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Introducing sit-stand desks increases classroom standing time among university students

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ABSTRACT

Excessive sedentary behavior has been associated with many negative health outcomes. While an understudied health topic, there is evidence that university students are excessively sedentary. Sit-stand desks have been shown to reduce sedentary time among pre-university students (ages 5–18 years) and sedentary workers but have not been tested in university classrooms. This study tested the effects of introducing sit-stand desks into a university classroom on student's classroom sitting and standing behaviors. Using a cross-over design, students received access to both traditional seated desks and sit-stand desks for six weeks. Data were collected between September and December, 2016. We recruited 304 healthy undergraduate university students enrolled in one of two small (25 seats) classrooms at a large Midwestern university during the fall of 2016. Average minutes of standing/hour/student, average percent class time spent standing, and the number of sit-stand transitions/student/hour were directly observed with video camera surveillance. Participants stood significantly more ($p < 0.001$) when provided access to sit-stand desks (7.2 min/h/student; 9.3% of class time spent standing) compared to when they had access to seated desks (0.7 min/h/student; 1.6% of class time spent standing) but no differences were observed for the number of sit-stand transitions ($p = 0.47$). Students reported high favorability for the sit-stand desks and improvements in several student engagement and affective outcomes while using the sit-stand desks. These findings support introducing sit-stand desks in university classrooms as an approach to reduce sedentary behaviors of university students.

1. Introduction

Excessive sedentary behavior (e.g. any wakeful activity expending ≤ 1.5 METs in a reclining or sitting position) has been associated with several chronic diseases including cardiovascular disease, diabetes and obesity independent of physical activity levels (Healy and Owen, 2010; Katzmarzyk et al., 2009; Tremblay et al., 2017; Tremblay et al., 2010; Wilmot et al., 2012). Additionally, evidence suggests breaking up sedentary time with light intensity activities such as standing, may be sufficient to improve important health risk factors (Healy et al., 2015; Thorp et al., 2014). Specifically, at the same level of sedentary behavior, individuals who replace more sitting time with standing time are more likely to have improved fasting plasma glucose levels, lower triglycerides, lower total/HDL cholesterol ratios, and higher HDL cholesterol ratios. These data support interventions focused on replacing sitting time with standing time as a simple approach for improving the health profiles of populations at risk for sedentary lifestyles (Manini et al., 2015).

While an understudied health topic, there is evidence that university students are excessively sedentary and that the college/university years are a critical transition time characterized by increasing sedentary behaviors (Keating et al., 2005; Nelson et al., 2008). For example, a cross-sectional study conducted in the UK concluded university students spent more than 8 h per day sitting (Rouse and Biddle, 2010). A study conducted in Argentina found 50% of university students reported sitting 6 to 10 h per day with 34% sitting > 10 h per day (Farinola and Bazan, 2011). Further, Johnston and colleagues found university student's daily sitting time significantly increased by 75 min/day from the first year to the final year (Johnston et al., 2010). Collectively, these findings support interventions aimed at reducing sedentary behaviors of university students.

Ecological models of health behavior change suggest aspects of the environment play a critical role in shaping health behaviors (Stokols, 1996). Given the large amount of time university students spend in classroom environments (roughly 15 h per week for a full-time U.S. student), which usually require students to sit, the university classroom may be an ideal setting for intervention aimed at reducing university students' sedentary time. In a qualitative study exploring the major

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determinants of sedentary behaviors of university students, Deliens et al. identified individual (e.g., norms), social (e.g., modeling, peer support), and environmental factors (e.g., availability and accessibility) that would support a classroom based intervention (Deliens et al., 2015). For example, students reported that much of their sitting time is due to the time they spend sitting in classes and that their own sedentary behaviors are often influenced by those of their peers (Deliens et al., 2015). Given sit-stand desks have been found to be both acceptable (Hinckson et al., 2013) and effective for reducing sitting time among younger school aged (5–18 years) students (Clemes et al., 2016) and sedentary office workers (Shrestha et al., 2016), it is possible sit-stand desks could also be effective for reducing sedentary behaviors of university students. To date, however, sit-stand desks have not been tested in the university classroom environment.

A recent study explored the acceptability and feasibility of introducing sit-stand desks into university classrooms. Out of 993 undergraduate university students surveyed, only 2.8% reported ever having taken a class in which sit-stand desks were available (Benzo et al., 2016). The large majority of students (83%) and instructors (87%) reported being in favor of introducing sit-stand desks into university classrooms. Interestingly, more than half of students and instructors also predicted having access to sit-stand desks would improve student's “physical health”, “attention“, and “restlessness”. These findings were supportive of further studies testing the effect of introducing sit-stand desks in university classrooms. Therefore, the purpose of the present study was to test the effect of retrofitting a traditional seated university classroom with sit-stand desks on university student's classroom standing time, classroom sitting time, and sit-stand transitions. As exploratory aims, we also sought to examine student's perceived impact of standing on health and student engagement outcomes, student's acceptability of sit-stand desks, and student's reasons for using/not using the desks when they were provided.

2. Methods

2.1. Participants

A purposive sample of students enrolled in 1 of 14 classes being taught in two classrooms (referred to as classroom A and B) at a large Midwestern university was recruited. All data was collected between September and December 2016. The two classrooms were chosen as they were of the same size, had the same number of desks (25) and were located near each other on the same floor. Students under 18 years of age were excluded. A total 304 students were enrolled in the 14 classes and eligible to participate in the study. Students were recruited for participation and explained the study during a presentation on the first day of class. During the presentation, students were provided a letter and verbal description of the study. Students were informed that the purpose of the study was to explore the influence of classroom designs on student behaviors and that the classrooms would be observed via video camera surveillance on two separate occasions. Students were asked to provide an email address if they wanted to participate in the study. A total of 257 students (84.5% recruitment rate) chose to enroll in the study. Students were given the option to opt out of the study (i.e., sit in section of class not captured by video and not complete surveys) if they objected to being observed with video cameras and were given a full week to consider their participation. No students enrolled in any of the classes chose to opt out. Thus all students who attended class on the video observation days were included in the final video analysis. Students who completed the study in full were entered into a lottery for a chance to win one of ten $50 gift cards. Free and informed consent of participants was obtained and the Institutional Review Board approved the study.

Fig. 1. Image of sit-stand desk and stool provided to students.

2.2. Study design

The study utilized a crossover design to test the question of whether students stood more and/or took more standing breaks when provided access to sit-stand desks compared to seated desks. The intervention consisted of replacing 25 traditional seated desks with armrests with 25 height adjustable sit-stand desks (BALT Up-Rite Student Table, MooreCo Inc.) that were accompanied by stools (see Fig. 1). The Up-Right desks were chosen because they were height adjustable (26–43 in.), included a foot rest, were mobile on two casters, and were priced comparably to seated desks ($240 each). The stools were provided to ensure students had the opportunity to either stand or sit during class. Participants were not provided specific goals related to sitting or standing in class but a point-of-decision prompt was placed on top of each sit-stand desk that included language designed to encourage more standing (i.e. “Did you know that standing burns up to 50 more calories/hour than sitting?”). The rationale for including the point-of-decision prompt was based on previous research which has found decisional prompts to be effective for promoting behavior change and research suggesting college student's motivation to be active tends is often related to weight loss/maintenance (Kilpatrick et al., 2005; Soler et al., 2010). Class instructors did not play a role in the study and thus did not offer participants any additional encouragement or incentive to stand during class.

The study was conducted over 12 weeks and included two evaluation time points for each participant. At the beginning of the study, classroom A was retrofitted with 25 sit-stand desks and stools while classroom B began the study with 25 traditional seated desks. The desks then remained in the respective classrooms for six weeks. The first observation of sitting and standing behavior was conducted during week six of the study. Immediately following the first observation, the sit-stand desks were moved to classroom B and the seated desks were moved to classroom A. Six weeks later, the second observation of sitting and standing behavior was conducted in both classrooms. Immediately following completion of the 12 week intervention, participants were emailed an online post-intervention survey (Qualtrics, Provo, UT) that asked questions about: 1) participant characteristics; 2) participant's

support for introducing sit-stand desks into university classes; 3) participant's perceived impact of using sit-stand desks on several student engagement and affective outcomes; and 4) participant's reasons for standing or not standing during class.

2.3. Variables

Direct observations of students' sitting and standing behaviors were conducted using video camera surveillance (Arlo Pro, Netgear). A single video camera was placed in the front corner of both classrooms. Each student's sitting and standing behavior was observed for a full class period during observation 1 and 2 (two classes total per student). To minimize expectation effects, the video cameras were left in the rooms on days in which observations were not conducted. Video recorded direct observation has been used previously in physical activity research studies and has been used to ensure accuracy when coding procedures are complex (McKenzie, 2010). We followed the previously validated BEACHES direct observation protocol, which was designed to code physical activity behaviors in various environmental settings using five distinct categories (laying down, sitting, standing, walking, very active) (McKenzie et al., 1991). Two separate researchers observed all video recorded data independently and coded the total amount of time each student spent standing or walking for each class. The time spent standing plus walking was subtracted from the total class duration to calculate sitting time. Sit-stand transitions were defined as moving from a seated to a standing position. Afterward, the two researchers met to resolve any disagreements. Only participants who were fully visible on the video screen were included in the data collection. Times in which students left the room were not included in the data collection. For each class, the video recording began at the time that the class was scheduled to begin. The video recordings were ended either at the time the class was scheduled to end, or when all students had left their desks to exit the classroom, whichever came first. After the data had been coded independently, inter-rater agreement correlations were calculated for minutes of standing time. During the post-intervention online survey, participants first reported their age, height, weight, gender, ethnicity, race, class status and physical activity history (see Table 1).

Height and weight were used to calculate body mass index. Physical activity history was assessed with using the Stanford Leisure-time Activity Categorical Item (Kiernan et al., 2013). The percent of participants meeting the Physical Activity guidelines for Americans was then calculated. Participant's support for introducing sit-stand desks into university classes was assessed with two questions ("Would you be willing to take another class in the future that included standing desks?" "Would you be supportive of adding standing desks to other classrooms on campus?"). Participants were asked to report whether 11 student engagement and affective outcomes 'declined', 'increased' or 'did not change' while using a sit-stand desk in class (see Table 3). Finally, participants who reported using the sit-stand desks at least once over six weeks were prompted to also report their primary reasons for standing during class, for not standing during class, and any approaches that would encourage them to stand more during class (see Table 4).

Table 1
Participant characteristics from process evaluation survey (n = 143).

	Mean (SD) %
Age (years)	20.1 (1.3)
Body mass index (kg/m^2)	23.3 (3.8)
Gender (%)	
Male	26.1
Female	73.9
Ethnicity (%)	
Hispanic or Latino	6.5
Not Hispanic or Latino	92.0
Don't know or prefer not to answer	1.5
Race (%)	
American Indian/Alaska Native	0.7
Asian	5.8
Native Hawaiian or Pacific Islander	0.0
Black or African American	2.9
White	85.5
Other	4.4
Don't know or prefer not to answer	0.7
Class status (%)	
Freshman	18.1
Sophomore	25.4
Junior	27.5
Senior	29.0
Report meeting physical activity guidelines (%)	
Yes	45.3
No	54.7

2.4. Statistical analysis

For our primary aim, we first tested for a main effect of sit-stand desks versus seated desks for: 1) average minutes of standing per hour per student; 2) average percent class time spent standing per student; and 3) average number of sit-stand transitions per hour per student. If a main effect was observed, we then tested for time effects (observation 1 vs observation 2) for classrooms A and B to determine whether adding or removing sit-stand desks impacted student's standing behaviors. Because the standing and sit-stand transition data were non-normally distributed, a Mann-Whitney *U* Test was used for all comparisons. Power was estimated based on our previous study which found sedentary office workers who had access to sit-stand desks stood 11.1% more during working hours than sedentary workers who had access to traditional seated desks (Carr et al., 2016). For a 60 minute class, this would translate to 6.7 min per hour. The power calculation estimated 77 participants were needed for 90% power to detect a treatment difference of 6.0 standing min/h at a two-sided 0.05 significance level. This was based on a within-participant standard deviation of the response variable of 11.3 standing min/power. Descriptive statistics (mean and SD) were calculated for demographic data, participant's perceived changes in student engagement and health outcomes, and process evaluation data. Data were analyzed using SPSS version 22.

3. Results

Participants were mostly White (85.5%) and female (73.9%), and had an average body mass index of 23.3 ± 3.8 kg/m^2 (Table 1). Over half of all participants (54.7%) reported not meeting the aerobic Physical Activity Guidelines for Americans (at least 150 min of moderate intensity activity per week).

A total of 257 participants were observed during observation 1 and 239 participants were observed during observation 2. A total of 245 participants were observed while having access to the sit-stand desks and 251 participants were observed while having access to the seated desks. The inter-rater agreement correlation for average standing time was 0.97. When both observations 1 and 2 were pooled together (N = 496), a Mann-Whitney test revealed participants stood significantly more minutes per hour per student on average (Mann U = 22,262; Z = −5.59; $p < 0.001$) and for a greater percent of class time (Mann U = 21,221; Z = −6.27; $p < 0.001$) when provided access to sit-stand desks compared to when they had access to seated desks. No significant between group differences (seated desks versus sit-stand desks) were observed for sit-stand transitions (Mann U = 29,680; Z = −0.72; p = 0.47).

Time effects analyses revealed participants in classroom A significantly decreased both absolute minutes of standing time/hour/student ($p < 0.001$) and the relative percent of class time spent standing ($p < 0.001$) when the sit-stand desks were replaced with seated desks. Conversely, when sit-stand desks were added to classroom B, participants significantly increased the average percent class time spent standing (p = 0.03) and absolute minutes spent standing per hour but

Table 2
Mean (95% C.I.) standing behaviors by classroom and observation period plus output for Mann Whitney *U* tests comparing observation 1 and 2 within classrooms A and B.

	Observation 1 (N = 257)	Observation 2 (N = 239)	Mann *U*	Z score	Significance (2 tailed)
Avg. minutes standing per hour per student					
Classroom A	7.8 (5.2, 10.5)	0.2 (0.1, 0.4)	7839	− 6.69	< 0.001
Classroom B	1.7 (0.9, 2.4)	5.9 (3.5, 8.2)	3206	− 1.53	0.13
Avg. % class time standing per student					
Classroom A	9.9 (6.8, 13.1)	0.5 (0.1, 1.0)	7734	− 6.82	< 0.001
Classroom B	3.3 (0.2, 6.4)	8.1 (4.3, 11.8)	3030	− 2.09	0.03

Note: Classroom A had sit-stand desks during observation 1 and seated desks during observation 2. Classroom B had seated desks during observation 1 and sit-stand desks during observation 2.

this did not reach statistical significance (p = 0.13). When examining the effect of introducing sit-stand desks on the number of sit-stand transitions, no significant between group differences (sit-stand desks versus seated desks) were observed (+ 0.02 sit-stand transitions/h, p = 0.47) (Table 2).

A total of 143 students (56% response rate) completed the post-intervention survey. When asked to report whether student engagement, health, and affective outcomes changed while using the sit-stand desks, more than a third of student's reported 'increases' in attention, participation, focus, and engagement while using the sit-stand desks (Table 3). More than a third of students reported declines in "restlessness", "boredom", "fatigue" and "cell phone use" during class while using the sit-stand desks (Table 3).

The most commonly reported reason for standing at sit-stand desks was "to alleviate restlessness" while the most commonly reported barrier to standing at sit-stand desks was "I prefer to sit" (Table 4). When asked to report strategies that might get them to stand more at sit-stand desks, the most common response was "seeing other students stand" (Table 4). Finally, most participants (69%) reported they would be willing to take another class in the future that had sit-stand desks available and most participants (71%) reported they would be supportive of adding sit-stand desks to other classrooms on campus.

4. Discussion

The findings from this study suggest providing university students access to sit-stand desks in a university classroom increases standing time but not the number of sit-stand transitions during class. To our knowledge, this is the first study to test the effect of sit-stand desks in a university setting. Therefore, we compare our study to those conducted in pre-university classrooms and sedentary office settings, which evaluate the impact of sit-stand desks over a longer portion of the day. A 2016 systematic review of eight studies testing sit-stand desks in pre-university classrooms concluded standing time increased in five of the eight studies that measured standing time (Minges et al., 2016). Two studies included in this review reported absolute increases in standing time of + 24.0 and + 40.0 min per school day which run 6.6 h in duration on average in the U.S. Participants in the present study stood an average of 7.2 min per hour per student (9.3% of total class time) which equates to 47.8 min if extrapolated to a full 6.6 hour class day. Therefore, our findings would be comparable to these two studies.

Table 3
Student's perceived changes in health, engagement and affective outcomes associated with use of sit-stand desks in class (N = 143).

Please tell us how/if each of the following changed for you while standing at a desk compared to sitting at a desk	Declined	No change	Increased
Restlessness during class	53.0%	36.0%	11.0%
Fatigue during class	42.6%	48.5%	8.9%
Boredom during class	45.5%	53.5%	1.0%
Use of cell phone during class	38.6%	59.4%	2.0%
Joint pain during class	21.0%	72.0%	7.0%
Anxiety during class	19.8%	76.2%	4.0%
Attention during class	7.9%	41.6%	50.5%
Participation in class	6.9%	56.4%	36.6%
Focus during class	7.9%	56.4%	35.6%
Engagement during class	9.9%	55.5%	34.7%
Academic performance	5.0%	79.2%	15.8%

Table 4
Student's self-reported factors influencing standing during class (N = 143).

Top 3 reasons for standing during class (% of respondents)		Top 3 reasons for NOT standing during class (% of respondents)		Top 3 approaches that would promote more standing during class (% of respondents)	
To alleviate restlessness	43.6%	I prefer to sit	52.2%	Seeing other students stand	77.2%
Burn more calories	40.6%	Standing felt awkward	46.3%	Encouragement from instructor	61.8%
Reduce boredom	39.6%	No stand desks available	29.1%	Reminders from instructor	58.1%

The observed increases in standing time in the present study are also comparable to increases in standing time observed among sedentary employees provided access to sit-stand desks. A recent Cochrane review of 20 studies (N = 2174) examined the effect of introducing sit-stand desks in the workplace and found employees provided access to sit-stand desks decreased work sitting time between 30 min and 2 h per work day with most of that time being replaced by standing time (Shrestha et al., 2016). Extrapolating our findings to a full eight hour workday would equate to 57.6 min. This is consistent with our previous cross-sectional study conducted among sedentary office workers which found long-term users of sit-stand desks stood on average 60 min more per 8-hour workday (11.1% of workday) compared to sedentary employees with traditional seated desks (Carr et al., 2016).

Providing students access to sit-stand desks did not result in an increase in sit-stand transitions. This finding makes intuitive sense in that students who were already standing at a desk would not need to stand up to go turn in an assignment. Video observations indicated students stood up during class in both classroom designs for a variety of reasons including using the restroom, handing in assignments, and reorganizing the classroom for group activities. This finding is consistent with those of a previous study conducted among 40 third and fourth graders. Students who received standing workstations reduced the number of sit-stand transitions compared to a control class that retained seated desks (Hinckson et al., 2013). This finding is also consistent with our previous study that observed long-term users of sit-stand desks in the work setting. Employees with sit-stand desks made similar sit-stand transitions (29.4 per 8-hour workday) as long-term users of seated desks (33.7 per 8-hour workday)(Carr et al., 2016). While evidence suggests taking breaks from sitting may improve several cardiometabolic health outcomes, the evidence from this study does not support the use of sit-stand desks as an approach to increase breaks from sitting. Future studies are needed that test the effect of combining sit-stand desks with other psychosocial interventions (e.g., set goals to stand, provide

reminders to stand) and/or curricular changes (e.g., instructor prompted standing, assignments that require standing) that encourage more breaks from sitting.

Introducing sit-stand desks may have resulted in improvements in several engagement and affective outcomes as well. Notably, more than half of all participants reported increased “attention” and decreased “restlessness” during class. More than one-third reported increases in “focus” and “engagement” and declines in “fatigue” and “boredom” during class. While these findings are promising and likely important to university administrators interested in promoting student learning, they warrant further investigation. In order to fully elucidate the impact of sit-stand desks on academic outcomes, future studies that include objective measures of academic performance and/or neurocognitive outcomes are needed.

The process evaluation data also unearthed several interesting findings that may be used to inform future interventions. For example, consistent with our previous needs assessment study, participants reported high favorability for the sit-stand desks (Benzo et al., 2016). This information would likely be important to administrators in charge of making decisions regarding furnishing and designing university classrooms. Students also reported several social norms-based barriers (e.g., “standing felt awkward”) and facilitators (e.g., “seeing other students stand”, “receiving encouragement from my instructor”) to standing during class. These findings are consistent with the review by Deliens et al. which also found social norms to be a major determinant of sedentary behaviors among university students (Deliens et al., 2015). These findings are also consistent with previous research that suggests the adoption of new innovations to be an innately social process influenced by peers, organizations, and societal norms (Straub, 2009).

Previous researchers have found university student's motivations to exercise tend to be more extrinsic and related to weight maintenance/loss (Kilpatrick et al., 2005). Additionally, previous research exploring the effectiveness of point-of-decision prompts have used messages promoting health benefits and health promotion (Soler et al., 2010). For these reasons, the point-of-decision prompt focused on ‘burning calories’ as we felt the message would resonate with college students. Future studies should test whether different messages are more or less effective at promoting standing among university students.

Understanding such barriers and facilitators to behavior change is important in the design of future programs that aim to further increase the use of sit-stand desks during in the university setting. These findings support future interventions that focus on making standing during class a more socially acceptable behavior. Combining sit-stand desks with instructor led standing breaks, for example, may result in additional standing time.

The findings of this study should be interpreted with caution for a few reasons. First, the findings are limited to a fairly homogenous sample of students attending a single university. Second, given previous research demonstrating the limitations of using self-report methods to study mental processes (Nisbett and Wilson, 1977), it is possible participants were not able to accurately report the reasons that they used the sit-stand desks during class. Finally, there is a possibility of a Hawthorne effect as students were aware they were being observed via video camera surveillance.

This study also had many strengths. First and foremost, this study extends previous research conducted among pre-university students and sedentary office workers to university students, a population that is sedentary, yet largely understudied. We found university students stood roughly 7 min more per hour when they had access to sit-stand desks. For the full time student taking 15 course credits, this would result in an additional 105 min of standing per week or 21 min of standing per day. While there is evidence that breaking up prolonged sitting with standing can result in significant improvements in post-prandial glucose control, it is not clear whether this dose of standing results in any academic, engagement or affective benefits. The present study is among the first to connect such outcomes to use of sit-stand desks in any population. Finally, the objective measurement of classroom standing time and the crossover design add confidence to our findings.

5. Conclusions

University students stood more during class when they had access to sit-stand desks as compared to traditional seated desks. A large number of participants also reported improvements in several important student engagement and affective outcomes while using the sit-stand desks. Students also reported high levels of support for introducing sit-stand desks to other university classrooms. Future studies that address the reported barriers and facilitators to standing during class are needed to further refine the effectiveness of sit-stand desk interventions in the university classroom.

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Conflicts of interest

None.

Transparency document

The Transparency document associated with this article can be found, in online version.

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