THE EFFECT OF PROLONGED SITTING VERSUS USE OF A TREADMILL DESK ON POSTURAL STABILITY

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Prolonged sitting is resulting in health risks to a growing number of the population. As a potential intervention, treadmill desks make it possible to interrupt prolonged sitting during the office worker's day. This study aimed to investigate the acute effect of breaking up prolonged sitting with treadmill desk walking on postural stability. Thirteen sedentary adults participated in a randomised two treatment crossover design: 1) sitting for 6.5 hrs versus 2) accumulated 2 hrs of light-intensity treadmill desk walking during the 6.5 hrs. Pre and post condition, participants performed postural stability tests on a pressure plate. Centre of Pressure (CoP) AP amplitude showed a significant interaction in Bilateral Eyes Closed, Bilateral Eyes Open and Unilateral Eyes Open tests, and CoP ML Amplitude in both Bilateral tests, where sway amplitude was less in the walking condition. Breaking up prolonged sitting with an accumulated 2 hrs of light-intensity treadmill desk walking had a positive effect on postural stability, supporting the use of walking desks in the workplace.

KEY WORDS: sedentary, occupational health, balance, active workstation

INTRODUCTION: The negative effects of chronic prolonged sitting on cardiometabolic disease and cancer risk are well established (Katzmarzyk et al., 2009). Contemporary desk-based jobs and lack of “free” time are barriers to interrupting prolonged sitting and increasing levels of activity for large numbers of the population. The introduction of active workstations, such as a treadmill desk, make it possible to incorporate physical activity into the office worker's day and thus achieve the recommended guidelines of initially accumulating at least 2 hrs of light activity per day (Buckley et al., 2015). Active workstations have been investigated in terms of their effects on health markers such as body composition, glucose and lipids, and quality of life, in addition to effects on work performance and cognition (Dunstan, 2015). However, few biomechanical measures have been investigated and a review of findings provided by Torbeyns et al. (2014) concluded that biomechanical research is required before a change to active workstations can be justified in working environments.
Postural stability is considered a sensorimotor process which includes the functional integration of sensory afferent information from visual, vestibular and somatosensory systems, as well as central processing of sensory information, and selecting motor responses (Horak, 2006). Since physical activity affects all levels of this sensorimotor process, postural stability is a good candidate health variable to help further understand the effects of prolonged sitting. Postural stability during quiet standing is most commonly assessed with centre of pressure (COP) measures recorded using a force platform (Piirtola & Era 2006; Pinsault & Vuillerme 2009). Different characteristics of postural sway have been studied to infer stability, including standard one-dimensional Medio-Lateral (AL) and Anterior-Posterior (AP) CoP variables (i.e., standard deviation of each variable, range, mean and maximal velocity) and two-dimensional CoP variables (i.e., area, path length and mean velocity) over a fixed time interval. Small amplitude, low velocity shifts in the CoP during quiet standing are considered to indicate the effectiveness of the postural control system as little effort is required to maintain equilibrium (Era et al. 1996). Therefore, functional postural stability is characterised by a small CoP Path Length, which has been shown to be a strong predictor of falls in prospective studies (Lord, Clark & Webster 1991). ML and AP sway variables (range and velocity) in particular may have a predictive value for subsequent falls in older adults and are used in many clinical assessments (Piirtola & Era, 2006). While it is accepted that physical activity, even of low intensity, has an acute, short lasting (5-20 min) negative effect on postural stability (Fox et al. 2008), the chronic effects of being physically

active have shown a positive effect on postural stability (Enoka, 1997). There is no research, however, investigating the effect of prolonged sitting versus interrupting sitting with the use of a treadmill desk on postural stability. Therefore, the aim of this study was to investigate the acute effect of breaking up prolonged sitting with an accumulated 2 hrs of light-intensity treadmill desk walking on postural stability in sedentary adults.

METHODS: The study was approved by the Research Institution Ethics panel, and participants signed informed consent before taking part. Thirteen sedentary adults (height: 1.72 ± 0.07 m; mass: 80.6 ± 18.9 kg; body mass index: 27.1 ± 5.1 kg/m^2; age: 39.2 ± 11.6 years) participated in the study. All participants were free from injuries at the time of testing and in the past 12 months and passed a PAR-Q. The study design was a randomised two treatment acute crossover. Participants attended the University of Bedfordshire Sport and Exercise Science Laboratories on three separate occasions; a familiarisation session, followed by two experimental days separated by ≥7 days. Participants refrained from moderate-to-vigorous physical activity for ≥ 72 hrs before the experiment and did not consume alcohol or caffeine 24 hrs prior to testing (Bailey et al 2014). During the familiarisation session, participant height (Horltain Ltd., Crymych, UK) and mass (Tanita Corp., Tokyo, Japan) were recorded. The treadmill desk speed that yielded a Rate of Perceived Exertion (RPE; Borg, 1982) of between 6 and 9 was recorded for each participant in order to standardise exertion during the experimental condition. During the experimental days, participants attended the laboratory at 0830. The two experimental conditions were: (1) Uninterrupted sitting for 6.5 hrs: participants remained seated and refrained from excessive movement, only rising to void, and (2) Interrupted sitting: participants and performed 20 minute bouts of standardised exertion treadmill desk walking each hr provided a total of 2 hrs of light treadmill desk walking. Two standardised meals were consumed at 0 h and 3 h and physiological measures not presented here (e.g. blood glucose) were taken intermittently during the experimental period. During trials, participants were permitted to read, watch dvd's or work on a computer. Postural stability tests were conducted on a pressure plate (RS Footscan, Foot Scan plate 0.5 m, 33 Hz) prior to and immediately following the conclusion of each 6.5 hr experimental condition. Participants were barefoot and stood with their hands on their hips (iliac crest). For each condition three 30 s trials were recorded with 15 seconds rest, and a further 1 minute rest was provided between tests (Pinsault & Vuillerme, 2009). Stability tests were; bilateral stance with eyes open and eyes closed (based on the Romberg's Test) and unilateral stance on the preferred standing leg with eyes open. For each trial, CoP Path length (total distance travelled of the CoP during the 30 s), COP amplitude (maximum displacement) in the ML and AP directions were calculated. Mean and SD values for the three trials in each test were calculated. Individual and group mean and SD were calculated for each test. Inter-trial reliability was deemed acceptable (ICC > 0.7 for all measures). A Repeated Measures Factorial ANOVA was conducted to investigate the main effects of time (pre v post) and condition (sitting v walking desk) and the interaction effect of time and condition on the dependent variables measured (CoP Path length, COP amplitude ML and COP amplitude AP; Microsoft SPSS (version 22.0, SPSS inc, Chicago). The alpha level for a statistically significant effect/interaction was set at $p < 0.05$.

RESULTS: The main effects of time and condition and the interaction effects are presented in Figure 1. COP AP amplitude showed a significant interaction for all three postural stability tests: Bilateral Eyes Closed, $F(1,12) = 8.669$, $p = 0.012$; Bilateral Eyes Open, $F(1,12) = 5.244$, $p = 0.041$ and Unilateral Eyes Open, $F(1,12) = 8.553$, p = 0.013. COP ML amplitude showed a significant interaction in Bilateral Eyes Closed, $F(1,12) = 6.549$, $p = 0.025$ and Bilateral Eyes Open, $F(1,12) = 6.864$, p = 0.022. In all of these significant interactions, the walking desk condition resulted in a mean reduction in COP amplitude between the pre and post condition measures. There was a significant effect of time (pre-post) for COP ML amplitude in Unilateral Eyes Open, $F(1,12) = 10.76$, p = 0.007, but no significant interaction effect for this variable. There were no significant interactions found for CoP Path Length in any of the tests.

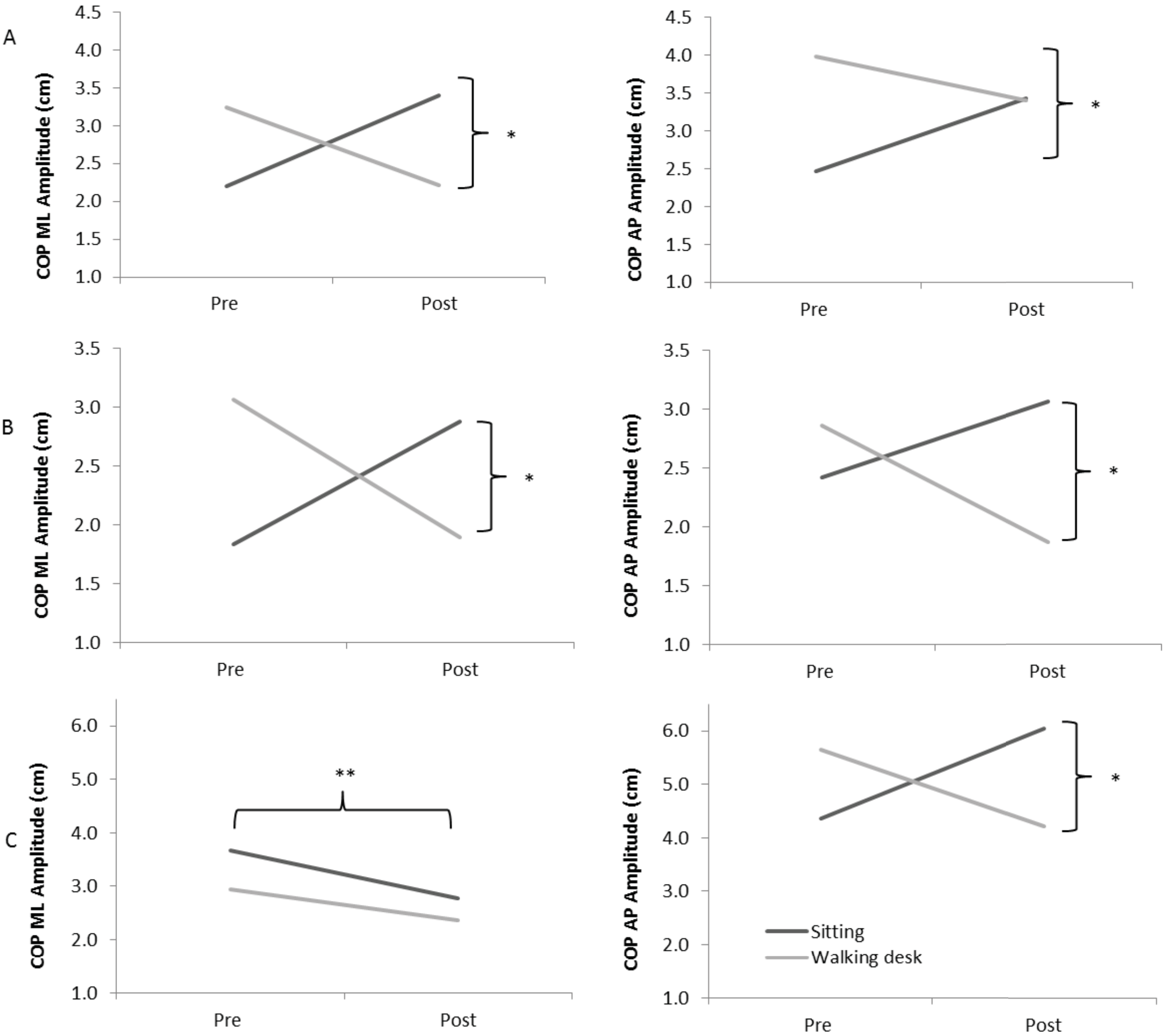

Figure 1. Profile plots of the sitting and walking desk conditions during Bilateral Eyes Closed (A), Bilateral Eyes Open (B) and Unilateral Eyes Open (C) tasks for CoP ML Amplitude (left) and CoP AP Amplitude (right). A single asterisk (*) indicates a significant interaction (*$p < 0.05$*) between time (pre-post) and condition (sitting-walking desk). A double asterisk (**) indicates a significant effect of time (pre-post).

DISCUSSION: The aim of this study was to investigate the acute effect of breaking up prolonged sitting with an accumulated 2 hrs of light-intensity treadmill desk walking on postural stability in sedentary adults. The main findings were significant interactions between time and sitting/walking desk condition for CoP AP Amplitude in all three tests; Bilateral Eyes Closed, Bilateral Eyes Open and unilateral Eyes Open. In addition, significant interactions between time and sitting/walking desk condition were found for CoP ML Amplitude in the bilateral tests (Bilateral Eyes Closed, Bilateral Eyes Open). Specifically, mean values for CoP amplitudes reduced with the walking desk condition and increased with the prolonged sitting condition in post compared to pre-tests. Overall, these findings can be interpreted as the walking desk having a positive effect on postural stability, since small amplitude, low velocity shifts in the CoP during quiet standing are considered to indicate the efficiency and effectiveness of the postural control system (Era et al. 1996). Low intensity physical activity has previously been shown to have an acute, short lasting (5-20 min) negative effect on postural stability (Fox et al. 2008). Since the periods of walking in the current study left a 40 minute period of sitting prior to the postural stability tests, these acute negative effects of physical activity were not seen. However, the positive effects of the waking desk compared to prolonged sitting are clearly visible. Therefore, this study goes some way to bridge the gap between current knowledge of short term and long term effects of physical activity on postural stability.

No significant interaction for time and condition was found for the CoP Path Length. CoP Path Length has previously been shown to be a strong predictor of falls in prospective studies (Lord et al., 2007). However, it is suggested that the lack of interaction found in the current study may be due to larger inter and intra participant variability in this global measure. Therefore, this contradiction adds further to the suggestion that there is no general agreement regarding which variables relating to CoP should be adopted for the assessment of functional postural sway (Palliard & Noe, 2015).

Maintaining balance is a complex task where the central nervous system must integrate visual, vestibular and proprioceptive information while modulating commands to the neuromuscular system (Enoka, 1997). Demonstration that prolonged sitting has a negative effect on these systems, but that this effect can be ameliorated by interrupting prolonged sitting with treadmill desk walking, could be a potentially effective tool for improving physical health and wellbeing in contemporary society.

It is suggested that future research should consider the effect of light walking to reduce prolonged periods of sitting in an elderly population for whom postural stability is in decline and risk of falling is increasing largely due to less efficient proprioceptive and neuromuscular systems (Piirtola & Era, 2006).

CONCLUSION: Interrupting prolonged sitting with an accumulated 2 hrs of light-intensity treadmill desk walking had a positive effect on postural stability, specifically a reduced CoP ML and AP Amplitude. The implication of this finding suggests that use of walking desks, or taking regular walking breaks, could have neuromuscular benefits in addition to other health benefits that have been more widely investigated to date.

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