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Variation in upper extremity, neck and trunk postures when performing computer work at a sit-stand station

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A R T I C L E I N F O

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A B S T R A C T

Sit-stand tables are introduced in offices to increase variation in gross body posture, but the extent to which upper body posture variation is also affected has not previously been addressed. Neck, trunk, and upper arm postures (means and minute-to-minute variances) were determined during periods of sitting and standing from 24 office workers using sit-stand tables to perform computer work. Posture variability resulting from different temporal compositions of sitting and standing computer work was then predicted for the neck, trunk and upper arm by simulations. Postural variability during computer work could be increased up to three-fold when 20–60% of the work was performed standing (i.e. 40–80% performed sitting), compared to performing computer work only sitting. The exact composition of sit-stand proportions leading to maximum variability, as well as the potential size of the increase in variability, differed considerably between workers. Guidelines for sit-stand table use should note these large inter-individual differences.

1. Introduction

Computer-intensive office work has been associated with a number of risk factors for developing musculoskeletal symptoms in the neck and shoulders, such as constrained postures with insufficient variation, and repetitive movements while performing keyboard and mouse work (Gerr et al., 2006, 2004, 2002; Hakala et al., 2006; Marcus et al., 2002; Wahlström, 2005). It is generally believed that increased postural variation would decrease risks in computer-intensive jobs (Mathiassen, 2006). However, how to achieve more variation in computer-intensive office work is still debated, let alone the effects of specific interventions of postural variation on relevant outcomes such as fatigue and discomfort. Some studies have argued that vigorous tasks beyond what is normally thought of as office work, such as cleaning, need be introduced to obtain sufficient variation (Barbieri et al., 2015; Richter et al., 2009; Straker and Mathiassen, 2009), but the potential for increased variation offered by more conventional office initiatives is still insufficiently explored.

Sit-stand workstations are becoming increasingly popular in office environments, where they are being introduced with the primary intention of replacing some of the time spent sitting by standing, and thus reduce cardiometabolic risks associated with sedentary behavior (Benatti and Ried-Larsen, 2015; Chau et al., 2014; Duvivier et al., 2017; MacEwen et al., 2015; Neuhaus et al., 2014), or even decrease fatigue and musculoskeletal discomfort (Thorp et al., 2014). Seated and standing office work may lead to different postural exposures to the upper body, with possible effects on musculoskeletal outcomes. For instance, some studies have reported sitting office work involving computer-intensive tasks to be associated with more flexed lumbar postures than standing (e.g. Callaghan and McGill, 2001). Recently, Ghesmaty Sangachin et al. (2016) measured neck, trunk and shoulder postures when workers performed standard office work tasks while sitting, standing and walking. They found that standing and walking were associated with more switches between five posture categories (0–5, 5–15, 15–30, 30–45 and > 45°) than sitting, and concluded that standing and walking were associated with more posture variation than

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sitting. Babski-Reeves and Calhoun (2016) had 24 participants doing a data entry task in three 20/5 min cycles of sit/stand. A non-neutral posture of the neck, elbow and back occurred more often in sitting than in standing. Lin et al. (2017) compared differences in upper extremity posture between sitting and standing workstations for 20 participants performing simulated office tasks. They showed that variation (measured as the difference between the 90th and 10th posture percentile) was larger for shoulder rotation and wrist extension during standing work than during sitting.

Based on these findings, it appears reasonable to assume that a combination of sitting and standing computer work, as likely facilitated by access to a sit-stand workstation, would lead to larger variability in upper extremity, neck and trunk postures than if work was performed only sitting. However, the extent to which postural variability would change with different combinations of sitting and standing work has not been examined.

Thus, the objective of the present study was to quantify the changes in upper arm, neck and trunk posture variability when combining seated and standing computer work, compared to performing computer work only seated. The research questions addressed in the study were:

1. To what extent does variability in neck, trunk and right upper arm postures change when computer work is performed both sitting and standing at a sit-stand station, compared to only sitting?
2. What temporal composition of sitting and standing computer work can be predicted to give the largest variability in neck, trunk and right upper arm postures?

These questions were addressed by first determining the mean and minute-to-minute variance of neck flexion, trunk flexion and upper arm elevation angles in sitting and standing postures among users of sit-stand workstations as they performed their routine computer-based work in their regular work environment. Numerical simulations based on this data were then performed to identify, for each individual participant, the temporal composition of seated and standing computer work that would hypothetically result in maximum possible posture variability.

2. Methods

2.1. Study sample

The study sample comprised 24 office workers from two public universities in Brazil (8 males, 16 females; Table 1). Initially, about 80 workers engaged in undergraduate and graduate courses, financial management and human resources were invited by the Human Resources department to participate in the study. In a second step, workers expressing interest were interviewed by one of the researchers. Inclusion criteria were, (I) no self-reported musculoskeletal discomfort or pain in the low-back, neck-shoulder, hand-arm or legs in the three months preceding the study, (II) self-reported computer use for more than four hours on a typical workday, (III) computer tasks at work for more than five years (as we intended to study workers experienced in performing computer work), and (IV) absence from work for, at the most, one month in the preceding year, excluding holidays (as we attempted to avoid workers with any disease or disorder).

Main work tasks performed by the participating workers were sending and answering e-mails, writing documents, browsing the internet, and providing support to students and staff through phone calls. These tasks were typical of office work among Brazilian university employees (Barbieri et al., 2015). The study was approved by the Human Ethics Committee of the Federal University of São Carlos (Process #13880213.9.0000.5504).

Table 1
Distribution of the sample (N = 24) according to demographic and anthropometric characteristics; and percentage of time spent in each task (with SD between subjects).

Socio-demographic characteristics	N	%
Gender		
Males	8	33.3
Females	16	66.7
Age, years	41.3 (8.8)	
Dominant side		
Right	23	95.8
Left	1	4.2
Education level		
High school diploma	4	16.7
University degree	9	37.5
Post-graduation	11	45.8
Administrative sectors		
Coordination of undergraduate courses	4	16.7
Coordination of graduate courses	9	37.5
Finance	4	16.7
Human resources	2	8.3
General administrative service	5	20.8
Body mass index, kg/m^2		
< 25	9	37.5
25 +	14	58.3
Unknown	1	4.2
Task proportion (Mean (SD between workers), percent of observed time		
CW-sit	–	37.5 (13.6)
CW-stand	–	14.5 (6.0)
NCW-sit	–	16.5 (6.5)
NCW-stand	–	6.0 (3.5)
NonDeskW	–	12.9 (9.6)
WBreak	–	12.5 (7.4)

2.2. Protocol

Initially, each worker received an adjustable sit-stand table, and guidance on standard workstation adjustments for sitting and standing work; i.e. sitting: top line of the screen at eye level, using both the backrest and armrest so that the arms could be supported; standing: top line of the screen at or below eye level, support of the arm on the table as often as possible. Also, the importance of actually using the adjustable table was emphasized. The worker then used the sit-stand table for two months, with no other changes in equipment. Observations of work and recordings of upper body kinematics were collected during the last three days of this two-month period so as to minimize possible effects of adaptation. The 24 workers received sit-stand tables with two different technical solutions for table position changes (Barbieri et al., 2016); but since our previous analyses of sit-stand behavior with the two table technologies suggested that the overall time proportion of sitting (and therefore even standing) did not depend on technology (Barbieri et al., 2017), we merged the two populations. Measurements were collected for 2 h each, on three consecutive days, to secure a sufficiently stable estimate of postural exposures (e.g. Trask et al., 2008).

2.3. Observations

On each measurement day, on-site observations were performed for two hours by an experienced ergonomist using a customized App for Android systems, for the purpose of classifying the work into six different tasks, i.e.:

1. CW-stand: Computer Work while standing
2. CW-sit: Computer Work while sitting
   Example of activities performed at the computer were reading or writing emails, writing or editing documents, browsing the web;
3. NCW-stand: Non-Computer Work while standing
4. NCW-sit: Non-Computer Work while sitting