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Weekend Schoolyard Accessibility, Physical Activity, and Obesity: The Trial of Activity in Adolescent Girls (TAAG) Study

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Abstract

Objectives—To assess the accessibility and suitability of schools as recreational sites and to determine whether they are associated with young adolescent girls' weekend metabolic equivalent-weighted moderate-to-vigorous (MW-MVPA) physical activity and body mass index (BMI).

Methods—We drew a half-mile (0.805 km) radius around the residences of participants in Trial of Activity for Adolescent Girls (n=1556) in Maryland, South Carolina, Minnesota, Louisiana, California, and Arizona. We visited all schools and parks within the defined distance and documented their amenities and accessibility on Saturdays in Spring 2003. Staff gathered data on each girls' height and weight and used accelerometers to record weekend MW-MVPA.

Results— Schools represented 44% of potential neighborhood sites for physical activity. However, a third of schools were inaccessible on the Saturday we visited. Neighborhoods with locked schools were primarily non-white, older, more densely populated, and of lower socioeconomic status. Though there was no relationship between school accessibility on Saturdays and weekend MW-MVPA, the number of locked schools was associated with significantly higher BMI.

Conclusions— The lack of relationship between MW-MVPA and school accessibility may imply that young adolescent girls do not identify schools as recreational resources. However, due to the association between BMI and locked schools, efforts to stem the obesity epidemic should include making schools more accessible.

Keywords

bmi; obesity; physical activity; built environment; schools; parks

INTRODUCTION

The Centers for Disease Control and Prevention (CDC) recognized schools as important components of healthy communities in its 1997 "Guidelines for School and Community Programs to Promote Lifetime Physical Activity Among Young People" and in Healthy People 2010 recommendations, published in 2000. In these reports, the CDC directed schools to

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provide safe places for children to play before, during, and after the school day, on weekends, and during summer and other vacations.

To date, several studies have examined school accessibility and the availability of "active amenities" like fields, playgrounds or courts which may be used to play sports or perform other physical activity (O'Hara Tompkins et al. 2004;Evenson and McGinn 2004; Wechsler et al. 2000; Burgeson et al. 2001). Most have found that the majority of schools make their grounds available after school hours and on weekends. However, these findings are based on school administrator self-report rather than on objective site assessments. Consequently, administrators may over-report how often their schools are open. Moreover, no studies have evaluated the potential contribution of schools to neighborhoods' overall recreational resource environment.

Some studies have linked the perception of *community* facility accessibility to physical activity and obesity in adolescents. For example, 20% of youth reported a lack of opportunities for physical activity in their neighborhoods as a barrier to exercise (CDC 2003). Other studies of adolescent girls showed that participants who perceived greater access to recreational facilities in their neighborhoods had higher levels of cardio respiratory fitness (Dunton et al. 2003) and walked or cycled to school more often (Timperio et al. 2004). Another study found that the adolescent daughters of parents who claimed their neighborhood had good places to be physically active rode their bikes for fun and walked their dogs more frequently (Carver et al. 2005).

Other researchers have linked the actual number of *community* facilities to outcomes for adolescents. Gorden-Larsen et al identified the total number of recreational facilities as a significant predictor of both adolescent obesity and physical activity (2006). Norman et al. found a strong association between the number of parks and levels of physical activity in adolescents (2006). Yet, no studies to date have explored the specific relationship between *school* accessibility and physical activity or obesity in the adolescent population.

This study first assesses school accessibility and the availability of active amenities on school grounds on Saturdays, and examines how these factors vary by site and school type. Next, the contribution made by schools to the overall supply of neighborhood recreational opportunities is evaluated. Then, this paper describes how neighborhoods differ by the presence of locked schools and explores the association between school accessibility and young adolescent girls' weekend activity and BMI.

METHODS

The Trial for Activity in Adolescent Girls (TAAG) is a multi-center randomized trial designed to test an intervention to reduce the usual decline in moderate to vigorous physical activity (MVPA) in middle-school girls (Stevens et al. 2005). TAAG has six field centers (at the Universities of Arizona, Maryland, Minnesota, and South Carolina; San Diego State University; and Tulane University), a Coordinating Center (at the University of North Carolina, Chapel Hill) and a Project Office at the National Heart Lung and Blood Institute. IRB approval was obtained at all involved institutions.

Of the 1603 6th grade girls who participated in the TAAG baseline measurements in the spring of 2003 and had usable data for total weekend MVPA, we were able to geocode the residences of 1556 girls using ArcGIS 9.0 to map and inter-relate data (ESRI). Since middle school-aged girls are not of driving age, we used a half-mile (0.805 km) radius around each girl's home to define the neighborhood within which she might be expected to walk or bicycle (Bureau of Transportation 2001).

School Accessibility and Amenities

In order to compile a comprehensive list of schools, we extracted the name, address, and identifier for all the schools located in the zipcodes within a mile (1.61 km) of the girls' residences from the Common Core Dataset, the Private School Survey, and the Integrated Postsecondary Education Data System (www.nces.ed.gov). Schools were then classified by type: public K-12, private K-12, or college/university. We were unable to classify them by level (i.e. elementary, middle, high schools) since definitions of these terms varied widely across geographic locations. All of these schools were geocoded, but only those that fell within a half-mile (0.805 km) radius of the girls' homes were retained.

In order to systematically inventory active amenities at school sites, we designed a direct observation instrument which allowed site visitors to record by hand the presence or absence of all active and passive amenities using a checklist. Staff used this instrument during their Saturday site visits between 9am and 5pm in the spring of 2003. If school grounds were locked, TAAG staff documented whatever amenities were visible from the street.

Park Amenities

We obtained local park geographic shapefiles from regional planning agencies in sites where possible. Then, we filled in areas for which there were no pre-existing shapefiles with hand-digitized polygons from hard-copy maps of the regions in our study. The TAAG staff then documented the all park amenities within our study area with a direct observation instrument similar to the one used for schools.

Neighborhood Census Measures

Using block group level data and geography from the 2000 US Census, we proportionately interpolated the population density for each of the half-mile (0.805 km) radii as well as data on percent unemployment, adults with less than a high school education, and households in poverty in order to calculate a socioeconomic (SES) index (Cronbach's alpha=0.88). In addition, we extracted the median year of construction for each girl's block group.

Physical Activity & Body Mass Index

Between January and June 2003, the girls wore an accelerometer which measured their physical activity for 6 days. The accelerometer measured vertical acceleration accumulated every 30 seconds and stored the summed value or activity count in memory. Readings above 1500 counts per half minute were treated as MVPA; this threshold was found in an earlier study to have optimal sensitivity and specificity for discriminating brisk walking from less vigorous activities in eighth grade girls (Treuth et al. 2004). Half-minute counts were used instead of full-minute counts based on the expectation that they would be more sensitive to fluctuations in activity levels.

Occasional missing accelerometry data within a girl's 6-day record were replaced via imputation based on the Expectation Maximization algorithm (Catellier et al. 2005). We considered data sufficiently complete if at least 80% of the data expected to be collected on each measurement day were valid. The probability of having one or more incomplete day of accelerometer data was not associated with race, age, or average activity based on completely observed days. Counts were then converted into METs using a regression equation developed which applied greater weight to more vigorous activities (Schmitz et al. 2005). METs were then summed over the 6am-midnight day to provide MET-minutes per day of MVPA, where one MET-minute represents the metabolic equivalent of energy expended sitting at rest for one minute. Even though school accessibility was only assessed on Saturdays, we chose to use total weekend MW-MVPA as our outcome in order to better estimate girls' typical activity.

Trained and certified TAAG staff members collected height and weight and calculated BMI. Data on race was obtained from a self-administered questionnaire. Participating TAAG schools provided data on the percentage of 6^{th}–8^{th} graders who received free or reduced price lunch.

Statistical Analyses

The first step in our analyses was to examine school level data. We explored the differences in the proportions of locked schools and unlocked schools (with and without active amenities) by site and by school type. Then, we looked at how the mean number of active amenities varied along the same dimensions. Next, we analyzed the proportion of recreational opportunities in girls' neighborhoods accounted for by school grounds and their amenities. Subsequently, we explored the schools' locations relative to the girls' homes and characterized the differences between neighborhoods with any locked schools and those with none.

We used a three-level hierarchical linear model to analyze the relationships between the outcomes of weekend MW-MVPA and BMI and the characteristics of a girl's neighborhood (Hox 2002). This allowed us to control for the clustering of girls within schools and schools within geographic sites. Girl-level covariates included race and SES, the number of parks, the number of accessible schools with active amenities, the number of locked schools, and a dummy variable for the presence of one or more schools within a half-mile (0.805 km) of her home. The only school-level covariate was the percent of students in the 6^{th}, 7^{th}, and 8^{th} grades who received free/reduced price lunch

Because the first-level residuals were not normally distributed, we used log-transformed versions of our dependent variables. Consequently, our parameter estimates are expressed as percent difference in our dependent variables for each unit change in our covariates. To make our explanations more understandable, we calculated the magnitude of this difference for the "average girl" by multiplying the parameter estimate by the mean value of BMI and MW-MVPA weekend minutes. We checked our models for multi-collinearity and found it to be minimal.

RESULTS

Description of Schools

There were a total of 407 schools within a half-mile radius of the girls' homes. Only a little more than half of the schools (57%) were both accessible and contained active amenities (Table 1). One in three schools was locked on the day we visited; and nearly one in ten of the unlocked schools had no structures in place for physical activity. However, it is important to note the high amount of variation across sites. For example, despite the fact that New Orleans had 93 schools, more than 62% of those schools had their grounds locked and 15% of the open schools had no places for girls to play, leaving only 21 available schoolyards. In contrast, Minneapolis had less than half the total number of schools of New Orleans, but had 41 accessible school recreational sites due to its low rates of locked schools (2.3%) and unequipped unlocked schools (5%). Schools in San Diego had twice the average number of active amenities as all other sites while South Carolina schools had the lowest number.

Three-fourths of the schools in our sample were public institutions. They were locked about as frequently as private schools, approximately 35% of the time. Public schools had the highest average number of active amenities and a significantly higher proportion of public schools contained baseball fields, blacktops (paved areas covered with asphalt used for games like basketball, jumprope, hopscotch,etc), basketball and handball courts, tetherball poles (poles with balls attached to a string for a game where opponents try to wrap the string around the

pole), and high level gymnastics equipment. However, football fields, tennis courts, and running tracks were significantly more prominent at colleges and universities.

The most common active amenities in schools included basketball courts (63%), playgrounds (60%), fields (50%), and blacktops (48%). Additional active amenities were present less frequently such as tetherball posts (16%), gymnastic bars (16%), tennis courts (15%), handball courts (14%), paths (11%), running tracks (9%), gymnasiums (5%), exercise circuits (4%), volleyball courts (3%), swimming pools (<1%), and ice-skating rinks (<1%).

Among the 670 public parks and unlocked schools with active amenities, unlocked schools accounted for a little more than a third (n=232) of the facilities (Table 2). Accessible schools provided 83% of the running tracks, 77% of the blacktop space, and 63% of the handball courts in these areas. They nearly doubled the number of basketball courts, volleyball courts, and athletic fields; and they offered around a third of tennis courts and playgrounds. Furthermore, opening the 113 locked schools would, at a minimum, increase the total number of blacktop spaces by 43%, basketball court availability by 20%, playgrounds by 18%, and athletic field space by 16%.

School Accessibility, BMI, and Weekend MW-MVPA

Thirty-five percent of girls had both parks and schools within a half-mile of their residences; 25% had neither schools nor parks. Twenty-one percent of girls only had parks nearby and 18% only had schools. In total, 824 (53%) of the girls lived near a school, but only 39% had at least one that was both unlocked and contained active amenities.

The characteristics of girls and neighborhoods with a locked school nearby differed significantly from those with only accessible schools (Table 3). Among girls with at least one school within a half-mile radius, those with at least one locked school were much less likely to be white or to live in Minnesota, South Carolina, or California. In addition, neighborhoods with locked schools had older median years of construction, more people per square mile, higher poverty and unemployment rates, and a lower percentage of residents with a high school education.

Girls with no schools within a half-mile radius registered 10% less weekend MW-MVPA ($p < 0.10$) (Table 4). This amounted to an average of 22 fewer minutes of moderate-to-vigorous activity. However, the number of accessible schools with active amenities was not significantly related to girls' MW-MVPA. In contrast, each additional park within the same half-mile distance was associated with almost 3% more weekend MW-MVPA ($p < 0.10$).

The model results further suggested that each additional locked school was associated with a 3% (or 0.6 units) increase in BMI ($p < 0.05$). For example, the average 5-foot (1.524 m) tall girl in New Orleans with a BMI of 21.8 kg/m^2 would be approximately 3.2 lbs. (1.5 kg) heavier with every additional locked school in her neighborhood (range: 0–7). The average girl in the Minneapolis area with a BMI of 19.1 kg/m^2 would weigh 2.9 lbs. (1.3 kg) more with a locked school present (range: 0–1). The absence of any school within a half mile of a girl's home was not significantly related to BMI, nor was the number of schools with active amenities. Taken together, this suggested that girls with a greater number of locked schools had higher BMI than either girls with no schools or schools with active amenities within a half-mile of their home.

Differences in BMI and physical activity by race and socioeconomic status persisted in both models. Hispanic and African American girls had 7.2% and 7.8% higher BMI ($p < 0.0001$) respectively and all non-white girls clocked significantly less physical activity than their white counterparts. For example, Hispanic girls on average, recorded about 19% fewer minutes of

MW-MVPA ($p < 0.0001$). While lower neighborhood SES was linked to higher BMI ($p < 0.01$), SES was not a factor in predicting levels of physical activity.

DISCUSSION

Schools are a tremendous resource of recreational facilities. Nevertheless, much can still be done to improve the accessibility of these active amenities at schools on weekends, especially in economically disadvantaged, older, dense neighborhoods. Overall, more than a third of the schoolyards we visited were not open to the public on Saturdays. This estimate is actually very close to the national estimate from the US School Health Policies and Programs Study (SHPPS), but quite a bit higher than in other US studies (Burgeson et al. 2001;O'Hara Tompkins et al. 2004;Evenson and McGinn 2004).

It remains to be seen whether increased access to school grounds and a better variety of active and passive amenities actually translates into more public usage of school facilities and higher levels of physical activity. Though girls with no schools at all within a half-mile tended to be less active on weekends, this may have little to do with the lack of nearby schools. Rather, having no schools nearby could be a proxy for residence in a more rural or sprawling neighborhood where people are less likely to walk for transportation or other purposes.

Moreover, the number and presence of only accessible schools with active amenities had no significant relationship with weekend MW-MVPA. It might be that young adolescent girls do not easily identify schools as recreational resources. One of the few studies to measure reported usage of school space for recreation would tend to support this theory. It found that only 5% of adult respondents in San Diego reported using school grounds to exercise despite the fact that they accounted for 68% of the free-for-use facilities in the area (Sallis et al.1990).

Consequently, the strong relationship identified between the number of locked schools and higher BMI may not be because of lower levels of physical activity resulting from more limited recreational resources, but rather because of other unmeasured factors like neighborhood stress and allostatic load. The allostatic load hypothesis states that people live in more stressful environments produce higher levels of cortisol which increases weight gain (McEwen and Seeman1999). Locked schools may signal higher rates of crime, lower levels of collective efficacy, or other factors unmeasured by our analyses. Alternative hypotheses might include inferior access to healthy food stores and fresh produce (MacIntyre et al 1993).

Even though the number of locked schools is a smaller and less significant predictor of BMI than race and neighborhood socioeconomic status, it is important because it offers health advocates a tangible way to begin to address obesity in the more economically disadvantaged neighborhoods where locked schools are often found. Girls cannot change their race or social class, but local school officials can work to open school grounds to the community for recreational use.

Limitations

While the objective nature of our accessibility assessments is perhaps the greatest strength of our study, it is also possible that it did not allow us a full picture of local school policies and practices. O'Hara Tompkins et al (2004) and Evenson and McGinn (2004) found higher rates of public school-ground accessibility, 81% and 77% respectively, but also counted facilities with limited hours, days, or types of facilities (indoor vs. outdoor). Our study did not gather information on these details or on more qualitative measures like the condition or attractiveness of amenities at the schools which might also influence their use by adolescent girls. We also did not collect information on the intra-rater reliability of our school and park direct observation instruments. Doing so would be useful if other researchers were to use them in the future.

Further, our use of total weekend MW-MVPA assumes that our Saturday school assessments are representative of the whole weekend when, in fact, this may not be the case. We did also run a separate model for only Saturday MW-MVPA in which all estimates were in the same direction and of similar magnitude. However, Saturday only measurements did not give us the power necessary to identify any statistically significant results for parks or schools.

Further, while we gathered detailed data on the girls' physical activity, we did not have any information on their actual usage of recreational resources in their neighborhoods. Therefore, we can say that parks are positively associated with weekend MW-MVPA, but have no way of knowing if girls are actually using the parks or if are more active because their environment promotes active lifestyles.

The racial distribution of the girls and the SES of their neighborhoods also vary widely by site. This makes it difficult to disentangle the effects of these factors from the effect of place.

Lastly, our results are only applicable to young adolescent girls. Since boys are generally more active than girls, it is possible the association between school facilities and physical activity may be stronger if they were included. On the other hand, our findings may not apply to older female adolescents who tend to have distinct preferences and patterns in physical activity.

CONCLUSIONS

Given the tremendous potential recreational resource that school grounds represent, public health advocates should seek to raise the profile of schools as sites for physical activity by offering organized recreational programs at these locations. In addition, it would be beneficial to work with school administrators and community leaders to address reasons why neighborhood schools are inaccessible on Saturdays. Future research should include a qualitative study examining adolescents' perceptions of locked schools as well as additional quantitative work directly linking weekend physical activity at schools with their accessibility.

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Table 1

Locked status and active amenities[+] for schools on Saturdays in Spring 2003, by site and school type: Trial of Activity for Adolescent Girls neighborhoods in Arizona, California, Lousiana, Maryland, Minnesota, and South Carolina

	N	Unlocked Schools With Active Amenities[+] %	Locked Schools %	Unlocked Schools with No Active Amenities[+] %	Mean Number of Active Amenities[+] (SD)
OVERALL	407	57	34	9	4.0 (3.0)
BY SITE					
Maryland	100	54[**]	39[**]	7[**]	4.0 (2.7)[**]
South Carolina	48	77	10	13	2.4 (1.9)
Minnesota	44	93	2	5	4.2 (1.7)
Louisiana	93	23	62	15	2.4 (2.0)
California	76	74	25	1	7.5 (2.5)
Arizona	46	50	39	11	3.1 (3.4)
BY SCHOOL TYPE					
Public K-12	309	59	35	6[*]	4.5 (3.1)[**]
Private K-12	88	52	34	14	2.4 (1.8)
College & University	10	40	10	50	3.0 (3.7)

[+] Active amenities include playgrounds, all individual athletic fields, blacktops, running tracks, basketball, tennis, paddle tennis, handball, volleyball courts, sw imming pools, gymnasiums and other indoor facilities, paths, exercise circuits, rollerskating, ice-skating, and skateboarding areas, tetherball poles, and high level exercise equipment like gymnastic bars.

[**] $p < 0.0001$ for Chi Square for tests of proportion, and Anovas for differences among means

[*] $p < 0.01$ for Chi Square for tests of proportion, and Anovas for differences among means

Note: Data for active amenities, if not visible from the street, are missing for locked schools. These features do not factor into the mean calculations.

Table 2

Active amenities[+] available in schools and parks in Spring 2003: Trial of Activity for Adolescent Girls neighborhoods in Arizona, California, Lousiana, Maryland, Minnesota, and South Carolina

	Accessible Neighborhood Sites						
	Total	Unlocked Schools		Parks		Locked Schools	
		N	% of total	N	% of total	N	% increase[++]
N	670	232	35	438	65	113	17
Playgrounds	485	160	33	325	67	86	18
Blacktop	164	126	77	38	23	70	43
Any Athletic Field	441	185	42	256	58	71	16
Bas ketball Court	380	179	47	201	53	77	20
Indoor Facilities	129	14	11	115	89	9	7
Path	237	34	14	203	86	10	4
Tennis Courts	172	51	30	121	70	9	5
Swimming Pool	39	4	10	35	90	0	0
Volleyball Court	82	39	48	43	52	11	13
Ice Rink	38	3	8	35	92	0	0
Handball Court	68	43	63	25	37	13	19
Running Track	41	34	83	7	17	4	10
Skateboarding Area	9	1	11	8	89	1	11

[+] Active amenities are ones which may be used to play sports or perform other physical activity

[++] % increase calculated by dividing the number of additional amenities by the total existing amenities in unlocked schools and parks

Note: Schools and Parks with no active amenities are not included.

Table 3

Differences between girls and neighborhoods in Spring 2003 by presence of a locked school within a half-mile (n=824)[+]: The Trial of Activity for Adolescent Girls in Arizona, California, Lousiana, Maryland, Minnesota, and South Carolina

	Girls with No Locked Schools	Girls with At Least 1 Locked School	Probability[++]
OVERALL (%)	57.6	42.4	
RACE (%)			<.0001
White	70.7	29.3	
Black	44.7	55.3	
Hispanic	48.0	52.0	
Other	62.8	37.2	
SITE (%)			<.0001
Maryland	49.0	51.0	
South Carolina	88.7	11.3	
Minnesota	96.8	3.2	
Louisiana	23.9	76.1	
California	64.2	35.8	
Arizona	49.5	50.5	
Mean Percent Households Below Poverty	8.65	13.04	<.0001
Mean Percent Unemployed	4.82	6.06	<.0001
Mean Percent Less Than High School Education	16.44	22.35	<.0001
Mean Population Density	4288.2	6517.9	<.0001
Mean Median Year Built	1972	1970	0.0144

[+] Table only includes girls who had at least one school within a half-mile of their homes.

[++] Chi Square for tests of proportion and T-tests for differences between means

Table 4

Mixed model analyses of schools' relationships with girls' body mass index and metabolic equivalent weighted minutes of weekend moderate-to-vigorous physical actvity: The Trial of Activity for Adolescent Girls in Arizona, California, Lousiana, Maryland, Minnesota, and South Carolina

	Body Mass Index			Metabolic equivalent weighted minutes of weekend moderate-to-vigorous physical actvity		
	Estimate	**Probability**	**Difference in kg/m2 for Girl with the Average Body Mass Index of 20.9kg/m2**	**Estimate**	**Probability**	**Difference in Minutes for Girl with the Average Activity of 231 Minutes**
Intercept	19.2	0.00	--	197.5	0.00	--
Locked Schools	2.8%	0.01	0.6	−3.4%	0.40	−7.8
Unlocked Schools w/Active Facilities	1.3%	0.20	0.3	−2.9%	0.42	−6.7
No Schools within a Half-Mile	2.3%	0.16	0.5	−9.6%	0.08	−22.3
Parks	−0.3%	0.42	−0.1	2.8%	0.06	6.5
SES	−2.3%	0.01	−0.5	2.6%	0.39	6.1
Race						
Hispanic	7.2%	0.00	1.5	−19.4%	0.00	−44.9
African American	7.8%	0.00	1.6	−7.5%	0.21	−17.4
Other Race	2.0%	0.24	0.4	−17.0%	0.00	−39.3
White	0.0%	--	0.0	0.0%	--	0.0
Free lunch*	0.0%	0.92	0.0	0.1%	0.58	0.2

*Free lunch is a school-level variable for the percentage of 6th, 7th, and 8th graders at the girls' schools who receive free or reduced price lunch.

Note: Because our dependent variables were log-transformed, 'Estimates' are expressed in terms of percent difference in the dependent per unit change in each covariate. In order to translate these estimates back into their original units, we calculated the 'Difference for the Average Girl' by multiplying the 'Estimate' by the average value of the dependent variables.