Disparities in Fitness and Physical Activity Among Children

John Bowser, PhD; Ana P. Martinez-Donate, PhD; Aaron Carrel, MD; David B. Allen, MD; D. Paul Moberg, PhD

ABSTRACT

Background: Adequate physical activity and cardiorespiratory fitness aid in the prevention of type 2 diabetes mellitus and obesity. Large sociodemographic/economic disparities exist for these conditions, which develop over time beginning in childhood. This paper examines disparities in both activity and fitness levels among children and adolescents in Wisconsin.

Methods: The Wisconsin Partnership for Childhood Fitness collected cardiorespiratory fitness and physical activity data on 3,798 6th grade students in 37 schools in fall 2011. Fitness data were collected via testing in physical education classes. Activity data were collected via self-report, 1-day activity logs administered during school. Using hierarchical linear models, disparities in fitness and physical activity by race/ethnicity and school-level characteristics were investigated.

Results: Widespread race and ethnic disparities exist in aerobic fitness, as well as more limited disparities in physical activity levels. In addition, students from schools with higher overall socioeconomic status (SES) were more active and had higher fitness levels than those from schools with overall lower SES levels.

Conclusions: Among Wisconsin adolescents, race/ethnicity and school-level SES contribute to significant differences in both fitness and physical activity levels. Modifiable elements of the school environment to increase physical activity, and potentially fitness, may provide opportunities to reduce health disparities among children, contributing to improved long-term health outcomes among Wisconsin adults.

BACKGROUND

Physical activity and cardiorespiratory fitness are commonly cited as factors in the prevention of obesity-related diseases, particularly type 2 diabetes mellitus, early-onset cardiovascular disease and, to a lesser degree, obesity itself. Racial and ethnic differences exist in the prevalence of these conditions,[1] and in general, minorities are more likely than white Americans to be obese and to suffer from conditions such as diabetes[2,3]—a difference that is particularly stark between black and white adults.

A majority of studies on the racial and ethnic disparities in fitness and activity among adolescents indicate that minorities are less active and physically fit than their white/non-Hispanic peers.[4-7] However, results are not entirely consistent[8,9] due to factors that include methodological differences and illustrate the need for continued investigation.

It would be beneficial to know if well-documented racial and ethnic disparities in adults are predicted by cardiorespiratory fitness and/or physical activity disparities among children. A link of low fitness among 18 year olds extending to an increased risk of type 2 diabetes later in adulthood has been investigated and shown to have merit among men.[10] Therefore, the relationship of fitness disparities in children contributing to disparities in adult health outcomes also is plausible. This study addresses this relationship, asking if—and to what degree—racial and ethnic disparities in physical activity and cardiorespiratory fitness are present among a sample of 6th grade students from 37 Wisconsin middle schools.

A complete understanding of disparities by race/ethnicity requires evaluation within the context of socioeconomic status (SES), as evaluation based on race/ethnicity alone would mask the influence of SES, which has been suggested previously.[11] In the case of the school environment, SES influences include resources available within the school itself and the surrounding neighborhoods in which the students reside. Therefore, this evaluation takes into account both race/ethnicity and a broader community-level variable: school-level SES.

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Author Affiliations: Wisconsin Department of Public Instruction, Madison, Wis (Bowser); Department of Community Health and Prevention, Dornsife School of Public Health, Drexel University, Philadephia, Penn (Martinez-Donate); Department of Pediatrics, University of Wisconsin School of Medicine and Public Health (UWSMPH), Madison, Wis (Carrel, Allen); Population Health Institute, UWSMPH (Moberg).

Corresponding Author: John Bowser, PhD, Wisconsin Department of Public Instruction, 125 S Webster St, Madison, WI 53707-7841; phone 608.266.2829; fax 608.266.3643; e-mail john.bowser@dpi.wi.gov.

METHODS

Data reported in this paper were collected as part of the Wisconsin Partnership for Childhood Fitness (Phase II), a collaborative project between state agencies (Wisconsin Department of Public Instruction, Wisconsin Department of Health Services), the University of Wisconsin, and schools throughout the state designed to increase activity and fitness levels while reducing disparities among Wisconsin students.

To recruit schools, the Department of Public Instruction (DPI) sent a request for application to all eligible Wisconsin schools, which were schools with a minimum of 40% economically disadvantaged students. In Wisconsin, "economically disadvantaged" students are those who are eligible for free or reduced lunch. This skewed the sample population towards lower SES levels than Wisconsin as a whole.

Thirty-seven schools participated. While schools from many geographic regions of Wisconsin were included, a higher number were condensed in urban areas (as defined by US Census criteria), resulting in under representation of white students and overrepresentation of Hispanic students in the race/ethnicity demographic.

Data analyzed were from fall 2011, which represents project baseline data. It was the first of 6 biannual waves of data collected during the 3-year project.

This research was determined to be exempt by the University of Wisconsin-Madison Minimal Risk Health Services Institutional Review Board.

Variables and Measurement—Individual-level data on fitness, activity, age, race/ethnicity, grade, and gender all were gathered via self-report in a *Student Activity Log Bookl*et developed for the project. Students completed the booklet in school under the supervision of a teacher (physical education or other). The booklets were then submitted to the University of Wisconsin Population Health Institute (Institute) for data coding and analysis.

For measurement of physical activity, a 1-day physical activity recall was used. Students listed all activities from the previous school day that they felt were "physical," including their intensity and length. From their logs, minutes of Moderate to Vigorous Physical Activity (MVPA) were calculated by the Institute by cross-referencing activities listed in the *Compendium of Physical Activities*[12] to determine if an activity rose to the level of moderate or higher. Criterion validity of the 1-day recall was assessed through comparison with same-day pedometer readings and found to be adequately valid ($r = .433$; $P < .001$), with correlation comparable to other activity logs for similar populations.[13,14] This validity assessment was conducted using 6th grade logs from a related project, "Active Schools," from which the Wisconsin Partnership for Childhood Fitness log was adapted.

Physical fitness was assessed through the use of *Fitnessgram*, a fitness assessment tool developed for use in schools.[15] The Progressive Aerobic Cardiovascular Endurance Run (PACER) test of aerobic fitness was employed during the students' physical education classes to measure their fitness. The PACER test involves running 20-meter distances, in succession, with the required average speed to complete the distance in the allotted time increasing by 0.5 kilometers per hour at growing lap intervals. Upon failure to complete the distance in the allotted time twice, the test is concluded. Following the test, students recorded their PACER score (in laps attained) in their activity booklet. The PACER score was then converted to VO_2 max, an indicator of cardiorespiratory fitness that refers to the maximum amount of oxygen consumed during physical exertion (in ml/kg/min). This has been validated previously among American children and adolescents.[16]

Self-reported individual variables, age, grade, gender, and race/ethnicity were used for our analyses. Race and ethnicity were reported by the students through 2 standard questions used in school-based instruments: (1) students were asked if they consider themselves Hispanic (yes/no); (2) they were asked to report their race/ethnicities, checking all that apply. Based on these responses, students' racial/ethnic backgrounds were coded for analysis. Categories used were white/non-Hispanic, black/non-Hispanic, Hispanic, mixed race/non-Hispanic, American Indian/non-Hispanic, other/non-Hispanic (Asian and Pacific Islander/Native Hawaiian).

School-level SES was dichotomized based on Wisconsin DPI data on students eligible for free or reduced price lunch. Schools with 49% to 59% economically disadvantaged students were referred to as "higher income" schools; those with 60% or greater economically disadvantaged students were referred to as "lower income" schools.

School-level control variables also were included in the analyses. Schools were classified as urban (vs rural) if they were located in an "urbanized area" as defined by the 2000 US Census.[17] This variable was determined to hold a confounding influence in analysis on physical activity. No other available school-level variable (eg, percent minority population) was significant in the analyses.

Statistical Analyses—All 6th grade students who submitted a valid previous-day activity recall and PACER score converted to VO_2 max in their log were included in analyses (N = 3,798; 37 schools). The analysis of interest is differences between race/ethnicity for activity and fitness. Preliminary analysis conducted a 1-way analysis of variance (ANOVA) and found significant differences between groups in fitness ($F = 14.3$, $P \leq .001$) and activity ($F = 6.65$, $P \leq .001$)

In our data structure, clustering is present due to having students nested within schools, and observations cannot be assumed to be independent. Hence, we used hierarchical (mixed) linear models to estimate correct standard errors. Intraclass correlation coefficients were computed and showed correlation within schools of 0.21 for MVPA and 0.26 for VO_2 max, indicating a significant, but relatively low level of within-school dependence.

Analysis was run using Hierarchical Linear Modeling, version 7 (Scientific Software International Inc; Skokie, Illinois).

RESULTS

Analysis Based on Race/Ethnicity—The overall sample (Table 1) contained 56% white/non-Hispanic students and 20.8% Hispanic students. This compares to the state average of 78.5% white/non-Hispanic students[18] and 9.7% Hispanic students, respectively. Remaining distributions were largely in line with state figures. For physical activity, the sample had an average MVPA level of 70.3 minutes (SD = 66.2), 49.2 of which were after school. Mean aerobic fitness levels (VO_2 max) were 43.9 ml/kg/min (SD = 4.4). For the PACER test, the average number of laps completed was 30.7 among boys and 24.2 among girls. Relative to established norms in Wisconsin among 12-year-old children, our sample had fitness levels that were at the 50th percentile level (31 laps) of boys and slightly above the 50th percentile (22 laps) among girls.[19]

Fitness and Activity Descriptive Statistics—Levels of physical activity and physical fitness indicate that the most active and fit students were the referent group (white/non-Hispanic). Students in the Asian/non-Hispanic category were the least active (n = 210). Descriptive statistics of VO_2 max show the lowest fitness levels are among American Indian/non-Hispanic (42.6 ml/kg/min) and black/non-Hispanic (42.7 ml/kg/min) students.

Physical Activity (Regression Analysis)—Results for physical activity showed few significant differences by race/ethnicity. The only groups with physical activity levels significantly lower than white/non-Hispanic students were Hispanic and Asian students. A secondary analysis limited to after-school activity was conducted, the rationale being that while within the school day there is a level of uniformity, after-school activity may introduce sociological variables that would influence levels of activity. Results, however, did not differ (Figure 1).

Cardiorespiratory Fitness (Regression Analysis)—Levels of aerobic fitness (VO_2 max) showed widespread disparities relative to the referent group of white/non-Hispanic students. With the exception of Hispanic students, all racial/ethnic groups were significantly less fit than white/non-Hispanic students (Figure 2).

Differences by SES—An additional analysis looked at differences in mean levels of fitness and activity by SES and by race/ethnicity between SES groups. For activity, students in the higher income schools were more active (73.3 minutes vs 68.2 minutes) than those in lower income schools. When analyzed by SES and race/ethnicity, differences were limited to white/non-Hispanic students.

Table 1. Descriptive Statistics (Wisconsin Partnership for Childhood Fitness – 6th Grade)

	Overall
Total students	3,798
Number of schools	37
Female	47.2%
White, non-Hispanic	55.6%
Black, non-Hispanic	7.2%
Hispanic	20.8%
Mixed race, non-Hispanic	9.3%
American Indian, non-Hispanic	1.5%
Other, non-Hispanic (primarily Asian)	5.8%
Urban schools	56.5%
Calculated VO_2 max (ml/kg/min), mean (SD)	43.9 (4.4)
MVPA (in minutes) – Total, mean (SD)	70.3 (66.2)

Abbreviation: MVPA, Moderate to Vigorous Physical Activity.

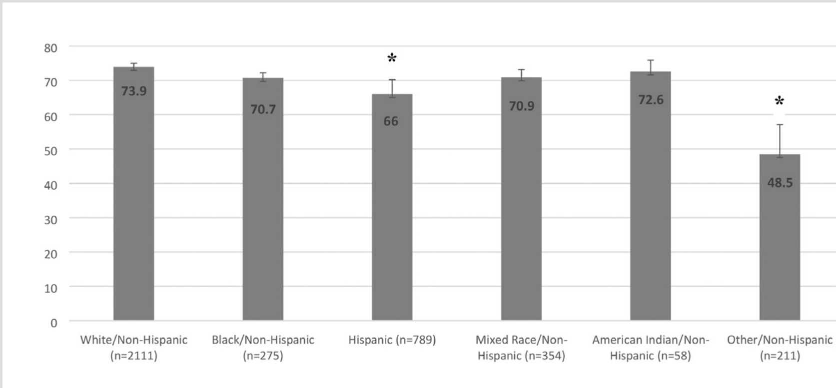
Students in higher SES schools scored higher on aerobic fitness than those in lower SES schools (44.5 ml/kg/min vs. 43.4 ml/kg/min). Unlike with activity, differences by SES among individual racial/ethnic groups were more pronounced. White/non-Hispanic students, Hispanic, and American Indian/non-Hispanic students from lower SES schools were significantly less fit than those in higher SES schools (Table 2).

As described earlier, the primary method of analysis was a hierarchical (mixed) linear modeling methodology. All potential risk factors were included in original models, and using backward selection methods, those factors that remained significant were retained. Analysis on VO_2 max (Table 2) controlled for age and gender. Similar analysis on MVPA controlled for gender and urban vs rural setting, which was retained due to its influence in a confounding role. For analyses stratified by SES, gender and age were retained. Additionally, the necessity of variable transformation into root or natural log forms was investigated and found to hold minimal differences to results and determined to be unnecessary.

DISCUSSION

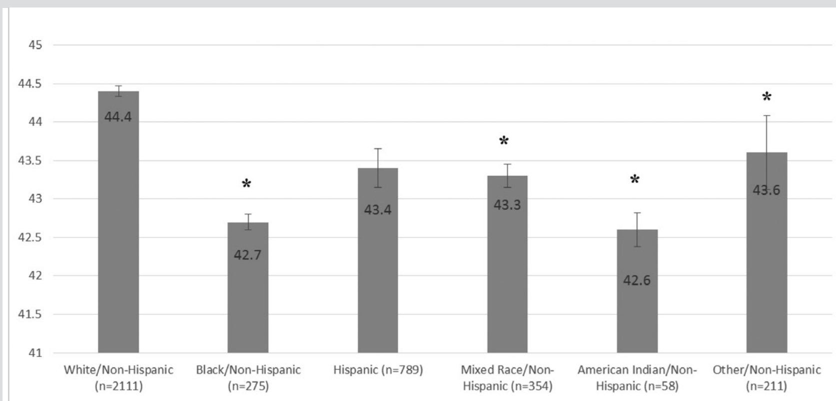
There are clear racial disparities in aerobic fitness; black, American Indian, mixed race, and Asian children are statistically significantly less fit than their white/non-Hispanic peers in Wisconsin. The disparity is greatest among black/non-Hispanic and American Indian/non-Hispanic children. Our results suggest that disparities in aerobic fitness across ethnic/racial groups are present among children and support interventions to reduce or eliminate these differences as part of a long-term strategy to reduce disparities in health outcomes among children and, in the future, adults.

Figure 1: Moderate to Vigorous Physical Activity by Race/Ethnicity Mean (+/- SE) Minutes Per Day



* Differences significant (P<.05) relative to white/non-Hispanic: hierarchical linear modeling methods; controlling for gender and urbanized area.

Figure 2: Aerobic Fitness by Race/Ethnicity: Calculated VO_2 Max (Mean and SE ml/kg/min)



* Differences significant (P<.05) relative to white/non-Hispanic: hierarchical linear modeling methods; controlling for gender and age.

The importance of the level of difference that exists at this age between white/non-Hispanic and black/non-Hispanic (~2 ml/kg/min) is difficult to assess; however, research has indicated associations of VO_2 max with markers of disease. In particular, VO_2 max levels among healthy adolescents, and differences within this group, are associated with favorable levels of aortic intima-media thickness and elasticity.[20] Also, longitudinally, the relationship between fitness and risk factors for cardiovascular disease indicates that VO_2 max is inversely related to total cholesterol and skinfold measurements,[21] both of which are markers for chronic disease later in life.

For physical activity, more limited differences exist. Two racial/ethnic groups—other/non-Hispanic and Hispanic (contingent on nontransformed MVPA values) children—reported disparities in minutes of moderate to vigorous physical activity. Similar results showing low physical activity levels among Asian children have been reported elsewhere.[22-24]

Analysis by SES indicates disparities in both fitness and activity. Those students from lower SES environments (schools) have lower levels of fitness and activity than those in higher SES environments, findings that have been reflected elsewhere as well.[6,25] Somewhat surprisingly, the differences based on SES are more consistent across racial/ethnic strata for fitness than activity. Significant differences by SES for activity are present only among the overall sample and among white/non-Hispanic students. This somewhat counterintuitive finding is due to the greater level of direct influence that the environment has on physical activity versus fitness.

We found that significant differences in fitness and activity exist between SES categories, as well as by race/ethnicity within each SES category. The combination of these differences within and between groups suggests that targeting specific races and/or SES groups in isolation may have limited impact, a conclusion that also has been found when addressing disparities in obesity.[26]

Table 2. Descriptive Statistics (Mean, SD) by Measure, Socioeconomic Status (SES), and Race/Ethnicity

	VO_2 Max (In ml of O2/kg/min)		MVPA (In Minutes)	
	Lower SES (n=2210)	Higher SES (n=1588)	Lower SES (n=2210)	Higher SES (n=1588)
Total	43.4 (4.3)	44.5 (4.5)*	68.2 (63.8)	73.3 (69.3)*
White, non-Hispanic	43.8 (4.6)	44.9 (4.6)*	68.7 (64.2)	78.9 (72.3)*
Black, non-Hispanic	42.7 (4.0)	43.1 (4.5)	71.0 (68.3)	68.7 (78.5)
Hispanic	43.1 (4.1)	44.0 (4.2)*	66.0 (62.9)	66.0 (56.5)
Mixed race, non-Hispanic	43.1 (4.1)	43.8 (4.3)	72.5 (61.8)	67.7 (60.4)
American Indian, non-Hispanic	41.2 (2.8)	44.0 (3.9)*	62.2 (47.4)	82.9 (78.8)
Other, non-Hispanic	43.6 (3.7)	43.6 (3.6)	58.3 (63.0)	42.8 (55.3)

*Differences significant (P < .05) between SES categories: hierarchical linear modeling methods, controlling for age and gender.
Abbreviation: MVPA, Moderate to Vigorous Physical Activity.

LIMITATIONS

This study has several limitations. A 1-day physical activity recall is used. It is often recommended that a minimum of 4 days of activity collection is needed for reliability of measurements to reach 0.80[27] among children and adolescents, although more days adds to the level of reliability. The use of a 1-day recall also may limit the opportunity to find potential disparities in activity, as evidenced by the large standard deviations. The recalls used are limited to a day when children are in school. With hierarchical linear modeling controlling for school impact, this leaves time outside of school as the primary driver of disparities.

Another limitation involves the lack of information on the individual's developmental stage. A measure of maturity, such as Tanner Stage, may have provided a better adjusted figure of aerobic fitness, as its use has been included previously to control for fitness testing.[7]

The sample represents a self-selected sample of Wisconsin schools with a large percentage of low-income children. To be eligible for the Wisconsin Partnership for Childhood Fitness project, a minimum of 40% of the school's student body had to be economically disadvantaged. This skews the population toward lower SES levels, and with SES subsequently dichotomized, it may attenuate the influence of SES. Further, SES is measured on the level of the school, so differences in SES among students within individual schools are not accounted for.

Finally, data on students' height and weight were not collected. While it is likely a significant predictor of aerobic fitness, the exclusion of body weight measures does not counter the surveillance value of these data. Additionally, for population health purposes, the impact of fitness and fitness improvement on insulin resistance has been shown to be independent of body composition metrics.[28,29]

CONCLUSION

In summary, disparities in both physical activity and aerobic fitness are present among children in Wisconsin, existing within 2 realms: individual and school-level. These results indicate the need for future research to increase understanding of the mechanisms underlying these disparities and to identify effective interventions to reduce and ultimately eliminate them. Future attention also may be warranted towards maximizing opportunities for physical activity among this age group and expanding into high school, which shows disparities in physical activity opportunities such as sports participation and attrition.[30,31]

While fitness does have a genetic component, our results also indicate that SES plays a role in individual fitness levels. Unlike race/ethnicity, an individual's socioeconomic status (via social mobility) and the environmental effects of their SES, currently are modifiable. With this in mind, since SES is a part of the "problem," it also can be a part of the solution in reducing fitness disparities and potential negative health outcomes that may arise from it.

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