Distribution Agreement

Signature:

____________________________ ______________

Eric Hyde Date

Analysis of a school-based intervention program on childhood physical activity:
Results from 4th grade students in Metro Atlanta public schools.

By

Eric Hyde

Master of Public Health

Epidemiology

____

Julie Gazmararian, PhD, MPH

Committee Chair

Analysis of a school-based intervention program on childhood physical activity: Results from 4th grade students in Metro Atlanta public schools.

By

Eric Hyde

Bachelor of Science

University of Michigan

2014

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

in partial fulfillment of the requirements for the degree of

Master of Public Health

in Epidemiology

2017

ABSTRACT

Analysis of a school-based intervention program on childhood physical activity: Results from 4th grade students in Metro Atlanta public schools.

By Eric Hyde

Childhood obesity is of increasing concern in the United States. While the health benefits of physical activity (PA) are well-known and a public health priority, most youth in the United States do not meet the recommended 60 minutes of daily PA. The school environment offers a valuable opportunity to engage students in PA through the day. The HealthMPowers program, an evidenced-based intervention, is a five component model that addresses the whole school environment in improving student health outcomes. HealthMPowers collected data on 2,641 fourth grade students in 24 intervention schools and 755 in seven control schools in three Metro Atlanta school districts during the 2015-2016 academic year. Activity measures include daily steps measured by pedometers, moderate-to-vigorous physical activity (MVPA) in physical education (PE) class measured by accelerometers, number of laps completed on the Progressive Aerobic Cardiovascular Endurance Run (PACER) test, and BMI-for-age percentiles. This analysis examined the effect of the intervention on these PA measures, as well as how the intervention's effect was modified by school socioeconomic status (SES) and the proportion of white students at schools. Crude and adjusted models were constructed to evaluate the association between the intervention on the various PA outcomes. Race/ethnicity was collinear with SES at the school level and was therefore dropped from the modeling analysis. After adjusting for gender and school SES, students at intervention schools had significantly higher increases in both the number of MVPA steps taken in PE, and also the percent of PE class time spent in MVPA than students at control schools ($p<0.01$). Intervention students did not have significant change in mean daily steps compared to control students. The effect of the intervention on change in PACER laps and BMI-for-age percentiles was significantly modified by school SES ($p<0.01$). This analysis demonstrates the effectiveness of the HealthMPowers program in producing positive change in school policies and practices, and student fitness—further supporting the use of school-based interventions to address childhood obesity. Future interventions should continue to tailor efforts to address schools of varying socioeconomic statuses and racial/ethnic student populations.

Analysis of a school-based intervention program on childhood physical activity:
Results from 4th grade students in Metro Atlanta public schools.

By

Eric Hyde

Bachelors of Science

University of Michigan

2014

Thesis Committee Chair: Julie Gazmararian, PhD, MPH

A thesis submitted to the Faculty of the

Rollins School of Public Health of Emory University

in partial fulfillment of the requirements for the degree of

Master of Public Health

in Epidemiology

2017

TABLE OF CONTENTS

BACKGROUND AND LITERATURE REVIEW

Childhood Obesity

Obesity is a significant public health problem in the United States, and childhood obesity has increasingly become a target of recent public health interventions.(1) Over the past 40 years, the prevalence of childhood obesity has more than tripled, from 5% in 1971-1974 to 17% in 2009-2010 (1, 2). Although the rate of childhood obesity has plateaued within the last decade, the overall prevalence remains high. Currently, "overweight" is defined by a body mass index (BMI)-for-age of greater than or equal to 85th percentile but less than the 95th percentile in children or adolescents. Those with a BMI-for-age of greater than or equal to the 95th percentile are categorized as "obese" (1, 3, 4). Children who are obese are more likely to develop multiple health risk factors such as hypertension, high cholesterol and type 2 diabetes later in life (1). Additionally, childhood obesity is associated with excess adiposity and high risk for adult obesity (5, 6). Mentally, children suffering from obesity are at risk for developing psychosocial health problems, such as depression and low self-esteem, due to societal stigmatization and these problems can manifest into impaired academic and social functioning into adolescence (7). Not only are there mental and physical health consequences of childhood obesity, but there are also considerable direct and indirect economic costs such as lost productivity, disability, morbidity, and premature death later in adulthood (8, 9).

According to a 2016 report, 23 of the 25 states with the highest rates of obesity are in the South and Midwest regions of the United States (10). In terms of prevalence of childhood obesity, Georgia ranked 17th in 2011 with 16.5% of children ages 10-17 reported as obese (11). This is an improvement from 2007, when Georgia ranked 2nd with 21.3% of children were categorized as obese (11). Still, obesity is still a problem in Georgia as over 30% of adults were categorized as obese in 2012, and that number could increase as obese children are more likely to become obese adults (6, 11).

Childhood Physical Activity

While childhood obesity is a complex condition influenced by both genetic-related and non-genetic-related determinants, improving physical activity behaviors during childhood has been shown to lessen the risk factors associated with obesity (4, 6, 10, 12). Children who participate in regular physical activity typically have higher levels of cardiorespiratory fitness, stronger muscles and bones, lower body fatness, less prevalence of chronic diseases, and reduced symptoms of anxiety and depression (12). Additionally, research has shown that school-age children's physical activity levels are correlated with their physical activity levels as adults (13). Implementing healthy lifestyle habits like regular physical activity may lower the risk of becoming overweight or obese as an adult (14).

The *2008 Physical Activity Guidelines for Americans* developed by the U.S. Health and Human Services recommends that children and adolescents engage in at least 60 minutes or more physical activity daily, most of which should be moderate-to-vigorous intensity. Additionally, as part of these 60 minutes daily, children should include muscle-and bone-strengthening exercises on at least three days of the week

(12). Based on the 2005-06 National Health and Nutrition Examination Survey (NHANES) where child physical activity levels were measured objectively by accelerometers, approximately 42.5% of children aged 6-11 years met the current physical activity guidelines of at least 60 min/day on at least 5 of 7 days of the week (15). In this age group, 48.6% of boys and 36.1% of girls were meeting the guidelines.

While state-specific data on physical activity behaviors is not available for elementary school aged children, the Youth Risk Behavior Surveillance System (YRBSS) includes representative samples of students in grades 9-12 in each state who answered 3 questions about physical activity and two questions about physical education via a classroom survey (16). The CDC's *2014 State Indicator Report on Physical Activity* states that 50.7% of adults and 25.2% of youth meet the aerobic physical activity guidelines (17). Among students in grades 9-12 in Georgia, 18.7% of students reported not performing at least 60 minutes of physical activity during the prior 7 days, 24.7% of respondents reported meeting the requirements of the aerobic activity guidelines, and 33.6% reported attending daily physical education classes at school (17). Using the results from this report, it can be inferred that elementary school aged children would likely exhibit similar, perhaps worse patterns of physical activity behaviors.

School-based Interventions

While interventions for addressing childhood physical activity levels exist for various settings, schools provide an ideal setting for population-based intervention programs because over 95% of youth are enrolled in schools, they spend a considerable period of time there (6-8 hours daily), and children across various demographic and socioeconomic statuses can derive some benefit (18-20). A 2015 systematic review found that interventions using multi-component models that addressed environment, curriculum, and individual health behaviors, were more effective in obesity reduction than single component interventions (21). Interventions that target the whole school, incorporating grade level teachers, physical education teachers, and the administration are more successful than those simply focused on the classroom environment. It is important to understand the efficacy of these components both isolated and in unison with other elements of a multi-component school-based intervention.

There are a number of different physical activity opportunities available throughout a typical school day. Students can engage in physical activity before/after school, during recess and physical education classes, incorporated into classroom teaching and during breaks, and through programs outside of school such as sports and clubs (20). For these reasons, interventions targeting physical activity in children should be focused on the whole school setting to be optimally effective. Additionally, these interventions should be tailored appropriately to student age groups (20). While school-based physical activity interventions have had mixed results in increasing physical activity in adolescent populations, a number of systematic reviews examining interventions in elementary students have yielded more promising results (22-25).

A 2013 Cochrane systematic review summarized evidence from 14 randomized controlled trails on the effectiveness of school-based interventions in promoting physical activity and fitness in children (25). In this review, four studies evaluated the impact of school-based physical activity interventions on physical activity behaviors in grade school children. While two studies did not produce statistically significant results, one study found a significant increase in physical activity in the intervention group compared to those in the control group, however physical activity rate was assessed subjectively through administered surveys (26). The other study found statistically significant increases in MVPA during recess measured by accelerometers in the intervention group schools compared to control schools (27). Seventeen studies in the review reported the impact of school-based physical interventions on physical activity duration (minutes/hours engaged in physical activity) in grade school children. Twelve reported statistically significant positive effects, but just six of the twelve used objective measures of physical activity. The magnitude of effect varied from just under five minutes to 45 minutes or more per week of MVPA, with confidence intervals ranging from 1.4 to 90 min more per week of MVPA than controls (25). In 2010, Demetriou & Höner identified 129 studies examined school-based physical activity interventions in children and adolescents (24). Of the 129 studies, fourteen (11%) used accelerometers and nine (7%) used pedometers to as assess physical activity levels. Additionally, seventy-three (57%) examined samples larger than 250 participants. The lack of high quality, large sample, objectively measured physical activity data in school-based physical activity interventions highlights the need for sound, thorough intervention evaluation.

A 2011 systematic review examined four relevant systematic reviews that had studies with a physical activity or fitness outcome measure, an intervention duration of at least 12 weeks, involvement of a healthy population aged 6-18 years, and published from 2007-2010. Within these reviews, 47-65% of studies were found to be effective in significantly improving PA or fitness outcomes, however conclusions regarding effective intervention strategies were not clear (23). Transparency of intervention models is needed to facilitate the direction of effective evaluation research.

When developing school-based interventions, considerations should be made regarding gender, race/ethnicity, and socioeconomic status (SES) of students. A large body of research has found that male students typically spend more time in daily physical activity, engage in more MVPA, and spend less daytime sedentary than female students (28-32). Physical activity levels of racial/ethnic minority school-aged children are generally found to be lower than their non-Hispanic white peers, while sedentary behaviors are higher (32-36). Similarly, children of low SES are also typically less physically active and participate in higher levels of sedentary behaviors than those of higher SES (32, 34). Research is clearly needed that addresses the disparities of physical activity engagement across gender, race/ethnicity, and SES, and the school environment is one that physical activity interventions should use to address these problems (20, 32).

Gaps in the Literature

Evaluations of school-based physical activity interventions in elementary schools provide key insight into effective strategies for improving physical activity levels in students (21-25). However, several gaps in the literature require further exploration and rigorous study. There is a lack of research that objectively assesses the impact of school-based physical activity interventions on physical activity levels, duration, and intensity (25). Additionally, few studies assess the difference in impact of physical activity interventions across gender, race/ethnicity, and SES (25). While the *Health Empowers You!* program used for this intervention has been evaluated previously, longitudinal physical activity measures such as daily steps or time spent in MVPA have not been assessed during the intervention (37). Considering these limitations, this study evaluated the effectiveness of the *Health Empowers You!* intervention on physical activity in a large sample size using objective measures of physical activity, and the effectiveness of the intervention across measures of gender, SES levels, and race/ethnicity.

HealthMPowers

In collaboration with the Centers for Disease Control and Prevention (CDC), Children's Healthcare of Atlanta (CHOA), and the Rollins School of Public Health at Emory University, HealthMPowers was founded in 1999 as a non-profit 501(C)(3) organization to promote healthy eating and physical activity in elementary schools. In 2016, HealthMPowers served 781 schools and centers for a total reach of more than half a million people in underserved communities. Additionally, HealthMPowers has performed trainings for more than 4,100 teachers and over

2,000 schools in Georgia as the training partner for Georgia Departments of Education, Public Health, and Student Health and Physical Education (SHAPE) initiative. With national recognition as an evidence-based program, HealthMPowers has established a 16-year track record of improving student health knowledge, physical activity, fitness and BMI. Following several years of formative work and preliminary evaluation research documenting promising intervention effects, HealthMPowers has emerged with a well-developed intervention protocol called *Health Empowers You!*, which has been shown to impact school physical activity policies and practices, and improve student-level physical activity outcomes. External evaluation of *Health Empowers You!* has demonstrated improvements in school practices and policies such as the daily integration of physical activity into the classroom, as well as student-level outcomes such as improved fitness, health knowledge, health behaviors, and healthy weight status (37, 38). The *Health Empowers You!* Program includes establishing a school health team, gathering baseline data to identify strengths and areas for improvement, providing trainings and on-going teacher meetings, curricular and physical activity resources and materials, and technical support. These components are expected to increase student physical activity and physical education activities during the school day through before-school programs, classroom physical activity, physical education, and recess. Figure A-1 is the proposed theory of change model that this intervention is based upon.

METHODS

Study Design

Once approval was granted from each district's research committee, recruitment of intervention schools began in August 2015. HealthMPowers research personnel operated directly with district health and physical education coordinators to facilitate the recruitment process. Together, they contacted PE teachers within their respective directs and obtained a convenience sample of elementary schools. After the PE teachers consulted with the school's fourth grade teachers and principal, consent for participation was ultimately given by the school principal. If a school agreed to participate, all fourth grade classrooms within the school participated in the intervention once individual consent was obtained from the students. Throughout the recruitment and consenting processes, HealthMPowers provided additional resources and information requested by the schools to inform the decision to participate. Once the recruitment period concluded, intervention training began in October 2015 with 28 schools enrolled.

Funding for control schools was secured past the intervention recruitment period. For this reason, data collection and measurement did not occur until January 2016. While ten schools were initially sought, seven control schools agreed to participant in the study. HealthMPowers informed school staff that, as control schools, they should resist deviating from normally scheduled activities to allow for typical physical activity behavior to be measured. For both intervention and control schools, HealthMPowers conducted brief in-person tutorials on data collection for both fourth grade and PE teachers. Teachers received compensation for their participation in the study, which included collecting and uploading physical activity data, maintenance of data collection devices, coordinating logistics of data with research personnel, and serving as the study point-of-contact for HealthMPowers.

Study Population

The study population consisted of Georgia public elementary schools in three Metro Atlanta counties that offered fourth grade classes during the 2015-2016 academic year; the intervention schools were in two school districts and control schools were recruited from a third district. Among the 28 intervention schools and 7 control schools, a total of 4,881 students were involved in this study. The intervention reached 3,889 students while 992 students participated in the control schools. Students in the fourth grade were selected as the target population because both *FITNESSGRAM* and standardized academic scores are state-mandated, *FITNESSGRAM* norms do not exist for grades younger than fourth, and students in fourth grade typically remain in one classroom throughout the school day which allows for more accurate measurement of classroom physical activity.

***Health Empowers You!* Intervention**

Through years of rigorous research and programmatic experience, HealthMPowers has developed the comprehensive *Health Empowers You!* intervention designed to impact school physical activity policies and practices, and improve student-level physical activity outcomes. The evidence-based model follows the guidelines established by the CDC for improving healthy eating and physical activity in schools using the Comprehensive School Physical Activity Program approach (CSPAP). In 2012-2013, a pilot study on the *Health Empowers*

You! intervention reached 39 schools in Georgia. External evaluation of the intervention demonstrated significant improvements in school-level outcomes such as increased classroom physical activity integration, as well as student-level outcomes such as improved health knowledge and behavior, physical fitness, and healthy weight status (37, 38).

Intervention Model

The *Health Empowers You!* intervention consisted of 5 main components: establishment of a school health team, collection of student physical activity data, staff implementation trainings, resource access and availability, and technical assistance.

The school health team was assigned as the point-of-contact at the school for the HealthMPowers team and was responsible to disseminate information provided at the intervention training to other school staff involved in the intervention. The teams consisted of 3 staff members: 1 physical education teacher, 1 fourth-grade teacher, and 1 other staff member of the school's choosing. All intervention schools had representatives attend the intervention training in October 2015.

HealthMPowers research personnel collected data on fourth graders' physical activity behavior throughout the 2015-2016 academic school year. Prior to the start of the intervention, HealthMPowers and Emory University staff evaluated five different activity measurement devices to identify the best device to use for this project. Based on evaluation findings and the need for the devices to upload via a Bluetooth option (to reduce the amount of management time for teachers), the

Pebble activity monitor was selected to track classroom steps and the Gopher FitStep Pro (GFSP) was selected to track moderate-to-vigorous physical activity (MVPA) during physical education class.

HealthMPowers offered three trainings throughout the 2015-2016 school year via two training modes: face-to-face and virtual. All participating schools attended the face-to-face kick-off training at the start of the intervention in October 2015. Half of the schools participated in asynchronous monthly virtual trainings for the remainder of the school year and the other half participated in two additional face-to-face trainings. The trainings focused on how teachers could incorporate additional physical activity into their classrooms, strategies to increase MVPA in physical education class, and activities that could be used in recess or before/after school programs to increase physical activity behaviors. In addition to these sessions, HealthMPowers provided the physical education teachers with different strategies every month, including the use of more equipment per class, making smaller groups of students to allow more focused attention on physical activity for each student, and using activities that incorporate movement into academic lessons so time is not taken away from teaching.

HealthMPowers provided a variety of resources that teachers could use to assist students in getting additional physical activity. During the initial training, each school was provided with three PA-based videos (Classrooms in Action, Mind-in-Motion 1, and Mind-in-Motion 2) for each fourth grade classroom. Mathtivity, a set of physical activities that are linked to specific grade level Georgia Performance

Math Standards was also provided. These resources allowed for classroom teachers to have "ready-made" activities to integrate physical activity into their classrooms. Providing recess equipment was also a focus of the intervention. Each school received one jump rope for every two students, as well as a set of physical activity equipment that included poly spot markers, six basketballs, footballs, kick balls, soccer balls, flying discs, cones, and mesh equipment bags. Schools used the equipment for physical education, recess, and before/afterschool activities. The GFSP devices that were used for data collection as previously mentioned were retained by the physical education teacher for future use.

Technical assistance was provided throughout the intervention for two purposes: First, whenever teachers asked for advice about integrating movement into their classrooms, ideas about how to transition students back into traditional classroom work, or general classroom management ideas to ensure students were able to participate fully. Second, technical assistance was provided around the data collection devices, which included changing out batteries and broken clips of the measurement devices and assisting in the download physical activity data from the pedometers and GFSP. The amount of HealthMPowers technical assistance response varied greatly by school and teacher. The priority of technical assistance was to alleviate teachers' concerns with implementing physical activity in the classroom, and to assist them in using the physical activity data collection devices.

Data Sources

The intervention was evaluated through the collection of five different data sources: pedometers, GFSP physical activity monitors, *FITNESSGRAM,* classroom teachers, and the Georgia Department of Education (DOE). In total, 2,641 students at intervention schools and 755 students at control schools contributed at least one physical activity measure during this study. Table A-1 in the Appendix describes the various data measures and timing of data collection for each measure.

Pedometers

Pebble pedometers were used to measure daily steps. A pedometer is a wearable device that records the acceleration and deceleration of movement in one direction (39). Pedometers provide accurate, objective measures of physical activity in both free-living populations and in research settings (40, 41). The Pebble pedometer was evaluated as the ideal pedometer for this study because of its ease of use, Bluetooth uploading capability, and affordable pricing. However, it should be noted that these devices are no longer available for purchase. The device is worn upright with the clip facing down on a belt or waistline. The student placed the pedometer on the waist as he or she walked into class at the beginning of the school day, and removed the device as they left the classroom at the end of the school day. The pedometers were then disconnected and stored for use on the following school day. Students in a particular classroom wore the Pebbles for five consecutive school days, after which the set of was given to the next classroom in the school. All 4th grade classrooms in a participating school shared a set of 30 Pebble pedometers, and a rotating schedule ensured that students in each classroom were measured approximately one week per month. A set of pedometers was shared between 3-4 classrooms in intervention schools, and no more than two classrooms in control schools. Each Friday, the data from the pedometers was downloaded (via Bluetooth), and the set of pedometers was given to the next teacher on the rotational calendar. The students wore the devices for a minimum of five complete weeks (one week per month), for 5 consecutive months during the intervention. Students at intervention schools were measured between October 2015 and May 2016; while students at control schools were measured between January 2016 and May 2016.

Physical Activity Monitor

The GFSP physical activity monitors were used to measure student MVPA during physical education class. The GFSP was selected for this study for its ease of use, reduced amount of time needed to record each measurement by hand, and reduced potential for human error. A subset of 84 fourth-grade students from the 24 intervention schools (three schools did not collect MVPA data) and 28 students from the seven control schools wore GFSPs during physical education classes to record the amount of time spent in MVPA at five different points during the school year (one time per month). The four students from each school were randomly selected, and the same four students were measured each month. Upon entering physical education class, the selected four students in the class would clip the GFSP at waist level and participate in normal PE activities for the entirety of the class period. For each student who wore the GFSP, the number of steps taken while performing MVPA and the amount of time spent in MVPA was recorded. Once class ended, physical education teachers retrieved the GFSP and placed in the GFSP data readers. The USB linked data reader would then upload the physical activity data onto the teacher's computer where it would be stored until extracted by study personnel. Physical education teachers at each school reported the total number of minutes allocated to each physical education class to enable a true calculation of the percent of class time spent in MVPA.

FITNESSGRAM®

FITNESSGRAM is the educational assessment and reporting software portion of the Presidential Youth Fitness Program (42). It is widely considered that the *FITNESSGRAM* battery is one of the most psychometrically sound assessments of fitness in youth presently available, and the reliability and validity of the *FITNESSGRAM* assessments have been previously published (42-44). As of 2012, all public schools in the state of Georgia are required to complete and report *FITNESSGRAM* assessments on all 4th through 10th grade students that are in a PE class taught by a certified PE teacher with testing occurring once per academic year. Physical education teachers, who have received state-mandated *FITNESSGRAM* training, conduct these tests and record results during physical education class. This protocol was reviewed and clarified by HealthMPowers personnel individually with each PE teacher. The PACER test, one of the *FITNESSGRAM* assessments, has been validated as a useful estimation of aerobic capacity when laboratory-based testing is not feasible (45). The PACER is a multistage aerobic test adapted from the 20-meter shuttle run first published in 1982 (46). The test involves running back and forth across a 20-meter course in time to music played from an audio recording.

Beeps on the sound track indicate when a person should reach the end of the 20-meter course, after which the participant turns around and again running back across the 20-meter course before the "beep" sound occurs. The test begins at a slow pace, and each minute the pace increases. A participant continues running until the pace can no longer be maintained. This test is similar to a graded exercise test on the treadmill in which the treadmill speed is increased at regular intervals. The longer a person continues, the higher the rate of estimated oxygen uptake. Aerobic capacity can be predicted from the number of laps completed during the test and a test equating procedure (47) which converts PACER laps into comparable one-mile run times, which are then used to predict aerobic capacity. In this study, students performed the PACER test twice in the school year. Intervention schools were measured in September and May, while control school students were measured in January and May.

Another measure taken from the *FITNESSGRAM* fitness battery for this study was BMI. BMI is calculated by dividing weight in kilograms by the square of height in meters to obtain a weight-to-height-ratio. BMI, specifically BMI-for-age percentile, is a validated measure for predicting underweight, healthy weight, and overweight status in school-aged children (48). During the *FITNESSGRAM* assessment, a fixed measuring stick and a flat digital scale were used by all schools to measure student height and weight, respectively. These data were then reported to research personnel who used CDC growth curve references to calculated age-and sex-specific BMI-for-age percentiles (49). Similar to the PACER test, BMI data were collected on two occasions throughout the school year: September and May for intervention students, and January and May for control students.

Classroom Teachers and DOE

Student gender was reported by classroom teachers. Research personnel gathered student identification numbers (ID), gender, and birthdays from teachers during the initial data-collection period. However, information on race/ethnicity and socioeconomic status could not be collected at the student level. The DOE provided information on the number of students in a racial/ethnicity group (white, black, Hispanic, Asian, two or more races, or other), and the proportion of students enrolled in the Free and Reduced Lunch (FRL) program at the school-level.

Data Measures

The outcome of interest for this intervention, physical activity, was evaluated using four measures: daily steps taken throughout the school day, the number of steps taken and amount of time spent while performing MVPA, fitness as measured by both body mass index (BMI) percentile and by performance on the Progressive Aerobic Cardiovascular Endurance Run (PACER) test measuring cardiovascular fitness. The exposure variable of interest, the intervention, was coded as 1 for intervention schools and 0 for control schools. The primary outcome of interest in this study was physical activity, and this was measured in three ways and fitness was measured in one: (1) the change in the number of steps taken over the 5 weeks of measurement, (2) the change in both the number of steps taken while performing MVPA and the amount of time spent in MVPA, (3) the change in the number of

PACER laps completed from pre/post intervention, and fitness was measured as the change in BMI percentile from pre/post intervention.

The number of steps taken in a school day were measured by Pebble pedometers. This was reported as the total number of steps taken while worn during the school day. Five additional variables were created to measure average number of steps per day by week. These were calculated by summing the total number of steps taken in five days in a given week and dividing by 5. The GFSP measures MVPA by first calculating the amount of steps-per-minute (SPM) needed to sustain an elevated heart rate. This SPM threshold is then entered into the pedometer, and when a student exceeds the threshold the pedometer records both the time and the number of steps taken as a bout of MVPA. The number of steps taken while performing MVPA was reported as the total number of steps taken while wearing the device and performing MVPA, and the amount of time spent in MVPA was reported in minutes. Teachers from both intervention and control schools reported the duration of PE classes at their schools, and this data was used to calculated the percent of time spent in MVPA in PE class. PACER laps was reported by *FITNESSGRAM* as the total number of laps completed during the assessment. A pre and post measure was collected for PACER laps. Completed PACER laps under 8 were deemed unfeasible and were set to missing. Lastly, change in BMI percentile was reported as the difference between BMI percentile measured at baseline and at post.

While gender information was available at the student-level, race/ethnicity and socioeconomic status was available at the school-level. Each of these covariates were dichotomized for analysis. Gender was coded as 1 for female and 0 for male. Race/ethnicity was dichotomized using the percent of white students at a school. This was calculated by taking the total number of white students at a school and dividing by the total school population. Schools with a student population that was 25% or lower white was coded as 1 and schools with greater than 25% white students was coded as 0. The proportion of students at each school who participated in the Free and Reduced Lunch (FRL) program was used as a proxy for measuring socioeconomic status at the school level. When individual-level information on socioeconomic status is not available, using school-level FRL percent is a validated proxy (50). This was measured by taking a count of the number of students who participate in FRL on October 6th, 2015. A proportion of all students in the school who participate in the FRL program is then reported to the DOE. A high percentage of students participating in the FRL program suggests low socioeconomic status at the school level. Schools with FRL rate greater than or equal to 50 were coded as 1 and those with less than 50% were coded as 0.

Analysis

From an initial dataset of 3,396 students, a total of four different analytic datasets were used to assess the four PA outcomes: one each for daily steps, MVPA, PACER laps, and BMI (Figure A-2). When analyzing daily steps, the dataset excluded students who were missing step data for all 25 days (N = 79). Observations where steps were less than 500 in a day or greater than 15,000 in a day were deemed implausible and set to missing. The total number of observations for this dataset was 3,317. Additionally, 22 measures in this dataset were missing gender information. For the second analytic dataset, observations missing either pre BMI or post BMI measurements were excluded (N = 1,041), and biologically implausible values were also removed from the dataset (N = 3). When examining the number of PACER laps completed, students who were missing either pre measurements or post measurements were excluded from the dataset (N = 1,561). Additionally, 81 observations were removed due to having implausible numbers of completed PACER laps in either pre or post measurements, which leaves the third analytic dataset with 1,754 observations. For the dataset with MVPA data, 112 students had the number of steps taken while engaging in MVPA measured as well as time spent in MVPA. Outlier measurements were set to missing (N = 1), however remaining MVPA data from this observation was not removed from the dataset.

Descriptive statistics regarding gender, percent students that are white in each school, and percent of students enrolled in the FRL program were calculated at baseline. Significant differences between intervention and control group physical activity measures were assessed with two sample t-tests. A significance level of $\alpha=0.05$ was used for all statistical analysis. Additionally, generalized estimating equations (GEE) were used to model the various physical activity outcomes while adjusting for gender, race/ethnicity, and SES. Three models were produced for each outcome variable: an empty (overall) model, a crude model, and an adjusted model that includes variables for gender, SES, and percentage of students at a school that are white. Given that students are clustered within schools, hierarchical models controlling for this clustering was used for each model regression. All analyses were performed using Statistical Analysis Software (SAS), Version 9.4 (Cary, NC).

RESULTS

Descriptive Results

Intervention and control schools did not differ significantly by gender or percent of school that is white (Table 1). However, the average total school proportion of students eligible for the FRL program was significantly different between intervention and control schools (72.4% vs 56.3%, respectively, $p<0.01$). Other than the average daily steps in week 2, the intervention students walked significantly more average steps per week than control students in each week. Both groups significantly increased their PACER laps from baseline to post measurement (intervention: 3 laps; control: 2.4 laps). Intervention students had significant increases in both the number of MVPA steps (1,062 average step increase from baseline) and percent of time spent in PE class in MVPA with each consecutive measurement post baseline (33.1% at baseline; 48.5% at final post measurement). BMI-for-age percentiles were not significantly different at baseline or post for both intervention students and control students.

Marginal (GEE) Models

The estimate from the GEE models are presented in Table 2. The outcome in each of these models are change in mean daily steps, average change in PACER laps from pre- to post-test, average change in both the number of steps of MVPA from baseline to Post 4 and the average percent of physical education class spent in MVPA from baseline to Post 4, and the average change in BMI-for-age percentile from baseline to post-test measurements. Statistically significant interaction was found for the change in mean daily steps, PACER laps, and BMI percentile. The percent of white students at a school was highly collinear with the percent of students eligible for FRL. As a result, the ethnicity variable was dropped from the modeling analysis. Graphical representations of change over time in physical activity outcomes by various covariate patterns are shown in Figures 1- 8.

Change in Mean Daily Steps

Change in steps was assessed by subtracting the average steps taken in week 1 (baseline) from the average steps taken in week 5 (Post 4). Across all students (regardless of intervention/control group assignment), the empty model showed that the average change in steps was 339, and this was a statistically significant change from baseline ($p<0.01$). The unadjusted model showed that students at intervention schools had an average change in steps that was 432 steps higher than students in control schools, although this finding was not statistically significant ($p=0.10$). However, the effect of the intervention on change in mean daily steps was not significant ($p=0.12$). Additionally, the effect of the intervention on change in steps did not differ significantly by gender or SES. In the adjusted model, female students on average increased their mean daily steps by 55 steps higher than male students ($p=0.12$). The adjusted model also showed that students attending low SES schools on average had 1,009 less mean daily steps than students at high SES schools ($p=0.55$).

Change in PACER laps

The change in PACER laps was assessed by subtracting the number of PACER laps completed at baseline from the number of PACER laps completed at post measurement. Across all students (regardless of intervention/control group assignment), the average change in PACER laps completed was 2.8 laps, and this was statistically significant ($p<0.01$). The unadjusted model shows that students attending intervention schools had an average change in PACER laps completed that was 0.7 laps higher than those attending control schools, however this finding was not statistically significant ($p=0.34$). In the adjusted model, female students on average completed 0.8 less laps than male students ($p=0.04$). Additionally, students attending low SES schools on average completed 0.8 more PACER laps than students at high SES schools in the adjusted model($p=0.04$).

Statistically significant interaction was present in the adjusted model by intervention and school SES on the change in PACER laps completed. Students at intervention schools with high SES completed on average 3.1 more PACER laps than students at comparable control schools and this difference was significant ($p=0.05$) while the difference in PACER laps between intervention and control amongst low SES school students was not significant.

Change in MVPA Measures

The change in MVPA steps was calculated as the difference between the number of steps taken while engaging in MVPA at baseline and the number taken at Post 4. The empty model showed that across all students regardless of intervention/control group assignment, the average change in MVPA steps from baseline to Post 4 was 795 steps ($p<0.01$). Examining just the effect of the intervention, the unadjusted model shows that students attending intervention schools had an average change of 1,033 MVPA steps higher than students attending control schools (p<0.01). The adjusted model indicates that students at intervention schools had an average change of 1,050 MVPA steps higher than students attending control schools (p<0.01). The effect of the intervention on MVPA steps did not differ significantly by gender or school SES. However, female students had an average change of 352 MVPA steps higher than male students in the adjusted model (p=0.03).

The change in percent of physical education class time spent in MVPA is assessed as the difference in percent of physical education class time in MVPA measured at baseline and the percent of physical education class time in MVPA measured at Post 4. Across all students regardless of intervention/control group assignment, the average change in the percent of physical education class spent in MVPA was a 11% increase (p<0.01). The unadjusted model shows that students at intervention schools had an average increase of 20% of physical education class time spent in MVPA more than students at control schools (p<0.01). In the adjusted model, students at intervention schools had an average of 18% of physical education class time spent in MVPA more than students at control schools (p<0.01). The effect of the intervention on the percent of physical education class time spent in MVPA did not differ significantly among gender or school SES. However, the adjusted model showed that female students had an average of 6% of physical education class time spent in MVPA more than male students (p<0.01).

Change in BMI-For-Age Percentile

Across the entire study sample, students had an average decrease of 3.2 BMI percentiles from baseline (p<0.01). The unadjusted model shows that students at intervention schools had an average decrease in BMI percentile change of 0.2 more than students at control schools, however this finding is not statistically significant (p=0.86). In the adjusted model, students at intervention schools had an average decrease in BMI percentile of 2.9 more than students at control schools (p<0.01). The adjusted model also showed that students attending schools with low SES on average decreased their BMI percentile by 1.6 more than students at high SES schools (p<0.01). The effect of the intervention on change BMI percentile did not differ significantly by gender.

Statistically significant interaction was present in the adjusted model by intervention and school SES. The students at high SES intervention schools on average decreased 2.9 BMI percentiles more than students at comparable control schools (p<0.01). Conversely, students at low SES intervention schools on average increased 1.0 BMI percentiles than students at comparable control schools however this finding is not statistically significant (p=0.32).

DISCUSSION

The effect of the *Health Empowers You!* program in students across 24 schools in Metro Atlanta significantly improved the physical activity outcomes over and above that of students at 7 control schools. Intervention students had higher average increases in PACER laps completed, and both percentage of time spent in MVPA and steps taken in MVPA during physical education class. On average, intervention students also had significantly higher decreases in BMI-for-age percentiles than control students from baseline to post-test. However, the effect of the intervention on mean daily steps was insignificant. Additionally, the effect of the intervention on the change in PACER laps completed and change in BMI-for-age percentile significantly differed by school SES.

While all students increased their mean daily steps over the course of the study, the intervention did not significantly improve this change compared to students at control schools. As mentioned before, the 2010 systematic review of school-based physical activity interventions by Demetriou & Höner identified 129 studies, and just 7% used pedometers to assess physical activity levels (24). With such wide variation in the change in daily steps for both intervention and control groups in this analysis, this finding suggests that further study regarding the use of pedometers as a measure of daily physical activity in school-based intervention evaluation should be conducted.

However, the intervention is particularly effective in high SES schools when examining the change in completed PACER laps and BMI-for-age percentiles from baseline. The intervention and control students' change in completed PACER laps and change in BMI-for-age percentile differed significantly by school SES. In fact, intervention students at low SES schools did not have a significant average increase in completed PACER laps above that of control students. This disparity in intervention effectiveness in these two physical activity outcomes is consistent with the literature, highlighting the need to tailor interventions to fit the needs of low SES schools with large populations of ethnic minority students (32, 34).

The effect of the intervention on all outcome measures was not significantly different by gender. Prior research has shown that male students are typically more physically active than female students (28-32). This intervention improved change in PACER laps, MVPA measures, and change in BMI-for-age percentiles similarly across gender. While it is promising that male students didn't improve significantly more than female students, future programmatic considerations should be given towards improving female students' physical activity levels specifically in order to decrease the gender disparity.

The effect of the intervention on both measures of MVPA did not differ significantly by gender or school SES. Intervention students had an approximately linear increase in both mean MVPA steps from baseline and mean percent of time spent in MVPA in physical education class and intervention students significantly increased both measures over and above that of control students. While the sample size is just 112 students, and only 28 of which are control students, this is nonetheless a promising finding that shows that the intervention is particularly effective in increasing physical activity in physical education classes.

Strengths and Limitations

There are at least six strengths of this analysis. First, data was collected from large number of schools and students, which enhances the generalizability of the results. Second, the comparison of intervention students to control students allows for stronger interpretation of physical activity outcomes attributable to the intervention. Third, unlike most other school-based physical activity interventions, there were numerous objective measures of physical activity. Fourth, student-level data was obtained on pre/post measures of BMI and aerobic capacity (PACER test), and daily steps and MVPA data were collected at numerous points throughout the study. Fifth, physical activity data was collected from September to May, which allowed for examination of the effect of the intervention over the course of an academic year. Fifth, the *Health Empowers You!* program is based on the CDC's CSPAP model that includes not only providing physical activity resources and increased opportunities for physical activity in the classroom, but also promotes cooperation from physical education teachers and school administration to reinforce healthy behaviors. Previous research has shown that the multi-components interventions are most effective in increasing physical activity outcomes (21). The type of intervention developed by HealthMPowers follows this format, and the promising results of the analysis further justifies the use of multi-component intervention models.

While the results of this study are promising for the effectiveness of the *Health Empowers You!* intervention, there are a number of limitations that should be noted. First, the control schools were added to the study later than intervention schools, resulting in differences in timing of data collection. Second, control schools were of significantly higher SES than intervention schools. While we were able to control for this difference at the school-level in the analysis, a more comparable control group would provide stronger interpretations of intervention effectiveness. Third, individual-level data on SES and ethnicity were not available for this study. However, validated proxies at the school-level were used and can inform future studies about likely trends in physical activity outcomes between schools of varying ethnicities and SES status. Fourth, our measures of ethnicity and SES where highly collinear and therefore ethnicity was dropped from all regression model analysis. Future studies should consider alternative forms of measuring ethnicity. Fifth, the subsample of student MVPA activity was relatively small, especially of control students. However, given that strong significant differences were observed between intervention and control student MVPA activity, a larger sample size would likely support our results.

Future Directions

Future research can further improve upon this analysis. First, a larger, diverse sample with a more comparable control group or a randomized controlled trial would allow for stronger interpretation of the outcome. Follow-up periods that extend beyond one school year would elucidate the long term effectiveness of the intervention. For example, change in BMI and BMI-for-age percentiles may show more meaningful change over a longer period of time. While cost is an obstacle in any study, a larger sample of MVPA steps and MVPA time measures would provide further insight into the effect of the intervention on this physical activity measure. Assessing the effect of this intervention on academic and social/behavioral outcomes would likely improve the receptiveness of schools to future intervention implementation. Future research in school-based physical activity interventions should focus on the specifics of the program that are effective in changing physical activity behaviors. The *Health Empowers You!* model is comprised of 5 components, but they were not individual assessed in this analysis. Determining the various parts of the intervention that are most effective may further improve the efficacy of future school-based physical activity programs. The implications of these findings suggest that the *Health Empowers You!* intervention is effective in improving a number of different physical activity outcomes, however certain programmatic consideration should be given based on school SES and racial/ethnic composition of student population. These results further suggest that whole school-based physical activity interventions based on the CSPAP model are effective in producing positive health and fitness benefits in children. Leaders in school curriculum and policy makers should consider the implementation of validated school-based physical activity programs when addressing student health outcomes. While childhood obesity continues to be an increasingly important national public health concern, rigorous intervention evaluation is needed to highlight effective health programs.

REFERENCES

1. Ogden CL, Carroll MD, Kit BK, et al. Prevalence of childhood and adult obesity in the United States, 2011-2012. *Journal of American Medical Association.* 2014;311(8):806-14.

2. National Center for Health Statistics. Health, United States, 2015: with special feature on racial and ethnic health disparities. 2016.

3. Barlow SE. Expert committee recommendations regarding the prevention, assessment, and treatment of child and adolescent overweight and obesity: summary report. *Pediatrics* 2007;120(Supplement 4):S164-S92.

4. Han JC, Lawlor DA, Kimm SYS. Childhood obesity. *The Lancet*;375(9727):1737-48.

5. Freedman DS, Mei Z, Srinivasan SR, et al. Cardiovascular risk factors and excess adiposity among overweight children and adolescents: the Bogalusa Heart Study. *The Journal of Pediatrics* 2007;150(1):12-7.e2.

6. Biro FM, Wien M. Childhood obesity and adult morbidities. *American Journal of Clinical Nutrition* 2010;91(5):1499S-505S.

7. Schwartz MB, Puhl R. Childhood obesity: a societal problem to solve. *Obesity Reviews* 2003;4(1):57-71.

8. Finkelstein EA, Graham WCK, Malhotra R. Lifetime direct medical costs of childhood obesity. *Pediatrics* 2014;133(5):854-62.

9. Sonntag D, Ali S, De Bock F. Lifetime indirect cost of childhood overweight and obesity: A decision analytic model. *Obesity* 2016;24(1):200-6.

10. Segal LM, Rayburn J, Martin A. The state of obesity: better policies for a healthier America. Trust for America's Health. 2016.

11. Overweight and physical activity among children: a portrait of states and the nation. National Survey of Children's Health (NSCH): Health Resources and Services Administration, Maternal and Child Health Bureau, 2007.

12. Physical Activity Guidelines Advisory Committee. Physical activity guidelines for Americans. Washington, DC. US Department of Health and Human Services 2008:15-34.

13. Telama R, Yang X, Viikari J, et al. Physical activity from childhood to adulthood: a 21-year tracking study. *American Journal of Preventive Medicine* 2005;28(3):267-73.

14. Street SJ, Wells JCK, Hills AP. Windows of opportunity for physical activity in the prevention of obesity. *Obesity Reviews* 2015;16(10):857-70.

15. National Physical Activity Plan Alliance. 2016 United States report card on physical activity for children and youth. Columbia, SC, 2016.

16. Kann L, Kinchen S, Shanklin SL, et al. Youth risk behavior surveillance--United States, 2013. Morbidity and Mortality Weekly Report (MMWR). Surveillance Summaries. Volume 63, Number SS-4. Centers for Disease Control and Prevention 2014.

17. Centers for Disease Control and Prevention. State indicator report on physical activity, 2014. Atlanta, GA. US Department of Health and Human Services 2014.

18. Hussar WJ, Bailey TM. Projections of education statistics to 2023. National Center for Education Statistics. 2015.

19. Thomas H. Obesity prevention programs for children and youth: why are their results so modest? *Health Education Research* 2006;21(6):783-95.

20. Centers for Disease Control and Prevention. Comprehensive school physical activity programs: a guide for schools. Atlanta, GA: U.S. Department of Health and Human Services; 2013.

21. Amini M, Djazayery A, Majdzadeh R, et al. Effect of school-based interventions to control childhood obesity: a review of reviews. *International Journal of Preventive Medicine* 2015;6:68.

22. Borde R, Smith JJ, Sutherland R, et al. Methodological considerations and impact of school-based interventions on objectively measured physical activity in adolescents: a systematic review and meta-analysis. *Obesity Reviews* 2017;18(4):476-90.

23. Kriemler S, Meyer U, Martin E, et al. Effect of school-based interventions on physical activity and fitness in children and adolescents: a review of reviews and systematic update. *British Journal of Sports Medicine* 2011;45(11).

24. Demetriou Y, Höner O. Physical activity interventions in the school setting: a systematic review. *Psychology of Sport and Exercise* 2012;13(2):186-96.

25. Dobbins M, Husson H, DeCorby K, et al. School-based physical activity programs for promoting physical activity and fitness in children and adolescents aged 6 to 18. *Cochrane Database of Systematic Reviews* 2013(2).

26. Simon C, Schweitzer B, Oujaa M, et al. Successful overweight prevention in adolescents by increasing physical activity: a 4-year randomized controlled intervention. *International Journal of Obesity* 2008;32(10):1489.

27. Verstraete SJM, Cardon GM, De Clercq DLR, et al. Increasing children's physical activity levels during recess periods in elementary schools: the effects of providing game equipment. *European Journal of Public Health* 2006;16(4):415-9.

28. Ekelund U, Luan Ja, Sherar LB, et al. Association of moderate to vigorous physical activity and sedentary time with cardiometabolic risk factors in children and adolescents. *Journal of American Medical Association.* 2012;307(7):704-12.

29. Trost SG, Pate RR, Sallis JF, et al. Age and gender differences in objectively measured physical activity in youth. *Medicine and Science in Sports and Exercise.* 2002;34(2):350-5.

30. Hallal PC, Andersen LB, Bull FC, et al. Global physical activity levels: surveillance progress, pitfalls, and prospects. *The Lancet*;380(9838):247-57.

31. Telford RM, Telford RD, Olive LS, et al. Why are girls less physically active than boys? findings from the LOOK Longitudinal Study. *PLoS ONE* 2016;11(3).

32. Whitt-Glover MC, Taylor WC, Floyd MF, et al. Disparities in physical activity and sedentary behaviors among us children and adolescents: prevalence, correlates, and intervention implications. *Journal of Public Health Policy* 2009;30(1):S309-S34.

33. Eaton DK, Kann L, Kinchen S, et al. Youth risk behavior surveillance—United States, 2007. *MMWR Surveill Summ* 2008;57(4):1-131.

34. Brodersen NH, Steptoe A, Boniface DR, et al. Trends in physical activity and sedentary behaviour in adolescence: ethnic and socioeconomic differences. *British Journal of Sports Medicine* 2007;41(3):140-4.

35. Kimm SYS, Glynn NW, Kriska AM, et al. Decline in physical activity in black girls and white girls during adolescence. *New England Journal of Medicine.* 2002;347(10):709-15.

36. Duncan SC, Strycker LA, Chaumeton NR. School influences on the physical activity of African-American, Latino, and white girls. *Journal of School Health* 2015;85(1):43-52.

37. Burke RM, Meyer A, Kay C, et al. A holistic school-based intervention for improving health-related knowledge, body composition, and fitness in elementary school students: an evaluation of the HealthMPowers program. *International Journal of Behavioral Nutrition and Physical Activity* 2014;11(1):78.

38. Mullis R, Davis M, Bason J, et al. Children's Physical Activity and Nutrition Program (CPAN) shows promising outcomes. *Results Matter*, 2011.

39. Saris WH, Binkhorst R. The use of pedometer and actometer in studying daily physical activity in man. Part I: reliability of pedometer and actometer. *European Journal of Applied Physiology and Occupational Physiology* 1977;37(3):219-28.

40. Sequeira MM, Rickenbach M, Wietlisbach V, et al. Physical activity assessment using a pedometer and its comparison with a questionnaire in a large population survey. *American Journal of Epidemiology* 1995;142(9):989-99.

41. Tudor-Locke C, Williams JE, Reis JP, et al. Utility of pedometers for assessing physical activity. *Sports Medicine* 2004;34(5):281-91.

42. Plowman SA, Meredith MD. *FITNESSGRAM/ACTIVITYGRAM* Reference Guide (4th Edition). Dallas, TX: The Cooper Institute; 2013.

43. Morrow JR, Martin SB, Jackson AW. Reliability and validity of the *FITNESSGRAM®*. *Research Quarterly for Exercise and Sport* 2010;81(sup3):S24-S30.

44. Plowman SA, Sterling CL, Corbin CB, et al. The history of *FITNESSGRAM®*. *Journal of Physical Activity and Health* 2006;3(s2):S5-S20.

45. Mayorga-Vega D, Aguilar-Soto P, Viciana J. Criterion-related validity of the 20-m shuttle run test for estimating cardiorespiratory fitness: a meta-analysis. *Journal of Sports Science & Medicine* 2015;14(3):536-47.

46. Léger LA, Lambert J. A maximal multistage 20-m shuttle run test to predict VO_{2max}. *European Journal of Applied Physiology and Occupational Physiology* 1982;49(1):1-12.

47. Zhu W, Plowman SA, Park Y. A primer-test centered equating method for setting cut-off scores. *Research Quarterly for Exercise and Sport* 2010;81(4):400-9.

48. Mei Z, Grummer-Strawn LM, Pietrobelli A, et al. Validity of body mass index compared with other body-composition screening indexes for the

assessment of body fatness in children and adolescents. *American Journal of Clinical Nutrition* 2002;75(6):978-85.

49. Kuczmarski RJ, Ogden CL, Guo SS, et al. 2000 CDC growth charts for the United States: methods and development. National Center for Health Statistics. *Vital Health* Statistics 11(246). 2002.

50. Day SE, Hinterland K, Myers C, et al. A school-level proxy measure for individual-level poverty using school-level eligibility for free and reduced-price meals. *Journal of School Health* 2016;86(3):204-14.

TABLES

Table 1. Descriptive Statistics of a Sample of 4th Grade Students at 31 Schools in Metro Atlanta[a], n = 3,396

	All (n=3,396) 31 Schools		Intervention (n=2,641) 24 Schools		Control (n=755) 7 Schools		
Variable	n	n (%) or mean (SD)	n	n (%) or mean (SD)	n	n (%) or mean (SD)	p-value*
Gender	3,374		2,619		755		0.13
Male		1,739 (51.5%)		1,368 (52.2%)		371 (49.1%)	
Female		1,635 (48.5%)		1,251 (47.8%)		384 (50.9%)	
% White[b]	3,396	18.0% (22.9%)	2,641	17.7% (21.5%)	755	19.3% (27.4%)	0.12
% FRL[c]	3,396	68.8%(29.0%)	2,641	71.9% (26.5%)	755	56.3% (33.7%)	**<0.01**
Average Daily Steps[d]	3,317		2,637		680		
Baseline		3,245 (695)		3,270 (702)		3,148 (661)	**<0.01**
Post 1		3,287 (681)		3,280 (668)		3,315 (727)	0.25
Post 2		3,416 (586)		3,550 (528)		2,894 (502)	**<0.01**
Post 3		3,528 (591)		3,630 (570)		3,139 (499)	**<0.01**
Post 4		3,584 (600)		3,698 (566)		3,143 (519)	**<0.01**
PACER Laps[e]	1,754		1,100		654		
Baseline		23.8 (12.3)		21.4 (10.2)		27.9 (14.4)	**<0.01**
Post		26.6 (13.5)		24.4 (11.7)		30.3 (15.4)	**<0.01**
MVPA – Steps[f]	112		84		28		
Baseline		2,244 (911)		2,163 (1,032)		2,487 (241)	**<0.01**
Post 1		2,210 (710)		2,244 (780)		2,105 (432)	0.24
Post 2		2,432 (764)		2,493 (854)		2,249 (335)	**0.03**
Post 3		2,727 (950)		2,843 (1,038)		2,378 (478)	**<0.01**
Post 4		3,045 (950)		3,225 (995)		2,510 (522)	**<0.01**
MVPA – Class Time[g]	112		84		28		
Baseline		33.6% (13.4)		33.1% (15.1)		35.2% (5.7)	0.29
Post 1		35.2% (11.2)		35.1% (12.7)		35.4% (4.2)	0.84
Post 2		37.6% (15.0)		39.2% (16.0)		32.8% (10.4)	**0.02**
Post 3		41.5% (16.2)		43.2% (18.0)		36.4% (7.1)	**<0.01**
Post 4		44.2% (20.5)		48.5% (21.7)		30.9% 5.4)	**<0.01**
BMI-For-Age Percentile	2,352		1,679		673		
Baseline		68.4 (29.3)		68.3 (28.8)		68.5 (30.6)	0.88
Post		65.2 (30.3)		65.1 (30.1)		65.5 (30.8)	0.80

[a]Intervention students were measured in October 2015, control students were measured in January 2016
[b]Mean percent of fourth grade students that are white at each school
[c]FRL: Free and Reduced Lunch; Mean percent of total school population that is eligible for the FRL program
[d]Average number of steps performed during 5-day week. Students were measured for one week each month
[e]Mean number of PACER laps completed
[f]Mean number of steps taken while engaging in MVPA during PE class
[g]Mean percent of PE class time spent while engaging in MVPA
*p-value for test of significant difference between intervention and control baseline characteristics; chi-square test for categorical variables (gender), two-sample t-test for continuous variables (%white, %FRL, average daily steps, PACER laps, MVPA, BMI percentiles). Bold font indicates statistically significant difference between intervention and control group at the alpha = 0.05 level

Table 2. Regression Models for Five Physical Activity Measures Comparing Intervention to Control from a Sample of 4th Grade Students in 31 schools in Metro Atlanta, n = 3,396

	n	Estimate	95% CI	p-value*
Change in mean daily steps[a]				
Overall Model	3,317			
Intercept		339.0	82.1, 595.9	**<0.01**
Crude Model	3,317			
Intercept		-4.6	-427.6, 418.4	0.98
Intervention		432.2	-88.0, 952.4	0.10
Adjusted Model	3,295			
Intercept		125.5	-522.6, 773.5	0.70
Intervention		470.8	-122.1, 1063.7	0.12
Gender		54.8	-14.3, 123.9	0.12
%FRL[d]		-230.0	-985.5, 525.6	0.55
Change in PACER laps[b]				
Overall Model	1,754			
Intercept		2.82	1.93, 3.70	**<0.01**
Crude Model	1,754			
Intercept		2.34	1.98, 2.78	**<0.01**
Intervention		0.71	-0.73, 2.15	0.34
Adjusted Model	1,754			
Intercept		3.10	2.45, 3.76	**<0.01**
Intervention		3.23	0.19, 6.27	**0.04**
Gender		-0.76	-1.49, -0.03	**0.04**
%FRL		-0.53	-1.30, 0.24	0.17
Intervention x %FRL		-3.14	-6.32, 0.04	**0.05**
Change in MVPA steps[c]				
Overall Model	111			
Intercept		794.5	522.6, 1066.3	**<0.01**
Crude Model	111			
Intercept		22.4	-288.4, 333.2	0.89
Intervention		1,032.5	622.1, 1,442.8	**<0.01**
Adjusted Model	111			
Intercept		-42.4	-406.2, 321.3	0.82
Intervention		1,050	618.7, 1,481.3	**<0.01**
Gender		352.3	25.7, 678.9	**0.03**
%FRL		-172.7	-602.6, 257.1	0.43

[a]Mean change in the number of steps measured by the difference between mean steps at Steps Baseline subtracted from mean steps taken during Steps Post 4
[b]Mean change in the number of completed PACER laps from pre to post
[c]Mean change in the number of steps taken while participating in MVPA measured by the number of MVPA steps taken at MVPA Baseline subtracted from the number of MVPA steps taken at MVPA Post 4
[d]Dichotomous variable indicating percentage of total school population greater than or equal to 50% eligible for FRL
*Bold font indicates a statistically significant predictor in the model at $\alpha = 0.05$

Table 2 cont.

	n	Estimate	95% CI	p-value
Change in MVPA time[d]				
Overall Model	111			
Intercept		0.11	0.06, 0.15	**<0.01**
Crude Model	111			
Intercept		-0.04	-0.08, -0.001	**0.02**
Intervention		0.2	0.14, 0.26	**<0.01**
Adjusted Model	111			
Intercept		-0.1	-0.18, -0.001	**0.05**
Intervention		0.18	0.11, 0.26	**<0.01**
Gender		0.06	0.02, 0.11	**<0.01**
%FRL		0.04	-0.09, 0.17	0.54
Change in BMI percentile[e]				
Overall Model	2, 352			
Intercept		-3.16	-4.20, -2.12	**<0.01**
Crude Model	2, 352			
Intercept		-3.04	-4.15, -1.94	**<0.01**
Intervention		-0.16	-1.94, 1.62	0.86
Adjusted Model	2, 352			
Intercept		-2.01	-3.63, -0.39	**0.02**
Intervention		-2.92	-4.63, -1.20	**<0.01**
Gender		0.68	-0.02, 1.38	0.06
%FRL		-1.60	-2.44, -0.77	**<0.01**
Intervention x %FRL		3.93	1.31, 6.54	**<0.01**

[d]Mean change in the percentage of PE class time spent performing MVPA measured by the percent of class spent in MVPA at MVPA Baseline subtracted from the percent of class spent in MVPA at MVPA Post 4

[e]Change in BMI percentile between baseline measurement and post

FIGURES

Figure 1. A Comparison of Mean Daily Steps by Week for Intervention and Control Students in a Sample of 4th Grade Students in Metro Atlanta, n = 3,317.

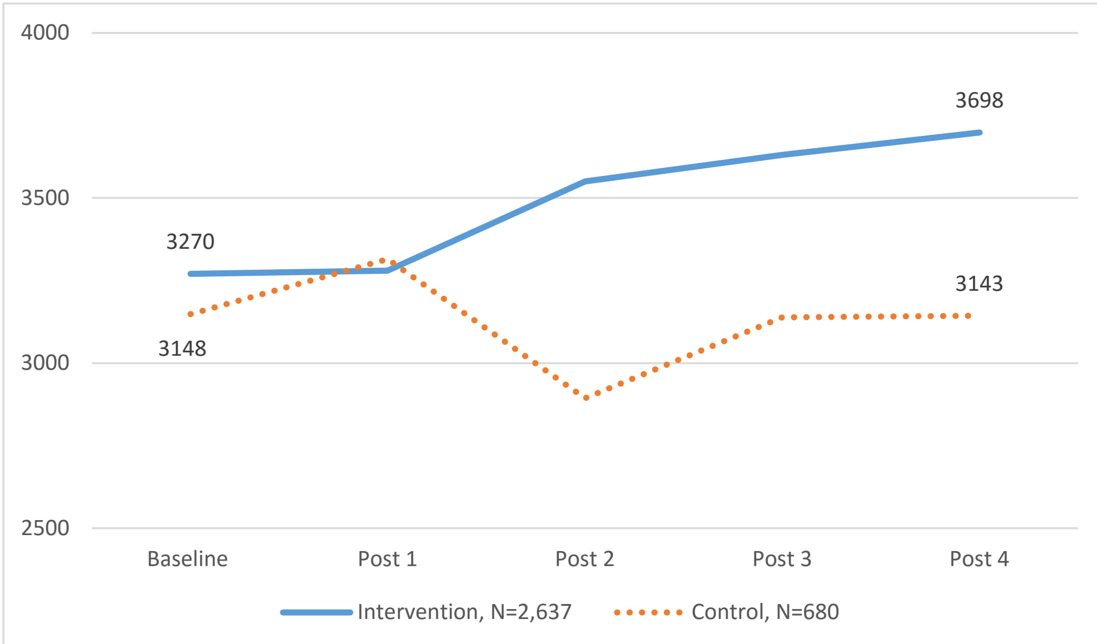


Figure 2. Mean PACER Laps Completed at Baseline and Post-Test for Intervention and Control Students in High Socioeconomic Status Schools in a Sample of 4th Grade Students in Metro Atlanta, n = 452.

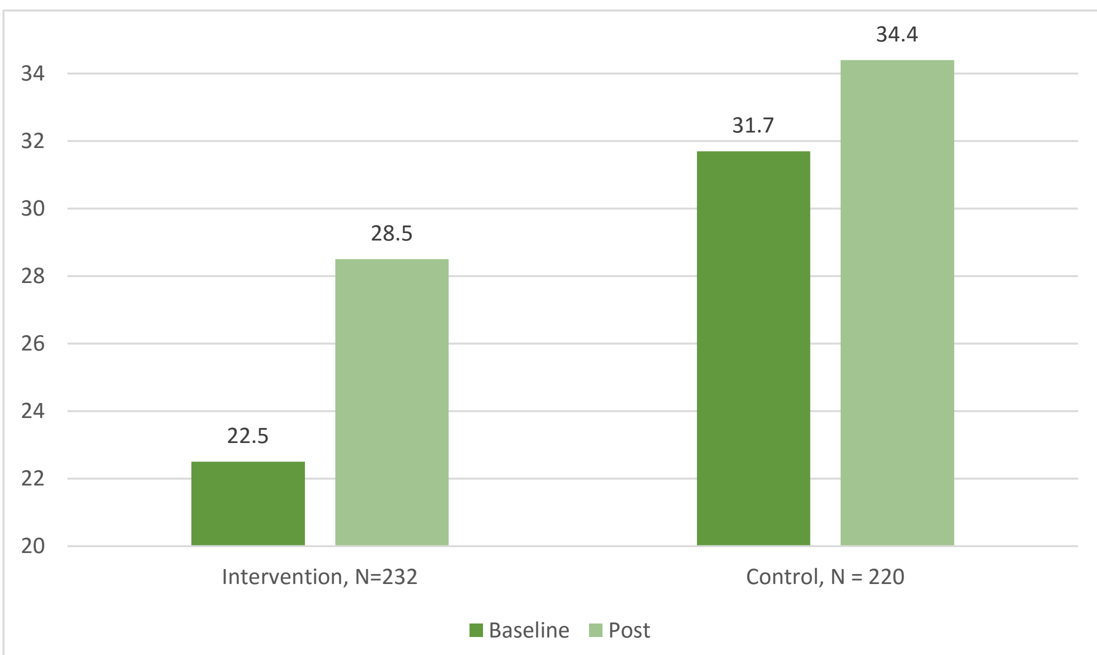


Figure 3. Mean PACER Laps Completed at Baseline and Post-Test for Intervention and Control Students in Low Socioeconomic Status Schools in a Sample of 4th Grade Students in Metro Atlanta, n =1,173.

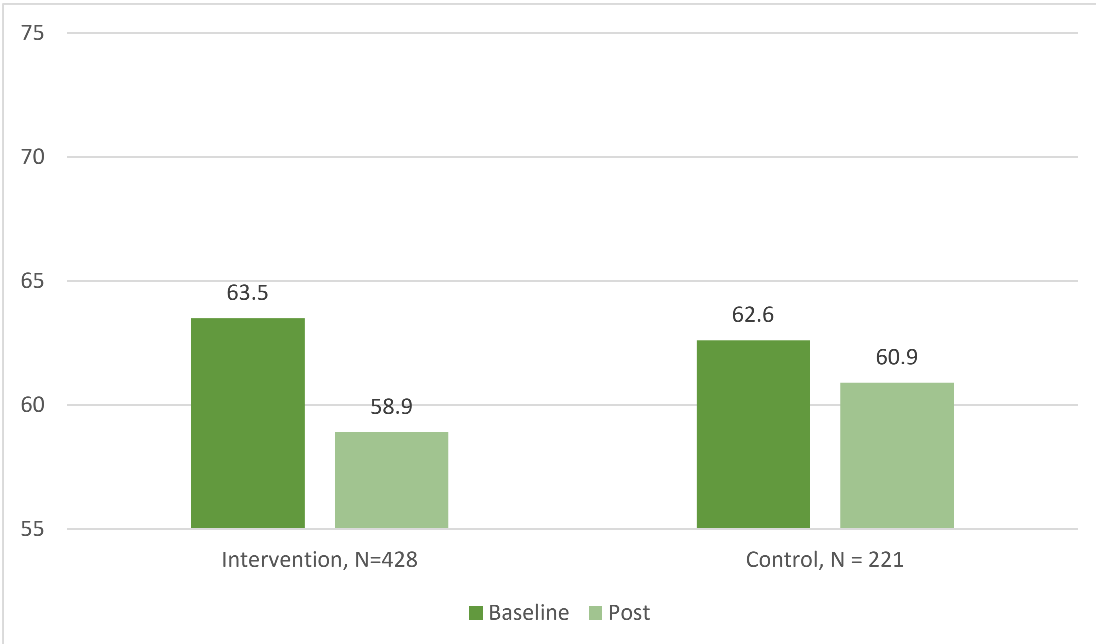


Figure 4. Mean BMI-For-Age Percentile at Baseline and Post-Test for Intervention and Control Students in High Socioeconomic Status Schools in a Sample of 4th Grade in Metro Atlanta, n = 649.

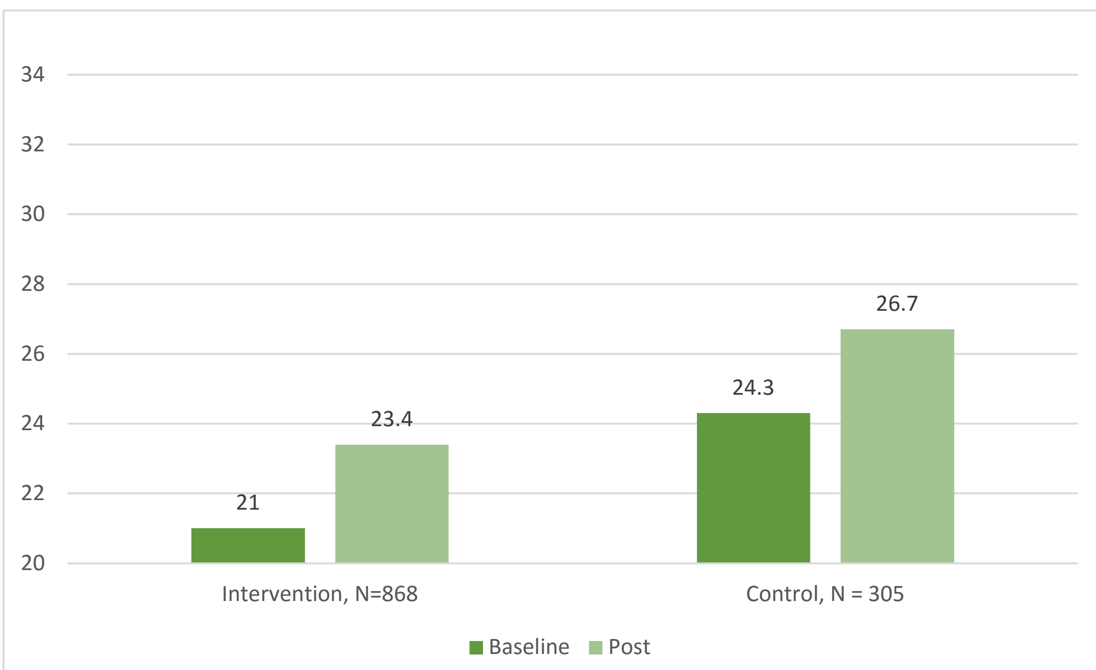


Figure 5. Mean BMI-For-Age Percentile at Baseline and Post-Test for Intervention and Control Students in Low Socioeconomic Status Schools in a Sample of 4th Grade Students in Metro Atlanta, n = 1,703.

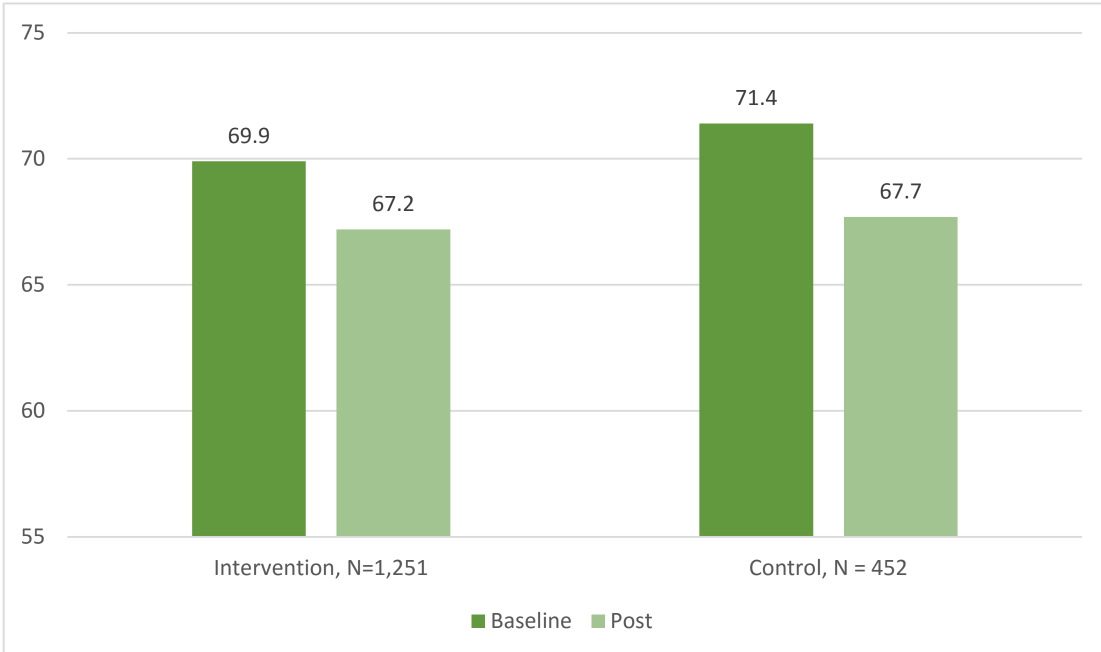


Figure 6. A Comparison of Mean MVPA Steps for Intervention and Control Students in 4th Grade Students in Metro Atlanta, n = 112.

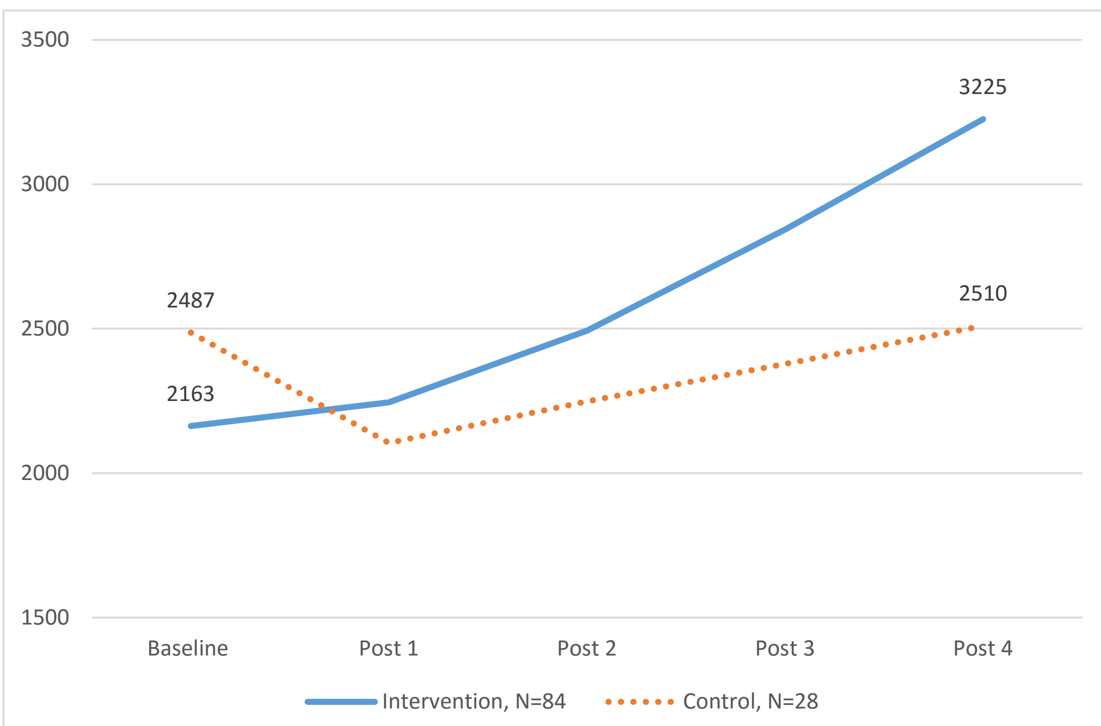
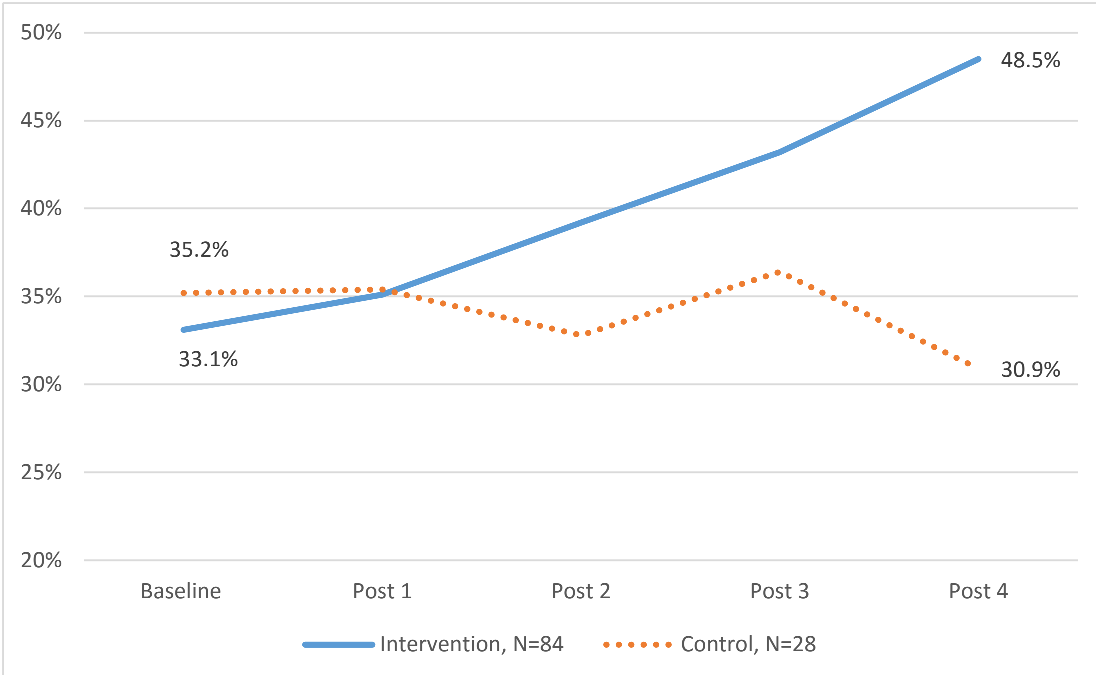


Figure 7. A Comparison of Mean Percent of PE Class Time Spent in MVPA for Intervention and Control Students in 4th Grade Students in Metro Atlanta, n = 112.



APPENDICES

Table A-1. Description of Data Measures, Instrument, Frequency and Source Collected from 31 Public Schools in Metro Atlanta

Data Measure	Data Instrument	Frequency/Timing of Measurement	Data Collection Source
Physical Activity			
MVPA in PE	GFSP	Six measures on same 4 students I: 6 months C: 5 months	Electronic data reported monthly
Step Data	Pebble	Five weeks I: 5 months C: 5 months	Waist clip activity tracker worn one week per month
Health-Related Fitness			
Aerobic capacity	Fitnessgram PACER	Pre-Post I: Sept 2015 & May 2016 C: Sept 2015 & May 2016	PE Teacher/District
BMI	Fitnessgram Height/Weight	Pre-Post I: Sept 2015 & May 2016 C: Sept 2015 & May 2016	PE Teacher
Demographic Characteristics			
Gender	Class Roster	I: Sept (2015) C: Jan (2016)	School Teacher
Race/ethnicity	DOE Records	October (2015)	School District
FRL	DOE Records	October (2015)	School District

Abbreviations: MVPA, moderate-to-vigorous physical activity; PE, physical education; GFSP, Gopher FitStep Pro; BMI, body mass index; FRL, free/reduced lunch

Figure A-1. Theory of Change Model

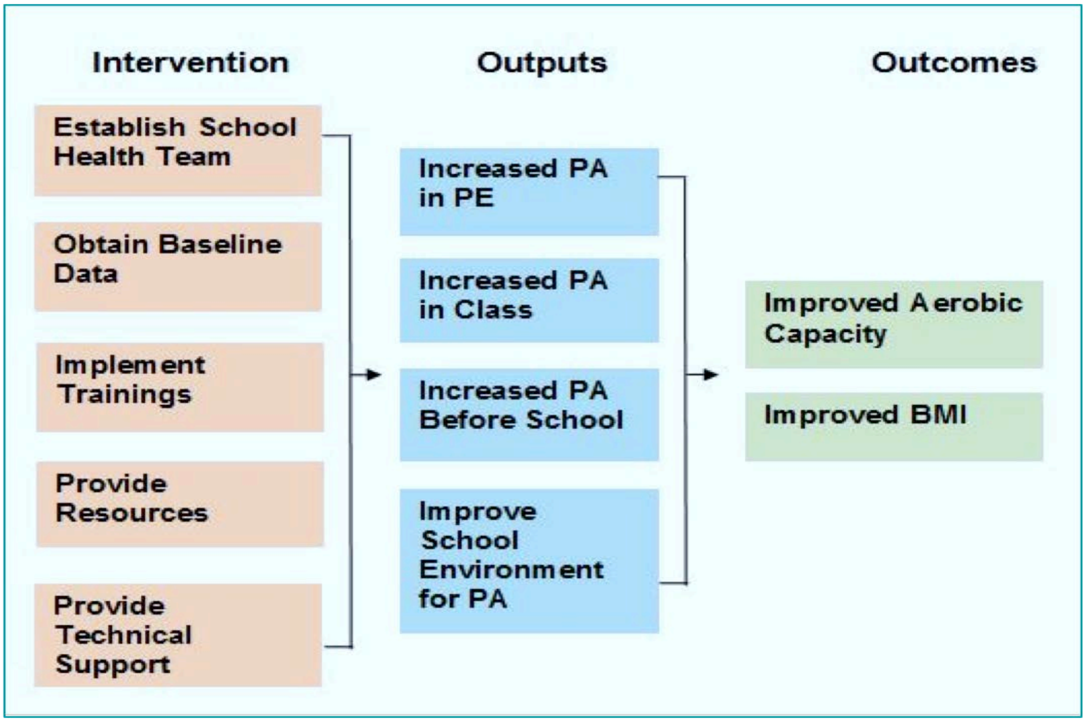


Figure A-2. Distribution of Students and Outcome Measures