Use of Stand-Biased Desks to Reduce Sedentary Time in High School Students: A Pilot Study

Adam W. Pickens*, Mark E. Benden, Drew E. Schneider and Hongwei Zhao

Environmental and Occupational Health Department, Texas A&M School of Public Health, 1266 TAMU, College Station, TX 77843-1266, USA

Abstract: *Background*: The purpose of this pilot study was to identify differences between sitting and standing time in high school students' pre and post stand-biased desk intervention.

Methods: ActivPal3™ activity monitors were affixed to 25 Bryan Collegiate High School students' to monitor their standing time and activity levels. Data were collected at the beginning of the school year (fall) in traditional seated desks and in the spring in stand-biased desks. After attrition, 18 of the original 25 students were included in the final analysis. The physical activity data (steps) as well as standing and sitting time data provided by the monitors was used for within subject intervention analyses.

Results: Descriptive statistics and a two-sided t-test were used to analyse differences between pre and post intervention sitting and standing times. Analysis indicated a significant reduction of sitting time post stand-biased desk intervention ($p<0.0001$) and a significant increase in standing time, post stand-biased desk intervention ($p<0.0001$). Analysis also revealed a non-statistically significant ($p < 0.0619$) average increase of 2,286 steps per school day when comparing mean steps pre-intervention (6,612) and post-intervention (8,898).

Conclusions: Standing desks have the potential to reduce sedentary behavior and increase light to moderate physical activity for high school students during the school day.

Keywords: Sedentary behavior, stand-biased desk, high school students.

BACKGROUND

Sedentary behavior has been linked to increased rates of obesity in adults, adolescents and children. These behaviors include sitting, sleeping, and lying down. The more sedentary behavior a person engages in, the harder it is to balance the calorie/energy expenditure equation. When a person consumes more calories than they expend, weight gain is one of the inevitable consequences [1-3]. In adults, sedentary behavior has been closely linked to increased morbidity and mortality rates [4]. In children and adolescents, research is showing similar trends. Children and adolescents tend to struggle with calorie intake regulation because they have less control over their diet than adults. In fact, it has been found that as sedentary behavior in children increase, the amount of calories consumed increases [5]. In school environments, with the widespread reduction of physical education classes and the increased emphasis on standardized test scores, students face extended periods of inactivity and sedentary time [2,6].

With the work from the research community clearly defining the negative effects of sedentary behavior, schools have begun implementing methodologies to reduce this behavior in school-aged children. Previous work done by the research team has sought to counter the negative effects of these trends in school-aged children with a primary focus on sedentary behavior, academic engagement, and posture [7-11]. The focus of this work is to assess impacts of stand-biased desks on increasing physical activity (PA) and reducing sedentary time on high school adolescents.

METHODS

This project utilized a pre/post intervention within-subjects study design similar to previous successful efforts [7,9]. This design assists in isolating the stand-biased desk's effect on PA and sedentary behavior. All data collection procedures were approved by Texas A&M IRB (TAMU-IRB) and the Bryan Independent School District for data collection at Bryan Collegiate High School in Bryan, TX. All subjects were paid $25 pre-intervention and post-intervention for their participation in the data collection using wearable monitors.

One hundred high school students were recruited as part of a larger study using informative handouts, explicitly detailing all requirements of participating in the study, distributed by teachers. Parental permission forms were required for participation. In total, 25 students were randomly selected of those who volunteered to participate in this portion of the study.

*Address correspondence to this author at the Environmental and Occupational Health Department, Texas A&M School of Public Health, 1266 TAMU, College Station, TX 77843-1266, USA; Tel: 979-436-9331;
E-mail: pickens@tamhsc.edu

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Pre-Intervention Data Collection

All study participants in the pre-intervention portion used traditional seated tables and chairs in their classroom and data were collected in the fall semester. Subject height and weight were recorded prior to the use of a wearable monitor to track subject activity. Height was recorded in centimetres using a portable stadiometer (Charder, HM-200Portstad, Taichung City, Taiwan) and weight was recorded in kilograms using an electronic weight scale (A&D Medical, UC-321 ProFIT Precision Personal Health Scale, San Jose, CA). The wearable monitor utilized in this study was the ActivPal3™ posture monitor (PAL Technologies, ActivPal3™, Glasgow, UK). The ActivePal3™ monitor is a fifteen-gram, 53x35x7 millimetre activity monitor that is affixed to the front mid-point of the participant's thigh. The ActivPal3™ monitor uses a 3-axis accelerometer (movement), an inclinometer (posture), and a series of proprietary algorithms to monitor and record subject movement throughout an assigned period of time. For this study, sitting time and standing times as well as step count were assessed. The ActivPal3™ was affixed to the subject's thigh using a water-tight finger cot and sealed in Tegaderm™ film (3M Company, Tegaderm Film, Maplewood, MN). Based on success in previous work that showed representative samples could be taken over three days of school [8,9]; monitors were worn for seventy-two consecutive hours, providing three days of uninterrupted data collection.

During the winter break, stand-biased desks were installed and adjusted to heights between 92-112 cm in order to accommodate student statures. After a 3-month acclimation period, a researcher returned in March and followed the same protocol as during the pre-intervention data collection. Tables and chairs (Virco Inc.) were converted to standing desks and stools (Stand2Learn, Inc.) for all grades and all students. In that sense, all 450 students in the school participated in the intervention with a random subset participating in the monitoring portion of our study.

Data Analysis

Data were truncated into 22 individual hourly breakdowns of PA and sedentary behavior. These 22 hourly segments represented the hourly data points of school time for each participant (defined as between 8am and 4pm). The data categories for this pilot study, as based on the data collected by the ActivPal3™ were "Time Sitting", "Time standing" (both values in minutes) and "Steps"(in number).

Participant data were analysed using the statistical software SAS (9.3)™ and basic analysis was preformed using Excel™. The dependent variables in this study were time sitting during school hours, time standing during school hours, and step count during school hours observed over 3 school days (22 hours). The independent variable for this study was desk type (seated and stand-biased, or pre and post intervention). The study design used for this research was pre intervention and post intervention within-subjects design. The difference between the pre and post-intervention for the dependent variables was calculated and used as the primary basis for analysis. A two-sided Paired T-test was used to identify any statistically significant changes from the pre and post intervention time periods.

RESULTS AND DISCUSSION

Distribution analysis of the data revealed that there were no outliers. However, seven participants had to be excluded from the original twenty-five participants. Two participants left the school, preventing post intervention data from being collected. One participant was excluded because of an ActivPal3™ malfunction during pre-intervention data collection. Two participants were excluded because of non-compliance in the pre-intervention portion of the study. Two participants were excluded because of non-compliance during the post intervention data collection period. Non-compliance was defined as three or more consecutive school hours with no movement recorded. In total, there were 13 female and 5 male subjects. Demographically, there were 12 Hispanic and 6 White/Non-Hispanic subjects.

Results indicate that 17 of the 18 subjects reduced their overall sitting time (on average 78.2% to 65%) and 16 of the 18 subjects increased their overall standing time post stand-biased desk intervention (on average 15.4% to 26.7%). The hour-by-hour averages of the 18 participants showed that with the exception of the 11am period, students sat less and stood more after the stand-biased desks were installed. This is unique because students were in the cafeteria during lunch break and were required to sit at standard lunch tables pre and post intervention (Figure **1**).

Paired T-test results (Table **1**) on the mean difference in sitting minutes between pre and post intervention was -174.8 minutes ($p < 0.0001$). Overall, over the 22-hour school day period, students, on average, sat approximately 3 fewer hours after the stand-biased desk intervention (approximately 1 hour

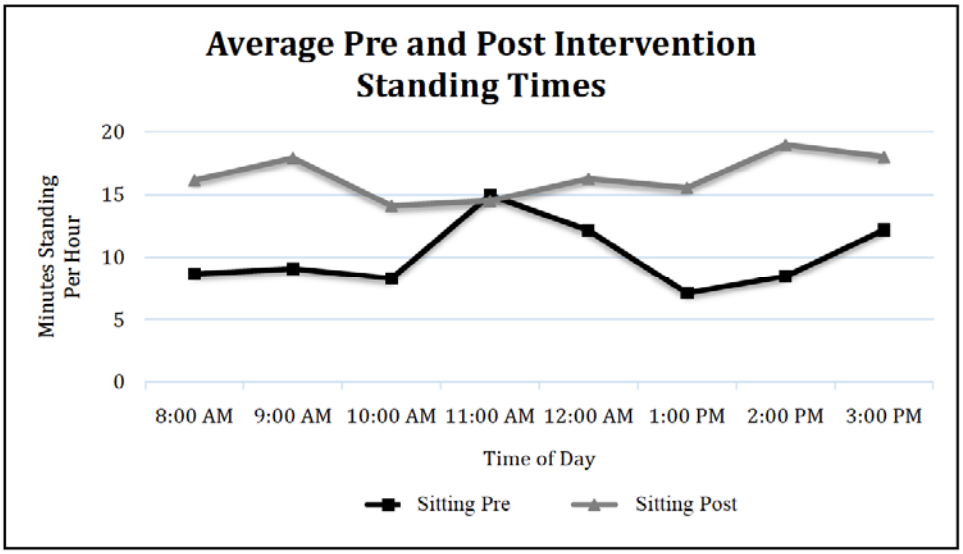

Figure 1: Average Pre and Post Intervention Standing Times.

Table 1: Sitting and Standing Results for Pre and Post-Intervention Observed Over 3 School Days (22 Total Hours)

N=18	TOTAL TIME (minutes)		Δ	Std	t-Value	P-Value
	Pre-Intervention	Post-Intervention				
Sitting	1032.4	857.6	-174.8	126.6	-5.86	<0.0001*
Standing	203.7	353	149.3	113.9	5.56	<0.0001*
Steps	6611.6	8898.4	2286.9	4855.0	2.00	0.0619

less per school day). Additionally, over that same 22-hour time period, the post-intervention mean difference of 149.2 minutes standing was a significant increase over the pre-intervention standing time.

On average, students stood approximately 50 minutes more per school day ($p < 0.0001$). These differences in the means for sitting and standing could potentially be attributed to additional walking time at their workstations post-intervention. The mean for steps pre-intervention was 6,612 and post intervention it was 8,898. This difference (2,286) was not statistically significant ($p < 0.0619$).

CONCLUSIONS

Sedentary behavior has been identified as a significant factor in childhood and adolescent obesity. Janssen *et al*. [6] found that, in countries with lower physical activity levels and higher television viewing times youth tended to be more overweight.

This study examined the impact of standing desks on the sedentary behavior of high school students during the school day. The data indicate approximately a 17% reduction in sitting time post intervention for the students sampled. The data also indicate approximately a 73% increase in standing time for the study population. Overall, there was an observed and statistically significant decrease in sedentary time and a corresponding statistically significant increase in standing time for high school students after the stand-biased desks were installed in their classrooms. Additionally, an average increase of 2,286 steps per school day was seen post intervention in the number of steps taken by our study population. Although this amount did not prove to be statistically significant for this sample size, we hold that there is a clinical relevance to this change. With a larger sample size, this change would have greater potential to move from clinical relevance to statistical significance from an energy expenditure perspective. It is well known that 100 calories of energy expenditure falls between 2,000 and 3,000 steps [12]. This amount of additional energy expenditure would be very important in the fight against obesity.

The fact that childhood and adolescent obesity is correlated with low activity levels should not be surprising. Cutting an hour of sedentary behavior during the school day while simultaneously increasing

their steps taken, without taking away from instruction time, requiring additional school personnel or additional training is an easy way to help adolescents reduce, or even reverse the effects of sedentary behavior.

CONFLICT OF INTEREST STATEMENT

Mark Benden declares a financial conflict of interest since his US patented designs have been licensed by Texas A&M University to Stand2Learn, and those designs were present on desks used for this study. The work was funded as part of a CDC grant, "*Development of a Stand-Biased School Desk to Reduce Childhood Obesity*." 2R44DP003339-02.

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