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Higher education: testing the efficacy of height adjustable sit-stand desks in college classrooms

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HIGHER EDUCATION: TESTING THE EFFICACY OF HEIGHT ADJUSTABLE SIT-STAND DESKS IN COLLEGE CLASSROOMS

by

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CERTIFICATE OF APPROVAL

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MASTER'S THESIS

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ABSTRACT

Sedentary behavior has been found to have independent and negative associations with several cardiometabolic risk factors while interrupting prolonged sedentary time may ameliorate these associations. College classrooms are a traditionally sedentary microenvironment and understudied setting for sedentary interventions. Introducing sit-stand desks into college classrooms may be an effective and sustainable approach to reduce classroom sedentary time of college students. The objective of this study was to test the efficacy of replacing seated desks with sit-stand desks in a college classroom on student's classroom standing time and sit-stand transitions, as well as health-related and academic behaviors.

We recruited 304 undergraduate college students taking one of 14 classes being taught in one of two small classrooms (25 seats per class) to participate. Using a cross-over design, each student's classroom sitting and standing time were measured by self-report and objectively (direct observation via video camera surveillance) after having access to only seated desks or only sit-stand desks for six continuous weeks. A process evaluation survey was administered at the end of the study to explore student's and instructor's perceptions of the intervention and its impact on student engagement.

The results suggest that students stood about 5.7 minutes per hour of class time on average when given access to sit-stand desks and about 0.9 minutes per hour of class time when using traditional seated desks, as measured by objective video surveillance data. There was no significant change in sit-stand transitions between sit-stand desks and seated desks. Students reported that a number of academic and health outcomes were favorably impacted as a result of using the sit-stand desks. Social acceptability appeared

to be the biggest barrier to use of the sit-stand desks. Overall, students reported a desire to use sit-stand desks again in future classes.

Students stood significantly more when provided access to sit-stand desks compared to seated desks. Sit-stand transitions were not significantly increased when sit-stand desks were implemented. Significantly more students reported improvements in academic and health related outcomes than students who reported declines in these areas as a result of using sit-stand desks. A majority of students reported they would use sit-stand desk again in the future and be supportive of adding sit-stand desks to other classrooms on campus. Sit-stand desks are a feasible environmental change in a college classroom to reduce student sedentary time.

PUBLIC ABSTRACT

Sitting for prolonged periods has been found to have negative impacts on health. College students are a particularly sedentary population, and introducing sit-stand desks into college classrooms may be an effective and sustainable approach to reduce their sitting time. The objective of this study was to test the effects of replacing seated desks with sit-stand desks in a college classroom on student's classroom sitting and standing behaviors, as well as health-related and academic behaviors.

We recruited 304 undergraduate college students taking one of 14 classes being taught in one of two small classrooms (25 seats per class) to participate. Each classroom received the sit-stand desks for 6 consecutive weeks throughout the semester, and seated desks for the rest of the time. A process evaluation survey was administered at the end of the study to explore student's and instructor's perceptions of the intervention and its impact on student engagement.

The results suggest that students stood significantly more on average when given access to sit-stand desks (5.7 minutes/hour) compared to seated desks (0.9 minutes/hour), as measured by video surveillance data. There was no change in sit-stand transitions between sit-stand desks and seated desks. Students reported that a number of academic and health outcomes were favorably impacted as a result of using the sit-stand desks. Overall, students reported a desire to use sit-stand desks again in future classes. Sit-stand desks appear to be a feasible environmental change in a college classroom to reduce student sedentary time.

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CHAPTER 1: INTRODUCTION

Evidence from multiple studies show sedentary behavior is associated with increased risk of chronic disease including cardiometabolic diseases, diabetes, obesity, and even some cancers, as well as increased risk of all-cause mortality (Healy et al., 2008; Katzmarzyk et al., 2009; Tremblay et al., 2010; Wilmot et al., 2012). Importantly, sedentary time has been associated with increased mortality independent of physical activity levels, which suggests sedentary behavior should be treated as a unique health behavior (Tremblay et al., 2010). In fact, interrupting prolonged bouts of sedentary behavior has been associated with healthier cardiometabolic risk profiles (Healy et al., 2015; Saunders et al., 2013). Based on this evidence, there is a need for interventions that focus specifically on reducing or interrupting prolonged periods of sedentary behavior for improved health.

Sedentary behavior is defined as any activity in the sitting or reclined position while expending <1.5 METs (Sedentary Behaviour Research Network, 2012). Many college students are highly sedentary. Evidence suggests college students sit 11 of 16 (69%) waking hours per day (Conroy et al., 2013). The traditional college classroom has been designed in a way that requires students to sit. This makes universities an ideal environment to intervene on sitting time of college students. Introducing sit-stand desks into college classrooms may be a cost-effective, sustainable approach to reduce/interrupt sedentary behaviors of college students. In September 2015, our group conducted a needs assessment focused on introducing sit-stand desks into college classrooms among college students and faculty members at the University of Iowa. Our results showed a majority of instructors and students favored introducing sit-stand desks into the classroom setting. To

date, no studies have tested whether introducing sit-stand desks in college classrooms reduces classroom sitting time amongst college students. In addition, college represents an important transition window in which health behaviors are being shaped and possibly vulnerable to interventions. Therefore, the proposed study will determine the efficacy of introducing sit-stand desks in college classrooms on student classroom standing time. We hypothesize that introducing sit-stand desks into a college classroom will increase standing time in the classroom. A secondary aim will be to quantify the overall use of the sit-stand desks. A third exploratory aim will examine student's overall perceptions of the sit-stand desks, their reasons for using the desks, and whether sit-stand desk users felt using the sit-stand desks impacted their engagement in the class.

This study is innovative because there is a lack of research investigating the use of sit-stand desks in college classrooms. Past research has shown promising positive effects of introducing sit-stand desks into elementary schools (Benden et al., 2011; Dornhecker et al., 2015; Mehta et al., 2015) and worksites (Shrestha et al., 2016). The proposed study will build upon previous research and explore an understudied population (college students) and environment (college classroom). Specifically, this study will aim to determine whether introducing 25 sit-stand desks into a college classroom increases standing time of students. This study will provide valuable insight into the feasibility and efficacy of introducing sit-stand desks in college classrooms and will inform best practices for designing college classrooms to improve student engagement and performance. Our long-term goal is to provide the findings of this study to the Office of Student Engagement and the Provost for Undergraduate Education at the University of Iowa to help inform future decisions regarding classroom designs.

There is a need for this research and the rationale for this study is supported in the following literature review. The University of Iowa's online libraries database, PubMed, and Google Scholar were used to identify the studies included in the review.

CHAPTER 2: LITERATURE REVIEW

The field of sedentary behavior is relatively new, but there is evidence that demonstrates negative health outcomes associated with prolonged bouts of sedentary time. The current definition of sedentary behavior is "any activity in the seated or reclined position while expending less than 1.5 METs (Metabolic Equivalents)" (Sedentary Behaviour Research Network, 2012). The existing evidence of the relationship between sedentary behavior and health consequences and the potential health benefits of interrupting sedentary time will be reviewed. Next the literature on the sedentary habits of college students and their environmental factors will be explored. This document will review recent interventions using sit-stand desks in school/workplace settings. Finally, the document will describe the significance and innovation of the proposed study and how this study moves the science forward.

Negative Health Consequences of Prolonged Sedentary Behavior

Being sedentary for prolonged periods of time has been associated with negative cardiometabolic health effects. A systematic review by Wilmot and colleagues (2012) analyzed 18 studies with 794,577 participants and examined the association between sedentary time and health outcomes. This review found that sedentary time was associated with increased risk for diabetes, cardiovascular disease/mortality, and all-cause mortality. The pooled risk ratio from multiple studies was 2.12 for diabetes. The pooled risk ratio across multiple studies for cardiovascular disease was 2.47. The pooled hazard ratio for cardiovascular mortality across studies was 1.9, and the pooled hazard ratio for all-cause mortality across studies was 1.49. A systematic review done by Thorp and colleagues (2011) examined 48 studies conducted between 1996 and 2011, and also

found a consistent trend of sedentary time predicting mortality independent of physical activity levels. Across multiple studies, sedentary time was linked to increased risk of all-cause mortality, mortality from cardiovascular disease, and obesity, although pooled risk/hazard ratios were not provided. They also concluded that there is reasonable evidence across studies to show associations between sedentary behavior and health outcomes are not mediated by time spent in physical activity.

A particularly influential study by Manson and colleagues examined the effect of prolonged sitting time on risk for cardiovascular events. This study examined the physical activity levels of 73,743 women and found that prolonged sitting time predicted increased cardiovascular events regardless of race, age, or body mass index. Women in increasing quintiles of energy expenditure measured in Metabolic Equivalents (METs) had age adjusted relative risks of coronary events of 1.00, 0.73, 0.69, 0.68, and 0.47, respectively (Manson et al., 2002). Another study by Warren and colleagues examined the association between sedentary behaviors (i.e. sitting in a car and watching TV) and cardiovascular death among 7,744 men in a 21-year follow-up. The study found that sedentary behaviors were significant predictors of mortality. Men who reported greater than 23 hours per week of combined sedentary behavior had 64% greater risk of dying from cardiovascular disease than those who reported less than 11 hours per week of combined sedentary activity (Warren et al., 2010). These studies conducted by Warren and Manson suggest that increased sitting time (and decreased energy expenditure) leads to earlier death and risk for cardiovascular events in people of varying ages, sizes, and ethnicities.

In a study done by Healy and colleagues, investigators examined how time spent in a specific sedentary behavior (TV viewing time) was correlated with continuous metabolic risk in men and women who reported meeting the recommended physical activity guidelines of 150 minutes per week of moderate-vigorous intensity activity. They found men who watched between 1.5-2.7 hours of TV per day had higher waist circumference (1.62 cm) and higher systolic blood pressure (2.28 mm Hg) compared to men who watched less than 0.9 hours of TV per day. Women who watched more than 2.1 hours of TV per day had a higher waist circumference (4.22 cm) and higher systolic blood pressure (2.53 mm Hg) compared to women who watched less than 0.7 hours of TV per day. Both men and women who watched over 2 hours of TV per day had higher 2-hour fasting blood glucose levels (0.035 mM) compared to men and women who watched less than an hour of TV per day (Healy et al., 2008).

Katzmarzyk and colleagues (2009) conducted a meta-analysis including 17,013 participants between the ages of 18-90 years. The investigators wanted to determine the whether or not there was a relationship between sitting time and mortality based on follow-up data spanning 13 years. The findings revealed a dose-response between sitting time and mortality from all causes and cardiovascular disease, independent of physical activity levels. Individuals who recorded sitting half of the time during a typical day had hazard ratios for all-cause mortality and cardiovascular disease mortality of 1.11 and 1.22, respectively. Individuals who recorded sitting three-fourths of the time during a typical day had hazard ratios for all-cause mortality and cardiovascular disease mortality of 1.36 and 1.47, respectively. Finally, those who recorded sitting almost all of the time had a hazard ratio for all-cause mortality and cardiovascular disease mortality of 1.54.

These findings suggest that the more a person sits, the more likely they are to die at an earlier age than their counterparts who sit less, independent of whether they are physically active or not.

Biswas and colleagues recently conducted a meta-analysis of 47 articles examining sedentary time and how it relates to health outcomes independent of physical activity levels. Significant hazard ratio (HR) associations were found between sedentary time and all-cause mortality (HR=1.24), cardiovascular disease mortality (HR=1.179), cardiovascular disease incidence (HR=1.143), cancer mortality (HR=1.173), cancer incidence (HR=1.13), and type II diabetes incidence (HR=1.91). The findings are consistent with previous studies suggesting sedentary time is a predictor of deleterious health outcomes independent of physical activity levels (Biswas et al., 2015).

When looked at collectively, the current body of evidence suggests engaging in high amounts of sedentary time, especially in prolonged bouts, is deleterious to health across a range of ages and diverse populations. Not only is sedentary time associated with negative health outcomes, it poses an increased risk for health problems independent of physical activity levels. This is an extremely important point that should not be overlooked, because an individual may be meeting the recommended physical activity guidelines (at least 150 minutes of moderate-vigorous activity per day) but may still be engaging in high amounts of sedentary behavior and be at increased risk for detrimental health outcomes (Hamilton et al., 2007).

Benefits of Interrupting Sedentary Time

While research has demonstrated sedentary time is associated with negative health effects, emerging research is finding breaking up prolonged bouts of sedentary time may

be effective at reducing these deleterious effects. A study done by Healy and colleagues (2008) examined accelerometry data from 168 adult participants and found that more interruptions in sedentary time were beneficially associated with healthier metabolic risk variables (adiposity, triglycerides, and 2-hour plasma glucose). Specifically, when using a standardized beta, increased breaks in sedentary time were associated with decreased waist circumference (-0.16), BMI (-0.19), triglycerides (-0.18), and 2-hour plasma glucose levels (-0.18). It is important to note is that these findings were independent of total sedentary time, moderate-to-vigorous intensity time, and mean intensity of the breaks. This finding suggests that the context in which sedentary time is accumulated could be important as well as the total amount.

A more recent study by Healy and colleagues used isotemporal substitution to analyze cardiometabolic risk factors with time reallocated from sitting to standing. The participants were 698 adults, with 57% of the cohort being female. They found replacing two hours of sitting with standing was associated with a significant decrease in fasting plasma glucose (2%), decreased triglycerides (11%), lower total/HDL cholesterol ratio (6%), and higher HDL cholesterol levels (0.06 mmol/L) (Healy, 2015). These findings suggest that replacing sitting time with standing during the day may have beneficial effects on cardiometabolic biomarkers.

Similar trends were observed in a study conducted by Henson and colleagues (2013) that examined 878 adults with risk factors for type II diabetes. After adjusting for BMI and moderate/vigorous activity levels, detrimental associations (using a standardized beta coefficient) were observed between sedentary time and 2-hour plasma glucose (0.22), triglycerides (0.206), and HDL cholesterol (-0.123). Importantly, more breaks in

sedentary time (as assessed by the accelerometry data) were inversely associated with 2-hour plasma glucose (-0.111), waist circumference (-0.215), and BMI (-0.151). These findings suggest that increased sedentary time is bad for health, and that breaking up sedentary time may be an effective way to combat those negative effects on health. Another study by Saunders and colleagues examined the impact of interrupting sedentary time on health outcomes in children aged 8-11, including 286 boys and 236 girls. They found that more breaks in sedentary time was associated with reduced cardiometabolic risk scores in boys (-0.057) and girls (-0.084), and lower BMI Z-scores in boys (-0.026) and girls (-0.032) as well (Saunders et al., 2013). Similar associations were also observed for the number of sedentary bouts lasting only 1-4 minutes. These results suggest that frequent interruptions in sedentary time could lead to improved cardiometabolic profiles independent of total sedentary time and physical activity.

A study done by Thorp and colleagues (2014) aimed to discover whether reducing sitting time by alternating 30-minute bouts of sitting and standing could reduce postprandial glucose levels, insulin, and triglyceride responses. The population for the intervention consisted of 23 overweight/obese sedentary adults. Despite the short length of the study (5 days), they found a significant decrease in postprandial glucose levels by 11% in those who alternated standing breaks compared to those who remained seated. These results suggest that breaking up sedentary bouts, even in the short term, can have beneficial health effects and warrant further research into breaking up sedentary bouts over a longer period of time.

Despite the current research suggesting health benefits from breaking up sedentary time, we still lack individual level recommendations for sedentary time and do

not have a solid understanding of the most optimal way to break up sedentary time. However the current evidence suggests that even short standing breaks may be sufficient to impart health benefits.

Sedentary Habits of College Students

College students are potentially at risk for sedentary related diseases. A meta-analysis of college students' physical activity behavior found that about 45% of college students are physically inactive (Keating et al., 2005). Leslie and colleagues assessed the physical activity habits of 2,729 college students and found that 47% of females and 32% of males were insufficiently active based on the current physical activity and health guidelines (Leslie et al., 1999). Huang and colleagues (2003) assessed physical activity habits of 736 college students and found 16% of all students (n=736) reported not exercising at all. Sparling & Snow (2002) analyzed data from 367 surveys of recent college graduates and found that 57% of respondents classified themselves as exercising less than or equal to 2 days per week their senior year of college. When asked further about their current level of activity, 44% of respondents said they were less active now than in college (Sparling & Snow, 2002). The collective findings from these studies indicate that between 45-57% of college students do not meet physical activity guidelines and that students tend to become less active as they get older.

Buckworth and Nigg analyzed the activity levels of 493 college students and found that students reported spending about 30 hours per week engaged in sedentary behaviors, not including time spent in the classroom (Buckworth & Nigg, 2004). The breakdown of sedentary behaviors was TV/video viewing time, studying, and computer use. On average, students spent about 10.5 hours per week watching television and/or

videos, 13 hours studying, and 6 hours using the computer. Interestingly, students reported 2.97 days per week spent doing moderate activity and 2.79 days per week doing vigorous intensity activity. These results indicate that it is possible for college students to meet physical activity guidelines, yet still accumulate a lot of sedentary hours per week. A recent study by Conroy and colleagues (2013) objectively measured sedentary habits of 128 college students. They found students sat for an average of 6 hours per day and the accelerometry data indicated that about 67% of waking hours were actually spent sedentary. Our group recently explored the self-reported time spent sedentary of 1,056 students at the University of Iowa and found students self-reported sitting an average of 6 hours per day as well. Despite these statistics, relatively few interventions have focused on the physical activity/sedentary habits of college students (Keating et al., 2005).

Given the potentially large amount of time college students spend sitting in class, the college classroom environment may be an ideal setting for interventions. According to the socio-ecological model, behavior is influenced by intrapersonal and interpersonal variables, cultural factors, environmental factors, and policies (Sallis et al., 1998). Environments that make being active easier than being sedentary support physical activity behaviors (Owen et al., 2000). The Community Guide recommends enhancing access to options that make individuals more active as well (The Guide to Community Preventive Services, 2013). The traditional classroom, which includes sitting desks and chairs, supports sedentary (sitting) behavior while at the same time discourages standing and physical activity.

Previous studies have found changing physical environments to be an effective approach for promoting healthy behaviors. A 2016 review of 38 sedentary focused

interventions concluded that the most promising interventions that have targeted sedentary behaviors included environmental restructuring, persuasion, and/or education. As an example, Russell and Hutchinson (2000) used point of decision prompts to persuade and educate people to use the stairs instead of an elevator/escalator at an airport. They found stair use rose from 8% to 14% when the signs were present. These results suggest that even a simple change in the environment can have a meaningful impact on behavior change.

Interventions Using Sit-Stand Desks

Sit-stand desks are an example of an environmental intervention. Sit-stand desks have been shown to reduce sitting behaviors of workers in the sedentary work environment. A study conducted by Alkhajah and colleagues analyzed data from 18 participants using sit-stand desks and compared them to 14 participants (aged 20-65 years) using traditional seated desks in the workplace. The results at 1-week follow-up showed that those using the sit-stand desks increased their standing time while at the workplace by 143 minutes per day, and 97 minutes per day during all waking time compared to the control group (Alkhajah et al., 2012). These findings suggest that replacing traditional seated desks with sit-stand desks can greatly increase standing time. Another study by Dutta and colleagues also examined whether sit-stand desks could reduce sitting time of 28 sedentary office workers (male and female) and the impact of the desks on well-being. They found that sitting time was reduced by 21% for those using the sit-stand desks. They concluded that for a 40-hour workweek, this translates into 8 hours of sitting time being replaced with standing. They also found that the desks

increased overall sense of well-being, decreased fatigue, and had no impact on productivity (Dutta et al., 2014).

A Cochrane review of the evidence on sit-stand desks and reducing sitting time in the workplace examined 20 studies with a total of 2,174 participants. They found that sit-stand desks alone decreased sitting time in the workplace in a range between 30 minutes to 2 hours per day. They also found that sit-stand desks decreased sitting time outside of work and decreased sitting bouts lasting 30 minutes or longer. Decreases in sitting time were found to persist up to 6 months follow-up (Shrestha et al., 2016). More research needs to be done, but these findings provide a promising base of evidence that warrants further exploration into the use of sit-stand desks as a way to decrease sedentary time.

More recent research has explored the efficacy of introducing sit-stand desks in the K-12 school setting as an approach to reduce sitting time of children and adolescents. Clemes and colleagues found that introducing sit-stand desks into elementary school classrooms significantly reduced time spent sitting by about 52 minutes per day in 30 UK children and 44 minutes per day in 44 Australian children (Clemes et al., 2015). A study done by Hinckson and colleagues (2013) analyzed data from 30 students in third and fourth grade who used sit-stand desks in the classroom over a 4-week period. They found that students using the sit-stand desks stood for about an hour longer each day compared to students using seated desks. Minges and colleagues conducted a systematic review of the literature on integration of sit-stand desks in elementary school classrooms. They found that across studies there was a 26%-30% increase in time children spent standing, and children using the sit-stand desks stood about 24 minutes longer per school day

(Minges et al., 2016). Collectively, these findings support the use of sit-stand desks in classrooms to increase standing time and decrease sitting time.

A major benefit of introducing sit-stand desks includes increasing caloric expenditure over the course of the day. For example, a study by Dornhecker and colleagues observed the academic engagement of 282 elementary school students through the fall and spring semester, and found that energy expenditure increased for the students using the sit-stand desks compared to control without affecting student engagement in class (Dornhecker et al., 2015). A study by Reiff and colleagues examined 20 male and female participants, conducted in a controlled laboratory setting. They confirmed that standing at a desk while working expended significantly more calories per minute (0.34) compared to sitting, and oxygen consumption increased by 0.06 liters per minute as well (Reiff et al., 2012). Another study by Benden and colleagues divided students into a treatment group receiving sit-stand desks (n=31) and a control group using traditional seated desks (n=27). They found that caloric expenditure in children using sit-stand desks was significantly higher (17% more calories burned) than students using traditional seated desks (Benden et al., 2011). The research is clear that introducing sit-stand desks significantly increases energy expenditure in children and adolescents who use the desks.

There are possibly other benefits of introducing sit-stand desks into classrooms that go beyond increased energy expenditure. Mehta and colleagues (2015) used infrared spectroscopy and a computerized neurocognitive test battery to assess whether mental processing actually improved from using sit-stand desks. While a small study (N=34), the results suggested an improvement or no change in neurocognitive function across the participants. These preliminary findings are consistent with other studies that suggest sit-

stand desks do not negatively affect productivity or engagement, and may actually enhance it. A recent study conducted by Garrett and colleagues compared objective measures of productivity in call center employees over time to see if sit-stand desks had beneficial effects. The intervention consisted of an intervention group (n=74) receiving sit-stand desks and a control group (n=93) using traditional seated desks. They found that sit-stand desk users were about 45% more productive than employees using seated desks on a daily basis. In addition, the productivity of sit-stand desk users increased over time from 23% in the first month to 53% over six months, and productivity increased across different job categories (Garrett et al., 2016). The use of objective measures in this study makes a strong case for sit-stand desks improving productivity in the workplace, which warrants further exploration in a classroom environment.

Sit-stand desks have also been found to be both acceptable and feasible for use in K-12 classrooms. Koepp and colleagues (2012) conducted a feasibility analysis for introducing sit-stand desks into a sixth grade classroom with eight students and found that it could be done easily without negative effects on the classroom learning environment. Another pilot study assessed the acceptability of standing workstations in two different elementary schools (n=30 students) and found overall that both students and teachers spoke enthusiastically of the sit-stand desks and supported using them in the classroom. Teachers specifically cited “flexibility in learning” as a positive influence of the sit-stand desks (Hinckson et al., 2013). Yet another study found sit-stand desks to be effective in reducing sitting time in a diverse population of children from the UK and Australia (n=74) (Clemes et al., 2015). The findings from these studies all suggest that the

classroom environment can successfully integrate sit-stand desks, while potentially improving productivity and increasing energy expenditure.

The research in the field of sedentary behavior and the health benefits related to sedentary time is still relatively new, but the current evidence suggests reducing or interrupting prolonged bouts of sedentary time is important for promoting health and sit-stand desks can be an effective approach for reducing sedentary behaviors in both occupational and K-12 classroom environments. It is now necessary to extend this research to an understudied population (college students) and environment (college classroom). To date, no studies have examined the efficacy of introducing sit-stand desks in the traditional college classroom environment. The proposed study will therefore aim to advance the science by filling this gap in the literature.

CHAPTER 3: RESEARCH PAPER

Abstract

Sedentary behavior has been found to have independent and negative associations with several cardiometabolic risk factors while interrupting prolonged sedentary time may ameliorate these associations. College classrooms are a traditionally sedentary microenvironment and understudied setting for sedentary interventions. Introducing sit-stand desks into college classrooms may be an effective and sustainable approach to reduce classroom sedentary time of college students. The objective of this study was to test the efficacy of replacing seated desks with sit-stand desks in a college classroom on student's classroom standing time and sit-stand transitions, as well as health-related and academic behaviors.

We recruited 304 undergraduate college students taking one of 14 classes being taught in one of two small classrooms (25 seats per class) to participate. Using a cross-over design, each student's classroom sitting and standing time were measured by self-report and objectively (direct observation via video camera surveillance) after having access to only seated desks or only sit-stand desks for six continuous weeks. A process evaluation survey was administered at the end of the study to explore student's and instructor's perceptions of the intervention and its impact on student engagement and health.

The results suggest that students stood about 9.5% of class time on average when given access to sit-stand desks and about 1.5% of class time when using traditional seated desks, as measured by objective video surveillance data. There was no significant change in sit-stand transitions between sit-stand desks and seated desks. Students reported that a

number of academic and health outcomes were favorably impacted as a result of using the sit-stand desks. Social acceptability appeared to be the biggest barrier to use of the sit-stand desks. Overall, students reported a desire to use sit-stand desks again in future classes.

Students stood significantly more when provided access to sit-stand desks compared to seated desks. Sit-stand transitions were not significantly increased when sit-stand desks were implemented. Significantly more students reported improvements in academic and health related outcomes than students who reported declines in these areas as a result of using sit-stand desks. A majority of students reported they would use sit-stand desk again in the future and be supportive of adding sit-stand desks to other classrooms on campus. Sit-stand desks are a feasible environmental change in a college classroom to reduce student sedentary time.

Funding

The Fraternal Order of Eagles, through the Robert W. Hansen Diabetes Fund, provided funding for this research.

Methods

Participants for this study were recruited from 14 classes being taught in one of two classrooms (referred to as classroom A and classroom B throughout this manuscript) on a large Midwestern university campus during the fall semester of 2016. A total of 304 students were recruited for this study. Each class had up to 25 students enrolled at the beginning of the semester. Anyone under the age of 18 was excluded from the study, but there was no maximum age limit. Participants were recruited for the study with a brief presentation given on the first day of class using a PowerPoint slide (Appendix C).

During this time our research team presented the study to the class and described the study details. Participants were informed that classrooms would be under video camera surveillance and that the purpose of the study was to explore the influence of classroom designs on student behaviors. Participants were asked to provide an email address if they wanted to participate in the study. Students who provided an email address and completed the study in full were entered into a lottery for a chance to win 1 of 10 $50 gift cards at the end of the semester.

We utilized a 2x2 crossover design to test our question of whether introducing sit-stand desks increased standing time during class for college students. We used "Arlo Pro" security cameras from Netgear to record the video data. The video cameras were placed discreetly in the front of each room, attached to the top of the wall near the ceiling. The project was implemented over 14 weeks and included three periods: 1) run-in period of two weeks (period 1); 2) six weeks in which Room A had 25 sit-stand desks/stools and Room B did not have sit-stand desks but had traditional seated desks (period 2); 3) six weeks in which Room B had 25 sit-stand desks/stools and Room A did not have sit-stand desks but had traditional seated desks (period 3). Measures of student standing/sitting behaviors were taken at three time points: 1) for one full class during week 2 of the run-in period; 2) for one full class at week 8 (end of period 2); and 3) for one full class at week 14 (end of period 3). Video data was only recorded for one full class period, for each class, during the last week of each time point. Only data collected at time points 2 and 3 were included in the final analysis. This design is advantageous, as it allowed us to compare treatment vs. control on the same subjects with each subject serving as their own control. The treatment included introducing 25 height adjustable "sit-stand" desks (Up-

Rite Student, MooreCo Inc.) with stools (see Figure B3). These desks were chosen as they were height adjustable, included a foot stand for added comfort, were tall enough to accommodate most adults, and were comparable in cost to traditional seated desks in college classrooms ($220/desk). Traditional seated arm desks range in price from $85-$300. The stools were provided to ensure students had the opportunity to either stand or sit during class. Students were not provided any recommendations related to standing or provided any specific goals for standing for this study. Finally, a point of decision prompt was placed on top of each sit-stand desk that was placed in the classrooms (see Figure B2). The prompt included language designed to encourage more standing "Did you know that standing burns up to 50 more calories/hour than sitting?"

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 et al., 2009). We followed a previously validated BEACHES direct observation protocol, which was designed to code physical activity behaviors in various environmental settings including classrooms (McKenzie et al., 2009). Two separate researchers observed the videos independently. Afterward, the researchers came together to discuss any disagreements and came to a resolution. The recorders only included participants that were fully visible on the camera. Times in which students left the room (out of camera sight) were not included in the data collection process. For each class, the video recording began at the exact time that the class was scheduled to begin. The video recordings were ended either at the exact 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, minutes of sitting time, and the number of sit-stand transitions. A total of 42 class periods were observed over the duration of the study.

Aims

The primary aims of the study were to determine whether introducing sit-stand desks increased the average student standing time (minutes per hour per student) as well as the number of sit-stand transitions (transitions per hour per student). We hypothesized time and group effects for average minutes spent standing during class such that average student standing time would be higher during time points in which students had access to the sit-stand desks. We also hypothesized that sit-stand transitions would be higher while students had access to sit-stand desks versus the seated desks. We measured student sitting/standing time and sit-stand transitions at the individual level directly with video recorded surveillance cameras, which were placed in each room during the last week of each time point.

A secondary aim explored student's perceptions of whether using the sit-stand desks impacted academic/health outcomes during class, student's perceptions of the sit-stand desks, student's reasons for using/not using the desks, and possible approaches that might promote increased standing (see Appendix C for survey). To answer these questions, all participants completed a process evaluation survey at the end of the study (week 14), which also included several demographic questions (e.g., age, sex, weight, height, race, ethnicity, class status, major). This aim was exploratory and was used to determine the demand for sit-stand desks in classrooms and to provide context regarding how the sit-stand desks are used.

Statistical Analysis

For our primary aims, we tested for both time and group effects of the sit-stand desks on average time spent standing and sitting in class per student (minutes per hour) and average number of sit-stand transitions per student. We made between group comparisons (classroom A and B) at time points 2 and 3. Because the standing, sitting and transition data were non-normally distributed we used a Mann Whitney U Test for all comparisons. We used descriptive statistics to quantify desk use during all time points. Specifically, we calculated the total time spent standing and sitting at each desk (minutes per hour) and the total number of sit-stand transitions per hour for each student. Statistical significance was set at $P < 0.05$. No power calculation was included for this analysis due to the novelty of this study, although we hope to use this study to power future studies. All statistical analyses were performed using SPSS version 22.

Results

A total of 304 undergraduate students were eligible to participate and enrolled in the study at the beginning of the semester. A total of 271 participants were observed by video camera surveillance. A total of 143 participants completed the process evaluation survey at the end of the study (see Table 1). Students were mostly White (85.5%) and female (73.9%), and had an average BMI of 23.3± 3.8 kg/m^2. Over half of the participants (54.7%) reported not meeting the Physical Activity Guidelines for Americans (at least 150 minutes of moderate intensity activity per week).

The number of students observed in the video surveillance data was as follows: time point 1 (n=271), time point 2 (n=257), and time point 3 (n=239). The inter-rater agreement correlation for average standing time was calculated at 0.97. At time point 2

(week 8), students who had access to sit-stand desks in classroom A stood significantly more, 6.0±12.4 minutes per hour, compared to students in classroom B who had access to traditional seated desks who stood for 0.7±0.6 minutes per hour ($p=0.049$) (see Figure B1). They also sat significantly less, 54.0±12.4 minutes per hour, compared to students in classroom B who had access to the traditional seated desks and sat for 59.3±0.6 minutes per hour ($p=0.049$). Conversely, six weeks after the sit-stand desks were moved to classroom B (time point 3; week 14), students who had access to sit-stand desks also stood significantly more, 5.6±11.7 minutes per hour, compared to students in classroom A who had access to traditional seated desks and sat for 0.3±1.9 minutes per hour ($p<0.01$) (see Figure B1). They also sat significantly less, 55.1±10.3 minutes per hour, compared to students in classroom A who had access to traditional seated desks and sat for 59.7±1.9 minutes per hour ($p<0.01$) (see Table A2). When pooling all of data from both time points 2 and 3 and comparing students with seated desks versus students with sit-stand desks, students stood significantly more ($p<0.001$) and sat significantly less ($p<0.001$) when they had access to sit-stand desks. Specifically, students stood 5.7±11.7 minutes of every hour when they had access to sit-stand desks compared to 0.9±5.6 minutes of every hour when they had access to seated desks.

At time point 2 (week 8), students who had access to sit-stand desks in classroom A had significantly fewer ($p=0.02$) sit-stand transitions compared to students in classroom B who had the seated desks. Conversely, six weeks after the sit-stand desks were moved to classroom B (time point 3; week 14), students who had access to sit-stand desks in classroom B had significantly more ($p<0.01$) sit-stand transitions compared to students in classroom A with the seated desks (see Table A2).

When asked to report whether academic and health outcomes changed while using the sit-stand desks, most students who reported using the sit-stand desks at least once during the study (N=101) reported either improvements or no change in each outcome with very few reporting declines (see Table A3). Several students reported improvements in fatigue (42.6%), boredom (45.5%), and restlessness (53.0%) during class while using the sit-stand desks. Several students also reported improvements in focus (35.6%), engagement (34.7%), attention (50.5%), and participation in class (36.6%) while using the sit-stand desks.

When asked to report the reasons why they chose to stand at a sit-stand desk, the most common answers were "to alleviate restlessness" (43.6%), "burn more calories" (40.6%), and "reduce boredom" (39.6%). When asked to report barriers that prevented them from standing at the sit-stand desks, the most common answers were "I prefer to sit" (52.2%), "standing felt awkward" (46.3%), and "there were no sit-stand desks available" (29.1%). When asked to report strategies that might get them to stand more at sit-stand desks, the most common responses were "seeing other students stand" (77.2%), "receiving encouragement from my instructor" (61.8%), and "reminders from my instructor to stand during class" (58.1%). When asked if they would be willing to take another class in the future with sit-stand desks available, most students (69.3%) reported "yes" while 24.8% of students reported "maybe". When asked whether or not they would be supportive of adding sit-stand desks to other classrooms on campus, most students (70.8%) reported "yes," while 20.4% reported "maybe." Finally, when asked whether the point-of-decision educational prompts placed on top of each desk influenced their decision to stand during class (see Figure B2), 36.8% reported the sign increased their

standing time while 61.8% of students reported that the sign did not impact their standing time.

Discussion

The findings from this study suggest that when students are provided access to sit-stand desks in a college classroom, they will stand more and sit less during class. When pooling all of data from both time points 2 and 3 and comparing students with seated desks versus students with sit-stand desks, students stood significantly more, 5.7±11.7 minutes of every hour, and sat significantly less, 0.9±5.6 minutes of every hour, when they had access to sit-stand desks compared to seated desks ($p<0.001$). While the absolute values of standing are not large, these findings are important considering the fact that these sit-stand desks will remain in this classroom for several years and will be used by thousands of students.

While there have been no previous studies examining the efficacy of sit-stand desks in college classrooms, our finding is consistent with previous research conducted in K-12 classrooms (Clemes et al., 2015, Hinckson et al., 2013, Minges et al., 2016). In a study by Clemes and colleagues that examined the impact of introducing sit-stand desks in K-12 classrooms, student sitting time over the entire school day was reduced by 10% (Clemes et al., 2015). To put this into context, standing for 10% of class time equates to 6 minutes per hour which is very comparable to our 5.7 minutes/hour.

We can also compare the findings of this study with research on sit-stand desks introduced into work settings. A recent Cochrane review focused on the effect of introducing sit-stand desks in the workplace examined 20 studies with a total of 2,174 participants. Participants provided access to sit-stand desks decreased sitting time in the

workplace between 30 minutes to 2 hours per day (Shrestha et al., 2016). Our team conducted a cross-sectional study that found sedentary office workers with sit-stand desks stand on average 60 minutes more per 8 hour work day compared to workers with traditional seated desks (Carr et al., 2016). This equates to 12.5% more standing time per 8 hour work day for workers provided sit-stand desks.

The results of the sit-stand transitions data (students going from a seated to standing position) after implementation of the sit-stand desks were mixed and did not support our hypothesis. This finding is consistent with our previous study with sedentary office workers. In that study, we found workers with sit-stand desks took roughly 4 fewer sit-stand transitions (29.4 per 8 hour work day) compared to employees with seated desks (33.7 per 8 hour work day (Carr et al., 2016). Collectively, our findings suggest providing sit-stand desks do not increase sit-stand transitions but rather have a larger impact on reducing the duration of sitting time.

About 1 in 3 students that completed the process evaluation survey said that the point-of-decision prompt (see Figure B2) placed on top of each desk increased their standing time. This is consistent with previous research that has found point of decision prompts to be effective for increasing physical activity behaviors such as taking the stairs (Russell & Hutchinson, 2000). Further research is needed to identify prompts that might be more effective for the college student population. This work could include focus groups with students to identify messages that motivate more standing.

Many students reported improved academic and health outcomes as a result of having access to sit-stand desks. Collectively, these findings suggest the sit-stand desks have potential for improving the overall classroom experience without decreasing focus

and engagement. Many students reported using the sit-stand desks in order to reduce boredom and restlessness. Roughly 35% of students reported their engagement, focus, participation, and/or attention in class improved as a result of using sit-stand desks. These outcomes are very important considering the primary objective of college is to stimulate learning. These positive perceptions support further exploration of sit-stand desk use in college classroom settings moving forward. These findings are consistent with the literature in K-12 classrooms as well as the workplace. A study by Dutta and colleagues found providing sit-stand desks to sedentary workers increased workers overall sense of well-being, decreased fatigue, and did not hinder productivity (Dutta et al., 2014). A study done by Mehta and colleagues used infrared spectroscopy and a computerized neurocognitive test battery to assess whether mental processing actually improved from using sit-stand desks. While a small study (N=34), the results suggested small improvements in neurocognitive function across the participants as a result of using sit-stand desks. Future research should include more objective measures of academic outcomes while using sit-stand desks compared to traditional seated desks.

The process evaluation data unearthed several interesting findings that could be used to inform future studies. For example, students reported a primary barrier to using the sit-stand desks was that "standing felt awkward." This finding is interesting given students also reported "seeing other students stand" and "encouragement from the instructor" would make it more likely for them to stand as well. These findings are less surprising when considering previous research that has found the adoption of new innovation is an innately social process influenced by peers, organizations, and societal norms (Straub et al., 2009). Taken together, these findings support future interventions

that focus on changing perceptions regarding standing in class and focusing on social norms of the classroom. A specific example would be an intervention that tests whether combining the sit-stand desks with instructor led standing breaks increases standing over sit-stand desks alone.

Participant's overall favorability for the sit-stand desks was high with students overwhelmingly reporting they would take another class with sit-stand desks in the future. A majority of students also reported they would be supportive of adding sit-stand desks into other classrooms on campus. This was consistent with a previous needs assessment performed by our group at the same university (Benzo et al., 2016). This warrants a need for future research to investigate the effects of using sit-stand desks in classrooms of different designs and sizes to better understand how sit-stand desks can fit into the overall learning environment at a university.

There were some notable limitations to this study. First, participants of this study were enrolled in classes that were primarily health focused. This could have led to a selection bias as it possible students enrolled in the analyzes classes were innately more educated and interested in health behaviors than the general student population and therefore more inclined to use the sit-stand desks. Therefore, these findings cannot necessarily be generalized to students of non-health focused degrees. Additionally, the sit-stand desks were assessed in small classrooms with less than or equal to 25 students thus we cannot comment on whether this approach would be effective in larger classrooms. Students also knew they were being observed so this may have increased the chances of a Hawthorne effect. Also, the process evaluation data was collected via self-report which is subject to potential recall and social desirability biases. Finally, it is

possible the sit-stand desks could have led to differential arrangements of the desks within each class/classroom. Despite setting up the desks in rows initially, we observed the desks were moved a U-shape pattern conducive to discussion almost immediately. However, we also observed the U-shape arrangement in the seated desk classrooms on several days as well so we don't believe this had a large impact on the outcomes of this study. Future research is needed to identify ideal arrangements for sit-stand desks that maximize their use.

This study also had several strengths. This was the first study to test the effect of sit-stand desks in college classrooms. College students are an understudied population in the field of health behavior research. The crossover design was advantageous as it allowed each student to act as his/her own control. In addition, the total sample size was relatively large compared to previous studies conducted in K-12 classrooms, allowing for increased statistical power. Our findings are strengthened by the use of an objective measure of sitting and standing behaviors and by including two independent coders of the video surveillance data. Finally, the observations were conducted six weeks after students were provided sit-stand desks which reduced the possibility of a novelty effect and provided a more true representation of student's typical sitting/standing behaviors when provided sit-stand desks.

Moving forward, research can build upon this study in many ways. Analyzing use of sit-stand desks among students in non-health majors and in classrooms of varying sizes and designs would be useful for improving the generalizability of our findings. Future interventions focused on manipulating social norms related to standing in class are also warranted given the feedback we received in our process evaluation survey. Finally, this

study was a comprised of mostly female participants, so examining potential gender differences may be necessary.

In conclusion, 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 academic and health outcomes as a result of using the sit-stand desks. Students also reported high levels of acceptability of the sit-stand desks. These findings are supportive of further research with sit-stand desks in college classrooms and could support the addition of sit-stand desks in other college classrooms on campus.

APPENDIX A: TABLES

Table A1. Participant Characteristics from Process Evaluation Survey (n=143)

	Mean (SD) %
Age (Years)	20.1(1.3)
BMI (kg/m^2)	23.3(3.8)
Female (%)	73.9
Ethnicity (%)	
Not Hispanic/Latino	93.5
Race (%)	
White	85.5
Class Status (%)	
Freshman	18.1
Sophomore	25.4
Junior	27.5
Senior	29.0
Class Enrollment (%)	
Therapeutic Rec	26.0
PA & Health	28.4
Writing for HHP	37.6
Sports Rec Management	8.0
Meet PA Guidelines[A] (%)	
Yes	45.3
No	54.7

[A] Physical Activity Guidelines for Americans are 150 minutes/week of moderate intensity activity, or 75 minutes per week of vigorous intensity activity.

Table A2. Between-Group Comparisons of Sedentary Behaviors (Primary Outcomes)

	Observation 1 (Week 8)		**Observation 2 (Week 14)**	
	Mean	SD	Mean	SD
Average Sit-Stand Transitions				
Sit Desks	2.2	1.0	1.4	0.7
Sit-Stand Desks	1.8*	1.0	1.7*	0.7
Average Standing Time (min/hr)				
Sit Desks	0.7	0.6	0.3	1.9
Sit-Stand Desks	6.0*	12.4	5.6*	11.7
Average Sitting Time (min/hr)				
Sit Desks	59.3	0.6	59.7	1.9
Sit-Stand Desks	54.0*	12.4	55.1*	10.3
$p<0.05$ between groups within time point				

Table A3. Students' Perceived Changes in Academic/Health Outcomes

Please tell us how/if each of the following changed for you while standing at a desk compared to sitting at a desk:

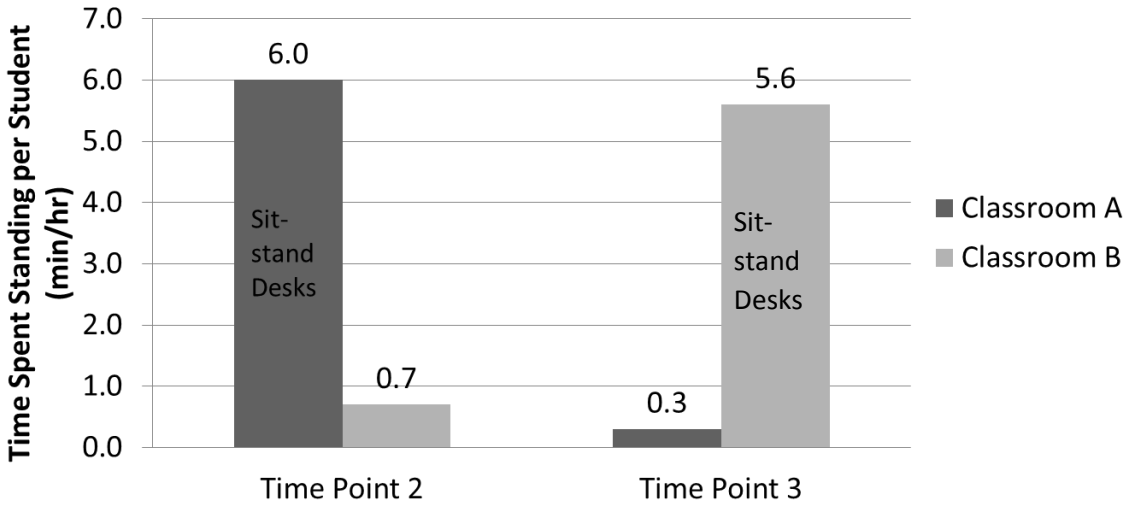
Question	Declined	No change	Increased	Total Responses
Fatigue during class	42.57%	48.51%	8.91%	101
Boredom during class	45.54%	53.47%	0.99%	101
Restlessness during class	53.00%	36.00%	11.00%	100
Joint pain during class	21.00%	72.00%	7.00%	100
Focus during class	7.92%	56.44%	35.64%	101
Engagement during class	9.90%	55.45%	34.65%	101
Attention during class	7.92%	41.58%	50.50%	101
Participation in class	6.93%	56.44%	36.63%	101
Academic Performance	4.95%	79.21%	15.84%	101
Use of cell phone during class	38.61%	59.41%	1.98%	101

Table A4. Students' Self-Reported Factors Influencing Sit-Stand Desk Use (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 to stand	61.8%
Reduce boredom	39.6%	No sit-stand desks available	29.1%	Reminders from instructor to stand	58.1%

APPENDIX B: FIGURES

Figure B1. Average Time Spent Standing per Student by Time Point and Classroom



P<0.05 between groups within each time point

Figure B2. Point of Decision Prompt Placed on Sit-stand Desks

Figure B3. Sit-Stand Desk (Up-Rite Student, MooreCo Inc.)

APPENDIX C: SUPPLEMENTAL MATERIALS

Default Question Block

Thank you for participating in this study. The purpose of this study was to examine the effect introducing standing desks into college classrooms has on student's standing and sitting behaviors during class. As you may recall, the class you took in Field House Room 302 or 402 had 10 standing desks for a 7 week period this semester.Please take a moment to answer the following questions about your experience with the standing desks.

What is your age (years)?

What is your height (in inches)?

What is your weight (in pounds)?

What is your sex?

- Male
- Female

Which of the following do you consider to be your ethnic group?

- Hispanic or Latino
- Not Hispanic or Latino
- Don't know or Prefer not to respond

Which of the following do you consider to be your racial group?

- American Indian/Alaskan Native
- Asian
- Native Hawaiian or Other Pacific Islander
- Black or African American
- White
- Other (describe):
- Don't know or Prefer not to respond

What is your class status?

- Freshman
- Sophomore
- Junior
- Senior
- Graduate Student

What is your major?

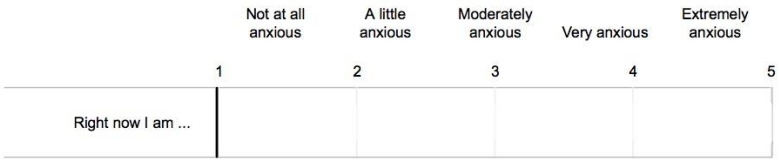
PHYSICAL ACTIVITY

During the past MONTH, which statement best describes the kinds of physical activity you usually did? Do not include the time you spent working at a job. Please read all six statements before selecting one.

- 1. I did not do much physical activity. I mostly did things like watching television, reading, playing cards, or playing computer games. Only occasionally, **no more than once or twice a month**, did I do anything more active such as going for a walk or playing tennis.
- 2. **Once or twice a week**, I did **light activities** such as getting outdoors on the weekends for an easy walk or stroll. Or once or twice a week, I did chores around the house such as sweeping floors or vacuuming.
- 3. **About three times a week**, I did **moderate activities** such as brisk walking, swimming, or riding a bike **for about 15–20 minutes each time**. Or about once a week, I did moderately difficult chores such as raking or mowing the lawn for about 45–60 minutes. Or about once a week, I played sports such as softball, basketball, or soccer for about 45–60 minutes.
- 4. **Almost daily, that is five or more times a week**, I did **moderate activities** such as brisk walking, swimming, or riding a bike **for 30 minutes or more each time**. Or about once a week, I did moderately difficult chores or played sports for 2 hours or more.
- 5. **About three times a week**, I did vigorous activities such as running or riding hard on a bike **for 30 minutes or more each time.**
- 6. **Almost daily, that is, five or more times a week**, I did vigorous activities such as running or riding hard on a bike **for 30 minutes or more each time**.

ANXIETY

Please choose the number that shows how anxious you feel at the moment. If you choose '1' you are feeling not at all anxious at the moment. If you choose '5' you are feeling the most anxious you could ever imagine. If you choose '3' you are feeling moderately anxious."



Over the past semester, about how often did you experience the following while attending this class?

	Never	Seldom	About half the time	Usually	Always
Anxiety during class	○	○	○	○	○
Fatigue during class	○	○	○	○	○
Boredom during class	○	○	○	○	○
Restlessness during class	○	○	○	○	○
Joint pain during class	○	○	○	○	○
Difficulty staying focused	○	○	○	○	○
Difficulty staying engaged	○	○	○	○	○
Difficulty paying attention	○	○	○	○	○

Over the course of this semester, did you EVER occupy any of the standing desks that were available in this classroom?

- ○ Yes
- ○ No

When they were available, about how often did you occupy one of the standing desks that were in this classroom?

- ○ Never
- ○ Seldom
- ○ About half the time
- ○ Usually
- ○ Always

On the days you occupied one of the standing desks, about what percentage of class time did you spend actually standing?

- I stood 0% of class time
- I stood 25% of class time
- I stood 50% of class time
- I stood 75% of class time
- I stood 100% of class time

Please tell us how/if each of the following changed <u>for you</u> while using the standing desks this semester?

	Worsened	No change	Improved
Anxiety during class			
Fatigue during class			
Boredom during class			
Restlessness during class			
Joint pain during class			
Focus during class			
Engagement during class			
Attention during class			

On the days you occupied the standing desks, what were your reasons for doing so? Choose all that apply. If none of the answers apply to you, please choose 'Other' and describe your reasons.

- To reduce anxiety
- To reduce fatigue
- To reduce boredom
- To alleviate restlessness
- To reduce joint pain
- To improve focus
- To improve engagement
- To improve attention
- To see better
- To burn more calories
- I prefer to be in the back of the room
- Other

On the days you did NOT occupy a standing desk, what were your reasons for doing so? Choose all that apply. If none of the options apply to you, please choose 'Other' and describe your reasons.

- [ ] I prefer to sit during class
- [ ] I do not like being in the back of the room
- [ ] Standing in class felt awkward
- [ ] It would be more difficult for me to see the instructor
- [ ] It would be more difficult for me to hear the instructor
- [ ] I would not be able to concentrate while standing
- [ ] I didn't want to cause a distraction in class
- [ ] There were no standing desks available
- [ ] Other

Which of the following (if any) would encourage you to stand more/sit less during class? Choose all that apply. If none of the options apply to you, please choose 'Other' and describe.

- ( ) Encouragement from my instructor to stand during class
- ( ) Seeing others in the class standing
- ( ) A reminder during class to stand up
- ( ) Other:

Research Study

- Purpose: Explore impact of classroom design on student behaviors
- Location: Field House
- What you need to do:
  1. Attend class regularly
     - Video recorded direct observation of student behaviors
  2. Complete 3 very brief surveys during semester and one 10-15 minute survey at end of semester
- Minimal risk to you
- No cost to you
- Voluntary
- Must be at least 18 years old to participate
- Questions?

Notice:

This room is being monitored with video surveillance as part of an ongoing research study.

Please direct questions to
Dr. Lucas Carr at 319-353-5432

REFERENCES

Alkhajah, T.A., Reeves, M.M., Eakin, E.G., et al. (2012). Sit-stand workstations: a pilot intervention to reduce office sitting time. *American Journal of Preventive Medicine*, 43(3), 298-303. doi: 10.1016/j.amepre.2012.05.027.

Benden, M.E., Blake, J.J., Wendel, M.L., Huber, J.C. (2011). The impact of stand-biased desks in classrooms on calorie expenditure in children. *American Journal of Public Health*, 101(8), 1433-1436. doi: 10.2105/AJPH.2010.300072.

Benzo, R.M., Gremaud, A.L., Jerome, M., Carr, L.J. (2016). Learning to Stand: The Acceptability and Feasibility of Introducing Standing Desks into College Classrooms. *International Journal of Environmental Research and Public Health*, 13(8), doi: 10.3390/ijerph13080823.

Biswas, A., Oh, P.I., Faulkner, G.E., et al. (2015). Sedentary time and its association with risk for disease incidence, mortality, and hospitalization in adults: a systematic review and meta-analysis. *Annals of Internal Medicine*, 162(2), 123-132. doi: 10.7326/M14-1651.

Buckworth, J. & Nigg, C. (2004). Physical Activity, Exercise, and Sedentary Behavior in College Students. *Journal of American College Health*, 53(1), 28-34.

Clemes, S.A., Barber, S.E., Bingham, D.D. (2015). Reducing children's classroom sitting time using sit-to-stand desks: findings from pilot studies in UK and Australian primary schools. *Journal of Public Health (Oxf)*.

Conroy, D.E., Maher, J.P., Elavsky, S., Hyde, A.L., Doerksen, S.E. (2013). Sedentary Behavior as a Daily Process Regulated by Habits and Intentions. *Health Psychology*, 32(11), 1149-1157. doi: 10.1037/a0031629.

Dornhecker, M., Blake, J., Benden, M., Zhao, H., Wendel, M. (2015). The Effect of Stand-biased Desks on Academic Engagement: An Exploratory Study. *International Journal of Health Promotion and Education*, 53(5), 271-280.

Dutta, N., Koepp, G.A., Stovitz, S.D., Levine, J.A., Pereira, M.A. (2014). Using sit-stand workstations to decrease sedentary time in office workers: a randomized crossover trial. *International Journal of Environmental Research and Public Health*, 11(7), 6653-6665. doi: 10.3390/ijerph110706653.

Epstein, L.H., Roemmich, J.N. (2001). Reducing sedentary behavior: role in modifying physical activity. *Exercise and Sport Sciences Reviews*, 29(3), 103-108.

Garrett, G., Benden, M., Mehta, R., et al. (2016). Call Center Productivity Over 6 Months Following a Standing Desk Intervention. *IIE Transactions on Occupational Ergonomics and Human Factors*. doi:10.1080/21577323.2016.1183534.

Hamilton, M.T., Hamilton D.G., Zderic, T.W. (2007). Role of low energy expenditure and sitting in obesity, metabolic syndrome, type 2 diabetes, and cardiovascular disease. *Diabetes*, 56(11), 2655-2667.

Healy, G.N., Dunstan, D.W., Salmon, J., et al. (2007). Objectively measured light-intensity physical activity is independently associated with 2-h plasma glucose. *Diabetes Care*, 30(6), 1384-1389.

Healy, G.N., Dunstan, D.W., Salmon, J., et al. (2008). Breaks in sedentary time: beneficial associations with metabolic risk. *Diabetes Care*, 31(4), 661-666. doi: 10.2337/dc07-2046.

Healy, G.N., Dunstan, D.W., Salmon, J., et al. (2008). Television time and continuous metabolic risk in physically active adults. *Medicine & Science in Sports & Exercise*, 40(4), 639-645. doi: 10.1249/MSS.0b013e3181607421.

Healy, G.N., Winkler, E.A., Owen, N., Anuradha, S., Dunstan, D.W. (2015). Replacing sitting time with standing or stepping: associations with cardio-metabolic risk biomarkers. *European Heart Journal*, 36(39), 2643-2649. doi: 10.1093/eurheartj/ehv308.

Henson, J., Yates, T., Biddle, S.J., et al. (2013). Associations of objectively measured sedentary behaviour and physical activity with markers of cardiometabolic health. *Diabetologia*, 56(5), 1012-1020. doi: 10.1007/s00125-013-2845-9.

Hinckson, E.A., Aminian, S., Ikeda, E. (2013). Acceptability of standing workstations in elementary schools: A pilot study. *Preventive Medicine*, 56(1), 82-85.

Huang, T., Harris, K.J., Lee, R.E., et al. (2003). Assessing Overweight, Obesity, Diet, and Physical Activity in College Students. *Journal of American College Health*, 52(2), 83-86.

Katzmarzyk, P.T., Church, T.S., Craig, C.L., Bouchard, C. (2009). Sitting time and mortality from all causes, cardiovascular disease, and cancer. *Medicine and Science in Sports and Exercise*, 41(5), 998-1005. doi: 10.1249/MSS.0b013e3181930355.

Keating, X.D., Guan, J., Pinero, J.C., Bridges, D.M. (2005). A meta-analysis of college students' physical activity behaviors. *Journal of American College Health*, 54(2), 116-125.

Koepp, G.A., Snedden, B.J., Flynn L. (2012). Feasibility Analysis of Standing Desks for Sixth Graders. *Childhood Obesity and Nutrition*, 4(2), 89-92. doi: 10.1177/1941406412439414.

Leslie, E., Owen, N., Salmon, J., et al. (1999). Insufficiently Active Australian College Students: Perceived Personal, Social, and Environmental Influences. *Preventive Medicine*, 28(1), 20-27.

Liem, G.A.D., Martin, A.J. 2012. The Motivation and Engagement Scale: Theoretical Framework, Psychometric Properties, and Applied Yields. Australian Psychologist, 47(1), 3-12.

Manson, J.E., Greenland, P., LaCroix, A.Z., et al. (2002). Walking compared with vigorous exercise for the prevention of cardiovascular events in women. *New England Journal of Medicine*, 347(10), 716-725.

McKenzie, T.L. 2009. C. H. McCloy Lecture. Seeing is believing: observing physical activity and its contexts. *Res Q Exerc Sport*, 2010; 81(2), 113-122.

Mehta, R.K., Shortz, A.E., Benden, M.E. (2015). Standing Up for Learning: A Pilot Investigation on the Neurocognitive Benefits of Stand-Biased School Desks. *International Journal of Environmental Research and Public Health*, 13(1). doi: 10.3390/ijerph13010059.

Minges, K.E., Chao, A.M., Irwin, M.L. et al. (2016). Classroom Standing Desks and Sedentary Behavior: A Systematic Review. *Pediatrics*, 137(2), 1-18. doi: 10.1542/peds.2015-3087.

Owen, N., Healy, G.N., Matthews, C.E., Dunstan, D.W. (2010). Too Much Sitting: The Population-Health Science of Sedentary Behavior. *Exercise and Sport Sciences Reviews*, 38(3), 105-113. doi: 10.1097/JES.0b013e3181e373a2.

Owen, N., Leslie, E., Salmon, J., Fotheringham, M.J. (2000). Environmental determinants of physical activity and sedentary behavior. *Exercise and Sport Sciences Reviews*, 28, 153-158.

Owen, N., Sparling, P.B., Healy, G.N., et al. (2010). Sedentary Behavior: Emerging Evidence for a New Health Risk. *Mayo Clinic Proceedings*, 85(12), 1138-1141.

Owen, N., Sugiyama, T., Eakin, E., et al. (2011). Adults' Sedentary Behavior: Determinants and Interventions. *American Journal of Preventive Medicine*, 41(2), 189-196. doi:10.1016/j.amepre.2011.05.013.

Prince, S.A., Adamo, K.B., Hamel, M.E., et al. (2008). A comparison of direct versus self-report measures for assessing physical activity in adults: a systematic review. *International Journal of Behavioral Nutrition and Physical Activity*, 5, 56. doi: 10.1186/1479-5868-5-56.

Reiff, C., Marlatt, K., Dengel, D.R. (2012). Difference in caloric expenditure in sitting versus standing desks. *Journal of Physical Activity and Health*, 9(7), 1009-1011.

Russell, W.D., Hutchinson, J. (2000). Comparison of Health Promotion and Deterrent Prompts in Increasing Use of Stairs Over Escalators. *Perceptual and Motor Skills*. 91(1), 55-61.

Sallis, J.F., Bauman, A., Pratt, M. (1998). Environmental and policy interventions to promote physical activity. *American Journal of Preventive Medicine*, 15(4), 379-397.

Saunders, T.J., Tremblay, M.S., Mathieu, M.E., et al. (2013). Associations of sedentary behavior, sedentary bouts and breaks in sedentary time with cardiometabolic risk in children with a family history of obesity. *PLoS One*, 8(11). doi: 10.1371/journal.pone.0079143.

Sedentary Behaviour Research Network. 2012. Standardized use of the terms "sedentary" and "sedentary behaviours". *Applied Physiology, Nutrition, and Metabolism*. 37, 540–542.

Shrestha, N., Kukkonen-Harjula, K.T., Verbeek, J.H., et al. (2016). Workplace interventions for reducing sitting at work. *Cochrane Database Systematic Review*. doi: 10.1002/14651858.CD010912.pub3.

Sparling, P.B. & Snow, T.K. (2002) Physical Activity Patterns in Recent College Alumni. *Research Quarterly for Exercise and Sport*, 73(2), 200-205, doi: 10.1080/02701367.2002.10609009.

Straub, E.T. (2009). Understanding Technology Adoption: Theory and Future Directions for Informal Learning. *Review of Educational Research*, 79(2), 625-649.

The Guide to Community Preventive Services (web site). Increasing Physical Activity. www.thecommunityguide.org. Published June 2013. Accessed April 13, 2016.

Thorp, A.A., Owen, N., Neuhaus, M., Dunstan, D.W. (2011). Sedentary behaviors and subsequent health outcomes in adults a systematic review of longitudinal studies, 1996-2011. *American Journal of Preventive Medicine*, 41(2), 207-215. doi: 10.1016/j.amepre.2011.05.004.

Thorp, A.A., Kingwell, B.A., Sethi, P., et al. (2014). Alternating bouts of sitting and standing attenuate postprandial glucose responses. *Medicine & Science in Sports & Exercise*, 46(11), 2053-2061. doi: 10.1249/MSS.0000000000000337.

Tremblay, M.S., Colley, R.C., Saunders, T.J., Healy, G.N., Owen, N. (2010). Physiological and health implications of a sedentary lifestyle. *Applied Physiology, Nutrition, and Metabolism*, 35(6), 725-740. doi: 10.1139/H10-079.

Tremblay, M.S., LeBlanc, A.G., Kho, M.E., et al. (2011). Systematic review of sedentary behaviour and health indicators in school-aged children and youth. *International Journal of Behavioral Nutrition and Physical Activity*, 8, 98. doi: 10.1186/1479-5868-8-98.

Warren, T.Y., Barry, V., Hooker, S.P., et al. (2010). Sedentary behaviors increase risk of cardiovascular disease mortality in men. *Medicine & Science in Sports & Exercise*, 42(5), 879-885. doi: 10.1249/MSS.0b013e3181c3aa7e.

Wilmot, E.G., Edwardson, C.L., Achana, F.A., et al. (2012). Sedentary time in adults and the association with diabetes, cardiovascular disease and death: systematic review and meta-analysis. *Diabetologia*, 55(11), 2895-2905. doi: 10.1007/s00125-012-2677-z.