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Physical Activity Opportunities at School and Academic Outcomes of 4th Grade Elementary School Students in Georgia.

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Epidemiology

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Erin Shore

Bachelor of Science
The University of Oklahoma
2013

Thesis Committee Chair: Julie Gazmararian, PhD, MPH

An abstract of
A thesis submitted to the Faculty of the
Rollins School of Public Health of Emory University
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Abstract

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By Erin Shore

Introduction: Physical activity at schools is an important component in combatting childhood obesity. Studies have shown that physical activity at school is positively associated with academic outcomes, such as standardized test scores. Large, state-wide, cross sectional studies have found positive associations between physical fitness and academic outcomes. However, little is known about physical activity time at school and academic outcomes and factors that may influence this relationship. The purpose of this study is to examine an association between time of physical activity opportunity at school and academic outcomes.

Methods: This statewide, cross-sectional study utilized two sources: Georgia State Department of Education and Georgia Shape. These datasets were combined to create an analysis dataset which contained amount of physical activity time at school, aerobic capacity measures, body mass index (BMI), standardized test scores, and school demographic measures. Multiple linear regression analysis was performed to assess the impact of the amount of time students had the opportunity to be physically active at school and standardized test scores, controlling for aerobic capacity, BMI, race, gender, school size, geographic category, and SES.

Results: Time of physical activity opportunity at school was not significantly associated with Mathematics, English, or Reading CRCT scores ($p = 0.56$, $p = 0.73$, $p = 0.49$, respectively). Schools with a higher percentage of students in the Healthy Fitness Zone for aerobic capacity had slightly higher average test scores ($p = 0.001$ for all test scores). However, SES had the greatest impact on test scores, where higher SES schools had higher standardized test scores ($p < 0.0001$ for all tests scores).

Discussion: Although the time of physical activity opportunities at school was not significantly associated with standardized test scores, aerobic capacity was associated with academic outcomes. SES appears to be the most important factor in academic outcomes. Time spent in physical activity at school does not negatively affect academic outcomes, and should be utilized in the efforts to prevent and reduce childhood overweight and obesity.

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Chapter I: Review of the Literature

Physical Activity in Schools

It is well studied that physical activity is an important component of reducing and preventing obesity in children. Schools are an ideal place to promote physical activity in children because 95% of American children are enrolled in schools and much of their time at school (between eight and nine hours) is typically spent in physical inactivity (1). The national recommendation for time spent on physical education in elementary schools is 150 minutes per week, yet, only 3.8% of elementary schools in the United States meet this standard (1). To achieve the recommended time spent on physical activity, the Centers for Disease Control and Prevention (CDC) proposed guidelines known as the Comprehensive School Physical Activity Program (CSPAP) in 2013 for children aged 6 and older. CSPAP recommends 60 minutes of physical activity per day through a quality physical education, staff involvement, physical activity before, during, and after school, and family and community engagement (1).

Many factors, such as school policies and student demographics can affect the amount of physical activity students achieve at schools. According to the Society of Health and Physical Educators, quality physical education is made up of four components: policy and environment, curriculum, appropriate instruction, and student assessment (2). It is also important to consider the time that students actually spend being physically active (3), including structured time for physical activity such as physical education class time, and unstructured physical activity, such as recess. Further attributes of quality physical education include a focus on developing motor skill competence and longer units of time in which to teach students specific motor skills during physical education (4). The 2012 School Health Policies and Practices Study (SHPPS) reported that among the states in which schools report student fitness data to a state or district agency, only 9.8% of them assess student performance in physical education (5). To date, only 13 states have policies regarding a requirement of time spent in physical activity during physical education (3).

Physical activity at schools has been shown to vary by student demographic factors such as gender, race, and socioeconomic status (SES). Several studies show that boys participated in more moderate physical activity than girls during recess (24.8% vs. 21.8%) (6) and (32.1% vs. 23.7%) (7). Boys also participate in more vigorous (15.5% vs. 9%), and moderate-to-vigorous (40.4% vs. 30.8%) physical activity during recess than girls (6). Furthermore, a study addressing students' perceptions of their personal physical activity competence, a measure of how good they are at physical activity, demonstrated that eight to nine-year-old boys overestimated their capabilities more often than eight to nine-year-old girls (effect size=0.47) (8).

In terms of race differences in the amount and/or type of physical activity students participate in at school, it has been shown that more 4^{th} grade Caucasian students participate in more moderate-to-vigorous physical activity (45.4%) than both Hispanic and African-American students (28.3% and 32.3%, respectively) (6). Another study showed that among 8^{th} grade girls, white students reported more time spent in moderate to vigorous physical activity than black students ($p < 0.001$) (9).

SES also affects elementary school students' physical activity behaviors. During recess, 26.1% of students considered low SES participated in moderate-to-vigorous physical activity, whereas 30.1% of students considered high SES participated in moderate-to-vigorous physical activity ($p < 0.001$). In this study SES was determined as a combination of socioeconomic parameters including unemployment rate, number of families living in the area, proportion of foreign-born residents, and housing density (7). Another study indicated that for 5th grade boys, area deprivation, which was measure of SES of the community in which each child lived, was associated with the amount of moderate-to-vigorous physical activity achieved during weekdays (10). SES also acts as an effect modifier with gender (7, 10). For example, the interaction between gender and SES for students' moderate-to-vigorous physical activity was statistically significant ($p < 0.01$) (7), meaning that the effects of SES on physical activity were different between boys and girls. Boys who were considered high SES spent more time in moderate-to-vigorous physical activity during recess than boys considered low SES (36.6% vs 28.9) whereas, there was not a statistically significant difference in moderate-to-vigorous physical activity at recess between low and high SES girls.

Academic Achievement

Data from 2012 indicate that many other industrialized countries outperform the United States in terms of academic achievement. For example, according to the National Center for Education Statistics, the United States ranked 30th in mathematics literacy and 20th in reading literacy among the 65 countries and education systems included in the Program for International Student Assessment (11). Despite the fact that the United States ranks so low in international standards, over the past few decades, test scores in the United States have been increasing. From the early 1970s to 2012, the average reading scores have improved by 13 points and math scores have improved by 25 points among nine year olds in the United States (12). Although there has been a general trend of improvement in academic achievement in the United States, there are still gaps in academic achievement by gender and between different racial groups (12).

A gap in academic achievement between black and white students has been evident over the past few decades. Among nine year olds, the achievement gap between black and white students in reading scores decreased from 44 points to 23 points from 1971 to 2012, and from 35 points to 25 points in math scores from 1973 to 2012 (12). Despite improvements in narrowing this achievement gap, a discrepancy in standardized test scores between black and white students persists (12). For example, discrepancies in academic achievement between black and white children can be seen as early as kindergarten. One study has shown that among kindergartners a difference in test scores by race was evident at the beginning of the school year, significantly widened by the end of the school year (13).

Similarly, a gender gap in academic achievement has been apparent over the past few decades. From the early the 1970s to 2012, among nine year olds, girls performed slightly better on both reading and math standardized tests, but the gap between scores has been narrowing over this time period. For example, the gap between scores female and male reading scores decreased from thirteen to five from 1971 to 2012 and math scores decreased from two to zero from 1973 to 2012 (12). However, the gender gap in math scores increases with age (12), which shows that even though there is no gender difference in math scores between nine-year-old boys and girls, there is still evidence of a gender gap in academic achievement among older children. Although the achievement gaps by race and gender have been narrowing over the past few decades, there is still need for improvement.

SES can also impact academic achievement (14). SES contributes to a difference in cognitive function, which is evident as early as kindergarten (15). For example, at entry to kindergarten, there is a distinctive positive, linear relationship between quintile of SES (measured as combination of occupation and education of parents, and household income) and cognitive ability for both math and reading where those in a higher SES quintile score higher on cognitive function (15). Geographic region can also impact academic performance. Students in suburban areas tend to have higher mean scores on standardized math and reading tests than students in inner city and rural areas (16). SES also functions as an effect modifier with geographic characteristics (e.g., urban, rural, suburban). For both kindergarten math and reading scores, increased family income was associated with increased test scores for large urban, suburb, and rural areas, but the impact of family income on test scores differed by geographic category (17).

Associations Between Physical Activity and Academic Achievement

Physical activity has been shown to have an association with academic achievement (18). A review of studies investigating the relationship between physical activity and cognitive control and memory in children shows that there are positive associations between physical activity and fitness level with cognitive function. Studies included in this review documented that more physically fit children aged 9 and 10 performed better on tests of attention, inhibition, and memory (18). Children with higher levels of aerobic fitness had higher cognitive control, motor integration, response resolution, better performance in relations memory, more ability to allocate resources for attention, and had faster cognitive processing speeds compared to less physically fit children (18).

Given that children who are more aerobically fit have better attention and memory capabilities (18), it follows that children who are more physically fit would perform better in school (19-20). Over the past few decades, there has been an increasing amount of research on the association between physical fitness and academic achievement. Studies addressing this association published from 1967-1999 mostly found positive associations, or at least no negative associations between physical activity and academic achievement in students ranging from age six to seventeen (19). Despite the positive associations noted, many of these studies neglected to account for potential confounders like SES, physical fitness, or BMI. Studies published between 2000-2009 have shifted focus from adolescence to early childhood (ages three to ten), and most of these studies also found positive associations between physical activity and academic achievements (19). Moreover, these studies indicated that it was feasible to increase physical activity throughout the day without sacrificing academic achievement. More recent articles, published between 2010-2012, often included measures of cognitive function, as well as SES as an effect modifier and/or a confounder in the association between physical activity and academic outcomes (19). The overall effect size noted in this recent review article was 0.564, which was "significantly higher than early research" (19). These studies focused on children ages seven to seventeen and study sizes ranged from 36 to 116; most measured physical activity as minutes per week of aerobic physical activity and the academic outcomes varied from standardized test scores to cognitive function tests to eye and relational movement (19). As more research in this subject area have been published, the number of positive associations between physical activity and academic outcomes have been demonstrated.

A 2010 review article from the CDC on the associations between physical activity and academic outcomes included 43 articles published between 1985 and 2008 that used different definitions of physical activity and/or academic outcomes as the exposure and outcome variables. Measures of physical activity included unstructured and structured physical activity (including physical education), and academic outcome measures examined were academic achievement, academic behavior, and cognitive skills and attitudes. The review indicated that slightly more than half (50.5%), of the associations tested were positive, 48% of the associations tested were neutral, and only 1.5% of the associations tested were negative. Of the 14 studies that assessed physical education and academic achievement, 11 found at least one positive association, and no negative associations were found, showing that academic performance is not hindered by time spent in physical education. Recess, physical activity breaks, and extracurricular physical activity all showed similar results, 59%, 40%, and 52% positive associations, respectively. Few studies examined differences by gender, race/ethnicity or SES. Other limitations to studies included in this review include small sample sizes (some as small as seven schools or 45 individuals) or a potentially biased sample, which may not be representative of the general population (20).

There have been a few statewide studies that have looked at this association. Once cross-sectional study in Texas assessed the association between student fitness (measured by the percentage of students attaining the healthy fitness zone (HFZ) of the FITNESSGRAM (FG) tests for cardiovascular fitness and body mass index (BMI)) on standardized test scores. Researchers used Texas State House Legislative districts to examine how the association between physical fitness and academic outcomes differs across space (21). Janak et al. divided students into quintiles of cardiovascular fitness HFZ and BMI HFZ to examine the association between physical fitness and test scores. Results showed regardless of gender or grade, students in the highest quintile of HFZ for cardiovascular fitness and BMI also performed better on the state's standardized tests. The districts which were more affluent had higher proportions of students in the HFZ for cardiovascular fitness and BMI, as well as students who performed satisfactorily on standardized exams. Although this study took into account SES, it did not consider other potential confounding variables such as race/ethnicity (21).

Another statewide study in Texas used data from 99 school districts to examine the magnitude and direction of the association between physical fitness, measured using FG data, and the state's standardized test (Texas Assessment of Knowledge and Skills (TAKS)). For both boys and girls, cardiovascular fitness had an association with academic outcomes, controlling for SES, grade level, and ethnicity. Additionally, a linear relationship between cardiovascular fitness and TAKS score was evident, demonstrating a dose-response relationship between cardiovascular fitness and standardized test scores (22).

Similar results were shown in a statewide cross sectional study in California. This analysis also utilized FG data and academic achievement was measured by the Stanford Achievement Test 9th edition (SAT/9). Results showed a linear relationship between the number of fitness standards achieved and both the mean SAT/9 reading score for grades 5, 7, and 9 and the mean SAT/9 math score for the same grades. Results varied by gender and SES, with the rate of change of SAT/9 score higher for girls and for those considered high SES, measured by students receiving free and reduced lunch (23).

A 2009 report in New York City also showed a positive linear association between physical fitness of elementary school students and academic outcomes (24). This report assessed grades four through eight, and used FG as the measure of physical fitness and used standardized English test scores and standardized math scores as the academic outcomes (24). Although this report is not statewide like the previous three mentioned, New York City, at an estimated population of 8,491,079, is larger than some states, and has a diverse population (25). Physical activity and academic achievement had very similar positive associations for all racial groups assessed (white, black, Asian, and Hispanic), but this report did not mention differences by SES or gender (24).

Gaps in the Literature

Statewide, cross-sectional studies have further supported the association between physical fitness and academic outcomes among elementary school students (21-24). These studies provide important data indicating a positive, linear association between a child's physical fitness and academic outcomes (21-24). Although some of these studies included potential confounding variables in their analysis such as SES, gender, and race/ethnicity, they did not control for other potential covariates such as geographic location (urban, rural, or suburban) and size of the school. Additionally, all of these studies used physical fitness by FG measurements as the primary exposure (21-24). While it is valuable to know that children who are more physical fit perform better on standardized academic tests, a child's fitness is not necessarily something a school influences. Whereas, the amount of time students have the opportunity to be physically active during school hours, which could help increase their physical fitness, is something the schools can influence. Considering the limitations of previous studies, this study aims to assess a possible association between the amount of time students have the opportunity to be physically active during the school day and academic outcomes in elementary school students across the state of Georgia, while considering other covariates that can affect academic outcomes such as SES, gender, race/ethnicity, geographic location, and size of school.

Chapter II: Manuscript

Introduction:

Increasing physical activity in children is a crucial element in reducing childhood obesity. As such, many researchers have chosen to implement interventions to increase the physical activity of children at school because almost American children (95%) are enrolled in school and spend a large portion of their day (seven to eight hours) at school in sedentary activity (1). According to the Centers for Disease Control and Prevention, in 2006, less than 4% of elementary schools nationwide provided adequate opportunities for students to achieve the recommended 150 minutes per week of physical activity (1). Several factors affect the type of physical activity students engage in at school, such as state policies regarding physical education and student characteristics like gender, race, and socioeconomic status (SES) (5-10). Studies typically show that boys spend more time moderate to vigorous in physical activity at school than their female counterparts, and even had higher perceptions of their physical activity capabilities than girls did (6-8). The research has also shown that white children are generally more physically active at school compared to children of other races or ethnicities, like Hispanic or African-American/Black (6, 9). Furthermore, children considered to be higher SES typically participate in more moderate to vigorous physical activity at schools than children considered to be low SES (7, 10).

Academic achievement, which has been associated with physical activity in elementary school children (18-24), is another area of research that has been studied greatly in recent years. Student characteristics like gender, race, and SES have an impact on academic achievement (12-15, 17). Generally speaking, studies have shown that in elementary school, girls academically outperform boys (12), Caucasian students outperform African-American/ black students (12-13), and students of higher SES outperform students of lower SES (14-15, 17).

Another area of study in recent years has been assessing the association between physical activity of children at school and academic achievement. Studies have shown that among children, physical activity is positively associated with cognitive function measures like memory and attention (18). Reviews of the literature have shown that numerous studies have found a positive association or no association between physical activity and academic achievement (19-20). Most of the research studies have been cross-sectional in design, had relatively small sample sizes, and only recently (after 2010) began considering the effects of SES on the association between physical activity and academic outcomes (19).

There have been a few statewide cross sectional studies assessing the possible associations between physical activity of children and academic outcomes. These studies have found a positive association between elementary school students' physical fitness, measured by FG tests and standardized test scores (21-24). These studies found that children who scored better on standardized physical fitness tests also performed better on standardized academic tests (21-24). While a few of these studies considered SES and gender in their analyses (21-24), only two considered race/ethnicity (22, 24). None considered geographic region of the school (urban, suburban, or rural) or size of school as potential confounding variables. All of these studies utilized FG, which is a standardized fitness test, and therefore useful in large-scale studies as these, but this is a measure a student's individual fitness, on which the schools have no real control. However, schools can impact the amount of time students have the opportunity be physically active at school, which could also have an impact on physical fitness and academic outcomes.

The primary purpose of this study is to examine the association between the amount of time children have the opportunity to be physically active at school and academic outcomes. Furthermore, it will assess covariates such as SES (measured by percent of students who qualify for free and reduced lunch), race/ethnicity, gender, geographic location (city, town, rural, suburban), and size of school.

Methods:

<u>Study Design:</u>

This study is a statewide, cross-sectional analysis using data from two sources, the the Georgia State Department of Education and Georgia Shape. The data were collected over the course of the 2013-2014 school year. IRB approval was not required for this analysis because all data were aggregate at the school level.

<u>Study Population:</u>

The study population is Georgia elementary schools that offer fourth grade for the academic year of 2013-2014. Schools with fourth grade are the target population because both standardized academic scores and FG data are available for this grade. Of the 1,320 schools who received the Power Up for 30 (PU30) School Setting Physical Activity Survey 1,078 (82%) schools provided a response. There were 8,787 individual respondents (administrators, grade level teachers, or physical education teachers) from the 1,078 schools. Of the 8,787 individual respondents, 2,846 were excluded for several reasons including: duplicate response (n=2,828), school closures during 2013-2014 school year (n=16), implausible data (n=2), resulting in 5,941 respondents representing

1,078 schools. Since this analysis was targeting physical activity opportunities at school among 4th grade students, only schools that had a response from both a physical education teacher and a fourth grade teacher were included, resulting in 662 schools in the analysis dataset.

Data Sources:

Each of the two sources of data utilized in this analysis are described below.

Georgia Department of Education: Criterion-Referenced Competency (CRCT) Scores for Mathematics, Reading, and English Language for the academic year of 2013-2014 were obtained from the Georgia Department of Education (DOE). Other data pertaining to school demographics, such as percentage of students on free and reduced lunch, student enrollment by race and gender, size of school, and geographic region of the school were obtained from the Georgia Department of Health. School demographic data is available to the public via the Georgia Department of Education website.

Georgia Shape: In 2010 the Governor of Georgia implemented the Georgia Shape initiative, which has instigated FG testing for all students in grades 4 through 12 who are enrolled in a physical education class. FG is a physical fitness assessment program developed by The Cooper Institute (26). Assessments are taken in aerobic capacity, muscular strength, muscular endurance, flexibility, and body composition. For each assessment, there is a Healthy Fitness Zone (HFZ), which differs across gender and age, and is based on criterion-referenced standards. Scoring in the HFZ means that child has achieved fitness levels that indicate good health. Additionally, Georgia Shape implemented the PU30 School Setting Physical Activity Survey to assess physical activity opportunities at Georgia elementary schools. The survey was administered electronically in the fall of 2013 to school administrators, grade level (k-5) teachers, and physical education teachers, and was comprised of questions about student demographics, physical education, recess, classroom integration of physical activity, staff wellness opportunities, and family and community involvement.

Data Measures:

The primary outcome variables are Mathematics, Reading, and English Language CRCT scores of fourth grade students attending Georgia elementary schools in the academic year of 2013-2014. Test scores were on a continuous scale, and mean scores for each school were reported.

The primary exposure variable is the amount of time fourth grade students had the opportunity to be physically active in school, derived from five questions on the PU30 School Setting Physical Activity Survey. These questions asked about the duration and frequency of physical activity during PE classes, recess, and physical activity integrated into the classroom. Due to the interval nature of the response choices in this survey, uniform random variables were created for time per week spent in physical education, recess, and physical activity time integrated into the classroom.

Time spent in physical education class was coded as 0 if the school did not provide physical education, and for the interval options from the survey (less than 15 minutes, 15-19 minutes, 20-29 minutes, 30-39 minutes, 40-49 minutes, and more than 50 minutes) random values between the minimum and maximum value of each interval were assigned using a random number generator in Statistical Analysis Software, Version 9.4 (SAS). This variable was then multiplied by the frequency of physical education classes per week to create a variable that estimated the total time fourth grade students spent in physical education during one week.

For duration of recess, if a school did not have recess, the variable was coded as 0 and for the interval options (less than 15 minutes, 15-19 minutes, 20-29 minutes, and 30 or more minutes) random values between the minimum and maximum value of each interval were assigned using a random number generator in SAS. This variable was then multiplied by the frequency of recess per week to create a variable for total time of recess per week.

For physical activity integrated into the classroom, a value of 0 was assigned if physical activity was not integrated into the classroom, and for the other options (one to five minutes, six to ten minutes, 11-15 minutes, 16-20 minutes, 21-25 minutes, and more than 25 minutes) random values between the minimum and maximum value in each interval were assigned using a random number generator in SAS. This variable was then multiplied by five to create a variable for total time of physical activity integration into the classroom for one week.

Total time spent in physical education per week, total time spent in recess per week, and total time of physical activity integration into the classroom per week were then summed to create a variable accounting for total amount of time per week students had the opportunity to be physically active at school. This variable was treated as a continuous variable for analysis.

Other covariates included in this analysis were school poverty, measured by the percent of students on free and reduced lunch (FRL) (high school poverty is greater than 75% students on FRL, mid-high school poverty is between 50% and 75% students on

FRL, mid-low school poverty is between 25% and 50% students on FRL, and low school poverty is less than or equal to 25% students on FRL). Geographic region was categorized as suburban, rural, city, or town. Size of school was categorized as small (less than 451 students), medium (451-621 students), and large schools (621 students or greater). Gender was measured as the proportion of male and female students, and treated as a continuous variable. Proportion of white students, black students, and students of other races were derived and treated as continuous. Proportion of Hispanic students were also derived and treated as continuous. Additional covariates were the proportion of students in the HFZ for aerobic capacity and BMI for each school which were derived and treated as continuous.

Data Analysis:

The three datasets were merged by school name and school district. Since there was not a unique identifier for schools, a variable was created that combined the school name and district name, and then the datasets were merged on that variable. If discrepancies existed in a school and/or district name, the names were changed in one of the datasets so that the names of the schools and districts were the same in all data sets, and the merge could work. Of the 662 schools which had survey responses from both a physical education teacher and a fourth grade teacher, 13 school were excluded due to a lack of FG data.

Bivariate analysis was performed between time of physical activity opportunity at school and CRCT scores and between physical activity opportunity at school and all potential covariates (school poverty, gender, proportion of black students, proportion of white students, proportion of Hispanic students, geographic region, school size, percent of students in the HFZ for aerobic capacity and BMI), using Pearson's correlation for continuous variables and F-tests for categorical variables. Bivariate analysis was also performed between CRCT scores and all covariates. Results of these analyses determined which variables were included in multiple linear regression models.

Unadjusted linear regression models between time of physical activity opportunity at school and CRCT mathematics, English, and reading scores were built. After this multiple linear regression models were built adjusting for gender, race, school poverty, geographic category, and size of school. All analysis was performed using Statistical Analysis Software, Version 9.4.

Results:

Among the 649 schools, 44% of schools were considered high poverty and only 12% were considered low poverty. Most of the schools were in a suburban area (44.7%). The average school size is 648 students (SD = 229.4). The average percentage of male students was 51.2% (SD = 5.3). The mean percentage of white students was 44.7% (SD = 28.8) and the mean percentage of black students was 37.2% (SD = 30.1). The mean time of opportunity to be physically active is 193 minutes per week (SD = 77.1). The average proportion of students in the aerobic capacity and BMI HFZ were 65.8% (SD = 19.8) and 59.0 (SD = 10.1), respectively. The mean Mathematics, Reading, and English CRCT scores are 835 (SD = 20.4), 834 (SD = 13.4), and 844 (SD = 12.7), respectively (Table 1).

Results of bivariate analysis show a correlation between the amount of time students have the opportunity to be physically active at school and CRCT Mathematics ($r^2 = 0.20$), English ($r^2 = 0.18$), and Reading ($r^2 = 0.21$) scores ($p < 0.0001$ for all) (Table 2). Schools that are higher SES generally give students more opportunity at school to be physically active. F-tests indicate a significant association between school poverty and the amount of time students have to be physically active at school ($F = 8.4$, $p < 0.0001$), with a mean time of physical activity opportunity per week among low poverty schools of 213 minutes (SD = 53.7) and 178 minutes (SD = 82.9) among high poverty schools. Race was also significantly associated with the amount of time students have the opportunity to be physically active. The Pearson's correlation coefficient between proportion of black students and opportunity to be physically active was -0.23 ($p < 0.0001$) and it was 0.19 ($p < 0.0001$) between the proportion of white students and the amount of opportunity to be physically active at school. The proportion of students in the HFZ for aerobic capacity ($r^2 = 0.11$, $p = 0.006$) and BMI ($r^2 = 0.13$, $p = 0.001$) were also associated with the amount of time students have the opportunity to be physically active at school (Table 2).

Similar results were produced for bivariate analysis of the CRCT Mathematics, Reading, and English scores. For ease of presentation, only the results of the CRCT Reading will be discussed here, but results for the Mathematics and English scores can be seen in Tables 3 and 4. School poverty was strongly correlated with CRCT Reading Scores ($F = 373.9$, $p < 0.0001$) (Table 3). As school poverty decreases, mean test scores increase. For example, the average CRCT Reading score among high poverty schools was 835 (SD = 9.3) compared to 865 (SD = 5.8) for low poverty schools (Table 3). Race was also associated with mean CRCT reading score. The Pearson's correlation coefficient between the proportion of black students and the average CRCT Reading score was -0.64 ($p < 0.0001$) and it was 0.56 ($p < 0.0001$) for the proportion of white students and the average CRCT Reading score (Table 3). Student fitness was also associated with standardized test scores. The Pearson's correlation coefficient for proportion of students in the HFZ for aerobic capacity and the mean CRCT Reading score was 0.36 ($p < 0.0001$) and it was 0.49 ($p < 0.0001$) for the proportion of students in the HFZ for BMI and the mean CRCT Reading score (Table 4).

Linear regression yielded similar results for the mean CRCT Mathematics, English, and Reading scores. For ease of presentation, only the results of the CRCT Reading test will be discussed. Results of linear regression for the mean CRCT Mathematics score can be seen in Table 5 and results of linear regression for the mean CRCT English score can be seen in Table 6. The association between time of physical activity opportunity at school and mean CRCT Reading score was statistically significant in the crude model (β Estimate = 0.03, $p < 0.0001$) (Table 7). But after adjusting for other covariates such as school poverty, proportion of students in the HFZ for aerobic capacity and BMI, gender, race/ethnicity, geographic region, and size of school, the association between amount of time students have the opportunity to be physically active at school and mean CRCT Reading score was no longer statistically significant (β Estimate = 0.003, $p = 0.49$). This indicates that the amount of time students have the opportunity to be physically active does not affect standardized test scores, and other factors like school poverty and the proportion of students in the HFZ for aerobic capacity and BMI have more impact on mean CRCT Reading score. School poverty has a great impact on mean CRCT Reading scores. For example, schools that are considered high poverty have mean scores that are 17 points lower ($p < 0.0001$) than low poverty schools. (Table 7). Fitness measures are also significantly associated with standardized test scores. As the percentage of students in the HFZ for aerobic capacity increases by one percent, the mean CRCT reading score increases by 0.1 points ($p = 0.001$) (Table 7). Similarly, as the percentage of students in the HFZ for BMI increases by one percent, the mean CRCT reading score increases by 0.1 points ($p < 0.0001$) (Table 7).

Interaction terms between school poverty and mean CRCT Mathematics, English, and Reading scores were statistically significant indicating that there could be effect modification due to school poverty. Thus, additional multiple linear regression models stratified by school poverty were conducted (see Appendix I). These stratified results indicated that time of physical activity opportunity at school remained insignificant across all strata of school poverty. Percent of students in the HFZ for aerobic capacity was only statistically significant in the Mid-High Poverty strata for all three CRCT exams ($p < 0.001$ for all).

Discussion:

This is the first statewide study to assess the association between the opportunity to be physically active at school and standardized test scores. Results indicate that the amount of time that children have the opportunity to be physically active at elementary school does not significantly impact standardized test scores among fourth grade students in Georgia. But results of this study were consistent with previous statewide cross sectional studies in that student fitness (measured by the proportion of students in the aerobic capacity HFZ) was significantly associated with standardized test scores (21-24). Although, the effect estimate was very small, schools with a higher proportion students physically fit students had higher mean CRCT scores. Although, in previous statewide studies, the association between student fitness and standardized scores was stronger than the association shown in this study (21-24).

The results of bivariate analysis revealed a small, but significant association between the opportunity to be physically active at school and the proportion of students in the HFZ for aerobic capacity. This makes the association between physical fitness and academic outcomes noteworthy because if students have the opportunity to spend more time being physically active at school, then may be more likely to become more physically fit.

The importance of SES (assessed by school poverty) on standardized test scores has been well documented (14-15, 17), and the results of this study are consistent with previous studies in that higher SES (low poverty) schools had higher mean CRCT scores. Of all the covariates assessed, school poverty had the most impact on standardized test scores, indicating that SES a very important predictor of academic outcomes in Georgia elementary school students.

<u>Strengths and Limitations</u>:

This study has at least three strengths. First, the initial PU30 School Setting Physical Activity Survey, which was sent to all Georgia elementary schools, had a 78% response rate. As a result, this sample is very large and a good representation of the state, which is an important strength in cross-sectional studies. There are few significant differences between schools that responded to the survey and schools that did not respond to the survey. Schools did not significantly differ by racial composition or mean CRCT scores, but schools did differ based on percent of students on FRL. Non-responding schools had more students on FRL. Second, the PU30 School Setting Physical Activity Survey has data about the amount of time students across the state of Georgia have the opportunity to be physically active at school, which, has not been captured before in statewide studies. Finally, this study has a very rich data set, which captures many school level demographic characteristics, such as percent of students on free and reduced lunch, school size, geographic category, gender, race, and FG data. Previous studies have assessed SES, gender, or race (21-22, 24), but none have assessed school size or geographic category.

Despite the strengths of this study, there are at least four limitations. First, as this study was done on the aggregate school level, it is subject to the ecological fallacy, and interpretations of results may not be applicable on the individual level. Second, as data regarding amount of time students have the opportunity to be physically active at school is self-reported respondents might have under or overestimated times of physical activity opportunity at school, which could lead to biased results in this study. Third, the main exposure variable is calculated from multiple survey responses, and as such is an estimation. An actual measure of the amount of time students have the opportunity to be physically active would be a stronger exposure variable. Finally, this is only an estimation of the opportunity students have to be physically active, rather than an actual measure of time spent in physical activity, which has previously been associated with academic outcomes in elementary school students (19-20), however, this would be difficult to capture on such a large scale.

<u>Future Directions and Public Health Implications</u>:

Future statewide studies should assess this association on the individual level. Assessing this association on the individual level would provide stronger evidence of this association than school level data. With both individual and school level data, a multi-level model approach could help indicate factors at the school level that impact the differences in the amount of time students have the opportunity to be physically active. For example, using this strategy would allow researchers to assess whether poverty on the school level affects individual students' physical activity opportunities at school. Further, it would be stronger evidence of an association to actually measure students' physical activity during a given week at school, rather than using an estimation. Another way to further assess this relationship would be to utilize a prospective cohort study design as opposed to a cross sectional design. This approach would allow researchers to assess a causal association between physical activity at school and academic outcomes.

Additionally, this study highlights the importance of SES on academic outcomes in elementary school students. Since SES is known to be associated with both student physical activity at school (6-7) and academic outcomes (14-15, 17), further research into the mechanism of the relationship between SES and physical activity and academic outcomes would be beneficial in creating and implementing interventions and programs to address these issues.

The results from this study indicate that while there is not an association between the amount of time students have the opportunity to be physically active at school and standardized test scores, there is no negative impact on academic performance. Therefore, physical activity at schools should still be utilized in the efforts to prevent and reduce childhood overweight and obesity, especially considering that students who are more physically fit perform better on standardized tests. Additionally, this study reaffirms the importance of SES on academic outcomes, student physical activity, and student fitness.

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Tables

Table 1. Selected School Characteristics of 4th Grade Students in Georgia Elementary Schools for the Academic Year 2013-2014 (N=649 schools n=69,823 4th grade students).

Variable	**N (%) or Mean (SD)**
School Demographic Characteristics	
School Poverty[a] (N, %)	
Low	76 (11.7%)
Mid-Low	113 (17.4%)
Mid-High	173 (26.7%)
High	287 (44.2%)
Geographic Region[b] (N, %)	
Suburban	290 (44.7%)
Rural	169 (26.0%)
City	135 (20.8%)
Town	55 (8.5%)
Size of School[c] (N, %)	
Small	107 (16.5%)
Medium	231 (35.6%)
Large	311 (47.9%)
Gender[b] (mean, SD[d])	
% Male	51.2 (5.3)
Race[b] (mean, SD[d])	
% White	44.7 (28.8)
% Black/African-American	37.2 (30.1)
% Other	3.5 (6.5)
Ethnicity[b] (mean, SD[d])	
% Hispanic	14.4 (17.1)
Physical Activity Characteristics	
Time of PA at school per week (min)[e] (mean, SD[d])	193.3 (77.1)
Proportion of students in Aerobic Capacity HFZ (mean, SD)	65.8 (19.8)
Proportion of students in BMI HFZ (mean, SD[d])	59.0 (10.1)
Academic Outcomes	
CRCT Scores	
Mathematics Score (mean, SD)	835.0 (20.4)
English Score (mean, SD)	834.1 (13.4)
Reading Score (mean, SD)	844.3 (12.7)

[a]School Poverty measured by percent of students on free and reduced lunch. Low considered less than or equal to 25% students on free and reduced lunch. Mid-low considered between 25% and 50% students on free and reduced lunch. Mid-high considered more than 50% and less than or equal to 75% students on free and reduced lunch. High considered greater than 75% students on free and reduced lunch.
[b]N is the total count for the entire sample of 4th grade students
[c]Variable is at the school level
[d]Standard Deviation
[e]Total time per week of the opportunity to be physically active

Table 2. Results of Bivariate Analysis Between Time of PA at School and School Demographics Among Georgia Elementary Schools (Pearson's Correlation or F-Tests) (N=649 schools).

	PA Time		
	Mean (SD)	Effect Estimate (r^2 or F)	p-value
CRCT Math Score		0.20	<0.0001
CRCT English Score		0.18	<0.0001
CRCT Reading Score		0.21	<0.0001
School Poverty[a]		8.40	<0.0001
Low	213.4 (53.7)		
Mid-Low	214.1 (68.8)		
Mid-High	195.8 (75.9)		
High	178.3 (82.9)		
Gender			
% Male		-0.03	0.38
% Black Students		-0.23	<0.0001
% White Students		0.19	<0.0001
% Other Race Students		0.07	0.06
% Hispanic Students		0.02	0.55
Geographic Region		2.05	0.11
Suburban	200.2 (74.6)		
Rural	189.5 (79.5)		
City	181.4 (80.3)		
Town	198.0 (71.8)		
School Size		3.35	0.04
Small	189.8 (90.1)		
Medium	184.3 (75.5)		
Large	201.2 (72.6)		
% Students in the Aerobic Capacity HFZ		0.11	0.006
% Students in the BMI HFZ		0.13	0.001

[a]School Poverty measured by percent of students on free and reduced lunch. Low considered less than or equal to 25% students on free and reduced lunch. Mid-low considered between 25% and 50% students on free and reduced lunch. Mid-high considered more than 50% and less than or equal to 75% students on free and reduced lunch. High considered greater than 75% students on free and reduced lunch.

Table 3. Results of Bivariate Analysis Between Mathematics, Reading, and English CRCT Scores of 4th Grade Students and School Demographics Among Georgia Elementary Schools (Pearson's Correlation or F-Tests) (N=649 schools).

Variable	CRCT Math Score			CRCT Reading Score			CRCT English Score		
	Mean (SD[b])	Effect Estimate (r^2 or F)	p-value	Mean (SD[b])	Effect Estimate (r^2 or F)	p-value	Mean (SD[b])	Effect Estimate (r^2 or F)	p-value
School Poverty[a]		265.62	<0.0001		373.90	<0.0001		413.18	<0.0001
Low	865.8 (12.4)			864.7 (5.8)			856.5 (7.3)		
Mid-Low	848.5 (13.2)			853.6 (6.3)			844.0 (7.5)		
Mid-High	836.4 (11.7)			844.9 (6.2)			834.1 (6.4)		
High	820.8 (15.2)			835.0 (9.3)			824.3 (8.9)		
Gender									
% Male		-0.06	0.09		-0.11	0.01		-0.10	0.01
% Black Students		-0.63	<0.0001		-0.64	<0.0001		-0.61	<0.0001
% White Students		0.53	<0.0001		0.56	<0.0001		0.51	<0.0001
% Other Students		0.46	<0.0001		0.44	<0.0001		0.48	<0.0001
% Hispanic Students		-0.12	<0.0001		-0.16	<0.0001		-0.16	<0.0001
Geographic Region		17.38	<0.0001		24.00	<0.0001		22.63	<0.0001
Suburban	839.4 (20.8)			847.7 (12.3)			838.0 (13.5)		
Rural	836.5 (14.7)			844.8 (8.4)			833.8 (8.5)		
City	824 (23.8)			837.2 (15.7)			827.3 (16.2)		
Town	832.8 (15.4)			842.5 (10.1)			831.4 (10.0)		
School Size		28.03	<0.0001		29.77	<0.0001		33.87	<0.0001
Small	825.8 (19.5)			838.1 (12.6)			827.2 (12.9)		
Medium	831.6 (20.0)			842.5 (12.2)			831.9 (12.5)		
Large	840.7 (19.4)			847.9 (11.9)			838.1 (12.9)		

[a]School Poverty measured by percent of students on free and reduced lunch. Low considered less than or equal to 25% students on free and reduced lunch. Mid-low considered between 25% and 50% students on free and reduced lunch. Mid-high considered more than 50% and less than or equal to 75% students on free and reduced lunch. High considered greater than 75% students on free and reduced lunch.
[b]Standard Deviation

Table 4. Results of Bivariate Analysis Between Mathematics, Reading, and English CRCT Scores of 4th Grade Students and School Physical Activity Characteristics Among Georgia Elementary Schools (Pearson's Correlation) (N=649 schools).

Variable	**CRCT Math**		**CRCT Reading**		**CRCT English**	
	r^2	p-value	r^2	p-value	r^2	p-value
% Students in Aerobic Capacity HFZ	0.37	<0.0001	0.36	<0.0001	0.37	<0.0001
% Students in BMI HFZ	0.47	<0.0001	0.49	<0.0001	0.50	<0.0001
PA Time	0.20	<0.0001	0.21	<0.0001	0.18	<0.0001

Table 5. Associations Between Physical Activity Opportunity at School and CRCT Mathematics Scores in 4th Grade Students in Georgia During the 2013-2014 School Year, Using Multiple Linear Regression (n = 649 schools).

Variable	β Estimate	Standard Error	p-value
Crude Model			
Intercept	825.6	2.1	<0.0001
Time of PA opportunity at school	0.05	0.01	<0.0001
Adjusted Model			
Intercept	845.0	19.5	<0.0001
Time of PA opportunity at school	-0.004	0.001	0.56
School Poverty[a]			
Low (ref)	--	--	--
Mid-Low	-8.0	2.0	<0.0001
Mid-High	-15.2	2.2	<0.0001
High	-21.6	2.6	<0.0001
% Students in Aerobic Capacity HFZ	0.1	0.03	0.001
% Students in BMI HFZ	0.2	0.1	0.0001
% Black Students	-0.3	0.2	0.13
% White Students	-0.1	0.2	0.70
% Other Race Students	0.4	0.2	0.06
% Hispanic Students	-0.2	0.2	0.39
Geographic Region			
Suburb (ref)	--	--	--
City	-0.6	1.4	0.65
Rural	0.6	1.5	0.69
Town	1.4	2.0	0.48
Size of school			
Small	--	--	--
Medium	-0.5	1.6	0.77
Large	2.2	1.6	0.17

*There were 33 schools with missing observations.

[a]School Poverty measured by percent of students on free and reduced lunch. Low considered less than or equal to 25% students on free and reduced lunch. Mid-low considered between 25% and 50% students on free and reduced lunch. Mid-high considered more than 50% and less than or equal to 75% students on free and reduced lunch. High considered greater than 75% students on free and reduced lunch.

Table 6. Associations Between Physical Activity Opportunity at School and CRCT English Scores in 4th Grade Students in Georgia During the 2013-2014 School Year, Using Multiple Linear Regression (n = 649 schools).

Variable	β Estimate	Standard Error	p-value
Crude Model			
Intercept	827.4	1.4	<0.0001
Time of PA opportunity at school	0.03	0.01	<0.0001
Adjusted Model			
Intercept	868.4	11.4	<0.0001
Time of PA opportunity at school	0.001	0.004	0.73
School Poverty[a]			
Low (ref)	--	--	--
Mid-Low	-7.2	1.2	<0.0001
Mid-High	-14.0	1.3	<0.0001
High	-19.1	1.5	<0.0001
% Students in Aerobic Capacity HFZ	0.05	0.02	0.001
% Students in BMI HFZ	0.1	0.03	<0.0001
Gender			
% Female (ref)	--	--	--
% Male	-0.2	0.1	0.0009
% Black Students	-0.3	0.1	0.01
% White Students	-0.2	0.10	0.06
% Other Race Students	0.1	0.1	0.68
% Hispanic Students	-0.3	0.1	0.02
Geographic Region			
Suburb (ref)	--	--	--
City	-1.6	0.8	0.05
Rural	-0.7	1.1	0.37
Town	0.01	1.1	0.99
Size of school			
Small (ref)	--	--	--
Medium	0.14	0.93	0.88
Large	1.4	0.93	0.12

*There were 33 schools with missing observations.

[a]School Poverty measured by percent of students on free and reduced lunch. Low considered less than or equal to 25% students on free and reduced lunch. Mid-low considered between 25% and 50% students on free and reduced lunch. Mid-high considered more than 50% and less than or equal to 75% students on free and reduced lunch. High considered greater than 75% students on free and reduced lunch.

Table 7. Associations Between Physical Activity Opportunity at School and CRCT Reading Scores in 4th Grade Students in Georgia During the 2013-2014 School Year, Using Multiple Linear Regression (n = 649 schools).

Variable	β Estimate	Standard Error	p-value
Crude Model			
Intercept	837.6	1.3	<0.0001
Time of PA opportunity at school	0.03	0.01	<0.0001
Adjusted Model			
Intercept	882.4	10.8	<0.0001
Time of PA opportunity at school	0.003	0.003	0.49
School Poverty[a]			
Low (ref)	--	--	--
Mid-Low	-6.4	1.1	<0.0001
Mid-High	-12.2	1.2	<0.0001
High	-16.5	1.4	<0.0001
% Students in Aerobic Capacity HFZ	0.1	0.01	0.001
% Students in BMI HFZ	0.1	0.03	<0.0001
Gender			
% Female (ref)	--	--	--
% Male	-0.2	0.1	<0.0001
% Black Students	-0.4	0.1	0.0009
% White Students	-0.2	0.1	0.03
% Other Race Students	-0.1	0.1	0.58
% Hispanic Students	-0.3	0.1	0.004
Geographic Region			
Suburb (ref)	--	--	--
City	-2.0	0.8	0.01
Rural	-0.8	0.8	0.33
Town	0.05	1.1	0.96
Size of school			
Small (ref)	--	--	--
Medium	0.4	0.9	0.68
Large	1.5	0.9	0.09

*There were 33 schools with missing observations.
[a]School Poverty measured by percent of students on free and reduced lunch. Low considered less than or equal to 25% students on free and reduced lunch. Mid-low considered between 25% and 50% students on free and reduced lunch. Mid-high considered more than 50% and less than or equal to 75% students on free and reduced lunch. High considered greater than 75% students on free and reduced lunch.

Chapter III: Summary, Future Directions, and Public Health Implications

Although this statewide study in Georgia did not indicate that the opportunity to be physically active in school is significantly related to standardized test scores among fourth grade students, results were consistent with previous studies indicating an association between physical fitness and academic outcomes (21-24). Although the associations in previous studies were stronger than the results of this study, the replication of previous results is important because it confirms the importance of the association between student fitness and academic outcomes.

It should be noted that not having an association between time of physical activity opportunity at school and academic outcomes provides evidence that giving students the time to be physically active at school does not harm their academic performance, therefore reducing the amount of time students have the opportunity to be physically active at school is unnecessary. Physical activity at school could even be beneficial to students because physical activity is an important component of preventing and reducing childhood obesity.

Future studies could utilize a prospective cohort study design, which could bring light to whether or not there may be a causal relationship between physical activity time at school and physical fitness. Furthermore, future studies could utilize a multi-level model approach in order to determine if differences in school level factors, like school poverty, significantly impact individual outcomes, like student fitness or academic outcomes. Additionally, since SES (school poverty in this study) is an important predictor of both academic outcomes and physical activity at school (12-16), it would be beneficial to further study the mechanism behind this association, so that interventions and programs could be developed to help improve both academics and physical fitness in children who live in low SES areas.

This study adds to the literature that indicates that more physical activity time at school is in the very least, not detrimental to standardized test scores in elementary school students. Therefore, physical activity time at schools should be utilized to help prevent and reduce childhood overweight and obesity. Additionally, this study further highlights the importance of SES on both physical activity at school and academic outcomes.

Appendix I: Supplementary Tables

Table S1. Associations between physical activity at school and CRCT Mathematics Scores in 4th Grade Students During the 2013-2014 School Year, Using Multiple Linear Regression Stratified by SES Status[a] (n = 649 schools).

Variable	Low School Poverty (n=75)			Mid-Low School Poverty (n=111)			Mid-High School Poverty (n=159)			High School Poverty (n=244)		
	β	SE	p-value	β	SE	p-value	β	SE	p-value	β	SE	p-value
Intercept	839.0	61.9	<0.0001	768.4	45.0	<0.0001	745.9	34.9	<0.0001	877.5	30.5	<0.0001
Time of PA opportunity at school	-0.02	0.02	0.49	0.01	0.02	0.74	0.01	0.01	0.27	-0.01	0.01	0.22
% Students in Aerobic Capacity HFZ	0.1	0.1	0.15	0.1	0.1	0.08	0.2	0.05	0.0005	0.1	0.04	0.08
% of Students in BMI HFZ	0.1	0.1	0.49	0.3	0.1	0.003	0.2	0.1	0.12	0.3	0.1	0.03
% Black Students	0.1	0.1	0.92	0.3	0.5	0.52	0.6	0.4	0.10	-0.8	0.3	0.01
% White Students	0.5	0.6	0.46	0.4	0.5	0.32	0.7	0.3	0.03	-0.6	0.3	0.08
% Other Race Students	0.9	0.6	0.14	1.4	0.5	0.01	1.2	0.5	0.01	-0.5	0.3	0.15
% Hispanic Students	-0.4	0.7	0.51	0.6	0.5	0.19	0.5	0.4	0.16	-0.7	0.3	0.02
Geographic Category												
Suburb (ref)	--	--	--	--	--	--	--	--	--	--	--	--
City	10.4	3.5	0.004	2.4	3.6	0.51	4.5	3.2	0.17	-4.2	2.1	0.05
Rural	2.8	4.4	0.52	4.8	3.2	0.13	0.5	2.4	0.83	-1.2	2.6	0.65
Town[b]	--	--	--	2.2	4.7	0.63	-0.4	3.3	0.91	0.8	3.0	0.79
Size of school												
Small (ref)	--	--	--	--	--	--	--	--	--	--	--	--
Medium	-34.8	10.9	0.002	1.4	5.3	0.79	1.1	2.7	0.69	-1.0	2.3	0.65
Large	-26.8	10.9	0.02	1.5	5.2	0.76	1.5	2.8	0.59	3.7	2.3	0.11

*There were 60 observations with missing data.
[a]School Poverty measured by percent of students on free and reduced lunch. Low considered less than or equal to 25% students on free and reduced lunch. Mid-low considered between 25% and 50% students on free and reduced lunch. Mid-high considered more than 50% and less than or equal to 75% students on free and reduced lunch. High considered greater than 75% students on free and reduced lunch.
[b]There were 0 schools that were both low poverty and in a town.

Table S2. Associations between physical activity at school and CRCT English Scores in 4th Grade Students During the 2013-2014 School Year, Using Multiple Linear Regression Stratified by SES Status[a] (n = 649 schools).

Variable	Low School Poverty (n=75)			Mid-Low School Poverty (n=111)			Mid-High School Poverty (n=159)			High School Poverty (n=244)		
	β	**SE**	**p-value**	**β**	**SE**	**p-value**	**β**	**SE**	**p-value**	**β**	**SE**	**p-value**
Intercept	844.9	31.2	<0.0001	848.8	25.7	<0.0001	797.6	19.0	<0.0001	878.5	17.8	<0.0001
Time of PA opportunity at school	-0.002	0.01	0.85	0.001	0.01	0.84	0.01	0.01	0.08	-0.005	0.01	0.44
% Students in Aerobic Capacity HFZ	0.1	0.04	0.06	0.1	0.04	0.12	0.1	0.02	<0.0001	0.04	0.02	0.10
% of Students in BMI HFZ	0.2	0.1	0.01	0.2	0.1	0.02	0.1	0.1	0.08	0.2	0.1	0.02
Gender												
% Male Students	-0.3	0.1	0.04	-0.2	0.1	0.04	-0.1	0.1	0.28	-0.2	0.1	0.02
% Black Students	0.4	0.3	0.27	-0.1	0.3	0.59	0.2	0.8	0.20	-0.6	0.2	0.001
% White Students	0.3	0.3	0.32	-0.05	0.2	0.85	0.3	0.2	0.13	-0.5	0.2	0.01
% Other Race Students	0.5	0.3	0.10	0.5	0.3	0.05	0.7	0.2	0.003	-0.5	0.2	0.01
% Hispanic Students	-0.3	0.3	0.35	0.02	0.3	0.95	0.2	0.2	0.38	-0.5	0.2	0.002
Geographic Category												
Suburb (ref)	--	--	--	--	--	--	--	--	--	--	--	--
City	5.6	1.7	0.002	2.5	2.0	0.21	1.1	1.7	0.53	-4.6	1.2	0.0002
Rural	-3.3	2.2	0.14	0.5	1.8	0.77	0.2	1.3	0.89	-1.1	1.5	0.46
Town[b]	--	--	--	0.7	2.6	0.78	-0.2	1.7	0.92	-0.6	1.7	0.71
Size of school												
Small (ref)	--	--	--	--	--	--	--	--	--	--	--	--
Medium	-27.5	5.4	<0.0001	-5.2	2.9	0.08	0.8	1.4	0.58	1.4	1.3	0.29
Large	-22.5	5.3	<0.0001	-4.5	2.8	0.12	1.2	1.5	0.40	3.5	1.3	0.01

*There were 60 observations with missing data.
[a]School Poverty measured by percent of students on free and reduced lunch. Low considered less than or equal to 25% students on free and reduced lunch. Mid-low considered between 25% and 50% students on free and reduced lunch. Mid-high considered more than 50% and less than or equal to 75% students on free and reduced lunch. High considered greater than 75% students on free and reduced lunch.
[b]There were 0 schools that were both low poverty and in a town.

Table S3. Associations between physical activity at school and CRCT Reading Scores in 4th Grade Students During the 2013-2014 School Year, Using Multiple Linear Regression Stratified by SES Status[a] (n = 649 schools).

Variable	Low School Poverty (n=75)			Mid-Low School Poverty (n=111)			Mid-High School Poverty (n=159)			High School Poverty (n=244)		
	β	SE	p-value	β	SE	p-value	β	SE	p-value	β	SE	p-value
Intercept	867.5	16.7	<0.0001	846.5	22.3	<0.0001	807.9	17.6	<0.0001	899.7	17.5	<0.0001
Time of PA opportunity at school	-0.003	0.01	0.76	0.01	0.01	0.44	0.01	0.01	0.04	-0.005	0.01	0.43
% Students in Aerobic Capacity HFZ	0.04	0.04	0.27	0.04	0.03	0.21	0.1	0.02	<0.0001	0.04	0.02	0.09
% Students in BMI HFZ	0.2	0.1	0.01	0.2	0.1	0.004	0.1	0.1	0.11	0.2	0.1	0.01
Gender												
% Male Students	-0.3	0.1	0.01	-0.2	0.1	0.04	-0.2	0.1	0.07	-0.2	0.1	0.01
% Black Students	0.2	0.3	0.54	-0.02	0.2	0.94	0.3	0.2	0.12	-0.7	0.2	<0.0001
% White Students	0.2	0.3	0.23	0.1	0.2	0.81	0.3	0.2	0.06	-0.5	0.2	0.004
% Other Race Students	0.3	0.3	0.26	0.5	0.24	0.05	0.7	0.2	0.001	-0.7	0.2	0.001
% Hispanic Students	-0.4	0.3	0.2	0.1	0.2	0.76	0.2	0.2	0.21	-0.7	0.2	0.0002
Geographic Category												
Suburb (ref)	--	--	--	--	--	--	--	--	--	--	--	--
City	4.7	1.5	0.002	2.1	1.7	0.22	1.0	1.6	0.53	-5.2	1.2	<0.0001
Rural	-2.7	1.9	0.15	0.7	1.5	0.63	0.7	1.2	0.58	-1.8	1.5	0.21
Town[b]	--	--	--	1.0	2.2	0.66	0.2	1.6	0.92	-0.8	1.7	0.65
Size of school										-0.8	1.7	0.65
Small (ref)	--	--	--	--	--	--	--	--	--	--	--	--
Medium	-19.3	4.6	<0.0001	-2.9	2.6	0.25	0.6	1.3	0.67	1.1	1.3	0.38
Large	-15.7	4.6	0.001	-2.8	2.5	0.27	1.0	1.4	0.47	3.2	1.3	0.01

*There were 60 observations with missing data.

[a]School Poverty measured by percent of students on free and reduced lunch. Low considered less than or equal to 25% students on free and reduced lunch. Mid-low considered between 25% and 50% students on free and reduced lunch. Mid-high considered more than 50% and less than or equal to 75% students on free and reduced lunch. High considered greater than 75% students on free and reduced lunch.

[b]There were 0 schools that were both low poverty and in a town.