Original Article

Pattern of attention, stress, anxiety, and musculoskeletal discomfort levels when using a sit-stand desk in a college class

JEREMY M. FROST¹, MARTY DOUGLAS², DONNA J. TERBIZAN²

¹Department of Human Performance, Minnesota State University, Mankato, UNITED STATES

²Department of Health, Nutrition, and Exercise Sciences, North Dakota State University, UNITED STATES

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Abstract.

Problem Statement: Increased amount of daily sitting time has been linked to increased risk of disease, independent of the amount of daily physical activity. A number of devices have been developed to address prolonged sitting in work and educational settings (e.g., sit-stand desks, treadmill-desks, cycle-desks, stepping desks). However, very little research has investigated the effect of a sit-stand desk on cognitive mood and performance in the college classroom. **Purpose:** To determine the effect of using adjustable-height (sit-stand) desks in a college class on attention (AT), stress (ST), musculoskeletal discomfort (MD), anxiety (AN), and academic performance (EXAM). **Approach:** A total of 18 subjects completed the 13 week intervention (week 3-15 of the semester). The standing group participants (S) used a sit-stand desk, placed in the back and one side of the classroom, to use as they desired; the control group (C) used standard desks. Participants completed a weekly visual analogue scale (VAS) for AT, ST, MD, and AN, and were given space to provide optional comments on why they answered the way they did. Class sessions were video recorded to allow for direct observation of attention (OAT). **Results:** The main findings indicated a significant interaction effect for AT ($F[12, 166] = 2.79$, $p = 0.002$) and ST ($F[12, 166] = 2.15$, $p = 0.017$), and significantly ($p=0.002$) lower overall MD for the intervention (12.81 ± 3.45) vs. control (35.12 ± 4.80). EXAM and OAT were not different between groups. **Conclusion:** A strength of this study is the week to week data collection on overall discomfort level and various measures of cognitive mood and performance. Use of a sit-stand desk was associated with lower MD scores and high variability in AT and ST scores from week to week.

Keywords: sit-stand desks, adjustable-height desks, attention, stress, musculoskeletal discomfort, anxiety

Introduction

The potential for movement, or not moving, exists for each person as they go about their daily activities. This encompasses work or school time and free/recreational time. Past recommendations often focused on increasing the amount and intensity of purposeful physical activity (i.e., exercise) (Haskell et al., 2007). However, there is a growing emphasis being placed on sedentary behaviors and the independent effects of these behaviors on health and wellness (Ekblom-Bak et al., 2010; Hamilton et al., 2007).

There have been numerous devices created or modified for gaining health benefits during what has always been, or has evolved into, a sedentary activity (Levine, 2007). For instance, standard desks are now height-adjustable so a person can stand while working. An important question to answer is whether these modifications, and their expense, provides any benefit during work, school, or free time. Since most studies have found only minimal increases in energy expenditure in standing compared to sitting (Levine, 2007; Benden et al., 2011; Creasy et al., 2016; Reiff et al., 2012), looking at other potential areas of improvement are necessary.

The increase in occupational and leisure-time sedentary behaviors can lead to deleterious effects on cognitive health and work performance as well. A cross-sectional sample of 3367 government employees in Australia evaluated the associations between sitting at work and mental health found that sitting more and engaging in less physical activity (PA) were correlated with more psychological distress (moderate distress for men and moderate to high distress for women), even after controlling for leisure time PA and body mass index (BMI) (Kilpatrick et al., 2013). To address prolonged sitting, the Take-A-Stand-Project introduced standing desks for a 4-week intervention period in a work setting (Pronk et al., 2011). The standing-desks resulted in significant improvements for the following self-reported mood states: fatigue, vigor, tension, confusion, depression, and total mood disturbance. Values for mood states were also evaluated after reverting to standard desks for a two-week period after the intervention and, interestingly, vigor and total mood disturbance reverted to original levels in this short time frame. Cognition and work productivity was maintained in a variety of other recent studies. For example, Bancroft et al. (2016) found no change in memory or attention when working in a standing position for an hour in young adults, Chau et al. (2016), found no change in productivity in call center employees using a sit-stand desk over 19 weeks, and Garrett et al. (2016) observed an overall increase in

productivity of about 45% in call-center employees in the 6-month study, with even better results in the first three months.

Musculoskeletal pain and fatigue during standing-desk interventions have also been investigated in workplace and educational settings to determine if these new positions lead to more discomfort than sitting, a result that could counteract any potential positive effects of standing. Half the participants reported leg or back pain when using the sit-stand desk in a seven week study in an Australian secondary school (Sudholz et al., 2016) and several workplace studies found that standing increased fatigue or musculoskeletal discomfort (Chester et al., 2002; Ebara et al., 2008; Hasegawa et al., 2001). In a longer study (6 months), Cifuentes et al. (2014) initially saw increased discomfort from standing, a similar result to the previously mentioned studies; however, the discomfort symptoms in the foot and knees receded after approximately two weeks and remained low throughout the study. In contrast to the studies showing increased pain or discomfort, musculoskeletal discomfort ratings have been shown to be better (i.e., lower) in a variety of settings, populations, and time frames: in adult workers using electronic-height adjustable workstations (EHAW) for 4-6 weeks (Hedge & Ray, 2004), in simulated office tasks over 19 days in women using sit-stand desks (Robertson et al., 2013), and in New Zealand elementary school third and fourth graders using standing desks in the classroom for four weeks (Hinckson et al., 2013). In addition, Botter et al. (2013) found that all standing workstations (conventional standing and treadmill desk) had lower cervical spine flexion and trunk flexion, which may have the potential to decrease musculoskeletal pain in the long run, but they did not assess participants' comfort levels. Lastly, Pickens et al. (2015) indicated that a majority of participants working in a call center cited comfort as a motive to stand at the beginning of the study.

The impact of sit-stand desks on performance, attention, and engagement have been investigated in school settings as well. In the 7-week study by Sudholz et al. (2016) mentioned above, 69% of participants indicated they "worked well during lessons" and 44% indicated they "concentrated better on doing my work". A longer school intervention using sit-stand desks in Grades 2-4 during a school year found a greater academic engagement score in the fall, but not in the spring, compared to classes with sitting desks, with females also showing a higher academic engagement score compared to males (Dornhecker et al., 2015). In contrast, an investigation into the effects of acute standing on cognitive function found that Complex Attention was the only factor that was significantly decreased in the standing position (Schraefel et al., 2012). Lastly, a survey of 993 college students by Benzo et al. (2016) indicated a majority (97.2%) have not used standing desks in a college class, most (83%) sit the entire class session, and a majority (76%) would stand for at least a quarter of the time they spend in class. In addition, over half of the students (51.4%) and instructors (67.1%) surveyed believed attention would "get better" when using the sit-stand desks, while also thinking fatigue and joint pain would "get worse".

The findings of these studies related to cognitive health and workplace and educational performance may necessitate the implementation of effective interventions to decrease distress, improve mood states and attention/engagement, and ultimately increase work and school performance. However, it is currently unknown if standing will influence cognitive health or performance, or musculoskeletal discomfort, in limited doses in a college class. Therefore, the purpose of this study is to determine the effect of using adjustable-height (sit-stand) desks in a college class on attention, stress, anxiety, musculoskeletal discomfort, and academic performance.

Material & Methods

Participants

Participants were recruited from two sections of a Human Anatomy & Kinesiology course at a public university in central Minnesota, USA. The class sections were randomly assigned as either intervention or control group prior to participant recruitment. A total of 23 students (14 standing; 9 control) signed informed consent to participate in the study. Prior approval of the study protocol was obtained from the university institutional review board (IRB).

Procedure

Data was collected during Spring semester (January - May) in classes that met three days per week (Monday & Wednesday for 110 minutes and Friday for 50 minutes). One section began at 10:00 am (control group) and the other at 1:00 pm (standing group). The first two weeks of the course were not utilized for data collection. Visual Analogue Scale measures of Attention (AT), Stress (ST), Musculoskeletal Discomfort (MD), and Anxiety (AN) were collected from weeks 3-15, with weeks 3-4 being utilized as baseline. Fourteen sit-stand desks were placed in the back of the classroom prior to week 5. Direct observation of attention (OAT) was obtained by watching video from weeks 9, 12, and 13 for attentive ("on-task") behavior.

The Sit-Stand desks (LearnFit model, Ergotron Inc., St. Paul, Minnesota) provided a work surface measuring 24" x 22" (61 x 56 cm) and height adjustment from a minimum height of 33.3" (85 cm) to a maximum height of 49.3" (125 cm). There were 15 Sit-Stand desks placed at the back of the classroom that replaced standard sitting desks so the total number of desks was the same as the room was previously set up. Each sit-stand desk setup had a high chair (24" or 29") with a back on it for the participants to use when seated and an 18"x24" anti-fatigue foam mat to stand on. A sit-stand desk was assigned to each participant (no sit-

stand desks were shared with any other students in the class); if a participant dropped out of the class, their sit-stand desk was removed from the classroom.

Participants were given instruction on how to adjust the height of the sit-stand desk at the beginning of week 5. They were told that it is believed sitting too much has a negative impact on overall health and standing can be good for your health in a variety of ways. The participants were instructed to use the sit-stand desks in the standing position as much as they want and to shift from one position to the other as they see fit and that any movement will not be disruptive.

Visual Analogue Scale (VAS). Subjective attention, stress, anxiety, and musculoskeletal discomfort level were measured using a VAS, which is a 100-mm long line with statements on both ends indicating the absence (e.g., “no stress”) or full amount (e.g., “high stress”) of that variable. A general definition for each subjective measure was created from definitions retrieved from The Free Dictionary website (<http://www.thefreedictionary.com/>) and was also included on each VAS. The definition of Attention was “the act of close or careful observing or listening; ability to concentrate”. The definition of Stress was “psychological strain, usually in response to adverse events”. The definition of Musculoskeletal Discomfort was “relating to the skeleton and musculature taken together; an absence of comfort or ease; hardship or mild pain”. The definition of Anxiety was “a state of uneasiness and apprehension, as about future uncertainties”. The participant was instructed to put a vertical mark on the line that best represents their feelings *right now*. The VAS has been shown to be reliable and valid for a variety of subjective measures (Cella & Perry, 1986; Davey et al. 2007; Hornblow & Kidson, 1976; Lesage & Berjot, 2011).

Direct Observation of Attention (OAT). Observed attentive (on-task) behavior was measured on three Wednesdays (week 9, 12, and 13) for both control and standing groups. Video recordings of the class sessions were used to complete the direct observation of participants. Observation sessions lasted 30 minutes with a maximum of three subjects observed per session and each subject being observed every third minute (total observation time per subject was 10 minutes per day). Similar to Mahar et al. (2006), an audio recording instructed the observers when to observe and record. Each subject was observed in one minute bouts in the following pattern: 10 seconds to observe followed by 5 seconds to record if the subject was attentive and if they were sitting or standing. After four observations, the second subject was observed in the same pattern for one minute, followed by the third subject, then returning to the first subject, and continued in this pattern until each subject accumulated 40 observations (10 minutes total). The observation time continued beyond thirty minutes only if a subject was blocked from view (e.g., instructor stood in front of the camera) and extra time was needed to reach 40 observations.

Two observers completed two practice sessions and observed all participants on the three observation days. The first practice session utilized eight subjects and the inter-observer reliability was 84.7% (287 agreements/360 total observations). The observers discussed and reviewed video for observations that disagreed. The definition of attentive (on-task) behavior was updated and a second round of practice utilizing seven subjects resulted in an inter-observer reliability of 88% (221 agreements/251 total observations). The observers again discussed and reviewed video for observations that disagreed. A subject was marked as being attentive if they were observed doing one of the following behaviors: appears they are looking at and/or listening to the instructor, video screen, textbook/handouts, or classmate who is discussing class material; actively writing or typing class notes; asking the instructor or classmate a question related to the class. A subject was marked as being non-attentive (off-task) if they were observed doing one of the following behaviors: appears they are *not* looking at and/or listening to the instructor, video screen, textbook/handouts, or classmate who is discussing class material, which may include sleeping, head on desk, spacing out, doodling in notebook, playing with hair, chewing nails, or engaging in non-class related discussion with classmates.

Data Analysis

All statistical analyses were conducted using SAS (version 9.4; SAS Institute Inc., Cary, NC, 2015). Descriptive statistics and correlations were conducted on the following data: participant age, year in college, height, weight, credit load, exam scores, and class grade; weekly VAS scores for attention, stress, anxiety, and musculoskeletal discomfort; and overall score for direct observation of attention. The data from the VAS for attention, stress, anxiety, and musculoskeletal discomfort, as well as scores for direct observation of attention and exams, were analyzed for weekly differences using a mixed-model repeated-measures Analysis of Variance (ANOVA). A heterogeneous compound symmetry variance-covariance structure was determined to be the best fit for the data. Tukey-Kramer post-hoc analysis was utilized. A level of significance (α) of .05 was used for all analyses.

Results

A total of 23 participants (14 standing, 9 control) started the study. Five students withdrew from the course and 18 participants (12 standing) completed the study; descriptive statistics for these participants are in Table 1. Data on the four VAS measures were analyzed for all 18 participants. Three standing group participants were excluded from direct observation of attention due to low attendance time on measurement days, leaving valid direct observation data for 15 participants (9 standing).

Table 1. Participant Characteristics

Group	n	Age	Height	Weight	Credits	Year
Control	6	23.8 (6.6)	65.5 (4.3)	153.0 (27.6)	13.7 (2.4)	3.3 (0.8)
Standing	12	21.2 (3.5)	66.7 (5.1)	157.8 (37.5)	14.0 (3.3)	2.3 (1.1)

Notes: Data are Mean (SD).

Attention (AT) scores (Figure 1) exhibited a significant interaction ($F[12, 166] = 2.79, p = 0.002$) and week ($F[12, 166] = 2.25, p = 0.012$) effect, but no treatment ($F[1, 16] = 0.02, p = 0.884$) effect. For ST scores (Figure 2), there was a significant interaction ($F[12, 166] = 2.15, p = 0.017$) and week ($F[12, 166] = 4.63, p < 0.0001$) effect, but no treatment ($F[1, 16] = 0.98, p = 0.338$) effect. For MD scores (Figure 3), there was not a significant interaction ($F[12, 166] = 0.89, p = .557$), but there was a significant treatment ($F[1, 16] = 14.24, p = 0.002$) and week ($F[12, 166] = 2.51, p = 0.005$) effect. For AN scores (Figure 4), there was not a significant interaction ($F[12, 166] = 1.50, p = 0.130$) or treatment ($F[1, 16] = 0.38, p = 0.544$) effect, but there was a time ($F[12, 166] = 2.26, p = 0.011$) effect.

Exam (EXAM; Week 4, 6, 8, 10, 12, 14, 15) and direct observation of attention (OAT; week 9, 12, and 13) scores were also compared. EXAM scores did not have a significant interaction ($F[6, 96] = 0.85, p = 0.537$) or treatment ($F[1, 16] = 1.52, p = 0.235$) effect, but did have a week ($F[6, 96] = 5.42, p < 0.0001$) effect. Exam in week 12 was higher than week 4, 6, and 14, and week 15 higher than week 4 ($p < 0.05$). There was no significant difference in OAT scores (week 9, 12, and 13) and OAT did not significantly correlate with AT in weeks 9, 12, or 13. AGE was significantly correlated with OAT ($r=0.54, p = 0.038$), ST with MD in weeks 6, 8, 14 and 15 (r range = .60-.72, $p < .05$), and ST with AN for all weeks except 5 and 11 (r range = .61-.95, $p < .05$).

Figure 1. Weekly VAS Scores - Attention (AT). Data are adjusted means $\pm$ SE. C = Control; S=Standing. ^aS-3 lower than C-8, S-10 and S-15 ($p < 0.05$). ^bS-4 lower than S-15 ($p < 0.05$). ^cweek 3 lower than week 15 ($p < 0.05$).

Figure 2. Weekly VAS Scores - Stress (ST). Data are adjusted means $\pm$ SE. C = Control; S=Standing. ^aC-6 sig. different than C-4, C-11, C-12, C-13, S-9, S-11, S-12, and S-13 ($p < 0.05$); ^bC-11 sig. different than C-15 and S-5; ^cS-5 sig. different than S-11 ($p < 0.05$); ^dweek 6 higher than week 4, 9, 12, and 13 ($p < 0.05$). ^eweek 11 lower than week 3, 4, 5, 6, 7, 8, 10, 14, and 15 ($p < 0.05$).

Figure 3. Weekly VAS Scores - Musculoskeletal Discomfort (MD). Data are adjusted means $\pm$ SE. Standing (S) lower than Control (C) group ($p < 0.05$). * week 3 higher than week 7, 10, and 11 ($p < 0.05$);

Figure 4. Weekly VAS Scores – Anxiety (AN). Data are adjusted means $\pm$ SE. C = Control; S=Standing; * = week 6 is higher than week 11 ($p < 0.05$).

Discussion

The purpose of this study was to examine the effect of using adjustable-height (sit-stand) desks in a college class on the pattern of attention (AT), stress (ST), musculoskeletal discomfort (MD), and anxiety (AN) levels. The main findings revealed lower MD scores for the standing group, higher week 6 than week 11 scores for AN and ST, and more fluctuation in AT and ST scores. Attendance was lowest for week 11 ($n=10$) compared to other weeks ($n=15-18$), which may account for the differences found in that week compared to other weeks. In addition, ST and AN scores were highly correlated for most weeks suggesting these measures captured similar information. There were no significant differences in exam scores or direct observation of attention scores between groups. Overall, these findings indicate that the amount of standing in this study did not negatively impact cognitive performance and was associated with less musculoskeletal discomfort.

Ebara et al. (2008) collected Visual Analogue Musculoskeletal Scale (VAMS) scores on 14 body regions and found higher scores for right and left lower leg, right forearm, and right wrist/hand in the sit-stand condition, whereas in this study MD scores represented discomfort in any region of the body. The lower discomfort ratings reported by Chester et al. (2002) may have been prevented in this study by allowing participants to move their feet and adjust the height of the desk, as well as providing a pad for participants to stand on. The results of this study support the lower amounts of subjective feelings of fatigue reported when using a combination of sitting and standing during a 60 or 90-minute task (Hasegawa et al. 2001). The results also support the lower musculoskeletal discomfort ratings associated with using standing desks in elementary school third and fourth graders (Hinckson et al., 2013), sit-stand desk usage in work settings (Hedge & Ray, 2004; Robertson et al., 2013), and supports the belief by college students that joint pain would get better if using a sit-stand desk (Benzo et al., 2016). However, it is unknown if using the sit-stand desks in this study resulted in lower MD scores for the intervention group, or if the higher MD scores in the control group were caused by restricted movement of the standard sitting desks or for other reasons (e.g., chronic pain, acute soreness from physical activity, etc.).

Attention and academic engagement has been investigated in several other studies. Schraefel et al. (2012) found that sitting resulted in higher Complex Attention scores as compared to standing, but was not different for several other measures related to the CNS Vital Signs (CNSVS) tests. The measure of attention in this study could be viewed as a general measure of attention, which may only partially relate to the CNSVS

measure of Complex Attention, and was measured at more time points. Dornhecker et al. (2015) investigated academic engagement in elementary-aged students using stand-biased desks and found significantly higher engagement score in the treatment group in fall but no difference in spring. The observation protocol included 48 15-second intervals (12-min total), once in fall and once in spring, whereas this study utilized 40 15-second intervals (10-min total) during three separate sessions separated by 1-3 weeks. A similar study by Koepp et al. (2012) investigated sixth graders using standing desks and found no difference in concentration levels after 5-months of use. The results of this study support the previously mentioned findings (Dornhecker et al.; Koepp et al.), as well as the perceptions of secondary school students (Sudholz et al., 2016) and college students (Benzo et al., 2016), that standing does not negatively impact the ability of students at different levels to engage in attentive behavior in an academic setting.

There are several potential limitations in this study. First, the number of participants in both groups was small. Second, the classes were offered at different times of the day (starting at 10:00 am for control group and 1:00 pm for the standing group), which may have affected the responses on the VAS measures. Third, the students who chose to participate in the study could have been more interested in standing during class and therefore may not accurately represent the standing patterns of all students. However, given the high variability in standing by the participants in this study, we feel it accurately represents the standing patterns of students when given the instructions to use the sit-stand desk as they see fit. Fourth, the participants in the control group sat in the first and second row of the class whereas the standing group sat in the back or side of the class, which may have affected attention (AT or OAT) scores. This classroom arrangement was necessary so that standing students did not block the view of sitting students. However, the classroom was only four rows deep with the sit-stand desks in the fourth row, which minimized the distance from the front row. In addition, three of the 12 intervention participants were on one side of the classroom which corresponded with the second and third row of standard desks. We feel this placement of the sit-stand desks was close enough to the other students, professor, and screen to not affect the results. In addition, participants in both groups were noticed engaging in non-attentive or off-task behavior (e.g., using cell phones, talking to classmates about non-class material, spacing out, etc.). A fifth limitation is that the visual-analogue-scale (VAS) used to capture subjective attention, stress, musculoskeletal discomfort, and anxiety level are easy and quick to administer but do not capture specific reasons for the responses (i.e., it does not indicate why a participant responded with a low or high score). Lastly, the use of exam scores as our measure of academic performance may also be a limitation. Like VAS questionnaires, fluctuations in exam scores may be attributed to variables not measured in this study (e.g., previous experience with the course material, amount of studying, ability to memorize information, etc.). The exam questions were the same between groups and were given on the same days so we feel this provided a consistent measure of performance during the semester.

Conclusion

In summary, a strength of this study is the collection of weekly data on Attention, Stress, Musculoskeletal Discomfort, and Anxiety levels over the course of a semester. The sit-stand desks did not appear to cause a decrease in attention or an increase in stress, anxiety, or musculoskeletal discomfort. This could be considered a positive outcome even though attention was not increased or stress/anxiety lowered as using this desk created allowed for sit-stand movement without negative impacts. Results of this study, as well as other research in educational and work settings, suggest that students at all levels and adults who spend significant time working at a desk can use sit-stand desks without a decline in performance. In addition, adding regular practice, training, and tips on implementing a sit-stand desk into specific work environments may improve usage and further lower discomfort levels. Further investigations should evaluate alternate sit-stand desk intervention protocols to determine if there is a specific amount or pattern of standing that results in positive effects on attention, stress/anxiety, musculoskeletal discomfort, and academic performance in educational settings.

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