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A classroom-based physical activity intervention for adolescents: Is there an effect on self-efficacy, physical activity, and on-task behavior?

background
Classroom-based physical activity is a newly explored avenue for providing physical activity opportunities to children within the school, but it is one that is showing academic gains in areas such as on-task behavior. The purpose of this study was to explore the impact of pedal desks placed in high school classrooms. Three main objectives were examined: 1) the possible increase in physical activity self-efficacy among high school students in the classroom, 2) the effectiveness of pedal desks on increased physical activity among high school students, and 3) the impact of pedal desks on increasing classroom on-task behavior.

participants and procedure
Participants included 114 high school students in a traditional high school setting. All of the students were enrolled in two Reserve Officers' Training Corps (ROTC) teachers' classrooms. The design was quasi-experimental. Two teachers and their respective classes were randomly assigned to a treatment or control group. The study included a baseline and 2 waves. Researchers gathered demographic information of students, as well as pre- and post-data on self-efficacy and physical activity participation. On-task behavior of students was also recorded daily by researchers via momentary time sampling.

results
The results indicated significance for self-efficacy confidence but not barriers to physical activity participation. When examining whether self-efficacy could be connected to student heart rate, no significance was found. However, treatment students did improve their mean heart rates from baseline to treatment. This increase was significantly greater when compared to the control group.

conclusions
This study indicates that pedal desks may be one means for feasibly increasing light physical activity during the school day. This study suggests that self-efficacy for exercise can be increased and that light intensity physical activity levels may be raised through placing pedal desks in a high school classroom. Limitations are discussed.

key words
exercise; adolescents; self-efficacy; academics; on-task behavior

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BACKGROUND

Less than one-third of school-age youth meet the 60-minute daily recommendation of physical activity (Centers for Disease Control and Prevention [CDC], 2015; World Health Organization [WHO], 2016). This proportion declines as children mature, with only an estimated one-quarter of high school students reporting that they reach daily physical activity (PA) standards (CDC, 2015) and as many as 15% of adolescents reporting that they have not performed 60 minutes of daily activity in the past week (CDC, 2015). It was also found that the prevalence of overweight and obesity in children had more than doubled in children and quadrupled in adolescents in the past three decades (CDC, 2017). These statistics occur despite common knowledge of physical health benefits of PA, including a reduction in body mass index (CDC, 2015; WHO, 2016). Research now shows that the benefits of PA may extend to other healthy living domains, specifically cognitive benefits such as academic achievement and on-task behavior. At present, most of the research literature has targeted elementary students (e.g., Donnelly et al., 2009; Kibbe et al., 2011; Mahar et al., 2006; Mura, Vellante, Nardi, Machado, & Carta, 2015; Pontifex, Saliba, Raine, Picchietti, & Hillman, 2013); however, a need exists to further explore the impact of physical activity on adolescents given the significant decline in activity levels as children reach adolescence coupled with preliminary PA research indicating that adolescents benefit cognitively as well as physiologically (e.g., Ardoy et al., 2014; Booth et al., 2013; Chang, Labban, Gapin, & Etnier, 2012; de Greeff, Bosker, Oosterlaan, Visscher, & Hartman, 2018; Singh et al., 2019).

ESTABLISHED BENEFITS OF PHYSICAL ACTIVITY

Documented physical and mental health benefits exist for PA (CDC, 2015; Kohl & Cook, 2013; Marques, Santos, Hillman, & Sardinha, 2018). Physical activity aids in the building and sustaining of healthy bones and muscles and decreases the risk for obesity and chronic diseases such as diabetes, cardiovascular disease, and colon cancer (CDC, 2015; Kohl & Cook, 2013). Psychosocial health benefits exist for PA as well, including increased self-efficacy, self-concept, and self-worth (Haugen, Säfvenbom, & Ommundsen, 2011; Huang et al., 2012); social behaviors (Cradock, Kawachi, Colditz, Gortmaker, & Buka, 2009; Ledford, Lane, Shepley, & Kroll, 2016); pro-school attitudes, motivation, and goal orientation (Digelidis, Papaioannou, Laparidis, & Christodoulidis, 2003; Owen et al., 2016); as well as connectedness and friendships (de la Haye, Robins, Mohr, & Wilson, 2011; Macdonald-Wallis, Jago, Page, Brockman, & Thompson, 2011). By contrast, sedentary behaviors such as sitting and watching television elevate health risks both due to and independently of their influence on physical activity (Kohl & Cook, 2013).

The benefits of physical activity may extend beyond the medical and mental health professionals' offices and into the school classrooms as well. The Centers for Disease Control (CDC) has publicly acknowledged that physical activity may help enhance academic achievement in the form of testing and grades, academic behavior (i.e., time on-task), as well as other areas that influence academic achievement, such as classroom alertness and attentiveness (CDC, 2015). These benefits occur independently of weight status (Davis, Tkacz, Tomporowski, & Bustamante, 2015) and account for both short- and long-term gains (Booth et al., 2013; de Greeff et al., 2018; Sardinha et al., 2016; So, 2012; Staiano, Abraham, & Calvert, 2012).

EFFECT OF PHYSICAL ACTIVITY ON ACADEMIC ACHIEVEMENT

Experimental intervention studies find that elementary and middle school students who engage in more vigorous activity attain higher grades and achievement (Caldas & Reilly, 2019; De Bruijn et al., 2020; Donnelly & Lambourne, 2011; Fedewa & Ahn, 2011; Lambourne et al., 2013) and similar results have been found for adolescents as well (Kwak et al., 2009; Ruiz et al., 2010; Snelling, Belson, Beard, & Young, 2015). Howie, Schatz, and Pate (2015) found a moderate improvement in math performance in 4th and 5th grade students (n = 96) after both 10- and 20-minute exercise breaks, while another randomized controlled study found positive effects for 3rd to 5th grade math and reading achievement using 5 minutes of classroom-based exercise breaks interspersed 4 times throughout the academic day (Fedewa, Ahn, Erwin, & Davis, 2015). Ardoy and colleagues (2014) explored the impact of exercise on adolescents (n = 67), increasing the time and intensity of physical education classes using a 4-month group-randomized control trial and found positive outcomes for nonverbal and verbal ability, abstract reasoning, spatial and numerical ability, as well as an improvement in school grades. Additionally, Pontifex and colleagues (2013) extended the literature in finding physical activity benefits for mathematics and reading performances for both typically developing children and children with attention-deficit hyperactivity disorder (ADHD). Meta-analytic reviews support academic achievement gains due to physical activity as well. Strong evidence (Singh et al., 2019) and small-to-medium effects (Chang et al., 2012; Fedewa & Ahn, 2011) have been found for physical activity on children's cognitive outcomes and academic achievement.

EFFECT OF PHYSICAL ACTIVITY ON BEHAVIOR

The effect of exercise on children's attention-to-task is another area that has been explored and has shown promise from several studies to date (e.g., Janssen et al., 2014; Mahar, 2011; Mavilidi et al., 2020; Webster, Wadsworth, & Robinson, 2015). Mura and colleagues (2015) found in a systematic review of 31 studies that embedding PA into the classroom may have positive links to student attention and concentration. Independent studies mirror these findings. For example, Ma and colleagues (2014) explored the impact of FUNtervals (i.e., brief high-intensity intervals that follow an interactive storyline) on 3rd to 5th grade student attention. The results showed that children decreased their errors on the d2 assessment after FUNtervals more so than the control group. Mahar and colleagues (2006) examined the impact of 10 minutes of daily classroom-based physical activity (i.e. energizers) on 3rd and 4th grade students and found that the intervention improved the amount of accumulated PA as well as the on-task engagement of children. Additionally, neurological research found that 8- and 9-year-old children who engaged in a 9-month physical activity intervention had increases in attention tasks, work completion, and lesson comprehension compared to a control group (Chaddock-Heyman et al., 2015). Research indicates that single bouts of physical activity can increase attention (Janssen et al., 2014; Podnar, Novak, & Radman, 2018; Pontifex, Scudder, Drollette, & Hillman, 2012), improve working memory (Benzing, Heinks, Eggenberger, & Schmidt, 2016; Pontifex, Hillman, Fernhall, Thompson, & Valentini, 2009) and enhance academic learning time while simultaneously decreasing off-task behaviors (Mahar et al., 2006; Bartholomew & Jowers, 2011; Webster et al., 2015).

THEORETICAL BASIS

Social cognitive theory uses cognition to explain human behavior through personal (e.g., cognitive, affective, biological), environmental (i.e., physical structures and the presence or absence of relationships) and behavioral factors (i.e., actions and habits) that interact in a triadic, reciprocal relationship (Bandura, 1977, 1986, 1997, 2001). Through Bandura's social cognitive theory (Bandura, 1977, 1986, 1997, 2001), providing a setting that permits access to and encouragement for physical activity participation from teachers, peers, and through personal goal setting, students may increase their self-efficacy beliefs for physical activity, thereby increasing their daily physical activity practices, and, ultimately, their academic achievement. Individuals' self-efficacy beliefs govern their level of motivation, which is shown in the amount of effort expended in an activity and the amount of perseverance that ensues in the face of obstacles (Bandura, 1989). Those who have high self-efficacy tend to perform well, try novel behaviors, and work harder on those behaviors by setting challenging but realistic goals (Gao, Xiang, Lee, & Harrison, 2008). In contrast, those with a low self-efficacy may not even engage in an activity due to a perceived lack of skill or knowledge (Gao et al., 2008). Considerable evidence exists for a relationship between physical activity and increased self-efficacy (Cetinkalp & Turksoy, 2011; Komarraju & Nadler, 2013; Wang & Zhang, 2016). Gao, Lee, Xiang, and Kosma (2011) found that higher physical activity self-efficacy predicted moderate-to-vigorous PA in middle school children (N = 225) and was reflective of more effort and persistence in physical education classes. Supporting this study, Kenyon and colleagues (2012) found that self-efficacy for physical activity partially mediated the relationship between perceived barriers to PA (i.e., lack of time and feeling tired) and levels of PA among alternative high school students. Longitudinal research has also examined this relationship with students transitioning from elementary to middle school (N = 857), a time when PA commonly decreases for youth (CDC, 2015); the study found that the PA drop was smallest for students who had less of a decline in physical activity self-efficacy (Dishman, Dowda, McIver, Saunders, & Pate, 2017). Thus, it is plausible that in increasing PA self-efficacy, the duration and effort (i.e., heart rate) children exert in PA may increase as well.

Based on previous literature, embedding physical activity into an adolescent classroom offers an opportunity to increase PA within the school day by enhancing students' self-efficacy beliefs for engaging in it (Annesi, Westcott, Faigenbaum, & Unruh, 2005; Gao et al., 2008; Hortz & Petosa, 2006). For one, research has shown that youth will engage in PA if given a conducive opportunity to participate in it (Mahar, 2011). Within the classroom, too, students will have access to verbal persuasion from their teacher and peers to engage in physical activity (Huang et al., 2012), which has also been linked to gains in PA (Beets, Pitetti, & Forlaw, 2007; Gao, 2012; Huang et al., 2012). Encouragement from friends has been linked to increases in physical activity in other literature as well (Maturo & Cunningham, 2013; Verloigne, Cardon, De Craemer, D'Heese, & De Bourdeaudhuij, 2016). Further, within the academic classroom, PA is offered as a low-stakes activity since academic performance, not PA, is what is being assessed by the teacher (Lodewyk & Sullivan, 2016). Finally, through cognitive personal goal-setting, students can build self-efficacy by increasing their self-monitoring and self-judgments of their performances (Carroll, Gordon, Haynes, & Houghton, 2013; Dishman et al., 2004; Zimmerman, Bandura, & Martinez-Pons, 1992) as the stronger a child's perceived self-efficacy, the loftier the goals that the student will set for him- or herself and the stronger the commitment to the goals

(Bandura, 1989). Achieving these goals may lead to increases in on-task behavior (Kwak et al., 2009; Ruiz et al., 2010; Snelling et al., 2015).

PURPOSE

The purpose of this study is to explore the impact of pedal desks placed in a high school classroom. Bicycle pedal desks, rather than bicycle workstations, were placed underneath traditional desks allowing students to maintain their comfort and desk space while still increasing their physical activity. The primary research questions are three-fold: 1) Can physical activity self-efficacy be increased through placing pedal desks in a high school classroom? 2) Can placing pedal desks in a high school classroom increase adolescent physical activity? and 3) Can pedal desks placed in a high school classroom increase classroom on-task behavior? It was hypothesized that placing pedal desks in a high school setting and providing modeling, encouragement, and goal setting for their use would prompt students to increase their physical activity self-efficacy and, as a result, cause them to be accumulate significantly more physical activity compared to a control classroom. In addition, it was hypothesized that there would be an increase in on-task behavior, measured through observations, for students who have higher levels of physical activity.

PARTICIPANTS AND PROCEDURE

PARTICIPANTS

The study setting was an urban secondary school in the Southeast United States. The enrollment of the school consisted of approximately 2,300 students (50.6% male) with an ethnic demographic of 62.4% White, 22.3% African American, 6.5% Hispanic, and 5.1% Asian (Kentucky Department of Education, 2017). Approximately 40% of the students received Free or Reduced Lunch (Kentucky Department of Education, 2017). Participants were drawn from two Reserve Officers' Training Corps (ROTC) teachers' classrooms. The two teachers volunteered for the study and were randomly assigned to either the treatment or control group. Students were assigned to the treatment or control group based on their teacher's assignment. One teacher taught 5 classes each day, while the other taught 4 classes (totaling 9 different groups of students each day across the 2 teachers). Teachers taught lessons covering topics such as land navigation, geography, math, and military history 3 days a week; the other 2 days a week students were out of the classroom. Each class was an hour in length; approximately 20 students were in each section. After full approval from the University Institutional Review Board, parental consent forms were sent home to the students' parents. In total, 180 students were recruited for the study and parental consent and student consent and assent forms were given to both treatment and control students. In all, consent and assents were collected from 114 students (63% consent participation rate) across the 9 sections of classes. Of those 114 students, 67% were male, while 62% were White; 14% were African American, 14% were Hispanic, 7% were Asian, and 3% were multiracial. The mean age of the students was 16 (see Table 1 for additional participant demographics). On average, there were 13 students in each class period who had consent and participated in the study.

PROCEDURE

A quasi-experimental design was used for the study whereby two intact classrooms were randomly assigned to a treatment and a control condition. The timeline included observer and teacher training in August and 14 weeks of data collection beginning in August and concluding in December 2017.

Prior to data collection, training occurred through several means. Teachers were trained on how to provide appropriate feedback to students during the intervention using a teacher training handout on how to help students set specific goals, as well as on the logistics of the study itself (e.g., use and storage of pedal desks and heart rate monitors). The treatment teacher was given a set of explicit instructions to pedal for at least 10 minutes each class period, to encourage each class to pedal, to offer specific encouragement to individual students, and to note students' progress towards their weekly goals (Siegle & McCoach, 2007). After training, fidelity checklists were used with teachers once during each of the treatment waves (2 times total) to ensure that appropriate feedback with students was occurring (Howell & Hosp, 2014). This allowed for consultation to occur with the teacher when 100% fidelity was not reached. Researchers were trained on the protocol via video recordings prior to the beginning of the study. They were then paired with another researcher during the

Table 1

Descriptive statistics for the sample of high school subjects (N = 114)

	M	*SD*	Range	*N*
Age (years)	16.00	1.25	5.00	113
Grade	10.00	1.11	3.00	113
Height (in)	5.50	0.37	2.60	93
Weight (lbs)	142.61	30.46	134.00	94

first week of baseline data collection 100% of the time and paired with another observer during the second week of data collection 50% of the time to ensure inter-rater reliability. To avoid observer drift, reliability checks with the lead researcher occurred 25% of the time throughout the study (Mahar, 2011). Interrater reliability throughout the study was 90%, while κ coefficient suggested good agreement (.74).

Treatment students were given access to the bicycles 12 school days prior to data collection to allow participants to become accustomed to using the pedal desks and to avoid the novelty effect (Caldwell & Ratliffe, 2014). Students were also trained in using each of the instruments (i.e., heart rate monitors, pedal desks, cycling logs; Mahar, 2011). All students were given the opportunity to use a heart rate monitor and pedal desk, though survey data were only collected on those students with consent.

Data were collected during baseline and two additional waves. Data collection waves encompassed 2.5 weeks (3 days each week for a total of 7 school days). All students were provided with a pedal desk and the option to pedal during class. Students wore heart rate monitors around their wrists (described below) in both the treatment and control rooms to collect heart rate data; these data were collected on Physical Activity Logs. Students with consent using pedal desks also provided additional data on their Physical Activity Logs (i.e., miles, resistance level, physical activity time accumulated), created a 3-day goal on the first day of each wave (i.e., miles or time pedaled, calories burned, average heart rate, or resistance used), and indicated at the end of the 3 days whether they met their goal. They had two opportunities to make and achieve goals in each treatment wave (4 in total).

At baseline, all participants completed the Self-Efficacy Scale (SES), the Self-Efficacy for Exercise (SEE) scale, the Physical Activity Questionnaire for Adolescents (PAQ-A) and a participant demographic form described below.

At the beginning of class, the researcher handed students heart rate monitors and instructed participants to make sure that previous data had been cleared on the pedal desk screens. Students were prompted by the teacher to start the heart rate monitors and to pedal during instruction time. As instructed by the fidelity checklist, the teacher encouraged students to pedal throughout class and pedaled himself for a minimum of 10 minutes for each class period.

During the intervention, researchers assessed the on- and off-task behavior of 8 students per class (4 minutes per student) for an average of 30 minutes each class period. This amount of time was short enough to fit into the typical one-hour class periods, accounting for transitions, but long enough to capture the behaviors that were occurring (Lewis, Scott, Wehby, & Wills, 2014). Neither the teacher nor the participants knew which students were being observed at a given time (Whitcomb & Merrell, 2013); the researchers randomly chose the order of the students each day (Mahar, 2011). After each 5-second interval, the researcher had 5 seconds to record on a document whether the student was on-task (i.e., verbal and motor behavior that follows class rules and is appropriate to the learning situation), motor off-task (i.e., fidgeting, drawing, restless), noise off-task (i.e., talking to a peer or speaking out) or passive/other off-task (i.e., gazing off, no eye contact, head down). Researchers also recorded whether students were pedaling on the pedal desks. After 1 minute (6 observations), researchers rotated to the next student. Rotations randomly moved (Altman, 1974) from student to student 4 times until each student had been observed for a total of approximately 4 minutes (24 observations for each student). To diminish observer reactivity, observers entered and left the classroom during natural breaks in the schedule, brought few materials with them, and sat quietly out of the way of instruction (Whitcomb & Merrell, 2013). Due to the nature of the intervention (i.e., students pedaling during instructional time), it was not possible to blind observers to the purpose of the study (Whitcomb & Merrell, 2013).

MEASURES

Instruments used aligned with the proposed theoretical framework. Self-efficacy, physical activity, and classroom on-task behavior outcomes were measured (see Figure 1 for conceptual model).

Self-efficacy. The student participants' self-efficacy for PA was measured via two scales: the Self-Efficacy Scale (McAuley & Mihalko, 1998) and the Self-Efficacy for Exercise scale (Resnick & Jenkins, 2000). The Self-Efficacy Scale (SES) has 9 items that measure how confident students are to do 10, 30, and 60 minutes of light, moderate, and vigorous intensity activity on five or more days of the week. The scale was modified from a 10-point scale (0% – *not at all confident* to 100% – *completely confident*) to a 4-point scale (*I cannot do this* to *I can definitely do this*). Six different forms of the scale were distributed randomly to students to address validity in their responses since questions were sectioned off into sets of 3 (light, moderate, vigorous physical activity; Payne, 1971). A total average was calculated with higher scores reflecting more self-efficacy.

The Self-Efficacy for Exercise (SEE) scale has research supporting its internal validity and reliability (Resnick & Jenkins, 2000). It too has 9 items that measure the confidence students have to participate in physical activity given specific barriers (e.g. weather, boredom, stress). The scale was also modified from a 10-point scale to a 4-point scale (*not certain*, *slightly*

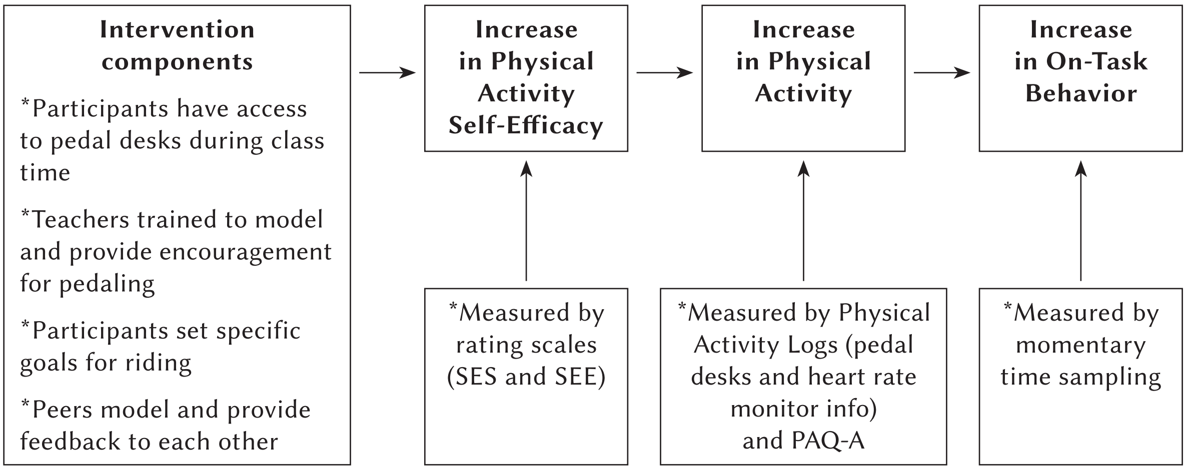

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Figure 1. Conceptual model of measurements and their alignment with the physical activity intervention.

certain, *moderately certain*, *very certain*). A total average was calculated with higher scores reflecting more self-efficacy.

Physical activity. The student participants' engagement and interest in PA was measured via the Physical Activity Questionnaire for Adolescents (PAQ-A). This 9-item measure prompts individuals to rate the amount of physical activity they have participated in over the previous 7 days. An overall mean score from 1 to 5 is calculated, whereby a higher score indicates more activity. It has been used in previous adolescent physical activity research (Crocker, Eklund, & Kowalski, 2000; Roberts, Maddison, Magnusson, & Prapavessis, 2010) and has been shown to have good internal consistency and acceptable validity (Janz, Lutuchy, Wenthe, & Levy, 2008).

Physical Activity Logs collected daily information from students including total riding time, miles pedaled, resistance, calories, and average heart rate. An area to create a weekly goal and to assess whether the goal was met was included for the treatment group as well.

The participants' daily heart rate was measured via a wrist-based heart rate monitor (Vivosmart HR). The Vivosmart HR (www.garmin.com) was chosen because it is considered valid and reliable in measuring heart rate data (Rozanski, Aqui, Sivakumaran, & Mansfield, 2018) and is easy to put on and take off in a classroom setting. Participants in both the control and treatment groups wore heart rate monitors during class and logged their data on the physical activity logs before class was dismissed.

The participants' amount of exercise was measured directly via the DeskCycle Desk Exercise Bike Pedal Exerciser (www.deskcycle.com). The pedal desk was chosen due to its ability to fit underneath adolescents' desks during the school day. Twenty-five pedal desks were provided to the treatment classroom. Each pedal desk captured riding time, miles pedaled, resistance, and calories. Participants in the treatment group recorded their daily data from the bicycle workstations on the Physical Activity Log before class was dismissed each day.

On-Task Behavior. On-task behavior was evaluated using systematic direct observation with momentary time sampling due to its efficiency and sensitivity to changes in behavior patterns (Hintze, 2005; Whitcomb & Merrell, 2013). Permission was given to use the protocol from Mahar and colleagues' (2006) study; previous research has achieved 90% (Stylianou et al., 2016; Webster et al., 2015) and 80% (Mahar et al., 2006) interobserver agreement with its use.

Based on the Mahar and colleagues (2006) protocol, momentary time sampling observations were used, which is supported in research as having more reliability and validity across observers than other types of observations (Rapp, Colby-Dirksen, Michalski, Carroll, & Lindenberg, 2008). Observations on the protocol were modified to occur at 5- instead of 10-second intervals to decrease the chance for unaccounted-for behaviors to occur and to increase the number of observations that happened in the time available (Gage, Prykanowski, & Hirn, 2014). In addition, an area to record whether treatment participants were pedaling on the bike was added. Intervals were signaled via the IntervalTimer app (www.play.google.com) for Android phones or the Simple Interval Timer (SIT) app (www.simpleintervaltimer.com) for Apple users; observers listened to the app with headphones to increase recording accuracy (Whitcomb & Merrell, 2013).

STATISTICAL ANALYSES

Data were generated using MPlus (version 6.1; Muthen & Muthen, 1998-2010) and SPSS Statistics (version 22). Descriptive data for survey data are shown

Table 2

Descriptives for survey data

	Control			Treatment		
	M	*SD*	Range	*M*	*SD*	Range
PA Pre Test	11.59	4.85	21.51	12.07	5.59	23.34
PA Post Test	9.61	5.40	17.88	12.49	5.81	23.31
SEE Pre Test	17.56	7.39	25.00	14.62	6.98	24.00
SEE Post Test	15.51	7.55	26.00	15.78	7.49	27.00
SES Pre Test	23.23	4.45	21.00	23.91	3.28	16.00
SES Post Test	23.80	3.67	13.00	22.70	4.36	17.00

Note. PA Pre Test – Pre Physical Activity Scale administration; PA Post Test – Post Physical Activity Scale administration; SEE Pre Test – Pre Self-Efficacy for Exercise scale administration; SEE Post Test – Post Self-Efficacy for Exercise scale administration; SES Pre Test – Pre Self-Efficacy Scale administration; SES Post Test – Post Self-Efficacy Scale administration.

in Table 2. Regression models were developed to predict the change in physical activity in the participating classrooms based on the residual change score for the Self-Efficacy Scale (SES), the Self-Efficacy for Exercise (SEE) scale, and the Physical Activity Questionnaire for Adolescents (PAQ-A). The intraclass correlation coefficient (ICC) was calculated for each scale, and in all cases was less than or around 5%, indicating that the nested data structure did not need to be addressed using multilevel modeling (Glaser & Hastings, 2011; Hayes, 2006; Kreft & de Leeuw, 1998). The design effects further supported this, as all estimates were less than 2, indicating that multilevel modeling was not necessary (Muthen & Satorra, 1995). See Table 3 for ICC and design effect figures. In addition, regression models were developed to predict the change in on-task behavior in participating classrooms based on physical activity.

Table 3

ICC and design effect survey data

	ICC	Design effect
PreSEE	.020	1.24
PostSEE	.046	1.55
PreSES	.002	1.02
PostSES	.062	1.74
PrePA	.001	1.01
PostPA	.053	1.64

Note. PreSEE – Pre Self-Efficacy for Exercise scale administration; PostSEE – Post Self-Efficacy for Exercise scale administration; PreSES – Pre Self-Efficacy Scale administration; PostSES – Post Self-Efficacy Scale administration; PrePA – Pre Physical Activity Questionnaire administration; PostPA – Post Physical Activity Questionnaire administration; ICC – intraclass correlation coefficient.

Missing data for surveys were addressed by using bootstraps, start points, and auxiliary covariate inclusion since research (Hayes & McArdle, 2017; Shin, Davison, & Long, 2017; Yuan, Yang-Wallentin, & Bentler, 2012) suggests that multiple imputation is not advised at smaller sizes. All analyses were performed using 5,000 bootstrap replications to handle non-normality and to gather observed, rather than estimated, standard errors. Further, all analyses were run using 200 random start values to promote the estimation convergence on the true maximum of the likelihood function compared to a localized likelihood function error (Hipp & Bauer, 2006). Auxiliary correlates were included in the analysis if the addition caused smaller standard errors (Enders, 2010; Mazza, Enders, & Ruehlman, 2015). The auxiliary correlates were included to offset the power loss from missing data. The auxiliary correlates resulted in lower standard errors in both the PAQ-A and the SEE; however, the standard errors were higher in the SES so they were not used in the SES regression model. The level of significance was set at $p < .05$.

To analyze the behavior data, a mean, standard deviation, and range across Baseline, Wave 1, and Wave 2 for both the treatment and control groups were found. Missing data points were removed from the data and were not included in the analyses. After descriptives were run (see Table 4), a correlation matrix with physical activity log data variables was conducted to examine the relationship between variables. Then a mixed-design ANOVA (time by comparison) was conducted for heart rate. Due to the significant interaction, a post hoc analysis was also run. Finally, a two-way univariate fixed ANOVA was used to examine the relationship between the on-task behavior data, examining teacher and time to determine whether an interaction occurred.

Table 4

Descriptive characteristics across Physical Activity Questionnaire variables

	Control						Treatment					
	Baseline		Wave 1		Wave 2		Baseline		Wave 1		Wave 2	
	M (*SD*)	Range	*M* (*SD*)	Range	*M* (*SD*)	Range	*M* (*SD*)	Range	*M* (*SD*)	Range	*M* (*SD*)	Range
O-T	0.60 (0.39)	1	0.66 (0.37)	1	0.61 (0.31)	1	0.63 (0.32)	1	0.36 (0.40)	1	0.49 (0.50)	1.14
HR	82.19 (16.16)	129	81.52 (17.19)	126	79.58 (12.81)	122	91.25 (19.31)	140	93.48 (24.06)	190	92.22 (20.97)	199
Time									16.75 (14.74)	52.31	14.72 (11.21)	54
Miles									2.02 (2.58)	13	3.14 (4.67)	46
Resist									2.77 (1.92)	12.0	2.07 (1.17)	8.0
Calories									153.53 (134.63)	794	147.81 (90.76)	457
Goal									0.49 (0.50)	1	0.74 (0.44)	1

Note. O-T – on-task behavior; HR – heart rate; Resist – resistance.

RESULTS

In comparing the self-efficacy surveys, results without auxiliary correlates produced larger standard errors and smaller point estimates and effect sizes; as a result a saturated auxiliary correlated model was used (Graham, 2003) and, prior to interpretation, a single-indicator latent variable approach (SILV) was applied to account for measurement error in the predictor variables. Only the SES revealed a significant regression equation, *F*(degrees of freedom) = *F* statistic, $p = .002$, with an R^2 of .38. In exploring the mean differences, students lowered or maintained their overall scores for self-efficacy in the control group, whereas self-efficacy means improved or remained similar for the treatment group (see Table 5 for self-efficacy survey regression models).

When examining whether self-efficacy could be connected to student heart rate, no significance was found for either survey measure (see Table 6 for self-efficacy regression for heart rate).

In exploring the self-efficacy measures and PA variables, correlations were found among the measures themselves (PA vs. SEE, PA vs. SES, SEE vs. SES), and small-to-moderate correlations were also found between variables such as Miles and PApost scores, Miles and SEEpost scores, heart rate and Miles, heart rate and calories, time and calories, and Miles and calories (see Table 7). The highest correlation was between time and calories ($r = .68$, $p < .001$).

Table 8 shows that treatment students improved their mean heart rates from baseline to treatment. This increase was significantly greater when compared to the control group. In order to test for sphericity, Mauchly's test was used. The test was highly significant, $W = .99$, $\chi^2(2) = 5.26$, $p = .072$, indicating that the observed matrix did not have estimated equivalent variances or covariances. To avoid an inflation of type I errors, the Huynh-Feldt epsilon correction was used (Huynh & Feldt, 1976). There was a significant change in heart rate across time, $F(1, 989) = 3.31$, $p = .037$. Further, treatment, heart rate, and their interaction were found to be significant across time points. In order to explore the temporal relationships between the interaction effect, follow-up post hoc analyses compared all time points against the treatment and control groups (see Table 9). The comparison of treatment to control heart rates across each wave was significant, producing the significant *F* values: $F(1) = 26.08$, $p < .001$, $F(1) = 39.33$, $p < .001$, and $F(1) = 70.31$, $p < .001$ respectively.

Since the on-task behavior data were not able to match participants and a dependent sample could not be gathered, a univariate fixed factor model ANOVA was conducted (see Table 10). Given the lack of variation within off-task behavioral categories, data were collapsed into two meaningful categories: percentage of on-task and off-task behavior. In order to prevent alpha inflation at this level of the analysis, a Šidák (1967) correction for multiple comparisons was applied. As shown in Table 11, there was no significant difference between treatment and control groups for the outcome of on-task behavior. A difference was observed between waves in on-task behavior, but there was no significant interaction of *waves* and *group.*

Table 5

Self-efficacy regression model result with SILV corrections, N = 114

	B	*SE B*	*d*	R^2	*SE*
PA Scale					
Post on Pre	0.93*	0.15		.81	.15
Post on Tx	1.50	1.09	.28		
Post Intercept	10.28*	0.83			
SES Scale					
Post on Pre	0.74*	0.12		.49*	.16
Post on Tx	−1.83*	0.67	−.75		
Post Intercept	24.01*	0.45			
SEE Scale					
Post on Pre	0.64*	0.13		.36	.13
Post on Tx	1.92	1.33	.27		
Post Intercept	14.76*	0.94			

Note. PA – Physical Activity Questionnaire; SES Scale – Self-efficacy Scale; SEE Scale – Self-efficacy for Exercise scale; Tx – treatment; $^*p < .05$.

Table 6

ANOVA for the regression equation, self-efficacy (post) score on heart rate mean

	PA Scale				SEE Scale				SES Scale			
	Sum of squares	*df*	Mean square	*F*	Sum of squares	*df*	Mean square	*F*	Sum of squares	*df*	Mean square	*F*
Regression	602.72	1	602.72	3.20	241.67	1	241.67	1.25	460.46	1	460.46	2.35
Residual	56,327.05	302	186.51		70,571.54	365	193.35	1.25	70,626.92	361	195.64	2.35
Total	56,929.78	303			70,813.21	366			71,087.38	362		

Note. $p < .05$.

Table 7

Pearson correlation matrix among Physical Activity Questionnaire variables

	PApre	PApost	SEEpre	SEEpost	SESpre	SESpost	HRM	TimeM	MilesM	ResistM	CaloriesM	GoalM
PApre												
PApost	.65**											
SEEpre	.32**	.11*										
SEEpost	.37**	.26**	.53**									
SESpre	.43**	.43**	.51**	.33**								
SESpost	.40**	.37**	.51**	.50**	.53**							
HRM	−.24**	−.10	−.08	−.06	−.07	−.08						
TimeM	−.44**	−.16	−.34**	−.15	−.16	−.06	.18					
MilesM	.32	.39*	.55**	.29*	.17	.27	−.45**	−.26				
ResistM	−.13	−.20	.27	.21	.12	.14	.06	−.12	−.06			
CaloriesM	−.29*	−.03	−.30*	−.25*	.14	−.14	.28*	.68**	−.29*	.16		
GoalM	−.03	.12	−.10	−.05	.08	−.15	−.04	.22	.05	.04	.08	

Note. PApre – Physical Activity Questionnaire pre-administration; PApost – Physical Activity Questionnaire post-administration; SEEpre – Self-Efficacy for Exercise scale pre-administration; SEEpost – Self-Efficacy for Exercise scale post-administration; SESpre – Self-Efficacy Scale pre-administration; SESpost – Self-Efficacy Scale post-administration; HRM – heart rate mean; TimeM – time mean; MilesM – miles mean; ResistM – resistance mean; CaloriesM – calories mean; GoalM – goal mean; $^*p < .05$, $^{**}p < .01$.

Table 8

Summary of mixed design ANOVA

	Heart rate				
	Type III Sum of squares	*df*	Mean square	*F*	*p*
Between groups	44,528.60	1	44,528.60	90.79	<.001
Within groups	1,736.02	2	868.01	3.31	.037
Within-subject contrast	1,590.68	1	1,590.68	6.87	.009

Table 9

Mixed design ANOVA post hoc for time-point comparison of heart rate

	Comparisons	Mean weight difference (kg)	Std. error	95% CI	
				Lower bound	Upper bound
Baseline	Control vs. Treatment	−9.34*	1.83	−12.93	−5.74
	Treatment vs. Control	9.34*	1.83	5.74	12.93
Wave 1	Control vs. Treatment	−12.74*	2.03	−16.74	−8.75
	Treatment vs. Control	12.74*	2.03	8.75	16.74
Wave 2	Control vs. Treatment	−14.43*	1.72	−17.81	−11.05
	Treatment vs. Control	14.43*	1.72	11.05	17.81

Note. *$p < .05$.

Table 10

Summary of univariate fixed factor model for on-task behavior

	On-Task Behavior				
	Type III Sum of squares	*df*	Mean square	*F*	*p*
Between groups					
Intercept	628.51	1	628.51	5,258.62	< .001
Wave	.73	2	.36	3.03	.048
Teacher	.27	1	.27	2.25	.133
Wave*Teacher	.53	2	.27	2.22	.109
Within groups	.27	1	.27	2.25	.133

Note. R^2 =.01 (adjusted R^2 =.01).

Table 11

Univariate fixed factor ANOVA post hoc for time-point comparison of on-task behavior

Comparisons	Mean weight difference (kg)	Std. error	95% CI	
			Lower bound	Upper bound
Baseline vs. Wave 1	−.01	.02	−.06	.04
Baseline vs. Wave 2	.04	.02	−.01	.09
Wave 1 vs. Wave 2	.05*	.02	−.00	.10

Note. *$p < .05$.

DISCUSSION

This study explored the impact of pedal desks placed in a high school classroom. As research has predominantly focused on younger children, the present research focused on adolescents, who also benefit from physical activity but are significantly below recommended guidelines (CDC, 2017).

The first question examined whether physical activity self-efficacy can be increased by placing pedal desks in a high school classroom. It was hypothesized that placing pedal desks in a high school setting and providing modeling, encouragement, and goal setting for student use would prompt students to increase their physical activity self-efficacy and to engage in significantly more physical activity. This hypothesis was partially correct. In exploring the mean differences between groups, students lowered or maintained their overall scores for self-efficacy in the control group, whereas self-efficacy means improved or remained similar across measures in the treatment group. Of the two surveys used to measure self-efficacy, only one (the SES) was significant. The Self-Efficacy Scale measured the student's confidence to participate in different amounts (10, 30, and 60 minutes) and intensities (light, moderate, and vigorous) of exercise compared to the Self-Efficacy for Exercise scale (SEE), which explored barriers to participating in exercise, such as being tired, stressed, or bothered by the weather. It is clear that the SES scale more closely aligned with the pedal desk intervention as students were improving their levels of activity throughout the day. However, these effects did not generalize to students' general self-efficacy regarding exercise as measured by the SEE, as students continued to perceive the same barriers to engaging in physical activity that they had prior to the start of the intervention. This finding aligns with other existing research exploring the role of peers and parents in adolescent physical activity engagement (Beets, Cardinal, & Alderman, 2010; Edwardson & Gorely, 2010; Yao & Rhodes, 2015). Verloigne and colleagues (2014) examined cross-sectional data of adolescents in Australia and found that parents, more so than peers, influenced the internal barriers students had for physical activity both at weekends and on weekdays. Thus, even though in the present study students were encouraged by peers, teachers, and goals in the classroom and gained confidence in their ability to pedal, perhaps to actually overcome barriers to exercise, a parental component to the study would need to be included. Further, the results may also have been impacted by factors outside of the study as the ROTC classes participated in Cross Fit two days a week and were in the classroom three days a week. Thus, even though it was a choice for participants to pedal on days they were in the classroom, students enrolled in ROTC classes were required to participate in Cross Fit the other two days a week. As a result, as is suggested in the literature (Kahn et al., 2008), students may have increased their self-efficacy for physical activity by optional participation in the study combined with required participation in ROTC exercise days.

A second question examined whether pedal desks placed in a high school classroom can increase adolescent physical activity. It was hypothesized that in allowing children access to physical activity during class that students would indeed increase their physical activity. The results supported this hypothesis. Treatment students improved their mean heart rate from baseline to treatment; this increase was significantly greater when compared to the control group. Further, treatment, heart rate, and their interaction were found to be significant across time points. This result is similar to prior studies with adolescents, indicating that when given the opportunity to exercise, students will do so (Deforche, Van Dyck, Verloigne, & De Bourdeaudhuij, 2010; Fedewa, Abel, & Erwin, 2017; Pilcher, Morris, Bryant, Merritt, & Feigl, 2017).

Unfortunately, when examining whether self-efficacy could be linked to heart rate, no significance was found across either of the survey measures. There are several reasons for this outcome. Research has shown that the relationship between different types of self-efficacy and youth physical activity is intricate (Efrat, 2016). Literature, though limited, has suggested that psychosocial correlates of physical activity can differ depending on the physical activity context (Efrat, 2016; Ommundsen, Klasson-Heggebø, & Anderssen, 2006). For example, Ryan and Dzewaltowski (2002) explored the impact of different types of self-efficacy on 6th and 7th graders and found that environmental-change efficacy, which is associated with the child's ability to locate and create environments that support physical activity, and asking efficacy, which pertains to the child's ability to ask others to be active, had a stronger relationship with youth physical activity than other types of self-efficacy, including barrier self-efficacy. Perhaps an exploration of other types of self-efficacy in explaining youth physical activity could elucidate whether implementation of desk cycles within a high school classroom setting impacts other types of self-efficacy not measured in the present study.

Another reason that a link between self-efficacy and PA was not found could be the lack of overall enthusiasm for exercise that begins during adolescence, making it difficult to engage in enough physical activity to increase self-efficacy (Lubans, Morgan, Callister, Collins, & Plotnikoff, 2010; Eather, Morgan, & Lubans, 2013). This may have factored into the present study, as the amount of time students on average spent pedaling was limited (Wave 1 = 16 minutes, 45 seconds and Wave 2 = 14 minutes, 42 seconds), and perhaps more time spent engaged in physical activity or a different level of intensity was needed for change to occur. Ross, Dowda, Beets, and Pate (2013) found a significant effect for a high-active group of adolescent girls compared to a low-active group for self-efficacy, barriers to self-efficacy, and enjoyment of PA. Research has shown, too, that higher intensities of physical activity are correlated with self-efficacy increases (D'Haese et al., 2016; Ray & Henry, 2011; Strauss, Rodzilsky, Burack, & Colin, 2001). However, in the current study, students engaged in only light physical activity throughout the duration of the intervention. Perhaps it is critical for teachers to encourage higher levels of exertion periodically during the instructional period. It is unclear whether this would be feasible or effective in improving student self-efficacy or on-task behavior. In the present study, students, on average, pedaled less than 5 minutes beyond the teacher's modeled 10 minutes in both waves, suggesting perhaps the influential role of the teacher in encouraging participation in physical activity. Findings in the literature have previously supported the important role of the teacher in encouraging physical activity and influencing its levels in students (e.g., Haerens, Kirk, Cardon, & De Bourdeaudhuij, 2011; Erwin, Beets, Centeio, & Morrow, 2014). For example, Eather and colleagues (2013), in the Fit-4-Fun physical activity intervention across 4 elementary schools, found that classroom teachers – not peers – contributed to student overall physical activity. Thus, maybe in order to combat lack of enthusiasm for exercise in adolescence and to promote longer engagement in PA participation, teacher modeling should occur for an extended period of time. Another option could be recruiting a peer model to encourage activity participation, as peer influence has been critical in promoting adolescents' activity levels. For example, Salvy and colleagues (2009) found that the presence of peers increased the motivation of overweight youth to be physically active, while Hamilton and colleagues (2016) found that adolescents with low self-efficacy improved their motivation to exercise through the support of friends

The third question explored whether placing pedal desks in a high school classroom would increase on-task behavior. It was hypothesized that students would participate in more physical activity, which would subsequently result in increased on-task behavior. This hypothesis was not supported in the present study. No significant difference between treatment and control groups was found for the percentage of on-task behavior. In fact, the mean level of on-task behavior for the treatment group dropped from Baseline (.63) to Wave 1 (.40) and was fairly similar for Wave 2 (.42). There was an observed difference between waves in on-task behavior, but there was no significant interaction of *waves* and *group*. There are several possible explanations for these results. One explanation pertains to the lessons that occurred during class time. Over one-third of the lessons delivered during the study were non-sedentary in nature (e.g., choosing a book at the library, marching practice, checking uniforms, and organizing military gear). As this was the case, students did not get to participate in the offered physical activity pedal desks during these activities. In addition, the activities that were sedentary varied and ranged from taking a quiz, to completing book work, organizing notebooks, listening to lectures, and/or watching presentations and videos. The range in the cognitive tasks while children were sedentary may have impacted their ability to pedal, as perhaps the bikes were a distraction in some of the activities. In other words, some tasks (such as completing written work or taking a quiz) may have required too much cognitive juggling to complete while simultaneously pedaling. Studies have reflected that some activities are better coupled with PA than others (Kercood & Banda, 2012). For example, Kercood and Grskovic (2010) found that adding a fine motor activity to a listening task was more effective than adding it to a reading task in children with ADHD, while a study by Fedewa, Abel, and Erwin (2017) indicated that adolescents (n = 17) suggested difficulty pedaling and completing academic tasks simultaneously. In general, listening to information is less cognitively complex for children then reading it (Brown, Waring, & Donkaewbua, 2008; Geva, Galili, Katzir, & Shany, 2017; Hudson, Scheff, Tarsha, & Cutting, 2016). Thus, it may be that pedal desks would be most effective if used during a lecture-based class where listening was the predominant task, versus reading or completing a written task. Moreover, using pedal desks as physical activity breaks may be more beneficial for impacting on-task behavior than having the pedal desks be an option to use while simultaneously completing the classroom curriculum. Most research on physical activity in the classroom has focused on the use of PA as an isolated activity (Glapa et al., 2018; Luke, Vail, & Ayres, 2014; Mahar, 2011) or has integrated it into the curriculum itself (Fedewa, Fettrow, Erwin, & Ahn, in press; Donnelly & Lambourne, 2011; Goh, Hannon, Webster, Podlog, & Newton, 2016; Kibbe et al., 2011), not provided it as a secondary option while completing academic tasks. In either case, the classroom curriculum is a factor to consider when using pedal desks in the classroom, as the required task could be coded and accounted for as another variable in the relationship between activity and on-task behavior.

Another explanation for the lack of significance for on-task behavior may involve the environment of the classroom. As the teacher in the treatment room was frequently in and out of the classroom handling other responsibilities with his job, students were expected to be working on assignments when the teacher was in the room and were not held accountable when the teacher was not present. Research has shown, however, that when the teacher is not present in the classroom that off-task behavior is more often the result (Gage, Scott, Hirn, & MacSuga-Gage, 2017; Riley, Mckevitt, Shriver, & Allen, 2011). Data on whether the teacher was present or absent in the classroom were not collected, so this variable was not explored in the current study but should be considered in future studies with secondary classrooms.

The significance found for on-task behavior across Wave 1 and Wave 2 may have been impacted by several factors. For one, fidelity checks occurred once during each treatment wave. If 100% fidelity was not met, the researcher discussed with the treatment teacher specific areas that needed adjusting, as poor implementation of the intervention could possibly negate the effectiveness of the study (McKenna & Parenti, 2017; O'Donnell, 2008). This occurred during Wave 1 of the study, as fidelity was not 100%, and Wave 2 data resulted in higher on-task behavior scores. Students also achieved more of their goals during Wave 2 (74%) compared to Wave 1 (49%) and pedaled more miles (Wave 1 = 2.02 miles vs. Wave 2 = 3.14 miles). Another factor to consider is the time of year. Wave 1 spanned from early October until early November, while Wave 2 spanned from mid-November until mid-December. It is important to recognize that there are two major school breaks that occur during the months of November and December, and these breaks may have impacted their on-task behavior (Christ, Silberglitt, Yeo, & Cormier, 2010; Responsive Classroom, 2017). Data on this were not specifically collected, but it is an area to consider for future research designs.

LIMITATIONS

Though the findings of this study suggest that self-efficacy for physical activity can be increased through exercise support and guidance in the classroom and that overall adolescent physical activity can be increased using classroom-based exercise, there were limitations. For one, the on-task behavior data were not matched to participants; students were randomly chosen each day. This did not allow survey data to be directly compared to on-task behavior data, which would have permitted firmer conclusions to be drawn. Further, the teacher and treatment could not be separated, meaning that there was no way to parse out the influence the teacher had on the intervention. A final limitation is that the sample was too small to effectively explore moderating variables (e.g., age, race, gender) in order to have a better understanding of the impact of physical activity on each of those variables.

CONCLUSIONS

Ultimately, adolescents today do not engage in the amount of recommended daily exercise despite established research confirming its importance for physical, mental, and now cognitive gains (CDC, 2017; Kohl & Cook, 2013). Classroom-based physical activity is one avenue for adding more PA into a teenager's day (Babey, Wu, & Cohen, 2014; Kohl & Cook, 2013). This study indicates that pedal desks may be one means for feasibly increasing light physical activity during the school day. The results of this study suggest that self-efficacy for exercise can be increased and that light intensity physical activity levels may be raised through placing pedal desks in a high school classroom. These preliminary findings offer a way for schools to serve as a platform to promote additional physical activity for adolescents throughout the school day, since currently the majority of adolescents are not meeting daily standards (CDC, 2017).

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