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Short Communication

# Sex differences in FITNESSGRAM® health risk based on aerobic capacity and body composition among urban public elementary school children

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ABSTRACT

Children residing in urban, low-resource neighborhoods may be at increased risk for poor aerobic fitness and obesity. The objective of this collaborative project with an urban public school district was to quantify the combination of poor aerobic capacity and high percent body fat using FITNESSGRAM® Healthy Fitness Zone (HFZ) standards among urban, predominantly Black, public elementary school boys and girls. Measurements of aerobic capacity with the 20-m Progressive Aerobic Cardiovascular Endurance Run (PACER) test and body composition by bioelectrical impedance analysis were completed on 1,775 fourth and fifth grade students in 45 public elementary schools in St. Louis, Missouri during three school years (2012–2015). Our findings reveal that a higher proportion of girls than boys failed to meet the HFZ for aerobic capacity (70.1% vs. 42.3%), percent body fat (53.0% vs. 29.9%), and the combination of aerobic capacity and percent body fat (44.4% vs. 21.8%, all $P < 0.001$). These results highlight the importance of addressing modifiable, lifestyle-related health risks among urban minority children, particularly girls.



## 1. Introduction

Poor aerobic capacity and excess adiposity are important modifiable risk factors for metabolic syndrome, type 2 diabetes, cardiovascular disease, and cancer (Plowman and Meredith, 2013). Urban children residing in under-resourced areas are at risk for low physical activity and adverse dietary patterns (Grow et al., 2010), predisposing them to poor aerobic fitness and obesity (Carroll-Scott et al., 2013; Saelens et al., 2012). Many studies indicate that girls engage in less physical activity than boys (Trost et al., 2002), but less is known about the combination of poor aerobic capacity and excess adiposity among minority children residing in low-resource, urban neighborhoods.

Health and fitness assessments are conducted routinely in schools nationwide, with FITNESSGRAM® serving as the most widely used tool. The Presidential Youth Fitness Program (https://www.pyfp.org) provides fitness education and assessment tools to promote excellence in physical education programs and has adopted FITNESSGRAM® as its official health-related fitness assessment. Five components of health-related fitness assessed using FITNESSGRAM® include aerobic capacity, muscular strength, muscular endurance, flexibility, and body composition (Meredith and Welk, 2010). Aerobic capacity and body composition are two health metrics that have well-documented, significant effects on health outcomes in adults (Kodama et al., 2009; Sha et al., 2016; Flint et al., 2010); evidence for these associations among youth has been increasing (Ekelund et al., 2007; Welk et al., 2011).

The objective of the current study was to quantify the combination of poor aerobic capacity and high percent body fat based on FITNESSGRAM® Healthy Fitness Zone standards among urban, predominantly minority, public elementary school boys and girls. A unique aspect of this project was the strong collaboration between an urban public school district and an academic medical center, with the common goals of identifying, quantifying, and addressing student health and fitness issues.

## 2. Methods

### 2.1. Setting and participants

The study was conducted in a large urban public school district in St. Louis, Missouri. Participants were students in fourth and fifth grades attending one of 45 elementary schools during the school years 2012–2013, 2013–2014, and 2014–2015. Each student was represented in the analysis only once (i.e., at one assessment time point during one

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school year only). Additional eligibility criteria for inclusion in this analysis were age ≥ 10 years, child assent, and written informed consent provided by a parent or guardian on forms approved by the Washington University School of Medicine Institutional Review Board.

### 2.2. FITNESSGRAM® measures

The FITNESSGRAM® health metrics recommended for school-aged children that were used in the current study include aerobic capacity and body composition. All assessments were performed by certified physical education (PE) teachers and/or our research team members during PE classes in the elementary schools. Our research personnel trained the PE teachers on performing these measures during formal professional development group training sessions for PE teachers each year and during individual training sessions at each school. All teachers received the same testing equipment, supplies, and instructions to ensure consistency across schools. Our research personnel assisted the PE teachers in performing the assessments and performed all computations of aerobic capacity and body composition.

### 2.3. Aerobic capacity

Aerobic capacity was assessed using the FITNESSGRAM® 20-m Progressive Aerobic Cardiovascular Endurance Run (PACER) (Plowman and Meredith, 2013), in which students run as many 20-m laps as they are able. Peak aerobic capacity ($VO_{2peak}$) was computed as recommended by the FITNESSGRAM Scientific Advisory Board (Burns et al., 2015) using the following formula: $VO_{2peak} = 0.353(\text{Laps}) - 1.121(\text{Age}) + 45.619$. Each child's $VO_{2peak}$ value was then compared to sex- and age-specific standards.

### 2.4. Body composition

Two FITNESSGRAM® measures of body composition were used: percent body fat and body mass index (BMI). BMI is a more common and easily-obtained measure with an abundance of referent data from children and adolescents worldwide. Percent body fat is advantageous for individuals who may be misclassified as overweight or obese by BMI due to increased muscle mass. Each child's height was measured with a stadiometer, weight with a digital scale, and body composition using bioelectrical impedance analysis (Tanita BF-2000 IronKids). Shoes and outwear were removed and pockets were emptied for these measurements. Tanita pediatric bioelectrical impedance scales have been shown to be valid and reliable in children (Kabiri et al., 2015). BMI was computed as weight in kg divided by height in meters squared ($kg/m^2$) and as sex- and age-specific percentiles and z-scores using CDC criteria (Centers for Disease Control and Prevention, 2014) and each student's precise age on the date of assessment. Percent body fat was compared to sex- and age-specific FITNESSGRAM® reference values.

### 2.5. Healthy Fitness Zone (HFZ) categories

For each outcome measure, three FITNESSGRAM® health-related fitness categories were determined based on sex- and age-specific criteria: Healthy Fitness Zone (HFZ), Needs Improvement (NI), and Needs Improvement–Health Risk (NI-HR). HFZ is the ideal category, signifying sex- and age-appropriate values. NI and NI-HR reflect failure to meet FITNESSGRAM® health-related fitness standards.

### 2.6. Risk score

A risk score of 0, 1, or 2 was computed based on whether a student met or failed to meet the FITNESSGRAM® HFZ standards for aerobic capacity and body composition (i.e., percent body fat or BMI). For this purpose, the FITNESSGRAM® categories NI and NI-HR were combined and defined as risk. A score of 0 indicates that a child was in the Healthy Fitness Zone for aerobic capacity and both body composition measures (i.e., percent body fat and BMI), 1 indicates that a child did not meet the HFZ standard for one metric only, and 2 represents lack of achievement of HFZ for aerobic capacity and one or both body composition measures.

### 2.7. Analyses

The primary outcome of interest was the combination of poor aerobic capacity and high percent body fat within a child. Aerobic capacity, percent body fat, BMI, and demographic characteristics (i.e., grade, age, school) were compared between boys and girls using two-sample Wilcoxon tests for continuous variables and chi-square tests for categorical variables. To explore the association between sex and the computed risk score (i.e., 0, 1, or 2), a Cochran-Armitage test for trend was performed using the SAS PROC FREQ TREND option and the Somers' D R|C statistic with 2-sided *P* values. Data were analyzed with and without stratification by grade. Results are expressed as a proportion of the sample or as mean and 95% confidence intervals. Analyses were performed using SAS version 9.4.

## 3. Results

Participants included 1775 children (879 boys, 896 girls) in grades 4 and 5. Students in this district are predominantly of low socioeconomic status, with >90% qualifying for the National School Lunch Program. The racial distribution of participants was 81.0% Black, 11.9% White, and 7.1% other. Mean age was 10.9 ± 0.6 years (range 10–14 y). Students younger than 10 y were excluded from our analysis because there are no FITNESSGRAM® aerobic capacity standards for children <10 y. Therefore, a larger proportion of our sample was in 5th grade (67%) than in 4th grade (33%). There were no sex differences with respect to age, grade, race, or school site among our participants.

Risk categorizations and results for each of the three health metrics are shown in Table 1. All outcomes of interest were statistically different by sex, with a higher proportion of girls not meeting the Healthy Fitness Zone standards for aerobic capacity, percent body fat, and BMI compared to boys. BMI, BMI-for-age percentile, and BMI z-score results showed similar sex effects, with higher values among girls than boys; this was reflected in a higher proportion of girls categorized as overweight or obese relative to boys. These sex differences persisted when the data were stratified by grade (i.e., 4th and 5th).

As shown in Fig. 1, the combination of aerobic capacity and body composition risk factors also was significantly different by sex ($P < 0.001$). A higher proportion of girls (44.4%) than boys (21.8%) did not meet the HFZ standards for aerobic capacity and percent body fat combined. Similarly, more girls (38.6%) than boys (23.7%) failed to meet the aerobic capacity and BMI HFZ standards combined. More than half of the girls in our sample (50.5%) failed to meet both the aerobic capacity HFZ standard and at least one of the body composition HFZ standards (i.e., percent body fat or BMI); this was greater than the 31.5% of boys who failed to meet both metrics ($P < 0.001$). Failure to meet the HFZ standard for aerobic capacity and both body composition metrics (i.e., percent body fat and BMI) was observed among 38.4% of girls and 20.6% of boys ($P < 0.0001$). Overall, only 33.5% of the fourth and fifth grade students in our sample met the HFZ criteria for all of these health metrics. As shown in Fig. 1, more boys (45.8%) than girls (21.3%) were in this zero risk category ($P < 0.001$).

Grade (4th or 5th), age, and school site (45 different elementary schools) did not influence the outcomes. Only sex was found to be a significant predictor of FITNESSGRAM aerobic capacity and body composition fitness categories.