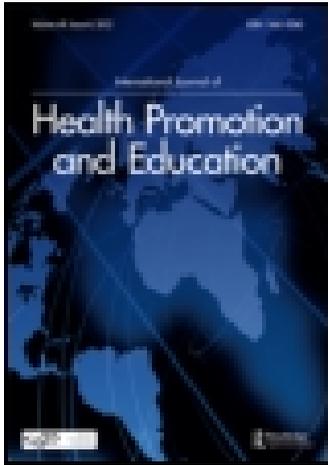


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The effect of stand-biased desks on academic engagement: an exploratory study

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Schools have been suggested as a viable avenue to combat childhood obesity. School administrators are sometimes faced with the conflicting demands of improving the health of their students and maintaining academic performance. Dynamic furniture such as stand-biased desks may be one way to address both academic and health demands placed on schools to prevent childhood obesity. Classrooms with stand-biased desks were compared with classrooms using traditional seated desks in 2nd, 3rd, and 4th grades. The academic engagement of 282 participants was observed in the fall and spring during one academic year. The engagement of the treatment classrooms was compared with the engagement of the control classrooms. Both groups showed general increases in their academic engagement over time. Stand-biased desks do not seem to result in adverse effects on academic engagement when used in elementary classrooms. The data suggest promising results for the use of stand-biased desks in elementary school classrooms. The results suggest that stand-biased desks can be introduced in the classroom to combat childhood obesity through increasing energy expenditure without affecting academic engagement.

Keywords: stand-biased desk; classroom design; academic engagement

In an effort to address childhood obesity there have been several interventions aimed at impacting children's level of physical activity and healthy eating behavior in the public school setting (Wechsler et al. 2000; Goran, Reynolds, and Lindquist 1999). Schools have been chosen as a target setting for obesity prevention and intervention due to the significant amount of time children spend in school (Wechsler et al. 2000). School administrators often struggle with managing conflicting demands surrounding the growing need for integrating healthy and active behaviors in the school setting with increasing the academic achievement and competitive standing of American children (Kahn et al. 2002). Recent research suggests that physical activity may have beneficial effects on cognitive ability and consequently academic achievement, thereby, encouraging the alignment of school-based efforts to meet students' health and educational needs (Hillman, Erickson, and Kramer 2008; Tomporowski et al. 2008).

Given the growing childhood obesity epidemic, health care professionals have suggested guidelines for reducing the prevalence of childhood obesity in the United States (Services USDoHaH 2000). In 2009–2010, obesity rates were as high as 16.9%, and rates for overweight children and adolescents aged 2–19 were 31.8% (body mass index (BMI) \geq 95th percentile and BMI \geq 85th percentile based on age and gender norms, respectively)

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(Ogden et al. 2012). More specifically, children between the ages of 6 and 11 show rates as high as 18% for obesity and 32.6% for overweight (Tompsonowski et al. 2008). The alarming rate of unhealthy weight for children is a relatively recent phenomenon. In the 1970s, the rate of obesity was as low as 5% in children and adolescents, but there has been an average increase of 3.7% per year between 1977 and 2008 in childhood obesity (Wang, Orleans, and Gortmaker 2012). The increase in BMI may be a result of the increasing sedentary lifestyle of children and adolescents (Cardon et al. 2004). For example, one study focusing on children in daycare facilities noted that preschool children spent 55% of their daycare time in sedentary activities, such as seated play (Bower et al. 2008). *Healthy People 2010* offered guidelines and recommendations to reduce the rate of childhood obesity back to the prevalence recorded in the 1970s (Hillman, Erickson, and Kramer 2008). Several interventions have been aimed at reducing the energy gap between energy intake and expenditure to combat sedentary behavior by increasing children's access to sports facilities in school or by limiting student access to calorie-dense foods in schools (Wechsler et al. 2000; Hillman, Erickson, and Kramer 2008; Tompsonowski et al. 2008; Story, Nanney, and Schwartz 2009). Although, there has been stabilization in the rate of increase each year, standards set by *Healthy People 2010* were not reached (Services USDoHaH 2000). In response, *Healthy People 2020* objectives were developed with the goal of reducing the prevalence rate of obesity recorded in 2008 by 5% for the year 2020, which would require an average reduction of 41 kcal/day for all children and adolescents, and specifically a reduction of 37 kcal/day for children 6 to 11 years old (Services USDoHaH 2000). There have been different opinions offered for how health professionals can achieve the *Healthy People 2020* goal. Wang suggests that reducing small amounts of daily caloric intake is a much more attainable goal than a massive reduction of caloric intake once a child reaches the obese category (Wang, Orleans, and Gortmaker 2012). Interventions targeted at schools, such as reducing the availability of sugar-sweetened beverages and implementing programs that decrease sedentary behavior, continue to be the most frequent suggested methods suggested for reaching the new standards set by *Healthy People 2020* (Wang, Orleans, and Gortmaker 2012). These interventions have demonstrated modest success in increasing energy expenditure in elementary school children (Goran, Reynolds, and Lindquist 1999; Kahn et al. 2002).

Several studies have shown that daily involvement in organized physical activity programs, such as physical education (PE), have resulted in reductions in BMI and decreases in body fat (Wechsler et al. 2000; Cardon et al. 2004; Bower et al. 2008; Story, Nanney, and Schwartz 2009; Sallis et al. 1997). For example, in a 2-year PE intervention, there was a significant increase in energy expenditure in children participating in an intervention group that replaced academic time with PE time (Sallis et al. 1997). In another study, an aerobic dance intervention with high school girls resulted in a significantly greater decrease in body weight, whereas body weight in the control group remained unchanged (Viskic-Stalec et al. 2007).

Due to concerns regarding loss of academic time as a result of greater involvement in PE classes and activities, numerous studies have investigated the positive effects of physical activity involvement on academic achievement and classroom behavior (Carlson et al. 2008; Coe et al. 2006; Nicholson et al. 2011; Sallis et al. 1999). Research with adults and animals has suggested that exercise results in an increase in oxygen levels to areas of the brain that support memory and learning (Hillman, Erickson, and Kramer 2008). Adults have shown improvements in cognitive functions such as processing speed and memory tasks, and animal research gives insight into which neural sights may be activated and nourished during physical activity. Tompsonowski et al. suggest that exercise has similar

cognitive effects for children (Tomporowski et al. 2008). Other studies have shown that children that replace some percentage of their time spent in academic activities with physical activity have comparable levels of academic achievement to children that did not replace academic time with physical activity (Viskic-Stalec et al. 2007). These results suggest that physical activity might improve the efficiency of learning, but more importantly does not adversely impact academic achievement.

The effects of physical activity on classroom behavior and academic engagement have also been investigated. For example, children with autism spectrum disorders (ASD) were found to exhibit higher levels of classroom engagement following a 20-min aerobic exercise routine that preceded instruction (Nicholson et al. 2011). Providing further support for the positive effects of physical activity on student engagement, children that were deprived from recess for longer periods of time showed more inattention, as measured by gaze directed at the teacher during instructional time before recess (Pellegrini, Huberty, and Jones 1995). Collectively, data from studies measuring academic achievement and classroom engagement suggest that increasing physical activity in the school setting is an important way to combat sedentary behavior and to improve the physical health of children without compromising students' academic achievement.

To achieve the childhood obesity-related objectives set by *Healthy People 2020*, some researchers have suggested increasing the amount of movement in the classroom as a method of combating sedentary behaviors and increasing caloric expenditure in children (Ogden et al. 2012; Pellegrini, Huberty, and Jones 1995; Lanningham-Foster et al. 2008; Donnelly et al. 2009). Cardon et al. found that children in traditional seated classrooms spent, on average, 97% of their day seated (Cardon et al. 2004). By increasing non-exercise activity thermogenesis (NEAT), research suggests that children can expend small amounts of energy that will facilitate a meaningful increase in caloric expenditure (Naylor et al. 2008). NEAT is the small amount of energy expended while doing daily tasks such as walking, standing, working (Levine et al. 2006). Biddle et al. found that some children exhibit large amounts of active (moderate and vigorous) and sedentary behaviors throughout the day, thereby suggesting there is sufficient time for both activities in the day. He concluded that increasing moderate and vigorous physical activity alone may not be sufficient to target sedentary behavior (Biddle, Gorely, and Stensel 2004). Interventions aimed at making classrooms more active are favorable because they allow for direct replacement of sedentary behavior with active behavior. Increasing physical activity may also be beneficial for learning because it allows children to be physically active while academically engaged.

To increase activity in the classroom, student desks have been altered to allow children to expend more energy during instructional activities and academic assignments. One such alteration involves allowing children to stand at their desk (Benden et al. 2011, 2012, 2013; Koepf et al. 2012). Benden et al. have shown that stand-biased desks result in statistically significant improvements in the energy expenditure of children during the school day and cause no discomfort to students (Benden et al. 2011, 2012, 2013; Koepf et al. 2012; Blake, Benden, and Wendel 2012). Stand-biased desks also do not appear to adversely impact student achievement, as there have been no significant adverse changes in 6th grade students' academic achievement when stand-biased desks are installed in classrooms, suggesting that the desks are not distracting to children (Koepf et al. 2012). The extant literature suggests that stand-biased desks aimed at reducing sedentary behavior by replacing it with more active behaviors have positive health benefits for children. Although there appear to be no adverse effects of standing behavior on students' academic achievement, the extent to which standing might have positive effects on

students' academic engagement has been largely unexplored. In a qualitative study examining the utility of stand-biased desks and consumer's perspective (i.e., classroom teachers) on the usability of stand-biased desks, Blake et al. found that many teachers associated stand-biased desks with improvements in students' attention and focus (Blake, Benden, and Wendel 2012).

The purpose of this study is to investigate the effects of standing behavior on student engagement in elementary classrooms by comparing classrooms that adopted stand-biased desks to classrooms that utilized traditional seated desks and chairs. Given research suggesting that physical activity, even at low levels, may provide both physical and cognitive benefits to children, it is possible that these cognitive benefits may be attributable to students' increased ability to sustain attention because the children have an opportunity to expend excess energy through physical activity while maintaining cognitive focus on classroom tasks. This study is an exploratory study that seeks to investigate the possible relationship between physical activity and classroom engagement.

Methods

Subjects

The sample consisted of 282 2nd, 3rd, and 4th grade students from 3 schools that participated in a larger study on the physiological effects of a stand-biased desk intervention. Classroom teachers ($n = 24$) who were identified by the school principal as being willing to participate in the study were recruited for their classroom to participate in the study through an informational meeting of grade level teachers. The teacher consent rate was 100%. Parent consent for student participation in the study was obtained through methods consistent with Institutional Review Board procedures. Letters explaining the study and its purpose were sent home to parents within a general start-of-the-year packet sent with students in September. Parental consent was obtained following a presentation about the study during parent orientation meetings at the start of the school year. Descriptive statistics for the final study sample ($N = 282$) are shown in Table 1.

Instruments

Behavioral observations of students in schools (BOSS) (Shapiro 2010). The BOSS was administered to assess the frequency in which students displayed active engagement (e.g., answering a question, raising a hand, participating in active discussion), passive

Table 1. Baseline characteristics and behavior measures for students participating in the study, expressed in means (standard deviation) or percentages.

	Treatment, $n = 158$	Control, $n = 124$
Female (%)	51.27	55.28
Grade 2 (%)	35.44	43.55
Grade 3 (%)	45.57	33.87
Grade 4 (%)	18.99	22.58
Black (%)	11.54	14.17
Hispanic (%)	10.90	10.00
Asian (%)	5.77	10.00
White (%)	71.29	66.83
Total engagement	41.9 (7.4)	37.6 (9.1)

engagement (e.g., attentive toward the lesson but the child does not take an active role in instructional activities), and off-task behavior in class. The BOSS uses time-sampling to record the frequency of behaviors that students exhibit within a 15-s interval. For this study, each student was observed for 12 min on a single day (48 15-s intervals). The BOSS is intended for practicing clinicians as a diagnostic tool to aid in treatment planning, but has been used in several research studies with success and adequate reliability (Nicholson et al. 2011; Vile Junod et al. 2006; Volpe et al. 2005; Amato-Zech, Hoff, and Doepke 2006; DiPerna 2006). The BOSS is scored by counting the total number of behaviors observed in each category, and dividing each total by the total number of intervals the child was observed. For this study, students' total engagement in class was calculated by averaging students' passive and active engagement scores. The inter-observer reliability as measured by the intra-class correlation was adequate and ranged from 0.81 to 0.90 for the fall and spring semesters of a single academic year.

Procedures

Participating schools used a team approach for instruction, in which one teacher instructed Science and Math and the other taught English and Social Studies. This team-teaching required students to switch classrooms twice each day to receive their lesson from the appropriate teacher. To address this potential confounder, teams of teachers rather than individual teachers were randomly assigned to either the treatment or control condition. Stand-biased desks and stools were installed in the treatment classrooms before the start of the school year and adjusted to a standard height for students' age group. Once school started, the furniture was adjusted to the unique height of each student.

Before data collection, 10 undergraduate research assistants were trained in the BOSS observation protocol and scoring procedures using a standardized training protocol. Research assistants had to achieve a 90% coding accuracy of videoed classrooms in order to engage in live training within participating classrooms. Live observational training served two purposes: to increase research assistants' accuracy in observing participants' behavior and to help the student participants with becoming acclimated to the presence of observers. The observers were paired and assigned to a classroom team in each grade for each school. All observers were blinded to the purpose of the study. Observations were conducted over a 3-week period at each school. Target students were identified with the assistance of teachers and by having students wear nametags for the first few weeks of school. Observations were conducted twice per week in 90-min intervals in the mornings during instructional time in the fall and spring. Each participating student was observed for 12 min on 1 day in the fall and 1 day in the spring.

Data analysis

Before performing formal statistical analysis, descriptive statistics and frequency tables were analyzed to examine the demographic characteristics of the sample. Missing data were then documented and examined.

Behavior performance measures are often correlated among students in the same classroom due to the effects of shared environment, particularly the teacher. The data are measured longitudinally for each of the variables of interest, once in the fall and once in the spring semester. In order to account for both the nested and longitudinal nature of these data, a random effect model (Laird and Ware 1982), also known as a hierarchical linear model, was used to examine whether the stand-biased desks impacted students' academic

engagement. The child and classroom were included in the model as random effects. The fixed effects (covariates) include treatment assignment, time, interaction between treatment and time, and other baseline covariates such as gender, grade level, race/ethnicity, and their interaction with the treatment, if necessary. All data analyses were conducted using SAS statistical software.

Results

Among the 282 participants who had behavior measurements in the fall, 158 were assigned to the stand-biased desks (treatment group) and 124 were assigned to the traditional desks (i.e. control group). The average total engagement score is higher for the treatment than the control group for the fall. The mean and standard error plots for the total engaged time (avgTotEng), for different treatment groups at fall and spring are shown in [Figure 1](#).

The SAS procedure Proc Mixed was used for performing the main analysis, and results are shown in [Table 2](#). The treatment group exhibited greater levels of academic engagement than the control group in the fall, with a statistically significant difference of the average total engagement score of 4.21 ($p = 0.003$) noted. In the spring semester, the control group showed a greater increase in academic engagement relative to the treatment group. Although the treatment effect on academic engagement is attenuated somewhat in the spring, the treatment group still evidenced a greater academic engagement in the spring, with the difference of the score being $4.21 - 3.49 = 0.72$. Females have an

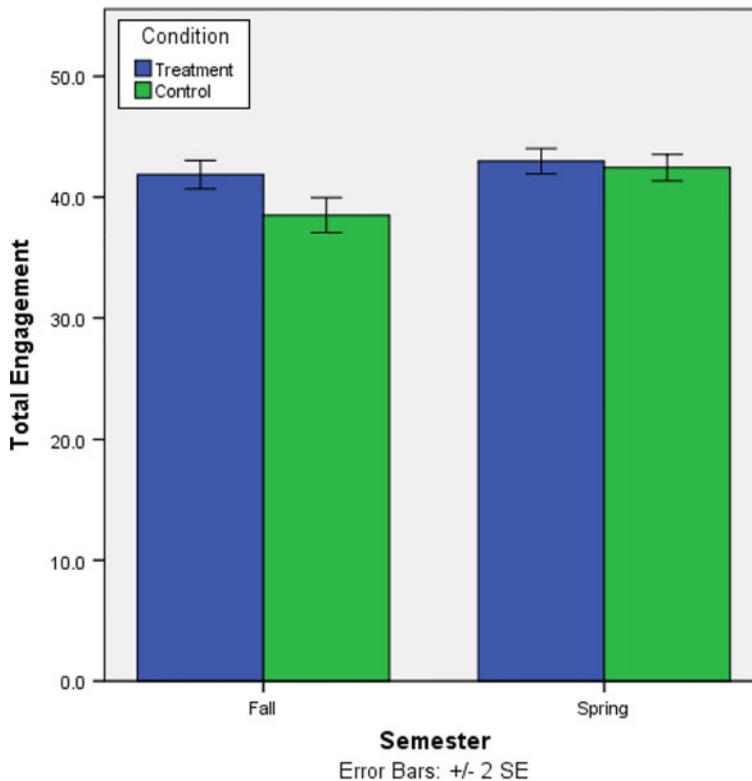


Figure 1. The means and standard errors for the total engaged time, at different times and for different groups.

Table 2. Results from mixed effect model examining the effects of covariates on the total engaged time.

Covariate	Coefficient	SE	P-value
Intercept	36.55	1.36	<0.0001
Treat	4.21	1.40	0.003
Time	4.70	0.87	<0.0001
Treat*time	-3.49	1.16	0.003
Female	2.07	0.61	0.0007
Black	-1.61	0.98	0.10
Hispanic	-0.18	1.03	0.86
Asian	2.04	1.18	0.09
Grade 2	-1.20	1.40	0.39
Grade 4	2.28	1.73	0.19

Note: White students are the reference group for racial/ethnic analyses.

estimated higher academic engagement score of 2.07 ($p = 0.0007$) than males. None of the other covariates were statistically significant; however, from the estimated coefficients, Black students exhibited lower levels of engagement than White students with the difference being 1.61 ($p = 0.10$). Hispanic students had similar scores of total engagement relative to White students, but Asian students had a higher engagement score of 2.04 than did White students ($p = 0.09$). Second graders' engagement score of 1.20 was lower than third graders ($p = 0.39$), and the fourth graders have a higher score of 2.28 than third graders ($p = 0.19$).

Discussion

Implications for school engagement

The purpose of this study was to examine the effect of stand-biased desks on student classroom engagement. The findings indicate that students provided with stand-biased desks did not decrease in their academic engagement in the classroom when compared with their seated counterparts. The significance of this finding is twofold. First, the effects of active classrooms on academic engagement and academic performance have been largely unexamined until now; thus, this research makes an important contribution to the existing knowledge base. Second, the results of this study document that the use of stand-biased desks in classrooms does not seem to disrupt students' level of engagement, allowing schools to address childhood obesity and energy expenditure without negatively academic performance. The study suggests that stand-biased desks do not create a distraction in the classroom with elementary school children, which extends the findings of Koepp et al. research (Koepp et al. 2012).

Limitations and future directions

Although careful consideration was given to the study design, results of this study should be evaluated in the context of study limitations. First, the student participants represented three grade levels from three schools in one suburban school district. While the participating schools were demographically diverse, additional research should examine effects in more rural and more metropolitan schools to enhance the generalizability of the findings. Second, students were observed for 2 days. Although it is possible that observing

students for this period may not have fully captured students' engagement behavior, this length of observation is common for clinical practice. However, future research should examine students' engagement over time and for longer intervals in order to be sure the level of engagement assessed provides an accurate reflection of student's academic engagement in class.

Conclusion

In conclusion, these findings yield promising results surrounding the use of stand-biased desks in elementary classrooms in that these desks do not appear to adversely affect students' academic engagement. Given research that suggests that stand-biased desks might be useful in combating childhood obesity, school health professionals might want to consider the incorporation of these desks in elementary classrooms to increase the physical health of students while also enhancing learning.

Human subjects approval statement

This study was approved by the Texas A&M Institutional Review Board and the review board of the participating school district.

Disclosure statement

No potential conflict of interest was reported by the authors.

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