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RESEARCH ARTICLE

Impact of Weight Status on the Cardiopulmonary Fitness Outcome of a School-Based Physical Activity Program

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ABSTRACT

BACKGROUND: The effectiveness of school-based physical activity interventions for improving cardiopulmonary fitness (CPF) of overweight and obese children is not well established. In this study, we evaluated whether overweight and obese children had similar changes in body mass index (BMI) and CPF as normal weight children after participating in a program for one academic year.

METHODS: Using purposive sampling at the school level, we selected 16 program and 7 control schools in a large metropolitan area in the Southeast during the 2015-2016 academic year. In these schools, 3396 fourth-graders participated with parental consent. Of these, 2332 (68.7%) participated in BMI measures and 1780 (52.4%) in Progressive Aerobic Cardiovascular Endurance Run (PACER) measures for CPF at two time points.

RESULTS: Students of all weight statuses pre-program did not show changes in BMI after program implementation. All students showed statistically significant improvements in the PACER test at follow-up, regardless of their participation in the program. However, overweight and obese children showed less improvement in CPF level than their normal weight classmates, regardless of their participation in the program.

CONCLUSION: Special attention for improving engagements of overweight and obese children may be needed to achieve improvements in their CPF level similar to that of normal weight students.

Keywords: childhood obesity; cardiopulmonary fitness; school-based physical activity; body mass index (BMI).

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In 2015-2016, 18.4% of children aged 6-11 years old in the United States were obese.[1] Obesity is an independent risk factor for cardiovascular diseases and is associated with hypertension, dyslipidemia, and insulin resistance in both children and adults.[2-7] However, good cardiopulmonary fitness has been shown to keep obese people metabolically healthy and decrease their risk of developing cardiovascular diseases.[8-17]

Physical activity can improve cardiopulmonary fitness.[18] Studies show that physical activity is associated with lower odds of children being metabolically unhealthy.[19-22] Other studies reported a dose-response relationship between physical activity and health, indicating that the more physical activity, the greater the health benefit.[23] For school-aged children, evidence suggests that moderate-to-vigorous or vigorous physical activity during physical education (PE) classes increased after PE-based physical activity interventions.[24-28] However, several studies report that cardiopulmonary fitness does not improve after interventions despite increases in physical activity levels.[29-32] Because most school-based physical activity programs do not measure changes in cardiopulmonary

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fitness after implementing a program,[33] more studies with objective cardiopulmonary fitness measures are needed to interpret the benefits of school-based physical activity programs accurately.

Baseline weight status is a significant predictor of future weight and can affect changes in body composition and cardiopulmonary fitness after an intervention.[34,35] Overweight and obese children are less physically fit and have lower gross motor coordination compared to normal weight children.[36,37] Functional limitations associated with obesity can aggravate inactivity and sedentary lifestyle, generating a vicious cycle for children who are experiencing obesity.[34,38] Therefore, the result of a program should be examined separately for different baseline weight statuses,[39] so that the effectiveness of the program for the overweight and obese population is not obscured by the results of their normal weight peers.

In this study, we evaluated whether overweight and obese children had similar changes (or no changes) in body mass index (BMI) and cardiopulmonary fitness as normal weight children after participating in a school-based physical activity program for one academic year.

METHODS

Study Design and Participants

A not-for-profit organization implemented a school-based program that was designed following the guidelines established by the US Centers for Disease Control and Prevention (CDC) to promote physical activity in schools.[40] The program aimed to train teachers (both PE and non-PE teachers) and school staff to integrate 30 additional minutes of physical activity per day during school hours. Main components of the program included establishing a School Health Team, implementing training for teachers, and providing resources for schools and teachers. The School Health Team composed of three staff members: one PE teacher, one fourth-grade teacher, and one other school staff member. Teachers did not receive any stipend. Fourth-grade teachers and PE teachers at each school were trained to collect data on participating students.

The program delivered three training sessions (one face-to-face training, and two face-to-face or virtual training). 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 were information videos and sports equipment.

In the 2015-2016 academic year, the program was implemented in 28 public schools using a voluntary convenience sampling (non-randomized) in three districts of a large metropolitan area in the Southeast. PE teachers at all public schools in these districts were contacted for recruitment. Participation benefited schools with resources mentioned above that did not incur any cost to each school. Seven schools were added 3 months after program implementation to serve as comparisons (''control schools''). In control schools, teachers were asked not to change any programming in their classrooms but were asked to collect the same data as program schools. They received a stipend ($200) for their effort in data collection because no program resources were provided to their students. Fourth-grade teachers obtained signed consent forms from the parents of the students; 3396 fourth-graders (approximately 80% of total enrolled fourth-graders in program and control schools) agreed to participate.

Data Sources

Progressive aerobic cardiovascular endurance run (PACER) test and BMI. The PACER test is part of the FITNESSGRAM assessment[41] and is a measure of cardiopulmonary fitness. The PACER test is a multistage aerobic test adapted from the 20-m shuttle run test; aerobic capacity is predicted from the number of laps completed during the test.[42-44] The goal of the PACER test is to run for as long as possible. When laboratory-based testing is not practical, the PACER test has been validated to be a useful estimation of aerobic capacity.[45]

Parents reported age and sex of the students at the beginning of the study. Each student's PACER test results and height and weight (also part of FITNESSGRAM assessment) were recorded at the beginning of the study to serve as baseline measurements for program assessments. Baseline information was obtained in October 2015 for students in program schools, and in January 2016 for students in control schools. After-program measurements were obtained in May 2016 for students in both program and control schools. Height in centimeters and weight in kilograms were measured by teachers once at each time point using a fixed measuring stick and a flat digital scale, respectively.

Race, ethnicity, and socioeconomic status information was not collected about the participating students. We obtained 2016 information from the Department of Education on race and ethnic composition of the student body at each school and the proportion of students participating in the free and reduced-price lunch (FRL) program.

Data Measures

We used the height and weight data measured by teachers to create BMI *z*-scores using the school-aged children World Health Organization (WHO) reference. Weight status was classified as underweight (SD for

BMI z-scores <-2.0), normal weight ($-2.0 \leq$ BMI z-scores < 1.0), overweight ($1.0 \leq$ BMI z-scores < 2.0), and obese (BMI z-scores ≥ 2.0).[46,47]

We created an indicator of ''changes in raw BMI,'' which would be used as a primary outcome variable. Raw BMI was used because BMI z-scores would have underestimated individual changes in children who were very obese.[48] The BMI at follow-up was subtracted from the BMI at baseline for each student, and the difference was treated as continuous.

We created an indicator of ''changes in the PACER test,'' which would also be used as a primary outcome variable. The number of laps (distance) at follow-up was subtracted from the number of laps at baseline for each student, and the difference was treated as continuous.

Additional measures were created to account for the difference in follow-up period between program and control schools. These were ''average monthly changes in raw BMI'' and ''average monthly changes in PACER test.'' Average monthly changes were calculated by dividing the ''changes in raw BMI'' and ''changes in the PACER test'' by 7 (months of follow-up) for program school students and by 4 (months of follow-up) for control school students. Control school students had higher median levels of PACER test at baseline than program school students, likely due to their baseline measurements taking place after PE classes have begun. Therefore, PACER test at baseline was treated as a control variable in models examining the ''changes in PACER test'' and ''average monthly changes in PACER.''

In multivariable models, we used student sex as a covariate. We also constructed an indicator of the most prevalence race/ethnic group at each school as a covariate (coded as non-Hispanic white, non-Hispanic black, and Hispanic). The other covariate was proportion of students at the school receiving free- or reduced-price lunch (FRL), categorized as $\geq$50% of students versus $<$50%. Age and sex were not significant predictors of changes in BMI and PACER test scores. Because ''proportion of FRL program participants'' and ''school race/ethnicity'' were correlated with each other (chi-square test of independence $p < .01$), adjusted models were analyzed separately, one with the school FRL covariates, and another with school race/ethnicity covariates.

Data Analysis

We excluded students with missing baseline age, height, or weight information (N = 658) (Figure 1). We then excluded additional 406 students who had implausible values (eg, age or height decreased at follow-up). The final sample size was 2332 for the BMI analysis and 1780 for the PACER analysis.

Frequencies and chi-square test were used for categorical variables. For continuous variables, means and pooled t test or median and Mann-Whitney test were used, as appropriate. Multiple linear regression models were fit, and the interaction terms between pre-program weight status and program status were assessed for each outcome. Robust standard errors were reported to account for the clustering of students in each school. Statistical analysis was performed using SAS (version 9.4, Cary, NC), with $p < .05$ regarded as statistically significant.

Missing Data

We examined differences between students with and without missing or implausible measures. Participants with missing or implausible values were less likely to attend white-prevalent schools (2.4% vs. 22.6%, $p < .01$), and less likely to attend high-FRL schools (31.0% vs. 78.2%, $p < .01$). Students in the program schools were more likely to have missing values than those in the control schools ($p < .01$). No differences were noted in the percentage of male students ($p > .05$). Of the 2332 students with BMI measures, 552 (23.7%) did not complete PACER measures. However, missing PACER measurements did not vary by weight and children with overweight and obesity were not less likely to participate in PACER measures ($p > .05$).

RESULTS

There were no differences in proportion of male students between program and control schools (53.4% and 50.6%, respectively) (Table 1). Students in the program group were more likely to attend Hispanic prevalent schools ($p < .01$) and more likely to attend schools with a high proportion of students receiving FRL ($p < .01$), than students in the control group.

In the program schools, 29.3% (N = 493) of the students were overweight and 12.6% (N = 212) were obese. In the control schools, 32.8% (N = 213) of the students were overweight and 13.2% (N = 86) were obese. The proportions of overweight and obese children were similar between students in program and control schools ($p > .05$). Median raw BMI and BMI z-scores were also similar.

Baseline median PACER score was 18.0 laps among program school students and 24.0 laps among control school students; control school students had higher median levels of PACER test at baseline than program school students ($p < .01$). After program implementation, control school students improved their PACER scores by 2.3 laps over a 4 month-period. Program school students improved their PACER scores by 3.1 laps over a 7 month-period. Average monthly changes were greater among control school students (0.57 laps) than those among program school students (0.44 laps).

Figure 1. **Flowchart of the Analytic Sample Size.**

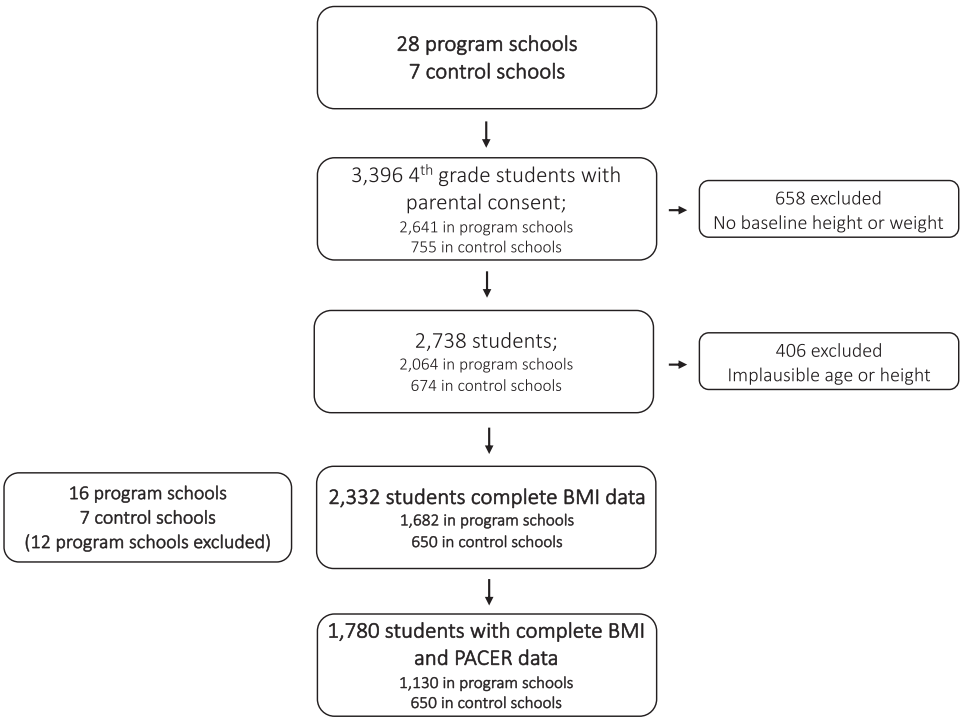

Table 1. **Characteristics of All Students and Students with Overweight and Obesity in Program and Control Schools**

	Total			Overweight			Obesity		
	Program (N = 1682)	Control (N = 650)	p-Value	Program (N = 493)	Control (N = 213)	p-Value	Program (N = 212)	Control (N = 86)	p-Value
Age (months), mean (SD)	114.3 (4.6)	114.6 (4.9)	>.05	114.1 (4.9)	115.1 (5.1)	.01	114.5 (4.6)	114.3 (5.4)	>.05
Boys, N (%)	898 (53.4)	329 (50.6)	>.05	280 (56.8)	126 (59.2)	.56	126 (59.4)	46 (53.5)	>.05
School race/ethnicity, N (%)*			<.01			<.01			<.01
Non-Hispanic White	313 (18.6)	213 (32.8)		79 (16.0)	61 (28.6)		14 (6.6)	16 (18.6)	
Non-Hispanic Black	325 (19.3)	334 (51.4)		87 (17.7)	122 (57.3)		30 (14.2)	51 (59.3)	
Hispanic	602 (35.8)	103 (15.9)		204 (41.4)	30 (14.1)		114 (53.8)	19 (22.1)	
School FRL percent, N (%)†			<.01			<.01			<.01
High	1386 (82.4)	437 (67.2)		411 (83.4)	152 (71.4)		199 (93.9)	70 (81.4)	
Low	296 (17.6)	213 (32.8)		82 (16.6)	61 (28.6)		13 (6.13)	16 (18.6)	
BMI *z*-score, median (q1, q3)	0.75 (−0.04, 1.56)	0.87 (0.02, 1.59)	>.05	1.48 (1.21, 1.73)	1.46 (1.22, 1.67)	.42	2.27 (2.12, 2.40)	2.28 (2.14, 2.50)	>.05
Raw BMI, median (q1, q3)	18.3 (16.4, 21.4)	18.6 (16.5, 21.4)	>.05	21.1 (19.9, 22.5)	21.0 (20.0, 22.2)	.66	27.0 (25.3, 29.2)	27.5 (25.5, 30.8)	>.05
PACER, median (q1, q3)	18.0 (13.0, 25.0)	24.0 (16.0, 36.0)	<.01	16.0(13.0, 23.0)	21.0 (16.0, 31.0)	<.01	12.0 (9.0, 15.0)	13.5 (10.0, 22.0)	<.01

FRL, Free and reduced lunch program; BMI, body mass index; PACER, Progressive aerobic cardiovascular endurance run.

* Number of students attending schools where one race/ethnicity is greater than or equal to 50% of the total student population.

† Number of student attending schools where the percentage of students receiving FRL are high (greater than or equal to 50%) or low (less than 50%).

Changes in Raw BMI

The interaction term between program status and pre-program weight status was not significant, indicating that pre-program weight status did not alter the relationship between changes in BMI and program status. In multivariable models (Table 2), program participation was not significantly associated with total decrease in raw BMI ($p > .05$). This was the case regardless of the student's pre-program weight status. Students who were overweight or obese at baseline showed a decrease in raw BMI in the school race/ethnicity-adjusted multivariable model, irrespective of whether they participated in the program (by 0.22 and 0.73 kg/m^2 respectively).

Similar results were observed for average monthly changes in raw BMI. In the race/ethnicity-adjusted multivariable model, overweight and obese children showed a greater average monthly decrease in

Table 2. **Results of Crude and Adjusted Multiple Linear Regression Models for the Association Between Program, Pre-Program Weight Status, and Changes in Raw BMI**

	Total changes[§]		Average monthly changes[§]	
	Parameter estimate (SE)	R^2	Parameter estimate (SE)	R^2
Crude model				
Intercept	0.100 (0.093)	0.027	0.013 (0.022)	0.031
Program	0.159 (0.115)		0.030 (0.024)	
Underweight	0.031 (0.137)		0.006 (0.020)	
Overweight	−0.223* (0.094)		−0.038* (0.014)	
Obesity	−0.736** (0.181)		−0.132** (0.032)	
Covariate adjusted model—school FRL percent[†]				
Intercept	0.071 (0.140)	0.027	0.016 (0.029)	0.032
Program	0.155 (0.113)		0.031 (0.022)	
Underweight	0.033 (0.136)		0.007 (0.020)	
Overweight	−0.228* (0.096)		−0.039* (0.014)	
Obesity	−0.743** (0.185)		−0.131** (0.032)	
Male	0.038 (0.058)		0.009 (0.010)	
School FRL percent	−0.180 (0.130)			
High (≥50%)			−0.012 (0.025)	
Covariate adjusted model—school race/ethnicity[‡]				
Intercept	0.020 (0.107)	0.031	−0.008 (0.021)	0.037
Program	0.078 (0.130)		0.017 (0.024)	
Underweight	0.056 (0.130)		0.011 (0.019)	
Overweight	−0.216* (0.095)		−0.037* (0.014)	
Obesity	−0.726** (0.182)		−0.129** (0.032)	
Male	0.032 (0.054)		0.008 (0.009)	
School race/ethnicity				
Non-Hispanic White	0.142 (0.150)		0.038 (0.027)	
Hispanic	0.081 (0.175)		0.018 (0.028)	
Mixed	0.325 (0.268)		0.054 (0.040)	

*$p < .05$; **$p < .01$.

BMI, body mass index; SE, standard error; FRL, free and reduced lunch.

[†] Attending schools with high (greater than or equal to 50%) proportion of students participating in Free and Reduced Lunch program.

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

[§] The interaction components of program*underweight, program*overweight, and program*obesity were not significant for changes in raw BMI.

raw BMI than normal weight students (by 0.04 and 0.13 kg/m^2 respectively), regardless of their participation in the program.

Changes in the PACER Test

Normal weight black girls in control schools improved their average monthly PACER scores by 0.87 laps while the same girls in program schools did so by 0.79 lap (Table 3—school race/ethnicity-adjusted model). Whereas the improvement was significant for students in both groups of schools, the difference of improvement between the two groups was not. In other words, those who participated in the program had similar improvement in the PACER test to those who did not in multivariable models, adjusting for sex, pre-program weight status, and baseline PACER scores.

Overweight and obese children showed less improvement in their average monthly PACER scores by 0.26-0.28 laps than their normal weight peers, regardless of program participation, sex, baseline PACER scores, and race/ethnicity.

Higher baseline PACER was significantly and consistently associated with less improvement in both total and average monthly changes in PACER test. In other words, children with higher PACER test scores at baseline showed less improvement than those with lower PACER test scores. Boys also showed greater improvement than girls in both total and average monthly changes in PACER test.

DISCUSSION

This study aimed to examine changes in fourth-graders' weight and cardiopulmonary fitness after participation in a school-based physical activity program. Furthermore, we aimed to show whether these changes were different for normal weight, overweight, and obese children at the beginning of the program. The program involved integrating 30 additional minutes of physical activity during school hours every day for one academic year. We found that participation in the program was not associated with changes in BMI or cardiopulmonary fitness, regardless of children's initial weight category.

Table 3. **Results of Crude and Adjusted Multiple Linear Regression Models for the Association Between Program, Pre-Program Weight Status, and Changes in the PACER Test**

	Total changes		Average monthly changes[§]	
	Parameter estimate (SE)	R^2	Parameter estimate (SE)	R^2
Crude model				
Intercept	2.397** (0.427)	0.019	0.674** (0.187)	0.011
Program	1.658 (1.034)		−0.135 (0.126)	
Underweight	−1.772 (1.745)		−0.410 (0.254)	
Overweight	−0.289 (0.399)		−0.214** (0.084)	
Obesity	0.115 (0.740)		−0.190 (0.118)	
Program*underweight	−0.807 (2.912)		-	
Program*overweight	−1.784* (0.707)		-	
Program*obesity	−2.294 (1.297)		-	
Covariate adjusted model—school FRL percent[†]				
Intercept	6.021** (1.486)	0.058	1.214** (0.249)	0.040
Program	1.315 (0.932)		−0.180 (0.102)	
Underweight	−1.222 (1.973)		−0.357 (0.259)	
Overweight	−0.755 (0.520)		−0.277** (0.076)	
Obesity	−0.721 (0.807)		−0.296* (0.114)	
Baseline PACER	−0.088** (0.029)		−0.013* (0.005)	
Male	0.981* (0.366)		0.148* (0.058)	
School FRL percent				
High (≥50%)	−2.246* (0.975)		−0.343* (0.147)	
Program*underweight	−1.163 (3.018)		-	
Program*overweight	−1.725* (0.733)		-	
Program*obesity	−2.116 (1.166)		-	
Covariate adjusted model—school race/ethnicity[‡]				
Intercept	3.798** (0.888)	0.061	0.870** (0.151)	0.042
Program	1.973 (1.097)		−0.077 (0.127)	
Underweight	−1.272 (1.925)		−0.367 (0.255)	
Overweight	−0.745 (0.518)		−0.263** (0.071)	
Obesity	−0.593 (0.782)		−0.275* (0.108)	
Baseline PACER	−0.082* (0.029)		−0.012* (0.005)	
Male	0.989* (0.378)		0.149* (0.060)	
School race/ethnicity				
Non-Hispanic White	2.133 (1.064)		0.329 (0.169)	
Hispanic	−1.054 (0.813)		−0.157 (0.121)	
Mixed	−0.662 (0.968)		−0.088 (0.142)	
Program*underweight	−1.206 (2.962)		-	
Program*overweight	−1.600* (0.649)		-	
Program*obesity	−2.102 (1.093)		-	

* $p < .05$; ** $p < .01$.

SE, standard error; PACER, progressive aerobic cardiovascular endurance run; FRL, free and reduced lunch.

[†] Attending schools with high (greater than or equal to 50%) proportion of students participating in Free and Reduced Lunch program.

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

[§] The interaction components of program*underweight, program*overweight, and program*obesity were not significant in the "average monthly changes" models.

The most significant predictors of changes in BMI or cardiopulmonary fitness were baseline weight status and cardiopulmonary fitness level of children. Normal weight children showed greater improvement in cardiopulmonary fitness than children who had started the program overweight or obese. Children with poorer cardiopulmonary fitness level at baseline showed greater improvement in cardiopulmonary fitness than children with better cardiopulmonary fitness level at baseline.

The results highlight a pattern with scientific and programmatic implications. Overweight and obese children face additional challenges and may need additional attention in PE classes or programs to achieve improved fitness; overweight and obese children showed poorer improvements in cardiopulmonary fitness level than their normal weight peers at follow-up. It is possible that these children were less likely to be physically active and fit at baseline, and therefore improvements take longer time than their normal weight classmates.[49] However, one question to be explored is whether these children were not as engaged in school-based physical activity programs or regular PE classes. For example, it may be that they were more likely to be absent, not have the required gym clothing, or skipped some of the components of the program or PE classes and that this lower level of participation was a reason for not achieving

improvements in fitness.[50] Overweight and obese children also can experience conditions such as asthma or arthritis, which prevent them from full engagement, and they may have been bystanders during the program or PE classes.[51,52] Children experiencing obesity may have been subject to weight-related prejudices of peers and teachers that discouraged them even more from participating in the program or PE classes.[53,54]

Then, a step forward for programs would be to find a way to make engagement easier or more appealing for overweight and obese children. Educating teachers to make sure that these participate and engage in physical activity programs or PE classes may be necessary.

Few studies have examined the results of school-based physical activity programs taking into account children's pre-program weight status. Of those that did, two reported that overweight and obese participants had better BMI or waist circumference reductions than normal weight participants.[33,55] In one of these studies, children in intervention schools had a higher SES level than those in control schools.[55]

Weight loss is complex and challenging to achieve, even for children. Programs may require both nutritional and physical activity components to address weight.[56-59] School-based programs may not be sufficient, as children also spend much time outside of school, and the family environment is an essential determinant of children's health.[60]

This was a large study using direct measurements of height, weight, and PACER, reducing concerns about bias. There were also limitations. There was no randomization in assigning schools to program and control groups; therefore, we are not able to draw causal inferences. It is possible that schools with more health-conscious parents and children or schools with more unhealthy kids were selected into the program. However, baseline mean BMI was comparable between the program and control groups. Second, teachers in control schools were compensated for their participation in data collection, while teachers in program schools were not. This is possibly reflected in the superior completeness of data (Figure 1, missing data analysis) among control school students compared to that of program school students. Third, control schools were recruited 3 months after program schools; however, average monthly changes in both BMI and PACER test were examined to account for this difference in follow-up period. Fourth, socioeconomic and race/ethnicity information was not available on individual students; school-level characteristics were used instead, entailing limited variability. These school-level covariates still improved model fit.

IMPLICATIONS FOR SCHOOL HEALTH

Good cardiopulmonary fitness is directly associated with a lower risk of cardiovascular diseases regardless of weight status. Improving cardiopulmonary health is one of the most important outcomes for school-level physical activity programs. The findings from this study suggest that 30 minutes of additional physical activity may not be sufficient to improve cardiopulmonary fitness among fourth-graders. Implementing routine measurements of cardiopulmonary function and tailoring physical activity programs to improve these measurements may be necessary in schools. Furthermore, overweight and obese children may need additional attention in PE classes or programs to achieve improved fitness; while teachers should be educated against weight-based discrimination or bias, they still should pay closer attention for the level of engagement among overweight and obese children.

Human Subjects Approval Statement

The study protocol was approved by the Institutional Review Board for each of the school districts, and subjects in this study provided assent and parents/guardians provided written informed consent to participate in the study. This secondary data analysis study was exempted by the Emory University Institutional Review Board.

Conflict of interest

All authors of this article declare they have no conflicts of interest.

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