ARTICLE

Physical Activity Opportunities Associated With Fitness and Weight Status Among Adolescents in Low-Income Communities

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Objective: To identify physical activity opportunities linked to fitness and weight status among adolescents in low-income communities.

Design, Setting, and Participants: Cross-sectional, ecological analysis of 9268 seventh- and ninth-grade students in 19 public schools participating in The California Endowment's Healthy Eating Active Communities program.

Main Outcome Measures: Cardiorespiratory fitness (mile time) and body mass index. Independent variables included students' perceptions and behaviors related to daily physical activity opportunities, assessed via anonymous survey. Ecological analysis was used to link survey data with fitness and body mass index data within each school. Linear regression identified associations between youths' perceptions/behaviors and fitness/body mass index.

Results: As the proportion of students reporting enjoying physical education, walking to school, and spending 20 minutes or longer in exercise during physical education increased from 0% to 100%, mile time decreased overall (−2.7 minutes; $P = .03$), mile time decreased among seventh graders (−3.3 minutes; $P = .02$), and body mass index z scores decreased among ninth graders (−0.7; $P = .045$), respectively. Each additional day students reported being active on school grounds outside school hours was associated with decreased mile time (−0.5 minute; $P = .02$). Active transport to school was associated with poorer weight status and greater odds of purchasing food while in transit (odds ratio = 1.5; $P < .001$).

Conclusions: Physical education is a valuable policy opportunity to improve student health. Promoting active transport may improve fitness but must be done in conjunction with community partnerships to improve the food environment in the vicinity of schools. Promoting the use of school grounds outside school hours (such as after-school programs) should also be prioritized in response to youth obesity.

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THE DRAMATIC RISE IN OBESITY in the United States over just 3 decades implicates environmental changes that contribute to positive energy balance. Of particular concern is the disproportionate effect on youth living in disadvantaged areas who are at high risk for physical inactivity, obesity, and cardiovascular disease and mortality.[1,2]

Policies aimed at supporting environmental change in low-income communities will be critical to reverse trends in obesity,[3] but it is unclear where to focus efforts to achieve the greatest initial effect. Additionally, school leaders refining their newly mandated wellness policies[4] need evidence as to the factors most strongly associated with student health. To appropriately target resources and intervention efforts, it is important to identify the environmental factors most strongly implicated in child health.

Physical activity and fitness are strong predictors of cardiovascular risk among youth and adults, independent of weight status.[5,6] Despite the known benefits of physical activity, activity declines through adolescence[7] and is consistently lower among low-income youth.[8,9] Environmental interventions to address disparities in physical activity are critical to prevent further disparities in cardiovascular morbidity. We therefore sought to identify those physical activity opportunities most strongly associated with student health (cardiorespiratory fitness and weight status) among adolescents in low-income communities and to determine whether associations are different in middle and high schools. The California Endowment's Healthy Eating Active Communities program provided a unique opportunity to examine this relationship among diverse seventh- and ninth-grade students.

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METHODS

HEALTHY EATING ACTIVE COMMUNITIES

Healthy Eating Active Communities is a multiyear program of The California Endowment to help communities transform nutrition and physical activity environments to promote healthy eating and active living (http://www.healthyeatingactivecommunities.org). Six geographically diverse, low-income communities throughout California were funded to make changes in a variety of sectors: schools, neighborhoods, after-school programs, health care, and media or marketing environments.

This article focuses on data (a survey assessing students' attitudes, behaviors, and perceptions related to their physical activity and nutrition environments, and a battery of fitness assessments conducted as part of the state-mandated Fitnessgram[10]) collected from students at 19 schools.

PARTICIPANTS

Participants were seventh-grade students from 9 middle schools, ninth-grade students from 9 high schools, and seventh- and ninth-grade students from 1 combined school. The 19 public schools represented a diverse mix of races/ethnicities. While Healthy Eating Active Communities interventions at the school level are districtwide, participating schools were selected based on involvement in intervention strategies in the 6 Healthy Eating Active Communities communities. Data from 3 comparison schools matched on participation in free or reduced-price lunch, ethnic profile of students, geographic area (urban or rural, northern or southern California), and school size are included. Based on classifications from US Census Bureau data, 7 schools were in large urban communities (population ≥250 000), 8 in midsized urban communities (population <250 000), and 4 in urban fringe (territory in metropolitan statistical area) or small towns (outside metropolitan statistical area, population <25 000). The proportion of students at each school who were eligible for free or reduced-price lunch was obtained from the California Department of Education Dataquest Web site (http://data1.cde.ca.gov/dataquest).

This study was approved by the Committee for the Protection of Human Subjects, University of California, Berkeley.

SURVEY METHODS

Survey questions were adapted whenever possible from existing instruments designed to measure similar concepts.[11,12] The initial survey was modified after pilot testing with middle school students for language and concept comprehension and time required to complete the survey. The final instrument consisted of 40 items (total of 138 subitems) in multiple choice and Likert-scale format and was available in English and Spanish languages.

Surveys were administered by trained research staff using a standardized protocol on a weekday other than Monday. Based on school preference, surveys were administered during physical education (PE) classes in 13 schools and during homeroom, language arts, English, or computer class in 6 other schools. At schools with more than 400 students enrolled in a grade, classes were randomly selected to complete the survey (sample ranged from 259-397 students). Parents received a letter prior to survey administration explaining the purpose of the survey and provided passive consent in all cases.

Overall, 2564 seventh-grade students (50% female) and 2793 ninth-grade students (49% female) completed the survey anonymously (200 students completed the survey in Spanish). Students were told that participation was voluntary; fewer than 0.5% of students refused. Students reported their sex and grade and indicated their race/ethnicity by selecting 1 or more of the following categories: Asian, American Indian/Alaska native, Hawaiian/Pacific Islander, African American, Hispanic/Latino, white, or other. In analyses, students were considered Hispanic if they selected Hispanic alone or in combination with other race categories. Students were classified as being of mixed race if they reported more than 1 non-Hispanic race.

SURVEY QUESTIONS RELATED TO PHYSICAL ACTIVITY

This study focuses on youths' routine opportunities for physical activity. Students reported on their mode of transportation to school (day of survey) and from school (day prior to survey) and PE enrollment (none, part of the year, or all year). Students taking PE responded to a 4-point Likert scale assessing enjoyment of PE ("I don't like PE at all" to "I like PE a lot") and estimated the number of minutes spent exercising or moving around during PE class: 0 to 10 minutes, 10 to 20 minutes, 20 to 30 minutes, or more than 30 minutes. Seven separate items assessed the number of days in the prior week on which youths used outdoor facilities (park, skate park, sports field, or ball court), indoor facilities (recreational or youth center, indoor skate park, or ball court), bike or jog paths, and schools and did physical activity in their neighborhood, on sports teams, and in classes.

Among other nutrition-related questions, students indicated whether they bought food from snack carts or trucks, fast food restaurants, or stores on their way to or from school.

FITNESS AND BODY MASS INDEX DATA

Mile times, height, and weight were assessed as part of the Fitnessgram, a battery of field tests assessing student fitness.[10] The California Department of Education requires that all fifth-, seventh-, and ninth-grade students participate in Fitnessgram assessments each year. Trained administrators at each school conducted the Fitnessgram according to the directions in the Fitnessgram manual.[10] The researchers provided additional documentation on proper administration, the PE-AIM-101 Portable Stadiometer (Perspective Enterprises, Inc, Portage, Michigan) to measure height, and the Digital Healthcare Scale (Tanita, Tokyo, Japan). Height was measured to the nearest inch and weight was recorded to the nearest pound with students wearing indoor clothes and no shoes. Cardiorespiratory fitness was assessed with the 1-mile run in 99% of students (1% completed the walk test). Teachers were to allow practice pacing prior to completing the mile run and to instruct students to complete the distance as quickly as possible, even if they needed to walk. Times were recorded in minutes and seconds. We assume that faster mile times are a proxy for greater cardiorespiratory fitness. The California Department of Education provided data on 9268 students: anonymous height and weight data were provided for 3463 seventh-grade students (50% female) and 4345 ninth-grade students (49% female), and mile times were provided for 3857 seventh-grade students (49% female) and 4958 ninth-grade students (48% female), along with age and race/ethnicity (parents indicated their child's race/ethnicity from a list of possible choices during school registration). Body mass index (BMI [calculated as weight in kilograms divided by height in meters squared]) z scores were calculated according to the Centers for Disease Control and Prevention guidelines using growth reference data from 2000.[13]

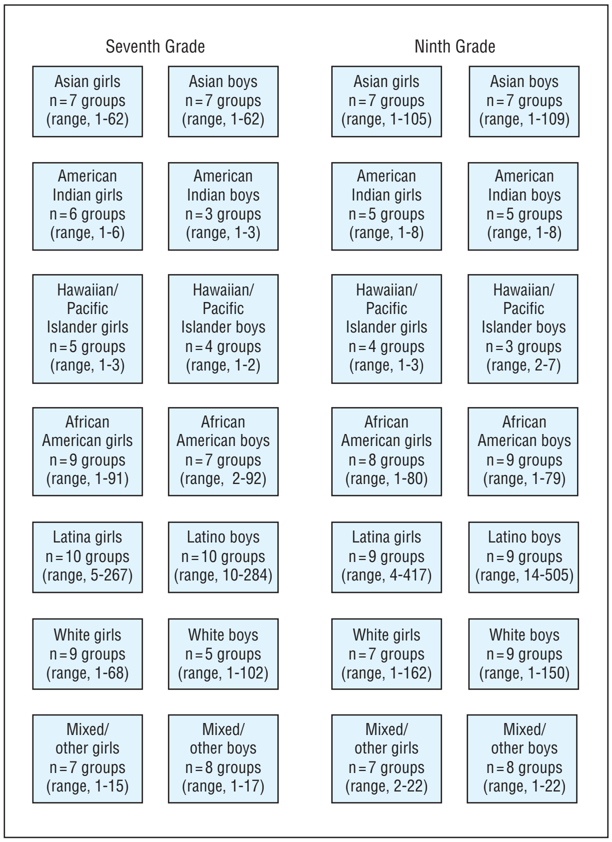

Figure 1. Groups for which data were aggregated. Within each school, subjects were grouped by grade, race/ethnicity, and sex; not all schools had students of every race/ethnicity. Range indicates the minimum and maximum numbers of subjects across groups.

DATA ANALYSIS

To link anonymous student survey data to Fitnessgram results, we used an ecological approach that involved aggregating survey response data and Fitnessgram measures for each group of students of the same grade, sex, and ethnicity within each school (**Figure 1**). Aggregate mile times and BMI z scores for each group could thereby be linked to aggregate survey response scores for the identical group. Within groups, means summarized mile times, BMI z scores, and survey items assessing the number of days per week students engaged in various activities. The proportion of students responding yes summarized yes or no items (active transport to school, being excused from PE for sports or for other reasons, taking PE all year, and purchasing food from specific locations on the way to or from school), and the proportion responding always or often (ie, the 2 highest responses from a 4-point response scale) summarized questions regarding access to facilities for physical activity. Similarly, the proportion of students reporting at least 20 minutes spent exercising or moving around during PE and the proportion enjoying PE a lot or a little (vs not enjoying) were calculated for each group.

Calculations were performed within Stata statistical software version 9.2 (StataCorp LP, College Station, Texas). We used linear regression, taking clustering by school into account (cluster option in Stata), to examine the relationship between mile times (or BMI z scores) and survey items. Analyses were frequency weighted by the number of students in each group with at least 1 Fitnessgram assessment. (All seventh- and ninth-grade students are expected to undergo the Fitnessgram assessment; surveys, when not administered to all students in a school, were intentionally administered to capture a representative sample.) Regression analyses included grade, sex, and a grade × sex interaction term to account for the expected and potential differences in mile times and BMI z scores by grade and sex and by sex within grade. To account for contextual factors (environmental characteristics common to students), the proportion of students eligible for free or reduced-price lunch (a proxy for neighborhood socioeconomic status) and the community's urbanization level (treated as a categorical variable) were included in an adjusted model. Finally, we examined interaction terms in all of the models to determine whether grade (ie, middle vs high school) modified the association between the survey and Fitnessgram items being examined; stratified models were created if interaction was suggested ($P < .20$ for the interaction term). To better understand group-level relationships that emerged from primary analyses, we calculated odds ratios at the individual level for the relationship between active transport and purchasing food from food carts on the way to or from school.

Table 1. Student Characteristics From Fitnessgram Data

Characteristic	No. (%) or Mean±SD	Range Across Schools, %
Race/ethnicity		
African American	743 (8)	0-31
Asian	459 (5)	0-51
Latino	6763 (73)	10-99
White	1003 (11)	0-79
Other	300 (3)	0-12
Female	4526 (49)	43-54
BMI z score (n=7808)	0.8±1.0	0.4-1.2[a]
Students with BMI ≥85th percentile	3389 (43)	25-60
Mile time, min (n=8815)	11.1±2.3	8.8-13.7[b]
Students meeting recommended mile time	4241 (48)	21-89

Abbreviation: BMI, body mass index (calculated as weight in kilograms divided by height in meters squared).
[a] Values are expressed as the range of BMI z scores across schools.
[b] Values are expressed as the range of mile times across schools.

RESULTS

Table 1 shows student demographics and average scores for Fitnessgram data. Almost half of the youth in these low-income communities were overweight or obese (BMI ≥85th percentile for age and sex), and more than half did not meet recommended fitness standards. **Table 2** summarizes survey responses.

ASSOCIATIONS BETWEEN OPPORTUNITIES FOR PHYSICAL ACTIVITY AND FITNESS

Use of bike or jog paths was significantly associated with greater cardiorespiratory fitness (lower mile times) ($P = .02$), while availability of indoor facilities was significantly associated with poorer fitness (higher mile times) ($P = .03$). Adjusting for contextual factors diminished the association between the use of bike or jog paths and fitness and completely attenuated the relationship with indoor facilities (**Table 3**). Enjoying PE and using school grounds outside school hours were significantly associated with greater fitness ($P = .03$ and $P = .02$, respec-

Table 2. Survey Data

Survey Item	All Students (n=5357)	Grade: Seventh (n=2564)	Grade: Ninth (n=2793)
School-related PA, proportion reporting yes (range across schools), %			
Active transport to school[a]	29 (6-58)	33 (15-58)	25 (6-38)
Active transport from school[a]	46 (15-78)	51 (23-78)	41 (15-67)
Full-year PE participation[a]	84 (60-99)	92 (78-99)	77 (60-89)
Enjoy PE	82 (71-92)	82 (74-94)	83 (71-90)
≥20 min of PA in PE[a]	57 (38-80)	53 (38-80)	62 (51-80)
Availability, proportion reporting always or often (range across schools), %			
Outdoor facilities[a]	57 (46-70)	59 (48-70)	56 (46-68)
Indoor facilities[a]	38 (20-54)	40 (20-53)	36 (24-54)
Facilities students enjoy[a]	41 (28-50)	43 (31-50)	38 (28-49)
Use, mean±SD (range across schools), d/wk			
Outdoor facilities[a]	1.9±2.0 (1.4-2.7)	2.1±2.1 (1.4-2.7)	1.8±2.0 (1.6-2.1)
Indoor facilities[a]	1.1±1.8 (0.9-1.4)	1.2±1.8 (0.9-1.7)	1.1±1.7 (0.9-1.2)
Bike or jog path[a]	1.9±2.1 (1.5-2.2)	2.0±2.1 (1.5-2.2)	1.8±2.1 (1.4-2.1)
Streets or yards for PA[a]	2.1±2.2 (1.4-3.2)	2.3±2.3 (1.6-3.2)	2.0±2.2 (1.4-2.5)
PA classes outside school	0.9±1.7 (0.6-1.2)	0.9±1.7 (0.7-1.4)	0.9±1.7 (0.6-1.2)
Sports team participation[a]	1.4±2.1 (0.8-1.9)	1.6±2.2 (0.9-1.9)	1.2±2.1 (0.8-1.6)
PA on school grounds not during school hours[a]	1.4±2.0 (0.9-1.8)	1.4±2.0 (1.3-1.7)	1.3±2.0 (0.9-1.8)
Bought food from snack cart on way to or from school, proportion reporting yes (range across schools), %	12 (2-26)	14 (5-26)	10 (2-20)

Abbreviations: PA, physical activity; PE, physical education.
[a] Proportions or means between seventh- and ninth-grade students are statistically different ($P<.05$ by χ^2 or t test, respectively).

tively), and walking to school showed a trend toward greater fitness in the adjusted model ($P=.07$).

Including a grade interaction term demonstrated stronger associations with fitness for seventh graders than for ninth graders. **Table 4** includes variables for which significant associations ($P<.05$) arose in analyses stratified by grade. **Figure 2** demonstrates that going from 50% to 100% of students reporting that they enjoyed PE was associated with a mean mile time improvement of 2.5 minutes for seventh graders ($P=.02$) and about a half-minute improvement for ninth graders ($P=.45$). Each mean additional day that groups of seventh graders reported using school grounds outside school hours was associated with a 1-minute decrease in mile time (Table 4). In the contextual model, mile times were faster by 3 minutes going from 0% to 100% of students walking to school and by almost 6 minutes going from 0% to 100% of students taking PE all year (Table 4). Most relationships went in similar directions for ninth graders but did not approach statistical significance.

ASSOCIATIONS BETWEEN OPPORTUNITIES FOR PHYSICAL ACTIVITY AND BMI *z* SCORES

Overall, relationships between weight status and survey responses were contrary to expectations. Student groups reporting higher rates of active transport (to or from school) had higher average BMI *z* scores. Analyses at the individual level (survey data only) demonstrated that active commuters were significantly more likely to purchase food on their way to or from school than were passive commuters (odds ratio=1.5; 95% confidence interval, 1.3-1.8). Relationships between active transport and BMI *z* score were no longer significant in models adjusted for the purchase of food from snack carts while in transit.

Students reporting at least 20 minutes of exercise during PE tended to have lower BMI *z* scores ($P=.13$), with apparent interaction by grade. For ninth graders, going from 38% to 80% of students reporting at least 20 minutes of physical activity during PE (the range across schools) was significantly associated with a BMI *z* score that was 0.3 unit smaller ($P=.045$) (Table 4), with a trend toward the same association in the contextual model. For a 14-year-old boy of average height with the average BMI *z* score for this population (0.8), a 0.3-unit change in BMI *z* score is equivalent to a BMI change of about 1.

Adjusting for socioeconomic status and urbanization level, student groups reporting more days per week of sports team participation had higher BMI *z* scores ($P=.03$).

COMMENT

The California Endowment's Healthy Eating Active Communities program aims to support environmental changes to prevent child (and adult) obesity and prevent future cardiovascular morbidity. This investigation focused on youths' opportunities for physical activity as areas for potential intervention. Given the high prevalence of obesity and low levels of fitness seen in this study, youths in these communities are at great risk for future cardiovascular morbidity and mortality. A major strength of this study is the use of objective measures of weight status and fitness in conjunction with youths' perceptions of all major opportunities for physical activity in low-income communities. Perceptions, although subject to reporting bias, reflect what youths experience as their re-

Table 3. Adjusted Associations Between Physical Activity Opportunities and Mile Time or Body Mass Index z Score

Survey Item	β (95% CI)[a] Mile Time, min: Simple Model	Mile Time, min: Model With Contextual Factors	BMI z Score: Simple Model	BMI z Score: Model With Contextual Factors
School-related PA, % reporting yes				
Active transport to school	−2.4 (−5.7 to 0.9)[b]	−2.0 (−4.2 to 0.2)[b]	0.7 (0.3 to 1.1)[b]	0.4 (0.0 to 0.8)[b]
Active transport from school	−1.4 (−3.9 to 1.2)	−0.8 (−2.6 to 0.9)	0.5 (0.2 to 0.8)	0.3 (0.1 to 0.6)
Full-year PE participation	−1.0 (−3.0 to 1.0)[b]	−0.5 (−2.5 to 1.6)[b]	0.2 (−0.3 to 0.7)	0.2 (−0.2 to 0.6)
Enjoy PE	−3.4 (−7.6 to 0.9)[b]	−2.7 (−5.0 to −0.3)[b]	0.4 (−0.2 to 1.0)	0.3 (−0.2 to 0.8)
≥20 min of PA in PE	0.4 (−2.9 to 3.7)	−0.6 (−3.0 to 1.7)	−0.3 (−0.8 to 0.1)[b]	−0.3 (−0.7 to 0.2)
Availability, % reporting always or often				
Outdoor facilities	0.8 (−1.7 to 3.3)	−1.1 (−3.1 to 1.0)	0.3 (−0.3 to 0.9)	0.3 (−0.0 to 0.7)
Indoor facilities	2.8 (0.4 to 5.3)	0.1 (−2.0 to 2.2)[b]	0.5 (0.0 to 0.9)	0.2 (−0.1 to 0.5)
Facilities students enjoy	0.7 (−2.1 to 3.4)	−0.6 (−2.7 to 1.6)	−0.0 (−0.7 to 0.7)	0.2 (−0.2 to 0.5)
Use, d/wk				
Outdoor facilities	−0.1 (−0.6 to 0.5)	−0.2 (−0.7 to 0.3)	−0.0 (−0.2 to 0.1)	0.0 (−0.1 to 0.1)
Indoor facilities	−0.2 (−0.9 to 0.6)	−0.2 (−0.8 to 0.3)	0.0 (−0.1 to 0.2)	0.0 (−0.1 to 0.2)
Bike or jog path	−0.8 (−1.4 to −0.2)[b]	−0.5 (−1.2 to 0.3)[b]	−0.0 (−0.2 to 0.2)	0.0 (−0.1 to 0.2)
Streets or yards for PA	0.2 (−0.3 to 0.8)	0.1 (−0.2 to 0.4)	0.0 (−0.2 to 0.2)	0.1 (−0.1 to 0.2)
PA classes outside school	0.1 (−0.6 to 0.7)	−0.2 (−0.7 to 0.4)	0.1 (−0.1 to 0.2)	0.1 (−0.0 to 0.2)
Sports team participation	0.0 (−0.6 to 0.7)	−0.3 (−0.8 to 0.2)	0.1 (−0.1 to 0.3)	0.1 (0.0 to 0.3)
PA on school grounds not during school hours	−0.3 (−0.7 to 0.1)[b]	−0.5 (−1.0 to −0.1)[b]	−0.1 (−0.2 to 0.1)	−0.0 (−0.1 to 0.1)

Abbreviations: BMI, body mass index (calculated as weight in kilograms divided by height in meters squared); CI, confidence interval; PA, physical activity; PE, physical education.

[a] Negative β values imply that higher survey scores (or more yes answers) were associated with a faster mile time (better fitness) or lower BMI z score (better weight status). All models are adjusted for grade, sex, and a grade × sex interaction term, take clustering by school into account, and are frequency weighted by Fitnessgram counts in each group. Contextual models are also adjusted for the proportion of students eligible for free or reduced-price lunch and urbanization level.

[b] Interaction by grade is suggested ($P < .20$).

Table 4. Associations With Physical Activity Opportunities by Grade

Survey Item	β (95% CI)[a] Seventh Grade: Simple Model	Seventh Grade: Model With Contextual Factors	Ninth Grade: Simple Model	Ninth Grade: Model With Contextual Factors
Mile time, min				
School-related PA, % reporting yes				
Active transport to school	−4.6 (−9.4 to 0.2)	−3.3 (−5.9 to −0.7)	−0.4 (−3.2 to 2.4)	−0.6 (−2.9 to 1.7)
Full-year PE participation	−5.4 (−10.9 to 0.0)	−5.7 (−10.8 to −0.6)	−0.3 (−2.7 to 2.1)	−0.2 (−2.0 to 1.6)
Enjoy PE	−8.6 (−16.3 to −0.9)	−5.0 (−9.2 to −0.9)	0.1 (−3.8 to 4.1)	−0.7 (−2.8 to 1.4)
Use of facilities, d/wk				
PA on school grounds not during school hours	−1.1 (−1.9 to −0.3)	−1.0 (−1.8 to −0.2)	−0.1 (−0.7 to 0.4)	−0.1 (−0.6 to 0.3)
BMI z score				
School-related PA, % reporting yes				
Active transport to school	0.3 (−0.5 to 1.2)	−0.0 (−0.9 to 0.9)	0.9 (0.5 to 1.4)	0.5 (0.0 to 0.9)
≥20 min of PA in PE	−0.1 (−0.8 to 0.5)	−0.1 (−0.6 to 0.5)	−0.7 (−1.4 to −0.0)	−0.5 (−1.2 to 0.2)

Abbreviations: BMI, body mass index (calculated as weight in kilograms divided by height in meters squared); CI, confidence interval; PA, physical activity; PE, physical education.

[a] Negative β values imply that higher survey scores (or more yes answers) were associated with a faster mile time (better fitness) or lower BMI z score (better weight status). All models are adjusted for sex, take clustering by school into account, and are frequency weighted by Fitnessgram counts in each group. Contextual models are also adjusted for the proportion of students eligible for free or reduced-price lunch and urbanization level.

ality and can take into account practical issues (eg, barriers related to access) that objective measures might not. Additionally, perceptions can be more closely linked to youths' behaviors than external measures.[9]

Among these at-risk adolescents, PE stands out as the highest-impact area. All facets of PE—exposure, intensity, enjoyability—positively affected students' health. These findings contribute to a growing body of literature identifying the importance of PE in increasing physical activity[14,15] and fitness.[16-18] Although there is currently less evidence to link PE and weight status,[14] we demonstrate an association between more time spent exercising during PE

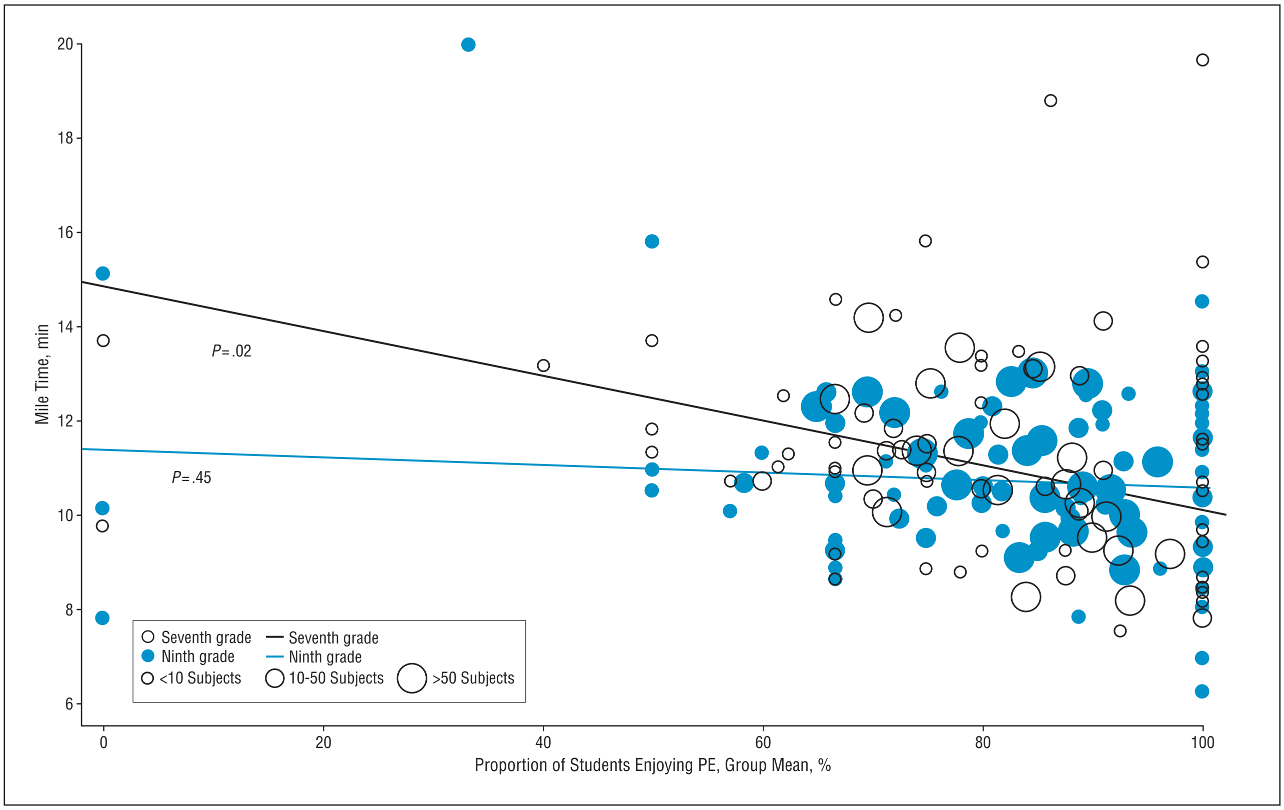

Figure 2. Group means for proportions of students enjoying physical education (PE) vs mile time with best-fit regression lines (adjusted for sex, proportion of students eligible for free or reduced-price lunch, and urbanization level).

and better weight status among ninth-grade students. The cross-sectional nature of this study prevents us from drawing causal inferences; however, 2 recent longitudinal studies[16,17] among elementary school children support the hypothesis that greater exposure to PE predicts lower BMI. Further, we extend findings to date by focusing on youths at greatest risk for future cardiovascular disease and by examining PE within the framework of all youths' major opportunities for physical activity.

While California legislation mandates that all seventh- and ninth-grade students take PE, we found significant variation in PE participation in this study, and up to 40% of students in some schools reported not taking a full year of PE. Further, while binding PE requirements are associated with greater physical activity during PE,[19] nearly half of the students reported less than 20 minutes of moderate activity during PE. Although PE is clearly an important area for further intervention, schools must have financial support for it, governing bodies must demonstrate commitment to it, and policies surrounding it must have teeth. An example of such a policy is a proposed (and much-debated) mandate requiring that students pass a physical fitness test to graduate from high school in California.

Although requiring a certain level of fitness prior to graduation translates readily into a policy with teeth, it does not address making PE enjoyable; our findings suggest that groups of students who report higher enjoyment of PE have higher overall levels of fitness. Greater enjoyment may reflect higher-quality PE instruction that results in students putting forth greater effort. While students who enjoy PE might simply be those who are more athletic to begin with, our data do not support this phenomenon as enjoying PE tended to be associated with slightly higher BMI z scores. Thus, it is unlikely that athletic students drive the relationship between enjoyment and fitness. Similar to these findings, a recent study[20] demonstrated that overweight high school students were just as active during PE as nonoverweight students. Further investigation identifying factors associated with enjoyment (eg, instructor's training and experience, equipment and facility availability) will be necessary to translate this association into action.

While student groups reporting higher rates of active transport to and from school showed a trend toward better mile times, they also had significantly higher BMI z scores. Active commuters may live very short distances from school (shorter distance to school has repeatedly been linked to active commuting[21-23]) such that the physical activity involved is minimal. Students being driven to school may come from higher-income families. It is also possible that those walking to or from school consume more calories because they purchase foods during their commute. We found that a significantly higher proportion of students using active transport purchased food from a snack cart while in transit than did students commuting by bus or car. Studies in low-income communities suggest that the foods widely available near schools are not healthy.[24,25] Access to unhealthy foods just outside a school's doors can readily undermine the school's efforts to provide a healthy environment. While a 15-minute walk may burn 100 calories, a visit to a fast-food establishment may layer on 500 calories in an even shorter period. Policies developed in collaboration with local vendors to provide a healthier nutrition environment in school zones could address this, and model community-based interventions to create healthy environments have demonstrated some success.[26,27]

Use of school grounds outside school hours was significantly associated with greater fitness, particularly for seventh graders, which may reflect participation in after-school programs. After-school programs are an important health focus, and recent studies in the after-school setting have shown promise among elementary school children in low-income areas.[28,29] While use of other recreational facilities was not significantly associated with fitness, based on 95% confidence intervals for these associations we cannot rule out an effect as large as a 1-minute improvement in mile time for each additional day of participation in these venues.

In this study, reported use of physical activity facilities was linked to better fitness, but greater reported access to indoor facilities was associated with poorer weight status. It is possible that greater access to recreational facilities also means access to other venues that promote ill health, such as fast food establishments. While our findings contradict those among adults linking greater access to recreational activities with lower rates of self-reported obesity,[30] the gap between providing access to facilities and getting youth to use them was well documented in a RAND study in a low-income community in southern California.[31] "Build it and they will come" may no longer apply, and interventions aimed at increasing access without additional social marketing efforts or use of incentives may not succeed.

Ecological analyses, which may be appropriate for studying community-level associations, are subject to special bias (factors aggregated at the community level do not take into account variation in exposure within the community) and confounding; therefore, demonstrated group-level associations might not be true at the individual level.[32] The self-reported survey data are also subject to bias. Additionally, Fitnessgram results were available for only 72% to 99% of enrolled students across schools in this study. Because fitness testing is typically done during PE, some schools' results may preferentially reflect students taking PE. Given the high mean rates of participation in and enjoyment of PE reported here and minimal variability between groups, we may have underestimated the effect of these factors. Similarly, although efforts were made to administer the surveys in classes other than PE, surveys were administered at many schools during PE class owing to the schools' limited capacity to release time from other classes.

While BMI is objective, it is does not distinguish between lean and fat mass; thus, a higher BMI z score may reflect higher muscle mass in some students.[33] For example, higher BMI z scores seen among sports team participants in this study could reflect higher muscle mass (certainly, other benefits accrue to youths participating in sports[34]). Additionally, fitness tests are effort dependent and fitness scores may reflect greater effort rather than greater fitness. However, students who put forth more effort during fitness testing are likely to make greater efforts throughout the year, not just during testing. While ninth-grade students who reported at least 20 minutes of exercise during PE had lower BMI z scores than their peers in unadjusted models, this cross-sectional association could reflect greater effort among leaner students. However, as noted, recent findings suggest that overweight students are just as active as normal-weight students in PE.[20]

Our findings point to potential policy opportunities to improve student health in low-income communities: shaping PE that youths enjoy and increasing the duration of participation, improving the quality of PE classes to achieve higher levels of physical exertion, promoting students' use of physical activity facilities at school and in the community, and working with neighborhood and community partners to surround youth with healthy options, particularly just outside schools' doors. Identifying appropriate incentives and developing monitoring systems in these areas should be prioritized in schools' and communities' responses to youth obesity.

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REFERENCES

1. Pickett KE, Pearl M. Multilevel analyses of neighbourhood socioeconomic context and health outcomes: a critical review. *J Epidemiol Community Health*. 2001;55(2):111-122.
2. Yen IH, Syme SL. The social environment and health: a discussion of the epidemiologic literature. *Annu Rev Public Health*. 1999;20:287-308.
3. Ashe M, Feldstein LM, Graff S, Kline R, Pinkas D, Zellers L. Local venues for change: legal strategies for healthy environments. *J Law Med Ethics*. 2007;35(1):138-147.
4. Moag-Stahlberg A, Howley N, Luscri L. A national snapshot of local school wellness policies. *J Sch Health*. 2008;78(10):562-568.
5. Andersen LB, Harro M, Sardinha LB, et al. Physical activity and clustered cardiovascular risk in children: a cross-sectional study (the European Youth Heart Study). *Lancet*. 2006;368(9532):299-304.
6. Blair SN, Kohl HW III, Barlow CE, Paffenbarger RS Jr, Gibbons LW, Macera CA. Changes in physical fitness and all-cause mortality: a prospective study of healthy and unhealthy men. *JAMA*. 1995;273(14):1093-1098.

7. Kimm SY, Glynn NW, Kriska AM, et al. Longitudinal changes in physical activity in a biracial cohort during adolescence. *Med Sci Sports Exerc*. 2000;32(8): 1445-1454.
8. Singh GK, Kogan MD, Siahpush M, van Dyck PC. Independent and joint effects of socioeconomic, behavioral, and neighborhood characteristics on physical inactivity and activity levels among US children and adolescents. *J Community Health*. 2008;33(4):206-216.
9. Madsen KA, McCulloch CE, Crawford PB. Parent modeling: perceptions of parents' physical activity predict girls' activity throughout adolescence. *J Pediatr*. 2009;154(2):278-283.
10. Welk GJ, Morrow JRJ, Falls HBE. *Fitnessgram Reference Guide.* Dallas, TX: Cooper Institute; 2002. http://www.cooperinstitute.org/products/grams/references.cfm. Accessed July 29, 2009.
11. Centers for Disease Control and Prevention. YRBSS: Youth Risk Behavior Surveillance System. http://www.cdc.gov/HealthyYouth/yrbs/index.htm. Accessed July 29, 2009.
12. WestEd. California Healthy Kids Survey. http://www.wested.org/cs/chks/print/docs/chks_overview.html. Accessed July 29, 2009.
13. Kuczmarski RJ, Ogden CL, Grummer-Strawn LM, et al. CDC growth charts: United States. *Adv Data*. 2000;(314):1-27.
14. Kahn EB, Ramsey LT, Brownson RC, et al. The effectiveness of interventions to increase physical activity: a systematic review. *Am J Prev Med*. 2002;22(4)(suppl):73-107.
15. Trudeau F, Shephard RJ. Physical education, school physical activity, school sports and academic performance. *Int J Behav Nutr Phys Act*. 2008;5:10.
16. Datar A, Sturm R. Physical education in elementary school and body mass index: evidence from the early childhood longitudinal study. *Am J Public Health*. 2004;94(9):1501-1506.
17. Sollerhed AC, Ejlertsson G. Physical benefits of expanded physical education in primary school: findings from a 3-year intervention study in Sweden. *Scand J Med Sci Sports*. 2008;18(1):102-107.
18. UCLA Center to Eliminate Health Disparities; Samuels & Associates. *Failing Fitness: Physical Activity and Physical Education in Schools.* Los Angeles, CA: UCLA Center to Eliminate Health Disparities, Samuels & Associates; 2007.
19. Cawley J, Meyerhoefer C, Newhouse D. The impact of state physical education requirements on youth physical activity and overweight. *Health Econ*. 2007; 16(12):1287-1301.
20. Hannon JC. Physical activity levels of overweight and nonoverweight high school students during physical education classes. *J Sch Health*. 2008;78(8):425-431.
21. Timperio A, Ball K, Salmon J, et al. Personal, family, social, and environmental correlates of active commuting to school. *Am J Prev Med*. 2006;30(1):45-51.
22. Kerr J, Rosenberg D, Sallis JF, Saelens BE, Frank LD, Conway TL. Active commuting to school: associations with environment and parental concerns. *Med Sci Sports Exerc*. 2006;38(4):787-794.
23. Greves HM, Lozano P, Liu L, Busby K, Cole J, Johnston B. Immigrant families' perceptions on walking to school and school breakfast: a focus group study. *Int J Behav Nutr Phys Act*. 2007;4:64.
24. Sturm R. Disparities in the food environment surrounding US middle and high schools. *Public Health*. 2008;122(7):681-690.
25. Kipke MD, Iverson E, Moore D, et al. Food and park environments: neighborhood-level risks for childhood obesity in east Los Angeles. *J Adolesc Health*. 2007; 40(4):325-333.
26. Romon M, Lommez A, Tafflet M, et al. Downward trends in the prevalence of childhood overweight in the setting of 12-year school- and community-based programmes [published online ahead of print December 23, 2008]. *Public Health Nutr*. 2008:1-8. doi:10.1017/S1368980008004278.
27. Economos CD, Hyatt RR, Goldberg JP, et al. A community intervention reduces BMI z-score in children: Shape Up Somerville first year results. *Obesity (Silver Spring)*. 2007;15(5):1325-1336.
28. Robinson TN, Killen JD, Kraemer HC, et al. Dance and reducing television viewing to prevent weight gain in African-American girls: the Stanford GEMS pilot study. *Ethn Dis*. 2003;13(1)(suppl 1):S65-S77.
29. Weintraub DL, Tirumalai EC, Haydel KF, Fujimoto M, Fulton JE, Robinson TN. Team sports for overweight children: the Stanford Sports to Prevent Obesity Randomized Trial (SPORT). *Arch Pediatr Adolesc Med*. 2008;162(3):232-237.
30. Poortinga W. Perceptions of the environment, physical activity, and obesity. *Soc Sci Med*. 2006;63(11):2835-2846.
31. Cohen D, Sehgal A, McKenzie TL, Williamson S, Golinelli D. *Effects of Park Improvements on Park Use and Physical Activity: Policy and Programming Implications.* Washington, DC: Active Living Research; 2008.
32. Wakefield J. Ecologic studies revisited. *Annu Rev Public Health*. 2008;29:75-90.
33. Ellis KJ, Abrams SA, Wong WW. Monitoring childhood obesity: assessment of the weight/height index. *Am J Epidemiol*. 1999;150(9):939-946.
34. Kjønniksen L, Anderssen N, Wold B. Organized youth sport as a predictor of physical activity in adulthood [published online ahead of print August 5, 2008]. *Scand J Med Sci Sports*. http://www3.interscience.wiley.com/journal/121371138/abstract. Accessed July 29, 2009.

Children have never been very good at listening to their elders, but they have never failed to imitate them.

—James Baldwin