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Comparison of changes in body mass index and cardiopulmonary fitness between normal weight vs. overweight and obese fourth grade students after a school-based physical activity program: non-randomized intervention study

By

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Degree to be awarded: M.P.H.

Executive MPH

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By

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Doctor of Medicine
Korea University
2007

Thesis Committee Chair: Julie Gazmararian, PhD, MPH

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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 Executive MPH
2018

Abstract

Comparison of changes in body mass index and cardiopulmonary fitness between normal weight vs. overweight and obese fourth grade students after a school-based physical activity program: non-randomized intervention study

By Rena C. Moon

Background: Approximately one in five children aged 6-11 are obese nationwide. Although obesity is associated with many negative health consequences, improving cardiopulmonary fitness can create a better health outcome. In order to improve cardiopulmonary fitness among children, many school-based physical activity (PA) programs have been implemented. Nevertheless, the outcomes of school-based PA interventions are often not stratified by baseline weight status, and how the intervention improves the health of overweight and obese children is not well established.
Aims: To evaluate whether overweight/obese children had similar changes in body mass index (BMI) and cardiopulmonary fitness as with normal weight children after a school-based PA intervention (*Health Empowers You!*), controlling for sex, race/ethnicity, and socioeconomic status
Methods: Using convenience sampling method at the school-level, 21 intervention and 7 control schools in Atlanta, GA were included in the study during 2015-2016 academic year. At the student-level, sample sizes were 2,341 for BMI analysis, and 1,799 for Progressive Cardiovascular Endurance Run (PACER) test analysis. Two sample t-tests and two-way ANOVA of the mean differences between pre- and post-intervention for BMI and PACER were conducted, stratified by pre-intervention weight status. Multiple linear regression models were fit for each subject.
Results: Normal weight, overweight, and obese students did not show changes in BMI after the intervention. However, being overweight or obese was significantly associated with the decrease in raw BMI, holding intervention status fixed ($p<0.01$ and $p<0.01$, respectively). Normal weight students showed a significant improvement in PACER test ($p<0.01$), while overweight and obese students did not show changes in PACER test after the intervention ($p=0.94$ and $p=0.25$, respectively). In other words, normal weight students had a better improvement in PACER test than overweight or obese students with the intervention.
In the control group, changes in PACER test were not different for overweight and obese vs. normal weight group ($p=0.86$ and 0.68, respectively). In the intervention group, overweight and obese students showed significantly less improvement in PACER test (by 1.61 laps and 2.12 laps, respectively) than normal weight students ($p=0.03$ and $p=0.02$, respectively).
Conclusion: This analysis contributes to the literature on how overweight and obese children are affected differently by school-based PA intervention from normal weight children. Different approaches for overweight and obese children may be needed to achieve improvements in cardiopulmonary fitness.

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Acknowledgements

First and foremost, I thank Jesus for guiding me and being the light on my path.

Next, I want to thank my in-law parents and my parents, for all their physical and emotional support throughout the course of this program.

Finally, I want to thank my husband, Nam, and my children, Elisha and Micah, for their unlimited support and patience throughout my career. We were all in this together and your sacrifices made it all possible.

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I. Introduction

A. Importance of Being Metabolically Healthy

In 2015-2016, 18.4% of children aged 6-11 years were obese in the United States (1). Although obesity itself is a physical condition, it has been declared a disease due to its serious health consequences (2). Obesity is an independent risk factor for cardiovascular diseases, and is associated with hypertension, dyslipidemia, and insulin resistance in both children and adults (3-8). Nevertheless, a subset of obese individuals who do not have any metabolic comorbidities are considered 'metabolically healthy obese' (9, 10). Studies have shown that metabolically healthy obese subjects are not at an increased risk of cardiovascular diseases (11, 12). Although defining what keeps obese subjects metabolically healthy is complex, one of the most significant predictors of being metabolically healthy was cardiorespiratory fitness (13, 14). In fact, obese individuals with preserved cardiopulmonary fitness were at significantly lower risk of cardiovascular diseases than obese individuals without preserved cardiopulmonary fitness (14-19).

B. Benefits of Cardiopulmonary Fitness and Physical Activity

Cardiopulmonary fitness is 'the overall capacity of the cardiovascular and respiratory systems and the ability to carry out prolonged strenuous exercise' (20). Increasing physical activity can improve cardiopulmonary fitness (20). Studies have shown that physical activity is associated with lower odds of being metabolically unhealthy for both obese and non-obese children (21-24).

Physical activity is also associated with numerous other health benefits in school-aged children, including controlling blood pressure, blood triglycerides levels, and blood glucose levels (25). Preventing obesity during childhood is another advantage of physical activity for normal weight children (26). Physical activity benefits children who are already obese, since moderate-to-vigorous physical activity was significantly associated with being 'metabolically healthy' among obese youth (27). Many studies reported a dose-response relationship between physical activity and health, indicating that the more physical activity, the greater the health benefit (25). Intensities and types of the physical activity were important as well, and physical activities with at least a moderate intensity and aerobic-based activities that focused on cardiorespiratory fitness had the greatest health benefits (25).

C. School-Based Efforts to Increase Physical Activity in Children

In the United States, federal physical activity guidelines for children is 60 minutes of daily moderate-to-vigorous physical activity (28). Currently, 76.1 % of children 6 to 8 years and 64.7 % of children 9 to 11 years meet this goal (29). In an effort to increase physical activity levels among children, many school-based physical activity intervention programs were implemented. Schools provide good settings for intervention programs because they enable the interventions to reach the vast majority of children and adolescents (30). In the United States, most children aged 5 to 17 years old attend school 180 days per year for six or more hours per day. This setting allows programs to have a continuous and intensive influence on children during their first two decades of life (31). In addition, because schools have dedicated time for physical activities such as physical education (PE) and recess, programs can easily increase the levels of physical activity (32).

The efficacy of school-based physical activity programs can be evaluated from many different perspectives. One of the primary outcome is changes in weight and body composition, as many of these programs aim to prevent childhood obesity. However, numerous studies reported that school-based physical activity programs were not effective in preventing obesity (33-35). In a systemic review of 12 PE-based physical activity interventions among elementary school children, the interventions did not have a significant effect on changing skinfold thickness and body fat percentage either (28).

Another outcome for school-based physical activity programs is improving cardiopulmonary fitness. Improving cardiopulmonary fitness and thereby encouraging children to be 'metabolically healthy' can have a substantial health benefit even if there are no changes in their body composition. In fact, in the same systemic review of PE-based physical activity interventions, studies consistently showed increases in moderate-to-vigorous physical activity or vigorous physical activity during PE classes after interventions (28). In other meta-analyses, the length of moderate-to-vigorous exercise among children increased significantly after school-level physical activity interventions (36-38).

D. Necessity of Additional Analysis for School-Based Physical Activity Programs

Children participating in school-based physical activity programs are at different weight statuses, and most school-based physical activity programs do not differentiate overweight and obese children from normal weight children. However, baseline weight status is a significant predictor of future weight and can affect the outcomes of both changes in body composition and cardiopulmonary fitness (39, 40).

When changes in body composition are the outcome of interest associated with an intervention program, it is important to note that fluctuations in body mass index (BMI) during maturation are expected characteristics of children (41). Because the rate of weight gain may not be the same as the rate of gain in stature, the interpretation of weight gain is often difficult (41). Therefore, it may be helpful to control for baseline weight status in the analysis or stratify the differential effects of the intervention based on weight (28).

When changes in cardiopulmonary fitness are the outcome of interest associated with an intervention program, it is also important to note that overweight and obese children are less physically fit and have lower values of gross motor coordination compared to normal weight children (42). Being obese was significantly associated with poorer gross motor skill performance including upper limb coordination, bilateral coordination, balance, running speed, agility, and strength (43). In a cross-sectional study of 304 elementary school children, being overweight and obese was inversely associated with physical fitness (44). Also, in a longitudinal study of 754 elementary school children, a higher baseline BMI z-score was predictive of decreased performance of gross motor coordination (45). Such functional limitations can aggravate inactivity and sedentary lifestyle, generating a vicious cycle for obese children (39, 46). This indicates that providing the same level of physical activity intervention to students of all weight status may not be the most effective way to increase physical activity for overweight and obese children.

E. Gaps in the Literature

Despite the significance of baseline weight status, many studies did not adjust their results for baseline weight status (47-49). While several studies controlled for the baseline weight status in their outcome analyses (50, 51), they did not report their outcomes separately for overweight and obese children (28). Overweight and obese children actually may be the greatest beneficiaries of physical activity programs, because even the modest amount of physical activity showed health benefits for these children (25). However, when the result of an intervention program is not stratified by baseline weight status, it may not represent how effective the intervention was for the overweight and obese population. Because the proportion of overweight and obese children are less than that of normal weight in most schools, changes (or no changes) in overweight and obese children may be overshadowed by significant changes among normal weight children.

In addition, many school-based physical activity programs did not report changes in cardiopulmonary fitness after the intervention (52). Theoretically, an increase in moderate-to-vigorous exercise should translate into a better cardiopulmonary fitness. However, several studies reported that aerobic fitness and endurance did not improve after interventions despite increases in physical activity levels (41, 50, 51, 53). Therefore, reporting an objective measurement of cardiopulmonary fitness is prudent in addition to reporting the length of moderate-to-vigorous physical activity after interventions.

A more detailed analysis of the outcomes in childhood obesity intervention programs is warranted, stratified by baseline weight status, and including objective measures of cardiopulmonary fitness.

II. Goals and Objectives

The primary goal of this analysis is to evaluate the association between pre-intervention weight status (normal weight vs. overweight and obese) and the BMI and cardiopulmonary fitness outcomes of a school-based physical activity intervention among a population of fourth graders in metropolitan Atlanta, Georgia over the period of one academic year. Specific objectives include the following:

1. To evaluate whether overweight and obese children had similar changes in BMI z-score and raw BMI as with normal weight children during one academic year with a non-randomized intervention, controlling for gender, race/ethnicity, and socioeconomic status; and
2. To evaluate whether overweight and obese children had similar changes in cardiopulmonary fitness (PACER) test as with normal weight children during one academic year with a non-randomized intervention, controlling for gender, race/ethnicity, and socioeconomic status

III. Methods

A. Study Design and Population

With funding from the Blue Cross and Blue Shield (BCBS) of Georgia Foundation and the Ardmore Institute of Health, a convenience sampling was done by contacting PE teachers in their respective districts. A total of 28 intervention schools and 7 control schools were non-randomly selected in the 2015-2016 academic year. These 35 schools were all located in three metropolitan Atlanta school districts. Intervention schools were in two districts (17 schools in Gwinnett County System and 11 schools in Atlanta Public School System), and control schools were in one district (7 schools in Fulton County System).

Prior to enrollment of fourth grade students in 28 intervention schools, district-level Health and PE Coordinators assisted HealthMPowers staff in school recruitment and participation. PE teachers at each school were the points of contact during recruitment, and fourth grade teachers and/or school principals ultimately made decisions to participate. All control schools were enrolled in January 2016 with a similar recruitment method. At the student level, 3,889 fourth grade students from intervention schools and 992 fourth grade students from control schools were included in the study.

Once the intervention was in place, points of contact at each school included 3 staff members (one PE teacher, one fourth grade teacher, and one other staff member of the schools' choosing). fourth grade teachers at each school served as points of contact and were trained for collecting and reporting physical activity data to the research team. In control schools, these teachers were instructed not to change anything in their classrooms and received $200 compensation for their participation. Final follow-up measurements were recorded in May 2016 for all intervention and control schools.

Fourth grade students were selected as the sample population for two reasons. First, fourth graders spend most of their school hours in one classroom, which would allow a more accurate measurement of classroom physical activity. Second, fourth grade is the lowest grade level for which the reporting of FITNESSGRAM is state-mandated.

B. Description of ***Health Empowers You!*** Intervention

HealthMPowers was founded in 1999, 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, to address obesity among elementary school children in Georgia. The *Health Empowers You!* intervention was designed using evidence-based strategies identified by the CDC. The program aims to train schools and teachers to integrate 30 additional minutes of physical activity during school hours. Five main components of the program include: establishing a school health team, implementing trainings for teachers, obtaining physical activity data, providing resources for schools and teachers, and providing technical assistance.

A descriptive study on the outcome of HealthMPowers program during the 2011-2012 and 2012-2013 school years among 40 elementary schools indicated that students who were overweight or obese at baseline had the most significant decrease in BMI z-scores (54). It also showed that the BMI z-scores decreased overall for fourth and fifth grade boys and girls over a period of one academic year. Using the Progressive Aerobic Cardiovascular Endurance Run (PACER) test to measure cardiopulmonary fitness, all grades and cohorts showed significant improvement after the physical activity intervention. However, these results were mainly descriptive, because these previous cohorts did not have a control group for comparison of the results.

For the 2015-2016 academic year cohort with a control group, HealthMPowers delivered three training sessions (one face-to-face training, and two face-to-face or virtual trainings). Contents of the training included strategies on incorporating additional physical activity into classrooms and increasing moderate-to-vigorous physical activity during PE hours. Resources for schools and teachers included physical activity videos and sports equipment. Other analyses from this project indicated that students in intervention schools showed significant increase in the length of moderate-to-vigorous physical activity compared to that of students in control schools. Furthermore, students in intervention schools showed significant increases in completed PACER test, indicating better cardiopulmonary fitness, compared to that of students in control schools overall. However, students in intervention schools did not show significant differences in changes of BMI percentiles compared to students in control schools overall (55, 56).

C. Data Sources

Following Institutional Review Board (IRB) approval in the three school districts, fourth grade teachers obtained signed consent forms from the parents of the students in their classes. The school system provided the research team with individual student information when parental consent was obtained. Students still participated in all components of the intervention when parental consent was not obtained, but the students' identifying information was not shared with the research team and data were not linked. Two data sources were used in the analysis: FITNESSGRAM and Department of Education, which are described in more detail below.

1. FITNESSGRAM

FITNESSGRAM is a validated and reliable health-related physical fitness assessment (57). The full battery of tests includes Progressive Aerobic Cardiovascular Endurance Run (PACER), height and weight measurement for BMI, Curl Ups, 90-degree Push Ups, and the Sit and Reach test (58). Beginning in the 2011-2012 academic year, *FITNESSGRAM* assessment became mandatory for all students in grades 4-12 who are in a PE class at a Georgia public school. *FITNESSGRAM* assessment was performed once per academic year (in May), and PE teachers conducted the assessments and recorded results. For this study, only PACER and BMI data were used from the *FITNESSGRAM* assessment.

The PACER test is a component of *FITNESSGRAM* assessment and is a measure of cardiopulmonary fitness. The PACER test is a multi-stage aerobic test adapted from the 20-meter shuttle run test, and aerobic capacity is predicted from the number of laps completed during the test (59-61). The goal of the PACER test is to run for as long as possible while maintaining a specific pace. When laboratory-based testing is not practical, the PACER test has been validated to be a useful estimation of aerobic capacity (62).

In addition to the mandatory *FITNESSGRAM* assessment, each student's PACER test, height and weight were recorded at the beginning of the study to serve as a baseline measurement. Baseline information for intervention school students was obtained in October 2015, and baseline information for control school students was obtained in January 2016.

Follow-up information for all students was obtained in May 2016, as part of the routine *FITNESSGRAM* assessment.

2. Department of Education

Because race/ethnicity and socioeconomic status information could not be obtained at the student level, school level race/ethnicity and socioeconomic status information from the Department of Education (DOE) data was used. The DOE reported race/ethnicity composition (non-Hispanic white, non-Hispanic black, Hispanic, Indian, Asian, Pacific Islander, and multi-race) and a proportion of students enrolled in the Free and Reduced Lunch (FRL) program for each participating school.

D. Data Measures

1. Exposure Variables

a. Intervention Status. The main exposure of interest was the *Health Empowers You!* intervention. Intervention status was coded dichotomously.

b. Pre-intervention Weight Status. Another main exposure of interest was the pre-intervention weight status of fourth grade students. BMI for each student was calculated by dividing weight in kilograms by the square of height in meters. Corresponding BMI z-score, also called BMI standard deviation score, was calculated for each student. BMI z-scores are 'measures of relative weight adjusted for child age and sex'; these scores are based on an external reference, and 'correspond to growth chart percentiles' (63). The CDC growth chart was referenced for calculating BMI z-scores (64).

Pre-intervention weight status was divided into three categories, as students with BMI z-scores less than 1 (normal weight), BMI z-scores equal to or greater than 1 and less than 2 (overweight), and students with BMI z-scores equal to or greater than 2 (obese).

2. Outcome Variables

a. Changes in Weight. The outcome of interest was changes in raw BMI. At the student level, BMI at follow-up was subtracted by BMI at baseline, and the difference was treated as a continuous variable. As an additional measure of changes, percent changes in raw BMI were identified. The percent changes in raw BMI were dichotomized to greater than 10 % and less than or equal to 10 %.

b. Changes in Cardiopulmonary Fitness. The outcome of interest was changes in PACER test. At the student level, PACER test result at follow-up was subtracted by the PACER test result at baseline, and this difference was treated as a continuous variable.

3. Covariates

a. Gender. Student-level gender was either male or female.

b. Race/Ethnicity. Race/Ethnicity has shown to be an important confounder in the outcome of childhood obesity. The proportion of each racial and ethnic groups was obtained at the school level. Because the DOE data does not report the number of students if one specific race/ethnicity is less than 15 students in one school, the proportion of racial and ethnic groups was still an approximation of true proportion for each school. Therefore, each school was identified with a predominant race/ethnicity. If the proportion of students with a single race/ethnicity was greater than 50 %, the school was identified as predominant for that specific race/ethnicity. Three race/ethnicity groups were identified as dominant, and these were non-

Hispanic white, non-Hispanic black, and Hispanic. This information was then coded using dummy variables, and non-Hispanic black dominant schools were coded as the reference level.

c. Socioeconomic Status. Socioeconomic status is another important covariate for outcomes of childhood obesity. However, because this information was not available at the student level, proportion of students receiving FRL was obtained for each school. The level of proportion was trichotomized, and schools with less than 33 % of students enrolled in FRL programs were identified as low-FRL schools, schools with 33-66 % of students enrolled in FRL programs were identified as moderate-FRL schools, whereas schools with greater than or equal to 66 % of students enrolled in FRL programs were identified as high-FRL schools. Dummy variables were then created, and low-FRL schools were coded as the reference level.

E. Data Analysis

A raw data file was obtained in Microsoft Excel spreadsheets and imported into SAS for analysis. This analysis utilized one dataset with gender information, exposure and outcome variables including BMI and PACER test. Students with a missing Georgia Testing Identification Number (GTID) were deleted from the dataset (n=265) (Figure 1). Additional 513 students were excluded because they did not have baseline height or weight information. For BMI, 1,667 in the intervention group and 674 in the control group had information at both baseline and follow-up. For PACER, 1,124 in the intervention group and 675 in the control group had information at both baseline and follow-up. Final sample size was 2,341 for BMI analysis, and 1,799 for PACER analysis. After cleaning the dataset, race/ethnicity and FRL information from the DOE data was added to the dataset.

For the descriptive analysis, frequencies and chi-square test were used for categorical variables and means and pooled t-test were used for continuous variables. For comparison of BMI z-scores of intervention vs. control group, median and Mann-Whitney test were used because the distribution of BMI z-scores was skewed by separating the group with extreme BMI z-scores.

Two-way analysis of variance (ANOVA) was performed for the two main exposure variables, pre-intervention weight status and intervention status. If significant, interaction terms of the two main exposure variables were assessed. The outcome variables were changes in raw BMI (post-intervention raw BMI subtracted by pre-intervention raw BMI) and changes in PACER test (post-intervention PACER subtracted by pre-intervention PACER). Multiple linear regression models were fit for each outcome variable, using school-level covariates of race/ethnicity and socioeconomic status. The interaction terms between pre-intervention weight status and intervention status were assessed for each outcome. Statistical analysis was performed using SAS 9.4 (Cary, NC), with $p < 0.05$ regarded as statistically significant.

Missing Data

When we compared included students versus excluded students, we did not find the difference in the percentage of male students (52.3 vs. 50.3, p=0.28) and percentage of overweight students (43.2 vs. 43.7, p=0.82). However, included participants were more likely to attend white-predominant schools (18.7 vs.15.6, p=0.02), and more likely to attend high-FRL schools (63.1 vs. 57.3, p<0.01).

IV. Results

A. Descriptive Statistics

Of the 1,943 students attending 21 intervention schools, 29.8% (n=579) were overweight and 13.1% (n=254) were obese at baseline. Of the 675 students attending 7 control schools, 32.6% (n=220) were overweight and 12.9 % (n=87) were obese (Table 1). Overall, the proportion of children with obesity was similar between intervention and control schools (p=0.63).

There were no differences in gender proportion between intervention and control groups among normal weight (p=0.08), overweight (p=0.18) and obese students (p=0.54). For all weight categories, less students in the intervention group attended non-Hispanic white predominant schools than the control group (p<0.01). For all weight categories, students in the intervention group were more likely to attend schools with a high proportion of students receiving FRL than students in the control group (p<0.01). The distributions of raw BMI and BMI z-scores were comparable between students in intervention and control schools, for all weight categories.

B. Changes in Raw BMI

Among normal weight students, the mean raw BMI slightly increased in both the intervention (0.26kg/m^2) and control (0.17 kg/m^2) groups (Table 2). The changes in BMI were not different between intervention and control groups (p=0.24). Also, there was no difference in the proportion of students who had a raw BMI change greater than 10% between intervention and control groups (p=0.21).

Among overweight students, the mean raw BMI slightly increased in the intervention group (0.02 kg/m^2) and slightly decreased in the control (0.07 kg/m^2) group. The changes in BMI were not different for intervention and control groups ($p=0.45$). More overweight students in the intervention group (7.1%) had a raw BMI change greater than 10% than the control group (3.2%) ($p=0.04$).

Among obese students, the mean raw BMI decreased in both intervention (0.45 kg/m^2) and control (0.83 kg/m^2) groups. Similarly, intervention was not associated with changes in BMI ($p=0.27$). There was no difference in the proportion of students who had a raw BMI change greater than 10% between intervention and control groups ($p=0.77$).

In the two-way ANOVA analysis, the interaction term between pre-intervention weight status and intervention status was not significant ($p=0.41$) and therefore was not included in the model. The decrease in raw BMI was greater in overweight students by 0.24 kg/m^2 and obese students by 0.80 kg/m^2 compared to normal weight students, holding the status of intervention fixed ($p<0.01$) (Table 3). In other words, being overweight or obese was associated with a greater decrease in raw BMI at follow-up, regardless of the intervention status. However, when pre-intervention weight status was fixed, intervention status did not have a significant effect on the changes of raw BMI ($p=0.07$).

C. Changes in PACER Test

Among normal weight students, both the intervention and control groups showed improvements in PACER test at follow-up (Table 2). However, the intervention group (3.96 laps) had a greater improvement than the control group (2.31 laps), indicating a valid improvement in cardiopulmonary fitness after intervention in the normal weight group students ($p<0.01$).

Among overweight and obese students, both the intervention and control groups showed improvements in PACER test at follow-up. However, unlike the normal weight students, there were no differences in the improvement of PACER test between the intervention and control groups (p=0.94 and p=0.25, respectively).

In the two-way ANOVA analysis, the interaction term between pre-intervention weight status and intervention status was significant (p=0.02) and therefore was retained in the model. This suggests that the mean changes in PACER test among normal weight, overweight, and obese students were not the same for control and intervention schools (Table 3). The changes in PACER test between normal weight vs. overweight, and normal weight vs. obese groups in control schools were not significant, meaning that pre-intervention weight status was not a significant predictor for changes in PACER for students attending control schools (p=0.86 and p=0.68, respectively). However, the corresponding changes were significant in intervention schools, meaning that pre-intervention weight status was a significant predictor for changes in PACER among students attending intervention schools (p<0.01 and p<0.01, respectively). Being overweight or obese was associated with a smaller improvement in PACER test than being normal weight in intervention schools. Also, among both overweight and obese students, changes in PACER test were not significantly associated with intervention status (p=0.94 and p=0.39, respectively).

D. Multiple Regression Model

The interaction terms between intervention status and pre-intervention weight status were considered in the model. Because the interaction terms were not significant for the BMI outcomes, they were dropped from BMI outcome models.

Intervention was not significantly associated with the decrease in raw BMI (p=0.07) in the crude model, holding pre-intervention weight status fixed (Table 4). However, being overweight or obese was significantly associated with the decrease in raw BMI in the crude model, holding intervention status fixed (p<0.01 and p<0.01, respectively). This suggests that the mean raw BMI decreased more among overweight and obese students than normal weight students, regardless of the intervention.

Intervention was significantly associated with the increase in PACER test (p<0.01) in the crude model. Because the interaction term was significant, the interpretation of PACER test needed to be stratified for each weight group. For the normal weight group, changes in PACER test increased by 1.65 laps when intervention was present. On the other hand, for the overweight and obese groups, changes in PACER test decreased when intervention was present (by 0.06 and 0.46 laps, respectively). This suggests that with intervention, normal weight students had a better improvement in PACER test than overweight or obese students. On the other hand, in the control group, changes in PACER test were not different for overweight vs. normal weight and obese vs. normal weight groups (p=0.86 and 0.68, respectively). This also suggests that only the normal weight students benefitted from the intervention.

However, these main effects did not account for the large variation in changes of raw BMI and PACER test (adjusted R-square = 0.028 and 0.015, respectively). Age and gender were not significantly associated with changes in outcome variables, and therefore were not included as covariates in the adjusted models.

When both socioeconomic status proxy (proportion of FRL program participants in each school) and school race/ethnicity were included in the model, students in schools with low proportions of FRL program participants were also students in non-Hispanic white predominant schools. Due to this reason, adjusted models were analyzed separately, one with socioeconomic status proxy covariates, and another with school race/ethnicity covariates. In both outcomes of changes in raw BMI and changes in PACER test, school race/ethnicity covariate model was better in explaining the variations than the socioeconomic status proxy covariate model (adjusted R-square 0.030 vs. 0.027, and adjusted R-square 0.033 vs. 0.029, respectively). Adding school race/ethnicity covariates to the crude model was also better in explaining the variations than the crude model itself.

However, adjusting for school race/ethnicity covariates did not significantly change the results observed from the crude model. Intervention status was not significantly associated with a decrease in raw BMI (p=0.51) but was significantly associated with an increase in PACER test in the adjusted model (p<0.01). Being overweight or obese was significantly associated with a decrease in raw BMI (p<0.01 and p<0.01, respectively) and both interaction terms were significantly associated with a decrease in PACER test in the adjusted model (p=0.04 and p=0.02, respectively).

Attending schools with a high proportion of non-Hispanic whites or Hispanics was not associated with changes in raw BMI compared to attending schools with a high proportion of non-Hispanic blacks (p=0.28 and p=0.55, respectively). However, attending schools with a high proportion of non-Hispanic whites was associated with better improvement of PACER test and attending schools with a high proportion of Hispanics was associated with less improvement of PACER test, than attending schools with a high proportion of non-Hispanic blacks (p<0.01 and p<0.01, respectively).

E. Sensitivity Analyses

For sensitivity analyses, we tested the outcomes by dichotomizing the pre-intervention weight status and grouping the overweight and obese students together (normal weight vs. overweight/obese). No significant improvement in PACER among overweight/obese students after the intervention was consistent with the dichotomized pre-intervention status (Appendix 1-3). No significant association between pre-intervention weight status and changes in BMI was also consistent with the dichotomized pre-intervention status (Appendix 1-3).

V. Discussion

This study aimed to examine the differences in outcomes of a school-based physical activity intervention program between normal weight vs. overweight and obese fourth graders in terms of changes in BMI and cardiopulmonary fitness (PACER). We found that intervention was not associated with changes in BMI in students of all weight statuses. However, among normal weight students, the intervention was associated with a significant improvement of cardiopulmonary fitness level. On the contrary, among overweight and obese students, the intervention was not associated with changes in cardiopulmonary fitness. These findings were the same for unadjusted and adjusted models.

While not many studies examined the results of school-based physical activity interventions by pre-intervention weight statuses, few reported that overweight and obese participants had better BMI reductions and/or better waist circumference reductions than normal weight participants (52, 65). Our result contradicts these reports in that the changes in mean raw BMI were not significant in normal weight, overweight, or obese students.

Although average changes in BMI percentile were similar between intervention and control school students overall (55), we were able to identify that being overweight or obese was a significant predictor for a mean BMI reduction. Overweight and obese students in control schools also showed a significant decrease in their mean BMI, indicating that the decrease in BMI among the overweight and obese population was not related to the intervention. This is not surprising, as a longitudinal survey of nationally-representative group of children also showed similar changes of BMI z-score in the normal weight, overweight, and obese groups between 9 and 11 years. The mean changes in BMI z-score were positive for normal weight children indicating weight gain, and negative for overweight and obese children indicating weight loss (66). Da Silva et al. (52) reported that a greater reduction in BMI percentile was observed in the overweight intervention group than the control group after 28 weeks of nutritional education and physical activity (n=238). However, the authors performed a Wald test for comparing the mean BMI, mean fat percentage, and mean BMI percentile before and after the intervention when they should have used paired sample tests such as a paired t-test. Therefore, the significance of differences before and after the intervention is not clear. Nevertheless, among the overweight children, changes in mean BMI, mean fat percentage, and mean BMI percentiles were not significantly different between the intervention and control groups at final check-point. This is consistent with our findings that changes in BMI were not significantly different between intervention and control groups among the overweight and obese children. In addition to the fact that changes in BMI are difficult to observe after school-based physical activity interventions (33, 34, 67, 68), we believe one academic year was not sufficiently long enough to show significant differences in BMI.

However, significant improvements were observed in terms of cardiopulmonary fitness after the intervention among normal weight students, while no corresponding improvements were observed among overweight and obese students. In the previous report of the same cohort, students in the intervention schools showed a greater increase in completed PACER test and percentage of time spent in moderate-to-vigorous physical activity (55). It is likely that the improvement among normal weight students overshadowed the non-improvement among overweight and obese students.

In the final adjusted model, normal weight students showed a greater improvement in cardiopulmonary fitness than overweight or obese students, controlling for race/ethnicity. This, to our knowledge, is a new finding for school-based physical activity interventions. While many studies have reported a significant increase in moderate-to-vigorous physical activity after physical activity interventions, not many studies reported on how it translated into cardiopulmonary fitness. Our findings confirm that physical activity interventions can improve cardiopulmonary fitness among fourth graders, paving the way for better exercise habits. However, our findings show that overweight and obese fourth graders did not benefit in cardiopulmonary fitness as their normal weight counterparts did. This may indicate that overweight and obese students need additional components or a more specialized physical activity intervention. Possible explanations include that overweight and obese children were less likely to be physically active and physically fit at baseline, and therefore improvements take more time than their normal weight peers (69). Also, because overweight and obese children can suffer from conditions such as asthma or arthritis that prevent them from fully exercising, they may have been bystanders during the intervention (70, 71). In a systemic review, van Hoek et al. (72) emphasized the importance of multicomponent intervention programs for the intervention to be effective among overweight or obese children aged 3-7 years old. In another review, Hernandez-Alvarez et al. (73) recommended a combination of dietary education and physical activity for the intervention to be effective among obese children population.

Strengths and Limitations

There were at least four strengths in this study. First, the biggest strength of this study is the intervention-control study design. By utilizing an intervention-based design, we were able to detect changes before and after the intervention. In addition, by including control schools, we were able to show that the changes in the outcome were in fact associated with the intervention. Second, we had a large sample size (n=2,341 for BMI, and n=1,799 for PACER). This gave us enough statistical power to detect any associations that existed and minimize type II errors. Third, we were able to link the changes in BMI and PACER test at the individual student level. Fourth, the measurements used in the analysis were not subject to bias, as only objective and validated data collection sources were utilized (BMI and PACER).

Despite these strengths, there were at least five limitations. First, there was a lack of randomization in assigning intervention and control schools. This limits our ability to draw causal inferences. Because randomization was not in place, it is possible that schools with more health-conscious parents and children were selected as intervention schools. However, baseline characteristics of the students showed that the mean BMI was comparable between intervention and control school students. Furthermore, baseline cardiopulmonary fitness was actually poorer in intervention than control school students, indicating a minimal bias in intervention school selection. Second, teachers in control schools were compensated ($200) for their participation in data collection, while teachers in intervention schools were not. This is possibly reflected in the superior completeness of data among control school students compared to that of intervention school students. Third, the follow-up period differed for intervention and control schools, as control schools were recruited later than intervention schools. However, the difference was approximately 3 months, and the final follow-up points were the same. Fourth, the socioeconomic status and race/ethnicity information was not available at the student level, and school-level proxies for these covariates were used in the analysis. However, gender information was available at the student level, and these proxy covariates were still significant in improving the fitness of multiple regression models. Fifth, 778 students were excluded from the initial dataset due to missing student ID or baseline height/weight information. There were no differences in the percentages of male, overweight, and obese students between the groups of included and excluded students. However, exclusion of these participants may have resulted in an under-estimation of associations between race/ethnicity and changes in BMI and PACER test, as well as associations between FRL level and changes in BMI and PACER test.

VI. Future Directions

There has been an increasing number of studies examining the outcomes of physical activity interventions. Because observational studies cannot make causal inferences, there is a need for randomized controlled trials. Analyzing randomized controlled trials based on pre-intervention weight status would further validate our results. A longer follow-up period on the study population would also be necessary to corroborate our findings, since one-year is a relatively short period to see the changes in BMI. Also, a longer follow-up with greater than two data points would be able to show the trajectory of changes in BMI.

Currently, a four-year randomized controlled trial that utilizes the *Health Empowers You!* intervention is being implemented. This trial would address both concerns from the current analysis and be able to further validate the outcome. Re-analyzing previously published large school-based obesity prevention studies by stratifying the results on pre-intervention weight status would also verify our results.

Implications

Although many schools have obesity prevention programs in place, not many focus on how to improve the health state of already overweight and obese children. Differentiating interventions for overweight and obese population in schools are further complicated by social stigma towards obesity. However, this study shows that overweight and obese children are affected differently by school-based intervention programs from normal weight children, especially from the perspective of cardiopulmonary fitness. Ironically, the ones that would benefit most from better cardiopulmonary fitness are showing less improvement from the intervention. This warrants the question on how to approach overweight and obese children in school-based intervention programs. With careful consideration of the social stigma, school-based intervention programs may need to develop a method to better benefit the already overweight and obese children.

VII. Tables

Table 1. Characteristics of students in intervention and control schools, according to pre-intervention weight status

	Normal Weight Students			**Overweight Students**			**Obese Students**		
	Intervention (n=1110)	Control (n=368)	p-value	Intervention (n=579)	Control (n=220)	p-value	Intervention (n=254)	Control (n=87)	p-value
Age (months), mean±std	114.4±4.8	114.4±4.6	*0.81*	114.1±4.8	115.2±5.1	*<0.01*	114.2±4.8	114.4±5.4	*0.79*
Male, n (%)	557 (50.2)	165 (44.8)	*0.08*	314 (54.2)	131 (59.6)	*0.18*	144 (56.7)	46 (52.9)	*0.54*
School Race/Ethnicity, n (%)[a]									
Non-Hispanic White	215 (19.4)	141 (38.3)	*<0.01*	80 (13.8)	65 (29.6)	*<0.01*	12 (4.7)	16 (18.4)	*<0.01*
Non-Hispanic Black	297 (26.8)	171 (46.5)	*<0.01*	159 (27.5)	125 (56.8)	*<0.01*	62 (24.4)	52 (59.8)	*<0.01*
Hispanic	322 (29.0)	56 (15.2)	*<0.01*	216 (37.3)	31 (14.1)	*<0.01*	126 (49.6)	19 (21.8)	*<0.01*
School FRL Percent, n (%)[b]									
High	663 (59.7)	154 (41.8)	*<0.01*	401 (69.3)	115 (52.3)	*<0.01*	196 (77.2)	55 (63.2)	*<0.01*
Moderate	232 (20.9)	73 (19.8)	*<0.01*	98 (16.9)	40 (18.2)	*<0.01*	46 (18.1)	16 (18.4)	*<0.01*
Low	215 (19.4)	141 (38.3)	*<0.01*	80 (13.8)	65 (29.6)	*<0.01*	12 (4.7)	16 (18.4)	*<0.01*
BMI z-score, median (q1, q3)	0.13 (-0.48, 0.57)	0.06 (-0.67, 0.52)	*0.06*	1.48 (1.20, 1.74)	1.44 (1.22, 1.67)	*0.41*	2.26 (2.12, 2.42)	2.29 (2.14, 2.50)	*0.19*
Raw BMI, median (q1, q3)	16.8 (15.6, 17.8)	16.6 (15.3, 17.8)	*0.10*	21.1 (19.9, 22.5)	21.0 (20.0, 22.2)	*0.66*	27.0 (25.3, 29.3)	27.5 (25.5, 30.8)	*0.21*

[a] Number of students attending schools where one race/ethnicity is greater than or equal to 50% of the total student population
[b] Number of student attending schools where the percentage of students receiving free and reduce lunch program are high (greater than or equal to 66%), moderate (33-66%) or low (less than 33%)

Table 2. Comparison of changes in mean raw BMI, BMI z-score and Progressive Aerobic Cardiovascular Endurance Run (PACER) test using pooled t-test

	Normal Weight Students (n=1,478)			**Overweight Students (n=799)**			**Obese Students (n=341)**		
	Intervention	Control	p-value	Intervention	Control	p-value	Intervention	Control	p-value
Raw BMI									
Pre	16.58±1.48	16.41±1.75		21.24±1.60	21.17±1.49		27.48±2.79	28.47±3.97	
Post	16.84±2.03	16.58±1.84		21.26±2.19	21.10±1.85		27.03±3.20	27.64±4.34	
Difference (Post-Pre)	0.26±1.39	0.17±1.02	*0.24*	0.02±1.47	-0.07±1.11	*0.45*	-0.45±2.79	-0.83±2.30	*0.27*
Mean BMI z-score									
Pre	-0.07±0.82	-0.22±1.05		1.48±0.30	1.46±0.27		2.27±0.19	2.33±0.23	
Post	-0.17±0.94	-0.30±1.02		1.30±0.53	1.29±0.38		2.11±0.39	2.13±0.46	
Difference (Post-Pre)	-0.10±0.53	-0.08±0.49	*0.61*	-0.18±0.44	-0.17±0.27	*0.86*	-0.16±0.37	-0.20±0.38	*0.50*
Mean PACER Test									
Pre	23.69±11.09	31.17±15.06		18.33±8.23	24.73±12.88		12.76±5.68	16.85±10.39	
Post	29.19±12.80	33.49±16.53		22.74±10.60	26.94±13.36		16.37±8.20	19.51±10.69	
Difference (Post-Pre)	3.96±8.18	2.31±6.13	*<0.01*	2.25±6.85	2.21±5.66	*0.94*	1.86±5.02	2.66±5.26	*0.25*

BMI: body mass index

Table 3. Result of the two-way analysis of variance (ANOVA) assessing two main effects (pre-intervention weight status and intervention status) on changes in raw BMI and PACER test

	Decrease in raw BMI at Follow-up (n=2,341)		**Increase in PACER at Follow-up (n=1,799)**[a]	
Main effects	Difference Between Means (95% CI)	p-value	Difference Between Means (95% CI)	p-value
***Overweight* (vs. Normal Weight)**	0.241 (0.098, 0.384)	*<0.01*		
Intervention Group			-1.715 (-2.636, -0.794)	*<0.01*
Control Group			-0.103 (-1.257, 1.050)	*0.86*
***Obese* (vs. Normal Weight)**	0.800 (0.601, 0.998)	*<0.01*		
Intervention Group			-2.107 (-3.321, -0.893)	*<0.01*
Control Group			0.343 (-1.271, 1.956)	*0.68*
***Intervention* (vs. Control)**	-0.127 (-0.267, 0.013)	*0.07*		
Normal Weight Group			1.652 (0.768, 2.535)	*<0.01*
Overweight Group			0.040 (-1.139, 1.222)	*0.94*
Obese Group			-0.798 (-2.612, 1.016)	*0.39*

[a] The interaction components of overweight*intervention and obese*intervention were significant for the results of PACER test. Therefore, the results are presented separately for all possible effects.

BMI: body mass index
PACER: Progressive Aerobic Cardiovascular Endurance Run

Table 4. Results of crude and adjusted multiple regression models for the association between intervention/pre-intervention weight status and changes in raw BMI and PACER test

	Changes in raw BMI				**Changes in PACER Test**			
	Parameter Estimate (SE)		Adj R-Square	p-value	Parameter Estimate (SE)		Adj R-Square	p-value
Crude Model								
Intercept	0.146	(0.067)	0.028	*0.03*	2.313	(0.360)	0.015	*<0.01*
Intervention	0.127	(0.071)		*0.07*	1.652	(0.451)		*<0.01*
Overweight	-0.241	(0.073)		*<0.01*	-0.103	(0.588)		*0.86*
Obese	-0.800	(0.101)		*<0.01*	0.343	(0.823)		*0.68*
Intervention*Overweight	-			-	-1.612	(0.752)		*0.03*
Intervention*Obese	-			-	-2.450	(1.029)		*0.02*
Covariate Adjusted Model – School Free and Reduced Lunch (FRL) Percent [a]								
Intercept	0.158	(0.084)	0.027	*0.06*	3.853	(0.447)	0.029	*<0.01*
Intervention	0.130	(0.072)		*0.07*	2.296	(0.461)		*<0.01*
Overweight	-0.239	(0.073)		*<0.01*	0.122	(0.584)		*0.83*
Obese	-0.796	(0.102)		*<0.01*	0.852	(0.821)		*0.30*
School FRL Percent								
High *(≥66%)*	-0.023	(0.083)		*0.78*	-2.544	(0.449)		*<0.01*
Moderate *(33-65.9%)*	-0.011	(0.099)		*0.91*	-2.401	(0.540)		*<0.01*
Intervention*Overweight	-	-		-	-1.720	(0.746)		*0.02*
Intervention*Obese	-	-		-	-2.667	(1.021)		*<0.01*
Covariate Adjusted Model – School Race/Ethnicity [b]								
Intercept	0.102	(0.078)	0.030	*0.19*	1.766	(0.416)	0.033	*<0.01*
Intervention	0.053	(0.080)		*0.51*	2.742	(0.491)		*<0.01*
Overweight	-0.235	(0.073)		*<0.01*	0.052	(0.583)		*0.93*
Obese	-0.790	(0.102)		*<0.01*	0.815	(0.818)		*0.32*
School Race/Ethnicity								
Non-Hispanic White	0.099	(0.099)		*0.28*	1.939	(0.473)		*<0.01*
Hispanic	0.054	(0.054)		*0.55*	-1.294	(0.441)		*<0.01*
Mixed	0.288	(0.288)		*<0.01*	-1.164	(0.538)		*0.03*
Intervention*Overweight	-			-	-1.535	(0.747)		*0.04*
Intervention*Obese	-			-	-2.472	(1.023)		*0.02*

[a] Attending schools with high (greater than or equal to 66%) or moderate (33 to 65.9%) proportion of students participating in Free and Reduced Lunch program

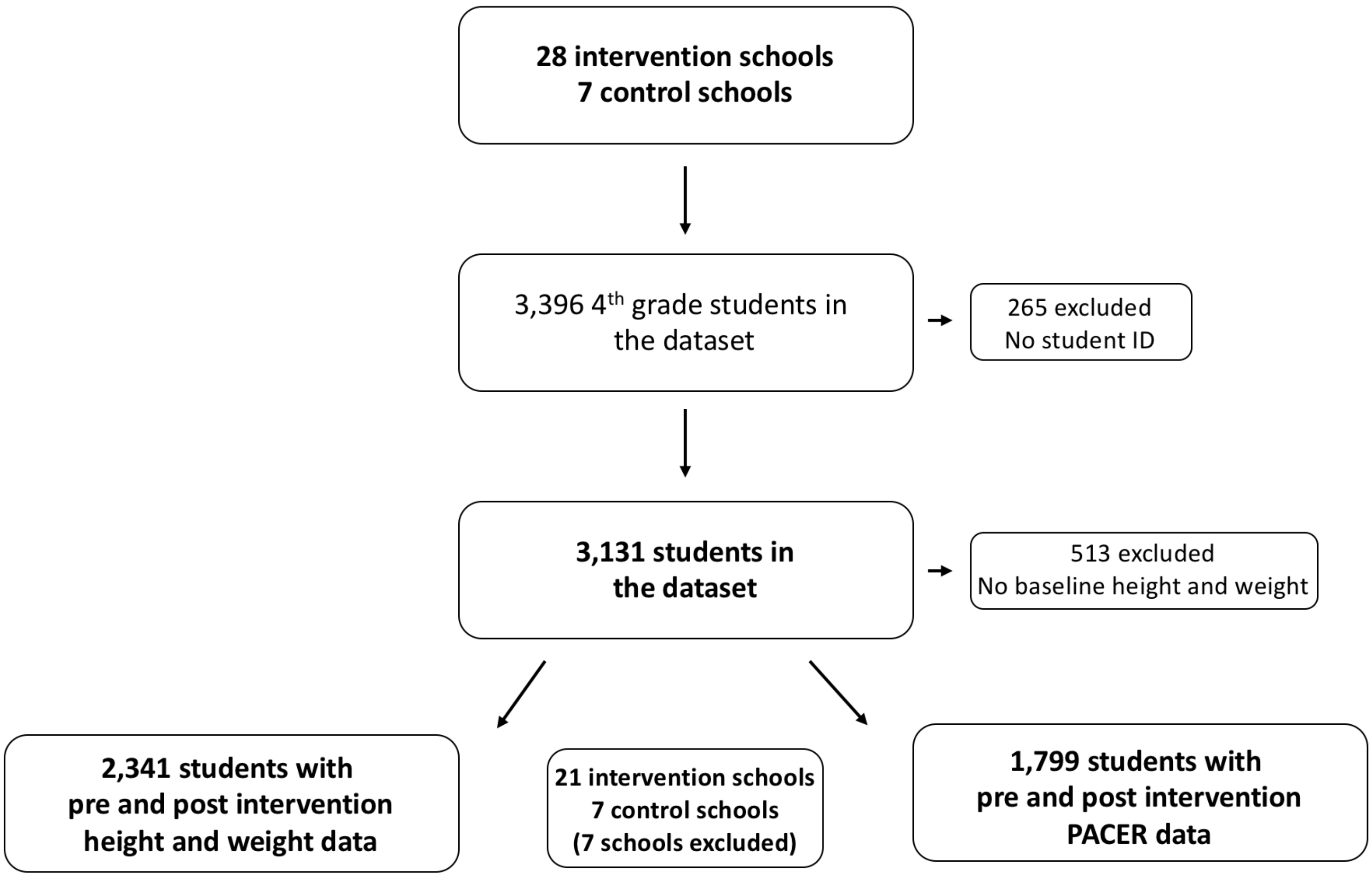
[b] Attending schools where one race/ethnicity is greater than or equal to 50% of the total student population

[c] The interaction components of overweight*intervention and obese*intervention were not significant for changes in BMI but were significant for changes in PACER.

BMI: body mass index
PACER: Progressive Aerobic Cardiovascular Endurance Run
SE: standard error

VIII. Figures

Figure 1. Flowchart of sample size for the analyzed dataset.



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X. Appendices

Appendix 1. When overweight and obese students are grouped together - comparison of changes in mean raw BMI, BMI z-score and Progressive Aerobic Cardiovascular Endurance Run (PACER) test using pooled t-test

	Normal Weight Students			Overweight/Obese Students		
	Intervention	Control	p-value	Intervention	Control	p-value
Raw BMI						
Pre	16.58±1.48	16.41±1.75		23.11±3.51	23.24±4.11	
Post	16.84±2.03	16.58±1.84		22.99±3.66	22.96±4.05	
Difference (Post-Pre)	0.26±1.39	0.17±1.02	0.24	-0.12±1.97	-0.28±1.58	0.21
Mean BMI z-score						
Pre	-0.07±0.82	-0.22±1.05		1.72±0.45	1.70±0.47	
Post	-0.17±0.94	-0.30±1.02		1.54±0.62	1.53±0.55	
Difference (Post-Pre)	-0.10±0.53	-0.08±0.49	0.61	-0.17±0.42	-0.18±0.31	0.84
Mean PACER Test						
Pre	23.69±11.09	31.17±15.06		16.54±7.94	22.50±12.72	
Post	29.19±12.80	33.49±16.53		20.82±10.35	24.83±13.08	
Difference (Post-Pre)	3.96±8.18	2.31±6.13	<0.01	2.12±6.32	2.34±5.54	0.63

Appendix 2. When overweight and obese students are grouped together - result of the two-way analysis of variance (ANOVA) assessing two main effects (pre-intervention weight status and intervention status) on changes in raw BMI/PACER test

	Decrease in raw BMI at Follow-up (n=2,341)		**Increase in PACER Test at Follow-up (n=1,799)[a]**	
Main effects	Difference Between Means (95% CI)	p-value	Difference Between Means (95% CI)	p-value
Overweight/Obese **(vs. Normal Weight)**	0.406 (0.276, 0.535)	*<0.01*		
Intervention Group			-1.841 (-2.657, -1.025)	*<0.01*
Control Group			0.023 (-1.022, 1.069)	*0.97*
Intervention **(vs. Control)**	-0.087 (-0.245, 0.070)	*0.28*		
Overweight/Obese Group			-0.212 (-1.201, 0.078)	*0.67*
Normal weight Group			1.652 (0.768, 2.567)	*<0.01*

[a] The interaction component of overweight/obese*intervention was significant for the results of PACER test. Therefore, the results are presented separately for all possible effects.
BMI: body mass index
PACER: Progressive Aerobic Cardiovascular Endurance Run

Appendix 3. When overweight and obese students are grouped together - results of crude and adjusted multiple regression models for the association between intervention status/pre-intervention weight status and changes in raw BMI/PACER test

	Changes in raw BMI				**Changes in PACER Test**			
	Parameter Estimate (SE)		Adj R-Square	p-value	Parameter Estimate (SE)		Adj R-Square	p-value
Crude Model								
Intercept	0.149	(0.067)	0.018	0.03	2.313	(0.360)	0.014	<0.01
Intervention	0.123	(0.072)		0.09	1.652	(0.451)		<0.01
Obese/Overweight	-0.406	(0.066)		<0.01	0.023	(0.533)		0.97
Interaction	-			-	-1.864	(0.676)		<0.01
Covariate Adjusted Model – School Free and Reduced Lunch (FRL) Percent [a]								
Intercept	0.182	(0.084)	0.018	0.03	3.845	(0.446)	0.032	<0.01
Intervention	0.131	(0.073)		0.07	2.292	(0.461)		<0.01
Obese/Overweight	-0.400	(0.067)		<0.01	0.327	(0.532)		0.54
School FRL Percent								
High *(≥66%)*	-0.057	(0.083)		0.49	-2.530	(0.448)		<0.01
Moderate *(33-65.9%)*	-0.039	(0.010)		0.69	-2.386	(0.540)		<0.01
Interaction	-			-	-1.996	(0.671)		<0.01
Covariate Adjusted Model – School Race/Ethnicity [b]								
Intercept	0.100	(0.078)	0.022	0.20	1.772	(0.416)	0.037	<0.01
Intervention	0.059	(0.080)		0.46	2.736	(0.491)		<0.01
Obese/Overweight	-0.394	(0.067)		<0.01	0.266	(0.530)		0.62
School Race/Ethnicity								
Non-Hispanic White	0.120	(0.092)		0.19	1.924	(0.472)		<0.01
Hispanic	0.027	(0.091)		0.77	-1.292	(0.441)		<0.01
Mixed	0.280	(0.105)		<0.01	-1.160	(0.538)		0.03
Interaction	-			-	-1.806	(0.673)		<0.01

[a] Attending schools with high (greater than or equal to 66%) or moderate (33 to 65.9%) proportion of students participating in Free and Reduced Lunch program
[b] Attending schools where one race/ethnicity is greater than or equal to 50% of the total student population
Interaction = Intervention*Obese/Overweight