension with hamstring resistance
External Oblique (EO)	2 finger widths below last rib and 3 inches toward body midline	Supine laying, 90° knee flexion	Upper trunk flexion-rotation against right pectoral resistance

developing MSDs (Juul-Kristensen and Jensen, 2005; Srinivasan and Mathiassen, 2012) and that greater variability may aid in preventing MSDs (Mathiassen et al., 2003; Madeleine et al., 2008a; Ciccarelli et al., 2013). Another muscular pattern related to MSD risk is Mutual Information (MI) which attempts to quantify shared activation patterns between two EMGs (Jeong et al., 2001). Previous research has shown MI in the trapezius to increase with muscle fatigue, to be higher in forearm muscles during a static task, and to increase over time in neck/shoulder muscles during seated typing (Fedorowich et al., 2015; Svendsen et al., 2011). Together, these studies suggest that not only EMG amplitude but also its variability and their inter-relationships may be indicative of MSD risks.

Anterior neck, shoulder and trunk postural deviations are often seen with prolonged and/or static computer work postures and may impede on blood delivery to the working upper limbs (Keller et al., 1998). Seated computer work studies have shown increases in blood flow to the trapezius over 30 min but decreases over the remaining 60 min (Strom et al., 2009a) and no effect over 90 min (Fedorowich et al., 2015). Overall, blood flow during static standing work has not been well researched, although standing-related reductions in venous return has been hypothesized (Tuchsen et al., 2005), supported by observations of lower limb blood pooling indicators after 30 and 120 min of static standing work (Baker et al., 2018; Antle et al., 2013).

In summary, little experimental research has been conducted on the effects of standing computer work tasks on upper limb muscular and vascular characteristics. Therefore, the objective of this study was to quantify neck/shoulder muscle patterns, typing performance, blood flow and discomfort in the postures of sitting and standing during a 90-min simulated computer work task. We hypothesized that standing would reduce neck/shoulder muscle activity amplitude, increase variability and induce less inter-muscle connectivity, and thereby increase blood flow to the upper limbs, which could help alleviate discomfort without impeding on performance.

2. Materials and methods

2.1. Participants

A convenience sample of 20 adults (10 males, 10 females; mean age = 27.65 ± 6.18 years; mean height = 169.72 ± 9.07 cm; mean mass 69.31 ± 12.41 kg) volunteered to participate in this study. They were deemed asymptomatic because none of them answered 'Yes' to any question of the Par-Q Health Questionnaire. Inclusion criteria consisted of weekly computer use of at least 40 h, never having used standing and walking workstation previously, aged between 20 and 50 years old, and asymptomatic and free of injuries and disorders as assessed by the Par-Q Health Questionnaire. The study location was the Occupational Biomechanics and Ergonomics Lab (OBEL) of the Jewish Rehabilitation Hospital in Laval, Quebec. Informed, written consent was obtained from the participants, prior to partaking, by signing forms approved by the Research Ethics Board of the Center for Interdisciplinary Research in Rehabilitation (CRIR) of Greater Montreal.

2.2. Session randomization

Data was recorded from three separate sessions during a computer work task performed in the postures of sitting, standing or walking on a treadmill. Sessions were assigned in semi-random order (the walking session, requiring acclimation, could not be the first session) with at least 48 h between sessions. This paper reports the results of the seated and standing data, as the walking data is published elsewhere (Fedorowich et al., 2015).

2.3. Experimental protocol

Participants were outfitted with EMG recording equipment (TeleMyo, Noraxon, USA, 10–350 Hz operating bandwidth). Eight muscles of the right arm, shoulder and trunk were marked, shaved and cleaned with rubbing alcohol to allow for better signal transmission. The Ag/AgCl surface electrodes (Ambu, DE) were placed side by side in bipolar configuration, parallel to the muscle fibers. The locations and MVIC actions for each muscle site are displayed in Table 1. A reference electrode was placed over the right external epicondyle. Normalization trials were conducted for each muscle using two ramp-up, ramp-down 5-s Maximal Voluntary Isometric Contractions (MVIC) with encouragement to push as hard as possible in the muscle's direction of action. Participants could rest 1 min between both trials. Two Laser Doppler Flowmetry (LDF) electrodes (FloLAB Monitor, Moor Instruments, Devon, England) were placed over the right upper trapezius (shoulder LDF (SLDF)), and wrist extensor (forearm LDF (FLDF)) muscles.

Next, the participant was positioned in the working posture. In the seated posture, the knee was at an angle of 90°. In the standing posture, the participant stood with feet hip-width apart, with instructions to shift weight as needed without moving the foot position. In both sessions, the work surface was adjusted, according to ergonomic standards, to 5 cm below elbow height (Grandjean and Kroemer, 1997). Then, baseline LDF measures were taken when the subject assumed a relaxed, static state.

2.4. Computer task

Participants reproduced article text on The Mavis Beacon Teaches Typing software (Straker et al., 2009). The participant performed 10 blocks of 9 min each with about 30s of break in between. Computer