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Cardiorespiratory Fitness and Proximity to Commercial Physical Activity Facilities Among 12th Grade Girls

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Abstract

Purpose—To investigate the relationship between proximity to commercial physical activity facilities and cardiorespiratory fitness of 12th grade girls.

Methods—Adolescent girls (N=786, 60% African American, mean age=17.6 ± 0.6 years) performed a submaximal fitness test (PWC_{170}). Commercial physical activity facilities were mapped and counted within a 0.75-mile street-network buffer around girls' homes using Geographic Information Systems (GIS). Sedentary activities and vigorous physical activity (VPA, greater or equal to 6 METs) were determined by the average number of 30-minute blocks reported per day on the 3-Day Physical Activity Recall (3DPAR). Mixed model regressions were calculated using school as a random variable.

Results—Girls had higher weight-relative PWC_{170} scores if there was a commercial physical activity facility (n=186, 12.4±4.2 kg·m/min/kg) within 0.75-mile street-network buffer of home as compared to girls without a nearby facility (n=600, 11.2±3.6 kg·m/min/kg). After adjusting for demographic variables, sports participation, sedentary behaviors and VPA, having one or more commercial physical activity facilities within a 0.75-mile street-network buffer of homes was significantly related to cardiorespiratory fitness.

Conclusions—Both with and without adjustment for covariates, the presence of a commercial physical activity facility within a 0.75-mile street-network buffer of a girl's home was associated with higher cardiorespiratory fitness.

Several recent studies reported that youth who live closer to physical activity facilities have higher levels of physical activity. [1–4] In one study, 12th grade girls who lived within a 0.75-mile street-network buffer of one or more commercial physical activity facilities participated in greater amounts of vigorous physical activity.[4]

Cardiorespiratory fitness is likely to be related to physical activity and is an independent marker of health in children and adolescents.[5] In a cross-sectional analysis of national data, cardiorespiratory fitness was associated with lower weight and higher tertile of self-reported vigorous physical activity (VPA) and negatively associated with television viewing.[6] Similarly, in a group of 1440 eighth grade girls, cardiorespiratory fitness was significantly related to objectively-measured physical activity.[7]

Environmental factors at the neighborhood level can influence several health factors in children, [8] including fitness.[5] In one study, availability of convenience stores was associated with higher BMI and overweight, while access to chain supermarkets was associated with lower BMI and normal weight. [9,10] In another study, Swiss children living in urban environments were less active and less fit compared to children living in rural areas.[8] However, little is known about the influence of proximity to physical activity facilities on fitness in youth, and it is possible that individuals who live close to commercial physical activity facilities utilize them, affecting their levels of physical activity and fitness. Therefore, the purpose of this study was to determine if there is a relationship between proximity to commercial physical activity facilities and cardiorespiratory fitness of 12th grade girls. Analyses were adjusted for demographic variables, VPA, sports participation and sedentary pursuits.

Methods

Participants and Study Design

Participants were 12th grade girls attending 22 high schools in both urban and rural areas in South Carolina (2002–2003). The schools had previously participated in a physical activity intervention study, and equal numbers of schools had been in intervention and control groups.[11] All 12th grade girls were invited to participate in the present study. A total of 1655 12th grade girls participated in the measurement protocol.[12]

Trained data collectors administered the measures to participants in groups of 20–30 girls. The data collectors employed standardized protocols and scripts when administering the measures. Of the 1655 participants, 1503 completed the physical activity measure (54.3% African-American, 41.1% White, 4.6% other race/ethnicity or missing race. Girls completed questionnaires and provided their home address, age, race, and parent education. The procedures were approved by the Institutional Review Board of the University of South Carolina. Participants or a parent or guardian signed consent forms (when the girl was a minor) and girls less than 18-years provided written assent.

Commercial Physical Activity Facilities and Geocoding

Commercial physical activity (PA) facilities (individual=736, multipurpose=76, and team=160) were identified through selected internet search engines (Smartpages, Whitepages, Qwestdex, and www.reversedirectory.com) and confirmed with phone books.[4] All searches were performed during the girls' 12th grade year. If the purpose of a facility related to PA was not clear from the name or description, a researcher called to verify the nature of the facility. Athletic organizations and baseball/softball, basketball, soccer, cheerleading, golf, gymnastics, hockey, paintball, and swimming facilities were classified as team facilities. Bowling, dance, diving, martial arts, racquetball, self-defense, skating, tennis, yoga, horseback riding, sky diving, scuba diving, sailing, and rock climbing facilities and health clubs were classified as individual facilities. Recreation centers and youth organizations and clubs were classified as multipurpose facilities. Overall, 85% of the addresses for the commercial PA facilities identified were successfully geocoded. Addresses for 1309 (53.1% African-American, 41.9% White) of the 1503 girls were successfully geocoded (87%). Commercial PA facilities around the girls' homes were counted within a 0.75-mile street-network buffer using ArcGIS™, version 9.1. A 0.75-mile street-network buffer was chosen because it represents approximately a 15-minute walk, which was the mean easy walking distance reported by 12th grade girls.[13] Due to missing values for race, age, BMI or sports participation, the data for 77 girls were not used in analyses for this study.

Cardiorespiratory Fitness

Cardiorespiratory fitness was measured on a subset of the girls (n=786) using a modified version of the Physical Work Capacity 170 test (PWC_{170}).[14] Research assistants followed a standard protocol designed to elicit heart rates of 120, 150, and 170 beats per minute (bpm) at the end of each of three 2-minute exercise stages (six minutes total). The PWC_{170} has been validated in adolescent boys and girls. [15,16] Students with a heart rate lower than 160 bpm at the end of the third stage performed a fourth stage to bring their heart rate to approximately 170 bpm. Each student was fitted with a Polar heart rate monitor (Polar USA, Inc., Lake Success, NY), which was used to assess heart rate during the final 10 seconds of each stage. For all participants, a common resistance (0.5 Kp) was used for the first stage. The linear association between workload and heart rate was confirmed by calculating the R^2 and only including tests with an $R^2 \geq 0.90$. Heart rate responses were individually extrapolated to the workload eliciting 170 bpm and are reported relative to body weight (kg·m/min/kg body weight). All testing took place in the girls' schools. Trained research assistants provided verbal encouragement to maintain pedaling frequency throughout the test.

Physical Activity and Sedentary Behaviors

The 3-Day Physical Activity Recall (3DPAR) was used to measure participation in physical activity and other activities.[17] The 3DPAR uses a script and graphic figures to explain the intensity level of common activities. Light activities are described as requiring little or no movement with slow breathing, moderate activities as requiring some movement and normal breathing, hard activities as requiring moderate movement and increased breathing, and very hard activities as requiring quick movements and hard breathing.

The 3DPAR was always administered on a Wednesday, with participants asked to recall their activities on the previous three days. Girls completed a grid for each day recalled. The grid was divided into 30-minute time blocks, beginning at 7 am and ending at 12 midnight. The girls were asked to report the predominant activity performed during each of the 30-minute blocks. A list of 59 activities was provided that included sedentary activities, activities of daily living, physical activities, job, physical education, and sports. For each time block girls entered the number of an activity and indicated if the activity was performed at a light, moderate, hard or very hard intensity. A script and graphic figures were used to explain the intensities of common activities. Light activities were described as requiring little or no movement with slow breathing, moderate activities as requiring some movement and normal breathing, hard activities as requiring moderate movement and increased breathing, and very hard activities as requiring quick movement and hard breathing.

MET values for the intensity level of each activity were obtained from the Compendium of Physical Activities.[18] Data across the three days were reduced to total MET-blocks per day. This was accomplished by summing the MET value of each of the 34 30-minute blocks for a day. Also, girls were categorized on the basis of meeting or not meeting a physical activity standard of 1 or more 30-minute blocks of VPA (≥ 6 METs) per day. Girls who reported 1 or more 30-minute blocks of VPA were considered to be consistent with the Physical Activity Guidelines for Americans.[19]

Approximately 50% of the girls reported working during the 3-day recall period. Because girls could not participate in physical activity at a neighborhood facility while they were working, physical activity reported during work hours was not included in the analyses. Also, in order to represent sedentary behaviors, the reported average number of blocks per day of electronic media use (TV, videos, computer games and Internet use), and talking on the phone were calculated.

Sports Participation

Girls were asked about school and other sport team participation within the past year, using questions adopted from the Youth Risk Behavior Surveillance Survey [20]: "During the past 12 months, how many sports teams run by your school did you play on? (DO NOT include PE classes)" and "During the past 12 months, how many sports teams run by organizations outside your school did you play on?" Girls who indicated on either question that they participated in one or more sports were considered sport team members.

Body Mass Index

Height was measured to the nearest 0.2 cm with a portable stadiometer and weight was measured to the nearest 0.2 kg with a standard beam scale (BeFour Inc, Saukville, WI). Body mass index (BMI) was calculated by dividing weight in kilograms by height in meters squared.

Socio-Economic Status

Two measures of socioeconomic status were obtained. The highest education reported by either parent was dichotomized into high school or less and greater than a high school education. The second measure of socioeconomic status was based on the geocoded address and 2000 US Census[21] data for the block group median household income.

Statistical Analyses

Means (SD), and t-tests were calculated to determine if there were differences in girls with and without fitness data. Also t-tests were used to determine if there were differences in weight-relative fitness for the dichotomous demographic variables and sport participation, number of blocks of sedentary activity, 1 or more blocks of VPA (Yes, No), and 1 or more commercial PA facilities (Yes, No). Pearson correlations were calculated between weight-relative fitness and continuous variables.

Mixed model regressions with weight-relative fitness as the dependent variable and with school as a random variable were performed. First, a model containing only an intercept was calculated. In the second model, independent variables included age, group (control, intervention), race, BMI, parent education, median household income, and number of blocks of sedentary activity. The third model had the independent variables from the second model and whether or not there was a commercial PA facility within the 0.75-mile street-network buffer around a girl's home. A fourth model also included whether or not the girl was a sport participant. VPA (Yes, No) was added to the fifth model. Because there is no consensus on the calculation of a pseudo R^2, two were calculated for each model. [22, 23] The first R^2 is a goodness-of-fit measure [22], and the second R^2 is the fraction of explainable variation that is explained.[23]

Results

The sample of girls with fitness data was younger, had a higher family income, and was more likely to be African-American, and to have attended a control school, reported higher total MET blocks, reported 1 or more blocks of VPA, and participated in sports (Table 1).

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Table 2 reports mean (SD) weight-relative fitness for girls by category of the study variables. Girls with 1 or more commercial PA facilities within the 0.75-mile street-network buffer (n=186) had significantly higher weight-relative fitness (12.4±4.2 kg·m/min/kg) than girls with no (n=600) commercial PA facility (11.2±3.6 kg·m/min/kg) within that buffer. Girls whose parents had greater than a high school education, and who were White, participated in sports during the past year, and reported 1 or more 30-minute blocks of VPA had higher weight-relative fitness than their counterparts. Pearson correlations for continuous study variables with weight-relative fitness were significant for age (r= −0.08, p<.05), BMI (r= −0.53, p<.001), median household income (r= 0.14, p<.001) and number of reported 30-minute sedentary blocks (r= −0.12, p<.001).

The five mixed regression models are reported in Table 3. In the second model BMI and number of sedentary blocks were negatively related to weight-relative fitness (p≤.001). PA commercial facilities was positively related to weight-relative fitness (p<.001). The addition of sports participation to the fourth model (positive relationship, p<.001), and participation in 1 or more blocks of VPA (positive relationship, p<.001) to the fifth model, attenuated the beta coefficient from 1.06 (Model 3) to 0.88 (Model 4) of the presence of a commercial PA facility in each model, but the p-value remained significant. Total variance explained was between 55 to 76% (depending on the pseudo-R^2).

Discussion

The major finding of the present study was that the availability of one or more commercial PA facilities within a 0.75-mile street-network buffer around a participant’s home was related to cardiorespiratory fitness in 12th grade girls. The relationship between fitness and 1 or more commercial PA facilities was independent of demographic characteristics (race, BMI, parent education and median household income) of the girls. This finding builds on previous research that has shown an association between environmental characteristics and PA in youth.

The relationship between fitness and presence of 1 or more commercial PA facilities was attenuated by the addition of sports and VPA participation. This implies that sport and VPA participation are part of the mechanism through which commercial PA facilities are related to cardiorespiratory fitness. Although, the study did not determine if girls used the commercial PA facilities within the 0.75-mile street-network buffer around their homes, girls with 1 or more PA commercial PA facilities were more likely to have higher cardiorespiratory fitness.

Relatively few studies have examined cardiorespiratory fitness and the physical environment of participants. One study was performed with 87 minimally active adolescent girls (ages 14–17) [24]. The girls’ perceptions of physical activity resources at home and in the community were positively related to peak oxygen consumption. A second study investigated physical activity opportunities and fitness among 7th and 9th grade adolescents in low-income communities.[25] Self-reported use of physical activity facilities was linked to better fitness (lower 1-mile run times). The present study is the first to use an objective measure of the number of commercial PA facilities around a girl’s home, rather than the girl’s perception of the availability of commercial PA facilities, to study the relationship between the environment and fitness.

The importance of having places to go to be active and maintain fitness has increased in recent years, because children and youth have fewer opportunities to be active while in school [26–28]. Daily physical education declined from 42% in 1991 to 30% in 2007, [26, 27] and some schools are reducing or eliminating regular PA breaks during the school day. [28] Also, fewer children walk or bike to school than previously; the percentage of students who walked or biked to school declined from 42% in 1969 to 16% in 2001.[29] During the adolescent years, girls are at particular risk of declining PA and fitness levels.[30] The findings of the present study suggest that having 1 or more commercial PA facilities within a 0.75-mile street-network buffer around a girl's home may provide an opportunity to be active and maintain fitness. However, additional studies are needed to identify patterns of use.

The mean difference in fitness between girls who had and did not have a commercial facility in the present study was 1.2 kg·m/min/kg, approximately a 9% difference. The difference is larger than the average yearly decline in fitness that has been reported in a study in girls from 8th to 12th grade.[30] Lower fit girls may find it more difficult to participate in physical activity than fitter girls, and they may be at higher risk for weight gain and cardiovascular disease risk factors.[5]

In the present study, BMI and sedentary pursuits were negatively related to weight-relative fitness. Similar findings were reported by Pate et al. using NHANES data from youth 12 to 19 years of age.[6] Normal-weight girls had higher fitness than at-risk or overweight girls, and youth with three or more hours per day of sedentary pursuits (TV, video games and computer use) were less fit than children who participated in fewer than three hours. Parents should limit the use of electronic media by school-age children[31] and encourage their children to become more physically active. Also, parents can help their children decrease time in sedentary behaviors by eliminating some common barriers to physical activity.[32] For example, by providing physical activity equipment and paying fees to use commercial facilities, parents can provide children with more opportunities to be active.

Participation in VPA and sports was positively associated with weight-relative fitness in the present study. Physical activity has been associated with fitness in several studies, [6, 7, 30] and past-year sports participation has been associated with fitness, as measured by a three-stage step test, in urban adolescent girls.[33] To maintain or improve fitness, activity levels need to be increased or maintained. Girls often report activities that are in the high intensity range, such as basketball and aerobics/dance [34]. Such activities can be performed at commercial facilities. But, just because a facility is near a girl's home does not insure that she will go there.[35] Commercial PA facilities need to offer girl-friendly programs at times when girls can participate.

Strengths of the present study include the use of an objective measure of commercial PA facilities, in a diverse group of high school girls from both rural and urban areas. Limitations include the cross-sectional nature of the study and the fact that it was limited to 12th grade girls. Although physical activity was self-reported, the 3DPAR has been validated using accelerometry.[17] The findings of this study need to be repeated in younger youth and in both boys and girls. Also, knowledge of the use of commercial facilities within a buffer around the home would strengthen this area of research.

Higher levels of cardiorespiratory fitness have been related to lower mortality in adults[36] and lower cardiovascular disease risk in youth, [37] and there is some evidence that fitness tracks from childhood into adulthood.[38, 39] The results of the present study support the role that environment plays in a child's fitness level. Proximity to commercial PA facilities was positively related to higher weight-relative fitness in 12th grade girls. Commercial PA facilities are one place where children can participate in the recommended 60 minutes of moderate-to-vigorous physical activity youth should accumulate each day.[19, 40] In the present study, girls with 1 or more commercial PA facilities within a 0.75-mile street-network buffer were more likely to report 1 or more blocks of VPA, compared to girls without a commercial PA facility. Participation in 1 or more blocks of VPA helps to attain the recommended daily 60 minutes of moderate-to-vigorous physical activity.

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Table 1

Study characteristics for girls (N=1232) with and without fitness data

Characteristic	**No fitness data N=446 Mean (SD) or percent**	**Fitness data N=786 Mean (SD) or percent**	**p**
Age, years	17.7 (0.6)	17.6 (0.6)	.01
BMI, kg/m^2	25.2 (6.3)	25.0 (6.4)	.59
Total MET blocks	52.0 (11.8)	54.4 (11.9)	.001
Sedentary blocks (TV, Games, Phone)	5.9 (3.5)	5.9 (3.6)	.92
Median household income	$38,910 ($13,958)	$40,430 ($15,762)	.01
Race, % African-American	53.3%	60.3%	.02
Parent education, >High School	62.6 %	65.3%	.34
Group, % Control	37.7%	47.3%	.001
1+ blocks of VPA, % yes	24.0%	33.1%	.001
Sports participant, % yes	46.4%	56.6%	.001
1+ commercial PA[a] facilities	26.9%	23.7%	.21

[a]Physical activity

Table 2

Means (SD) fitness (kg·m/min/kg) and p-values by categories of study variables

Characteristic		**n**	**Mean (SD)**	**p**
Parent education, > High school	Yes	513	11.8 (3.8)	.001
	No	273	10.9 (3.7)	
Race	African-American	419	10.7 (3.7)	<.001
	White	367	12.3 (3.6)	
Sport participant	Yes	445	12.4 (3.8)	<.001
	No	341	10.2 (3.4)	
1+ Block of VPA	Yes	260	12.9 (4.1)	<.001
	No	526	10.8 (3.4)	
Community PA facility	Yes	186	12.4 (4.2)	<.001
	No	600	11.2 (3.6)	
Group	Control	372	11.4 (3.6)	.42
	Intervention	414	11.6 (3.9)	

Table 3

Regression coefficients (SE) and p-values from mixed models for weight relative fitness (n=786)

	Model 1	Model 2		Model 3		Model 4		Model 5	
	Null model	Demographic variables and sedentary blocks		Commercial PA[a] facilities added		Sport participation added		VPA added	
Independent Variables		*b* (SE)	p	*b* (SE)	p	***b*** (SE)	p	*b* (SE)	p
Group, Control versus intervention		−.05 (.32)	.89	−.09 (.30)	.76	−.16 (.30)	.60	−.18 (.28)	.54
Age, years		.14 (.19)	.47	.14 (.19)	.46	.25 (.19)	.18	.24 (.18)	.19
Race, White versus Black		.43 (.26)	.10	.50 (.26)	.05	.43 (.25)	.09	.35 (.25)	.16
BMI, kg/m^2		−.29 .02)	<.001	−.29 (.02)	<.001	−.28 (.02)	<.001	−.27 (.02)	<.001
Parent education, <HS versus ≥ HS		−.21 (.25)	.40	−.19 (.25)	.43	−.07 (.24)	.78	−.07 (.24)	.77
Median HH[b] income		0 (0)	.93	0 (0)	.93	0 (0)	.89	0 (0)	.68
Sedentary blocks		−.11 (.03)	.001	−.11 (.03)	.001	−.10 (.03)	.002	−.09 (.03)	.003
Commercial PA facilities 1 or more versus 0				1.06 (.26)	<.001	.99 (.26)	<.001	.88 (.26)	.001
Sports participation, yes						1.30 (.23)	<.001	1.06 (.23)	<.001
VPA, 1 or more 30-minute blocks versus 0 blocks								1.20 (.24)	<.001
R^2 [c]	.100	.485		.496		.526		.546	
R^2 [d]	-	.587		.729		.704		.760	

[a] PA= physical activity

[b] HH=household

[c] Goodness-of- fit [22]

[d] Between-subject variance that is explained by independent variables compared to null model [23]