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Failure to meet aerobic fitness standards among urban elementary students

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ABSTRACT

The aim of this study was to explore the relationship of aerobic fitness with the elementary school environment and student characteristics among 4th and 5th grade children attending urban public schools in St. Louis, MO, USA. This cross-sectional study was conducted during 2012–2015 and included 2381 children (mean age 10.5 y) who completed the FITNESSGRAM® 20-m Progressive Aerobic Cardiovascular Endurance Run. Healthy Fitness Zone (HFZ) was defined according to FITNESSGRAM® aerobic capacity criteria. Other student-level variables included age, race, National School Lunch Program eligibility, BMI z-score, weight status, and daily pedometer steps. School environment variables included playground features and playground safety, physical education and recess practices, and school census tract data on vacant houses and median household income. Bivariate analyses with sex stratification were used to identify student-level and school-level predictors of failure to achieve the aerobic HFZ; predictors were then included in a multivariable logistic regression model. Failure to meet the aerobic HFZ was observed among 33% of boys and 57% of girls. School environment was not predictive, but higher age and fewer daily steps were: each additional year of age was associated with 41% higher odds of failing to meet the aerobic HFZ among boys and 100% higher odds among girls. Conversely, each additional 1000 daily steps was associated with 15% (boys) and 13% (girls) lower odds of failure. Obesity posed a 60% higher risk of failure to meet HFZ among girls. These results highlight the importance of childhood physical activity opportunities, especially for girls residing in low-resource areas.

1. Introduction

Aerobic fitness, also referred to as cardiorespiratory fitness or cardiorespiratory endurance, is an important indicator of health (Blair et al., 1989) that reflects the integrated functional status of cardiovascular, respiratory, and muscular systems. Higher aerobic fitness in children and adolescents is associated with healthier cardiovascular profiles (Ortega et al., 2008), whereas low levels of physical activity (PA) and low aerobic fitness are associated with cardiovascular disease risk (Andersen et al., 2006) and pose a major public health concern.

The transition from childhood to adolescence is an important developmental stage during which fitness (Bai et al., 2015) and PA levels decline dramatically (Troiano et al., 2008). The 2016 United States Report Card on Physical Activity for Children and Youth reports that only 50% of boys and 34% of girls aged 12–15 years achieve appropriate health-related fitness levels (National Physical Activity Plan Alliance, 2016). Schools serve as important environments for PA opportunities and promotion of healthy lifestyle behaviors in youth. The National Academy of Medicine (formerly the Institute of Medicine) recommends a whole-of-school approach for promoting PA (Institute of Medicine, 2013). Key strategies include offering quality physical education (PE) and PA opportunities before, throughout, and after the school day. Constraints in physical space, equipment, financial resources, and curricular time, however, present barriers to providing optimal PE and PA opportunities in many schools.

Fitness evaluations in schools play a pivotal role in identifying students with low physical fitness (Ortega et al., 2008). FITNESSGRAM® is the recommended assessment tool to determine health-related fitness (i.e., "sufficient fitness for good health") in school-aged youth and includes tests of aerobic fitness, body composition, muscle strength,

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muscle endurance, and flexibility (Meredith and Welk, 2010). The Progressive Aerobic Cardiovascular Endurance Run (PACER) is a FITNESSGRAM® test of aerobic fitness, based on a moderately strong linear relationship between PACER laps and peak oxygen consumption ($\dot{V}O_{2peak}$) (Burns et al., 2015).

Multiple factors determine a child's aerobic fitness, including genetics, sex, age, body composition, and patterns of PA (Dencker et al., 2006; Dencker et al., 2007; Schutte et al., 2016). Active travel to school (e.g., walking, cycling) has been associated positively with aerobic fitness (Lubans et al., 2011). In low-income urban neighborhoods, parents' perception of the neighborhood as unpleasant (e.g., abandoned buildings, graffiti) was associated with a lower likelihood for active travel to school (DeWeese et al., 2013). Social disorder (e.g., loitering, selling drugs, fighting) and lower neighborhood safety were associated with less PA among youth residing in Chicago, IL (Molnar et al., 2004). Police reports of neighborhood crime influenced PA among children in San Diego, CA, where children residing in the highest crime quartile had, on average, 40 min/day less moderate-to-vigorous PA (MVPA) than children residing in the lowest crime quartile (Kneeshaw-Price et al., 2015).

Crimes against persons and property in the city of St. Louis are markedly higher than state and national averages (The City of St. Louis Department of Health, 2016). Furthermore, this city is characterized by a lower life expectancy and a higher poverty rate than the state of Missouri and the U.S. overall. Racial disparities in St. Louis are prominent for life expectancy and socioeconomic status, with 33.3% of black and 8.1% of white residents living below the federal poverty line.

The Saint Louis Public School district serves approximately 24,000 children, > 80% of whom are black (Missouri Department of Elementary & Secondary Education, Comprehensive Data System). The district has taken action to address student health and fitness through a collaborative partnership with Washington University investigators. Previous studies demonstrated an alarming prevalence of poor aerobic fitness among students (Clark et al., 2015). The aim of this study was to determine the relationship of aerobic fitness with characteristics of the elementary school environment (i.e., playground features, open play areas, PE and recess practices, school census tract data) and student-level characteristics among 4th and 5th grade children attending urban public schools. Identifying characteristics of the school environment that impact a child's ability to meet aerobic fitness standards is proposed to have important public health implications by promoting school facility and policy changes and informing urban renewal initiatives.

2. Materials and methods

2.1. Setting and participants

An observational, cross-sectional study was conducted in all elementary schools in the Saint Louis Public School district in St. Louis, Missouri during school years 2012–2013, 2013–2014, and 2014–2015. Participants included students in 4th and 5th grades who completed assessments of aerobic fitness and body composition as part of PE class. Study eligibility required parent/guardian written permission and student verbal assent. Student-level demographic information was provided by the school district and included date of birth, sex, race/ethnicity (combined format), and eligibility for the National School Lunch Program. This study was approved by The Washington University in St. Louis Institutional Review Board and the Saint Louis Public Schools Research Review Committee.

2.2. Assessment of school environment

Research team members conducted on-site evaluations of school environments during the 2014–2015 school year. Playground features and playground safety were quantified using an adapted version of the Play Across Boston (PAB) Facility Survey (Arroyo-Johnson et al., 2016; Cradock et al., 2005). The overall safety score was calculated using 15 of the 25 national safety standards from the PAB Facility Survey, which included assessment of climbers (6-ft fall zone, surfacing, height, debris, rust, trip hazards, cracks/holes, entrapments, broken/missing parts, peeling/chipping paint, and snag hazards) and supervision (locking gates, adult presence, children in view on equipment and in crawl-space). Ten of the 25 PAB survey items were not relevant because the school playgrounds in this school district did not have swings, sprinklers, or sandboxes. The overall safety score indicates the percentage of national standards met (0–100%). Additionally, horizontal (e.g., hopscotch, soccer goals) and vertical (e.g., slides, climbers) playground features were counted at each school.

School environment assessments included outdoor recess play areas and availability of sports equipment. PE teachers were surveyed regarding PE and recess practices at each school: "Are students withheld from PE for classroom misconduct?" and "Where is recess held during inclement weather?" Percent vacant houses and median household income for each school's census tract were determined by geocoding each school's address and linking American Community Survey 2014 data (5-year estimates) (United States Census Bureau, American Community Survey, 2014). Geocoding and spatial data manipulation were performed using ArcGIS (Version 10.4, ESRI, Redlands, CA).

2.3. Assessment of aerobic fitness

Aerobic fitness was assessed with the FITNESSGRAM® 20-m PACER, a multistage running test that requires progressively higher running speeds (Meredith and Welk, 2010). Assessments were conducted by certified PE teachers and university personnel during PE class in the school gymnasium, with 5–6 students (boys and girls) tested simultaneously. A student's PACER score is the number of laps completed. $\dot{V}O_{2peak}$ was estimated using the equation recommended by the FITNESSGRAM® Scientific Advisory Board (Burns et al., 2015):

$\dot{V}O_{2peak} = 0.353 \times \text{laps} - 1.121 \times \text{age} + 45.619$. Each student's aerobic fitness was categorized as Healthy Fitness Zone (HFZ), Needs Improvement – Some Risk, or Needs Improvement – High Risk according to sex- and age-specific FITNESSGRAM® standards (Meredith and Welk, 2010). We applied 10 year-old FITNESSGRAM® standards for students younger than 10 because the aerobic HFZ standard has not been established for this age group. Our primary outcome was failure to meet the aerobic HFZ.

2.4. Assessment of weight status

Height was measured with a stadiometer and weight with a digital scale (Tanita BF-2000 Iron Kids) during PE class by PE teachers or university personnel; shoes and outerwear were removed and pockets were emptied. Body mass index (BMI), BMI-for-age percentiles, and BMI z-scores were computed using SAS code from the Centers for Disease Control and Prevention (A SAS Program for the 2000 Growth Charts, CDC). Weight status was classified according to the CDC's sex-specific BMI-for-age criteria: underweight (< 5th percentile), normal weight (5th to < 85th percentile), overweight (85th to < 95th percentile), or obese (≥ 95th percentile) (Kuczmarski et al., 2002).

2.5. Assessment of physical activity (PA)

Daily PA was quantified in a subset of students using Ekho accelerometer pedometers for up to 4 weeks throughout the academic year. Children were instructed to wear the pedometer on their waistband all day and to record their steps on a log sheet each day. Steps were saved in the pedometer's seven-day memory and were checked by teachers and university personnel. Daily step counts below 1000 and above 30,000 were excluded from analysis, per reliability criteria for children (Rowe et al., 2004). A minimum of 4 days of step counts was required for participant inclusion in the step count analyses (Trost et al., 2000). We computed average daily step counts for weekdays and weekend days.

2.6. Data analysis

Statistical analyses were performed using SAS Version 9.4 (SAS Institute, Cary, NC). The threshold for statistical significance was set at α = 0.05. Descriptive statistics were used to report student-level characteristics for the overall sample, by sex, and by FITNESSGRAM® aerobic fitness category. We calculated Cohen's d as a measure of effect size for the difference in steps between sexes. Bivariate analyses using simple logistic regressions were performed to compute odds ratios and to identify student-level and school-level predictors of failure to meet the aerobic HFZ. Multivariable logistic regression models with sex stratification were used to predict failure to meet aerobic HFZ standards, based on the variables identified as statistically significant in the bivariate analyses. The *c* statistic for discriminative ability of the model was calculated for final models. The bivariate and multivariable models accounted for clustering at the school level using a random intercept via a generalized linear mixed model (PROC GLIMMIX) with a variance components covariance matrix. Daily steps were modeled as a continuous variable.

3. Results

The analysis sample included 2381 students in 4th and 5th grades at 45 elementary schools. The age range was 8.6–13.2 years (mean 10.5, SD 0.7); 51.5% of students were female. The majority of the sample was black (82%) and qualified for the National School Lunch Program (63.3%), consistent with school district demographics.

The school playgrounds had an average of 20.5 features (95% CI 18.2, 22.9; range 5–48) and a safety score of 84.5% (95% CI 81.2, 87.6; range 46–100%). All elementary schools had outdoor open play spaces and sports equipment (e.g., balls, jump ropes) that was available during recess. Teachers at 37 schools (82%) reported that students were withheld from PE for classroom misconduct. When recess could not be held outdoors (e.g., during inclement weather), 49% of schools held recess in a gym, 22% in a cafeteria, and 29% cancelled recess. School census tract analyses revealed that 22% of houses were vacant (95% CI 19.2, 25.6; range 7%–51%) and median annual household income averaged $32,937 (range $11,627 – $61,083).

Weight status, fitness parameters, and pedometer steps are shown in Table 1. Failure to meet the aerobic HFZ standard was observed in 45.4% of students. More girls (56.7%) than boys (33.3%) were in the "Needs Improvement" categories. Physical activity also differed by sex, with boys taking 889 more steps/day than girls, and a small to medium effect size (Cohen's d = 0.35).

Table 2 displays student characteristics by FITNESSGRAM® aerobic fitness category. Failure to achieve the aerobic HFZ was influenced by BMI and weight status. The highest mean BMI z-score and BMI-for-age percentile values were observed among students in the lowest fitness category (i.e., NI-HR). Furthermore, 50.4% of students who were categorized as obese failed to achieve the aerobic HFZ.

Table 3 presents the odds ratios for student-level and school-level predictors of failure to meet aerobic HFZ standards, derived from bivariate analyses. For the sample overall, several variables were significant predictors, including higher age, higher BMI z-score, obese weight status, fewer daily steps, and lower median household income in the school census tract. Most school environment variables, including playground features, playground safety score, recess practices, and vacant houses in the school census tract, were not significant predictors of fitness. In bivariate analyses with sex stratification, median household income was no longer predictive, whereas the total number of playground features was significantly associated with failure to meet HFZ among girls only. However, when incorporated into the multivariable logistic regression model (Table 4), the total number of playground features was no longer predictive.

The final multivariable logistic regression model included 1289 students with data for step counts, BMI, and aerobic fitness. School environment variables were not included in the final model because either they were not associated significantly with failure to meet aerobic HFZ in the bivariate analyses or the effects were attenuated when individual-level characteristics were controlled for in the analysis. The models for both sexes demonstrated good to strong fit based on the *c* statistic (boys: *c* = 0.76, girls: *c* = 0.77). As shown in Table 4,

Table 1
Weight status and aerobic fitness of 4th and 5th grade students in St. Louis, MO during school years 2012–2015.

Characteristic	Total (N = 2381)	Boys (N = 1154)	Girls (N = 1227)
BMI *z*-score, mean (SD)	0.66 (1.11)	0.63 (1.11)	0.70 (1.10)
BMI-for-age percentile, mean (SD)	67.1 (28.6)	66.4 (28.5)	67.9 (28.7)
Weight category, N (column %)			
Underweight	45 (2.2%)	23 (2.3%)	22 (2.1%)
Healthy weight	1212 (59.4%)	601 (60.7%)	611 (58.3%)
Overweight	320 (15.7%)	154 (15.5%)	166 (15.8%)
Obese	462 (22.7%)	213 (21.5%)	249 (23.8%)
PACER score, mean (SD)	22.3 (12.2)	26.4 (13.7)	18.4 (9.0)
$\dot{V}O_{2peak}$ (ml/kg/min)*, mean (SD)	41.8 (4.3)	43.2 (4.8)	40.4 (3.2)
FITNESSGRAM® categories*, N (column %)			
Healthy Fitness Zone (HFZ)	1300 (54.6%)	770 (66.7%)	530 (43.3%)
Needs improvement-some risk	760 (31.9%)	279 (24.2%)	481 (39.1%)
Needs improvement-high risk	321 (13.5%)	105 (9.1%)	216 (17.6%)
Students who met the HFZ by age, N (% by age and sex)			
< 10 years-of age (N = 705)	417 (59.1%)	217 (68.0%)	200 (51.8%)
10 years-of-age (N = 1119)	610 (54.5%)	369 (66.7%)	241 (42.6%)
11 years-of-age (N = 491)	251 (51.1%)	166 (67.5%)	85 (34.8%)
12–13 years-of-age (N = 66)	22 (33.3%)	18 (51.4%)	4 (13.0%)
Daily steps*, mean (SD)	6949 (2540)	7418 (2813)	6529 (2185)

Abbreviations: BMI (Body Mass Index), PACER (20-m Progressive Aerobic Cardiovascular Endurance Run).
N = 2039 for BMI and weight category, N = 1442 for average daily steps.
* $p < 0.05$ for test of difference by sex.

Table 2
Characteristics of 4th and 5th grade students in St. Louis, MO by FITNESSGRAM® aerobic fitness category during school years 2012–2015.

Characteristic	Mean (SD) or n (Row %)		
	HFZ (N = 1300)	NI-SR (N = 760)	NI-HR (N = 321)
Age (years)*	10.4 (0.7)	10.5 (0.7)	10.6 (0.9)
NSLP eligibility*			
Yes (free/reduced lunch)	838 (56.1%)	479 (32.1%)	177 (11.8%)
No	450 (52.0%)	273 (31.5%)	143 (16.5%)
BMI *z*-score*	0.58 (1.10)	0.74 (1.11)	0.84 (1.10)
BMI-for-age percentile*	65.3 (28.7)	68.8 (28.6)	71.0 (27.8)
Weight category*			
Underweight	28 (62.2%)	13 (28.9%)	4 (8.9%)
Healthy weight	708 (58.4%)	360 (29.7%)	144 (11.9%)
Overweight	166 (51.9%)	111 (34.7%)	43 (13.4%)
Obese	229 (49.6%)	156 (33.8%)	77 (16.6%)
PACER Score*	30.3 (10.9)	14.3 (2.8)	8.6 (2.0)
$\dot{V}O_{2peak}$ (ml/kg/min)*	44.7 (3.7)	38.9 (0.8)	36.8 (0.9)

Values in this table represent mean (SD) for age, BMI, $\dot{V}O_{2peak}$, and daily steps; all other values represent N (% of sample by row).
Abbreviations: NSLP (National School Lunch Program), BMI (Body Mass Index), PACER (20-m Progressive Aerobic Cardiovascular Endurance Run), HFZ (Healthy Fitness Zone), NI-SR (Needs Improvement - Some Risk), NI-HR (Needs Improvement - High Risk).
N = 2381 for fitness categories, N = 2360 for NSLP eligibility, N = 2039 for BMI and weight category, N = 1442 for daily steps.
* $p < 0.05$ for test of difference by FITNESSGRAM® aerobic fitness category.

Table 3
Odds ratios for predictors of failure to meet FITNESSGRAM® aerobic HFZ from bivariate analyses among 4th and 5th grade students in St. Louis, MO, 2012–2015.

Predictor	Total		Boys		Girls	
	OR	p-value	OR	p-value	OR	p-value
Age	1.42	**< 0.0001**	1.21	**0.0397**	1.75	**< 0.0001**
Non-black race (ref: black)	1.10	0.4931	1.63	**0.0159**	0.69	**0.0487**
NSLP eligibility (ref: no)	0.73	**0.0370**	0.89	0.5587	0.69	**0.0467**
BMI z-score	1.13	**0.0038**	1.10	0.1610	1.16	**0.0158**
Weight category (ref: healthy weight)						
Underweight	0.77	0.4460	0.89	0.8131	0.81	0.6661
Overweight	1.19	0.2056	1.01	0.6332	1.31	0.1498
Obese	1.35	**0.0104**	1.21	0.2697	1.42	**0.0321**
Daily steps (all days)	0.83	**< 0.0001**	0.86	**< 0.0001**	0.88	**0.0004**
Weekdays	0.83	**< 0.0001**	0.75	**< 0.0001**	0.88	**0.0006**
Weekend days	0.93	**< 0.0002**	0.96	0.1616	0.94	**0.0133**
Total playground features	0.98	0.1651	1.00	0.8956	0.97	**0.0383**
# Vertical features	0.99	0.4380	1.02	0.6647	0.97	0.0898
# Horizontal features	0.97	0.1649	0.98	0.4603	0.97	0.1466
Playground safety score	0.99	0.2714	1.00	0.6897	0.83	0.1480
Withheld from recess (ref: no)	0.85	0.6506	0.74	0.3927	0.88	0.7316
Alternate recess location (ref:gym)	0.78	0.2595	0.71	0.1319	0.89	0.6426
Median household income	0.98	**0.0432**	0.99	0.1153	0.99	0.2055
Percent vacant houses	1.01	0.3212	1.01	0.4338	1.01	0.3244

HFZ (Healthy Fitness Zone), OR (Odds Ratio), ref. (reference group), NSLP (National School Lunch Program), BMI (Body Mass Index).
Bolded p-values represent $p < 0.05$.
N = 2381 age and aerobic fitness, N = 2360 for race and NSLP eligibility, N = 2039 for BMI z-score and weight category, N = 1442 daily steps.

Table 4
Odds ratios for predictors of failure to meet FITNESSGRAM® aerobic HFZ from multivariable logistic regression; St. Louis, MO, 2012–2015.

Predictor	Boys (N = 612)		Girls (N = 677)	
	OR	p-value	OR	p-value
Age	1.41	**0.0162**	2.03	**< 0.0001**
Non-black race (ref: black)	1.17	0.5777	0.66	0.1001
NSLP eligibility (ref: no)	0.79	0.4158	0.63	0.0675
Weight category (ref: healthy weight)				
Underweight	0.93	0.9100	1.25	0.7150
Overweight	1.26	0.3966	1.27	0.3357
Obese	1.28	0.2987	1.60	**0.0252**
Daily steps (thousands)	0.85	**< 0.0001**	0.87	**0.0006**

HFZ (Healthy Fitness Zone), OR (Odds Ratio), ref. (reference group), NSLP (National School Lunch Program).
Bolded p-values represent $p < 0.05$.

older age and fewer daily steps were associated significantly with failure to meet aerobic HFZ standards in boys and girls. Each year of age older was associated with 41% higher odds of failing to meet the HFZ among boys and approximately 100% higher odds among girls. Obese weight status in girls was associated with 60% higher odds of failing to meet the HFZ. PA had a favorable influence on aerobic fitness: for each additional 1000 daily steps, boys had 15% and girls had 13% lower odds of failure to meet the HFZ when all other individual characteristics were controlled. In a multivariable logistic regression model that included all students, the results were consistent, indicating that older age and obese weight status in girls were significant predictors of failure to achieve the aerobic HFZ.

4. Discussion

Urban public school students' failure to meet the FITNESSGRAM® sex- and age-specific standards for aerobic capacity was not associated with most characteristics of the school environment. Although modest associations were observed for school playground features and median household income of the school census tract in bivariate analyses, these effects were attenuated and no longer significant in multivariable logistic regression models.

Several student-level characteristics were associated with lower aerobic capacity and failure to meet the aerobic HFZ, the most significant of which were female sex, older age, and fewer daily steps. Higher BMI z-score and weight status were predictive in bivariate models, but these effects of body weight were attenuated in multivariable models, with obese weight status being a predictor only among girls. Poor aerobic fitness among girls has been demonstrated previously particularly among minority girls (Bai et al., 2016; Clark et al., 2015).

Our observation that age was highly negatively associated with aerobic fitness is quite concerning. Although the FITNESSGRAM® equation, by design, produces lower $\dot{V}O_{2peak}$ values with increasing age, it does not account for the dramatic 41–100% increased risk of failing to meet the aerobic HFZ for each additional year of age in our study. This result is likely attributable to a combination of physiologic, behavioral, and cultural factors that will be important to address in future studies.

The 2008 Physical Activity Guidelines for Americans (US Department of Health and Human Services, 2008) recommend that children aged 6–18 years accumulate at least 60 min of MVPA daily, based on an abundance of evidence that PA enhances aerobic fitness and overall health. Consistent with our observation that daily steps predicted aerobic fitness, pedometer step counts were moderately associated with aerobic fitness (based on FITNESSGRAM® PACER results) among 4th–6th grade children in Canada (Larouche et al., 2014) and accelerometer-measured PA was predictive of aerobic fitness among European children aged 8–11 years (Dencker et al., 2006).

The average daily step counts of children in the present study were below the recommended 12,000 steps/day, a benchmark that approximates 60 min of MVPA (Colley et al., 2012). Accelerometer data from the 2003–2004 National Health and Nutrition Examination Survey revealed that only 48.9% of boys and 34.7% of girls aged 6–11 years achieved the recommended 60 min of MVPA daily (Troiano et al., 2008). Potential factors contributing to the low levels of PA in our population may include neighborhood safety concerns, single-parent households, and the low socioeconomic status of many children, which limits opportunities for recreational activities and sports participation outside of school. National trends indicate that the proportion of youth meeting the physical activity guidelines declines in adolescence to

11.9% of boys and 3.4% of girls aged 12–15 years (Troiano et al., 2008). Importantly, the rate of decline in PA is greater among black compared to white girls (Kimm et al., 2002). These results highlight the need for PA opportunities for all children and the necessity to tailor activities specifically for minority girls.

The proportion of 4th and 5th grade students in our urban sample who met the aerobic HFZ standard (54.6%) is lower than that reported in a study of school-aggregated data from 160 schools in San Diego, CA, where 65.7% of 5th grade students achieved the HFZ (Kahan and McKenzie, 2017). We previously assessed aerobic fitness of 4th and 5th grade students (Saint Louis Public Schools) and reported that 67.5% (N = 155) met the aerobic HFZ, based on the President's Challenge 1-mile run (Clark et al., 2015). Comparison of the 2 study cohorts is problematic due to differences in aerobic fitness field tests and sample sizes in these studies.

School-level practices that promote cardiovascular fitness include PE as a grade-level requirement, state-mandated time requirements for PE, access to a gym or field, and instruction by certified PE teachers (Kelly et al., 2010). PE time requirements have been shown to be an effective strategy, especially among girls (Taber et al., 2013) and minority students (Dauenhauer and Keating, 2011). The latter study demonstrated that African American and Hispanic children achieved significantly more pedometer steps on school days with 60-min PE classes than on days with 30-min PE classes or no PE. Furthermore, a large-scale study in California public schools demonstrated improvements in aerobic fitness among 5th grade students (from 61.6% meeting HFZ in 2003 to 66.4% in 2008) following changes in state laws that increased PE time requirements to 200 min per 10 school days (Aryana et al., 2012).

The state of Missouri is among the few states in which legislation mandates recess and a time requirement for elementary PE (Whitehouse and Shafer, 2017). Saint Louis Public Schools comply with the state-mandated requirement of 150 min of PA each week for elementary school students by providing 50 min/week of instructional PE by certified PE teachers and 20 min/day of recess (Missouri Department of Elementary & Secondary Education, Minutes of Instruction). We previously reported that children in elementary grades achieve higher in-school daily steps and more minutes of MVPA on days with PE class compared to days without PE (Castillo et al., 2015; Racette et al., 2015), supporting the National Academy of Medicine's recommendation that all elementary school students should have PE daily (Institute of Medicine, 2013). The amount of PE class time that is spent engaged in MVPA has been observed to be < 40% of the time allocated (Nader, 2003; Racette et al., 2015), whereas the National Academy of Medicine recommendation is that ≥50% of PE class time should be spent engaged in vigorous or moderate-intensity PA (Institute of Medicine, 2013). Furthermore, because students generally have the option to choose their own activity during recess (or to be sedentary), combined with the challenges that many schools face with providing appropriate recess activities during inclement weather, students may not accumulate meaningful PA during recess.

A proposed model to promote PA in the school physical environment supports providing access to game equipment, open play spaces and bright playground markings (Harrison and Jones, 2012). A microgeographic analysis revealed that elementary school playground design influences utilization (Anthamatten et al., 2014). Fixed playground equipment in schoolyard play areas was shown to promote MVPA more than open access areas (Farley et al., 2008). School playgrounds did not influence aerobic fitness in our study, perhaps due to similar open play areas, sports equipment, and playground features.

The primary limitation of this study is potential misclassification of fitness category for students who did not give their best effort on the PACER test. Another limitation is a smaller sample size for pedometer data. We acknowledge that our study included only one urban school district; therefore, the results may not be representative of other elementary schools. Strengths include student-level data for aerobic fitness, BMI, and daily steps; the focus on low-resource urban public schools with a high proportion of minority students; and comprehensive evaluations of school playgrounds and environments.

5. Conclusion

The findings of this study highlight the important influence of daily PA on aerobic fitness among urban public school children and emphasize the need for enhanced PA opportunities, particularly for girls. The American Heart Association's 2016 Scientific Statement Cardiovascular Health Promotion in Children: Challenges and Opportunities for 2020 and Beyond (Steinberger et al., 2016) emphasizes the importance of children engaging in at least 60 min of MVPA daily to promote aerobic fitness and ideal cardiovascular health. This goal is elusive for many youth in low-resource neighborhoods, necessitating school, community, and family-based efforts to address this important public health issue.

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Conflict of interest

The authors have no conflict or competing interests to declare.

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