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Comparing Perceived and Objectively Measured Access to Recreational Facilities as Predictors of Physical Activity in Adolescent Girls

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ABSTRACT *A number of studies in recent years have identified both self-report and objectively measured accessibility of recreational facilities as important predictors of physical activity in youth. Yet, few studies have: (1) examined the relationship between the number and proximity of objectively measured neighborhood physical activity facilities and respondents' perceptions and (2) compared objective and self-report measures as predictors of physical activity. This study uses data on 1,367 6th-grade girls who participated in the Trial of Activity for Adolescent Girls (TAAG) to explore these issues. Girls reported whether nine different types of recreational facilities were easily accessible. These facilities included basketball courts, golf courses, martial arts studios, playing fields, tracks, skating rinks, swimming pools, tennis courts, and dance/gymnastic clubs. Next, geographic information systems (GIS) were used to identify all the parks, schools, and commercial sites for physical activity located within a mile of each girl's home. These sites were then visited to inventory the types of facilities available. Girls wore accelerometers to measure their weekly minutes of non-school metabolic equivalent weighted moderate-to-vigorous physical activity (MW-MVPA). The number of facilities within a half-mile of girls' homes strongly predicted the perception of easy access to seven out of nine facility types. Both individual facility perceptions and the total number of facilities perceived were associated with increased physical activity. For each additional facility perceived, girls clocked 3% more metabolic equivalent weighted moderate-to-vigorous physical activity ($p<0.001$). Although girls tended to record 3% more of this kind of physical activity ($p<0.05$) per basketball court within a mile of their homes, objective facility measures were otherwise unrelated to physical activity. The results from this study suggest that raising the profile of existing facilities may help increase physical activity among adolescent girls.*

KEYWORDS *Adolescent girls, Parks, Physical activity, Recreational facilities, Schools.*

INTRODUCTION

A number of studies in recent years have identified the accessibility of recreational facilities as an important predictor of physical activity in youth. Some of these studies have quantified access to facilities in terms of respondents' self-reported perceptions[1–3] while others have calculated objective measures[4–6] like the number

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of facilities within a defined radius or the distance to the nearest facility using geographic information systems (GIS).

What is not understood is whether there is a close relationship between the number and proximity of objectively measured neighborhood physical activity facilities and youths' perceptions of access to these resources. To date, most research on this topic has focused on the perceptions of adults. One study detected only fair to slight agreement between self-report and geographic information system (GIS) measures of various neighborhood characteristics including public recreation facilities, sidewalks, street lighting, and crime.[7] Other researchers found similarly low levels of agreement for matched pairs of perceived and objective measures of facilities supporting physical activity.[8,9] However, one study using counts for both perceived and objectively measured recreational facilities identified significant correlations ranging from 0.45 to 0.54.[10]

One possible explanation for low levels of agreement is that people do not all perceive their environment the same way. Women, children, and long-term residents may perceive their neighborhood as a smaller place than others,[11] as do the foreign-born, individuals with lower levels of education, lower income, and those with fewer family and friends in the immediate area.[12] Studies also have shown that people who live in metropolitan areas define their neighborhoods as smaller areas than those who live in rural areas.[12,13]

Furthermore, what people perceive in their neighborhood has much to do with their own lifestyles.[14] The modes of transportation that people use, for example, play a role in determining what people observe in their surroundings. Someone who primarily walks and/or uses public transportation may be limited to a smaller geographic area, but have a better idea of what is on the ground within that space. In contrast, someone who primarily travels by private car is exposed to a larger geographic area but may not perceive the same level of detail as someone who walks. In addition, people's own preferences may influence their perceptions.[15] More active people who play organized sports or take recreational classes may be more likely to notice facilities that provide opportunities for physical activity.

This paper uses data from the Trial of Activity for Adolescent Girls (TAAG) to further clarify the relationship between physical activity and specific types of neighborhood recreational facilities. First, we explore the relationship between adolescent girls' perceptions of specific types of recreational facilities and the actual presence of such facilities in the girls' neighborhoods. We hypothesize that objective and perceived measures will be more closely related within shorter distances of the girls' homes. We further hypothesize that girls who participate in after school sports or report that their family frequently provides transportation to recreational sites will be more likely to perceive recreational facilities. Second, we examine how and if both objective and perceived measures are associated with objectively measured non-school met-weighted moderate-to-vigorous physical activity (MW-MVPA). We hypothesize that the perception of facilities rather than their objective presence will be more strongly associated with higher levels of nonschool MW-MVPA.

METHODS

Sampling

The TAAG Study is a multicenter group-randomized trial designed to test an intervention to reduce the usual decline in moderate to vigorous physical activity in middle-school girls.[16] TAAG has six field centers in metropolitan areas (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. Each center's Human Subjects Institutional Review Board approved the study protocol. Written informed consent was obtained from one parent, and written assent was obtained from each girl. Using ArcGIS 9.0 (ESRI), we were able to geocode the residences of 1,556 of the 1,603 girls in the 6th grade cohort measured at baseline. A total of 1,367 of these girls had sufficiently complete data for physical activity, both self-report and objectively measured facilities, and all of our relevant covariates.

Instrumentation and Data Collection

Physical Activity Participants wore an Actigraph (model #AM7164) uniaxial monitor on their right hip secured by a belt to measure accelerations. The accelerometer measured vertical acceleration accumulated every 30 seconds and stored the summed value or activity count in memory. We processed accelerometer readings using methods similar to those reported by Puyau et al.[17] We treated readings above 1,500 counts per half minute 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 8th grade girls.[18] We used half-minute counts instead of full-minute counts based on the expectation that they would be more sensitive to fluctuations in activity levels.

We replaced occasional missing accelerometry data within a girl's 6-day record via imputation based on the expectation maximization (EM) algorithm.[19] 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 days of accelerometer data was not associated with race, age, or average activity based on completely observed days.[16] We converted counts above 1,500 per half minute into METs using a regression equation developed from a pilot study for TAAG.[20] One MET-minute represents the metabolic equivalent of energy expended sitting at rest for 1 minute. For example, 10 minutes of activity at an intensity of 6 METs would correspond to 60 minutes of MET-weighted moderate-to-vigorous physical activity (MW-MVPA).

We quantified physical activity in terms of non-school minutes of MW-MVPA—that is, activity measured on weekdays after 2 P.M. and on weekends. Accelerometers recorded the girls' activity during a total of 6 days during the Winter and Spring of 2003. These days included 4 weekdays and 2 weekend days. To explain our analyses in terms of total non-school activity per week, rather than for 6 days, we weighted the total after school minutes of MW-MVPA recorded on each weekday by 5/4 before summing all the weekday and weekend data.

Perception of Neighborhood Facilities Data collectors participated in a centralized training to ensure standardized procedures, scripts, and protocols. Students completed the self-administered questionnaire at school, supervised by the data collectors in the spring of 2003. A standardized introduction to the survey was read, and data collectors were available for questions. The questionnaire included a list of 14 physical activity facilities, which asked them to reply yes or no to the following question: "Is it easy to get to and from this place from home or school?" We chose to use nine of these facilities because we were able to generate objective measures of them and because they were mutually exclusive of each other. The nine facilities included in our analyses were: (1) basketball courts, (2) golf courses, (3) martial arts studios, (4) playing fields, (5) tracks, (6) skating rinks, (7) swimming pools, (8) tennis courts, and (9) dance or gymnastic clubs. Furthermore, we created a variable for the total number of facility types perceived to be easy to get to and from home or school by summing the individual indicators for each type of facility.

Objective Measures of Facilities To achieve the best equivalency possible with the self-report categories of physical activity facilities, we gathered observed data for three different kinds of facilities—parks, schools, and commercial sources (e.g., local businesses). For parks, we first obtained local park geographic shapefiles, or systems of files with both tabular and spatial data, from regional planning agencies in sites where such resources were available. 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. Subsequently, we cross-checked these files with public directories of recreational resources. For schools, we extracted the name and address for all the schools located near the girls' residences from the common core dataset (CCD) for public schools, the Private School Survey (PSS) for private schools, and the Integrated Postsecondary Education Data System (IPEDS) for colleges and universities and then geocoded all of the addresses.

We then selected only those recreational sites located within a mile of girls' homes and developed an instrument for direct observation, which allowed site visitors to systematically inventory all the facilities available at parks and schools. Next, trained TAAG staff visited all the parks and schools on Saturdays between 9 A.M. and 5 P.M. in the spring of 2003 and used the instrument to document the presence or absence of each facility. To find available commercial facilities, we queried The Smart Pages (http://www.SMARTpages.com) and Info USA (http://www.infousa.com). We telephoned each establishment to verify its address, the types of physical activity offered, and whether the business was still in operation, verifying a total of 510 different commercial facilities for physical activity.

We then combined data from parks, schools, and local businesses to create both indicator and count variables for each type of facility within two half-mile concentric circles around the girls' homes (Figure 1). If the point (in the case of schools) or any part of the polygon (in the case of parks) fell within these distances, all of the facilities contained at these sites were assumed to fall within these distances as well. For commercial facilities like martial arts studios, a single data source was available (Table 1). In other cases, we were able to identify available facilities from all three sources. For example, tennis courts were present in parks, schools, and also private clubs listed in the commercial facilities database. Moreover, we summed the counts of all types of facilities within a mile of the girls' homes to create a variable for the total number of objectively measured facilities for each girl.

Participation in Community Teams or Classes Girls responded to a series of questions about their participation in a wide variety of community teams and classes. We used these responses to determine whether girls might use each of the nine different kinds of facilities for these activities (Table 1). For example, we created a variable for whether the girls participated in a sports team or class requiring a playing field: baseball or softball, soccer, field hockey, or lacrosse.

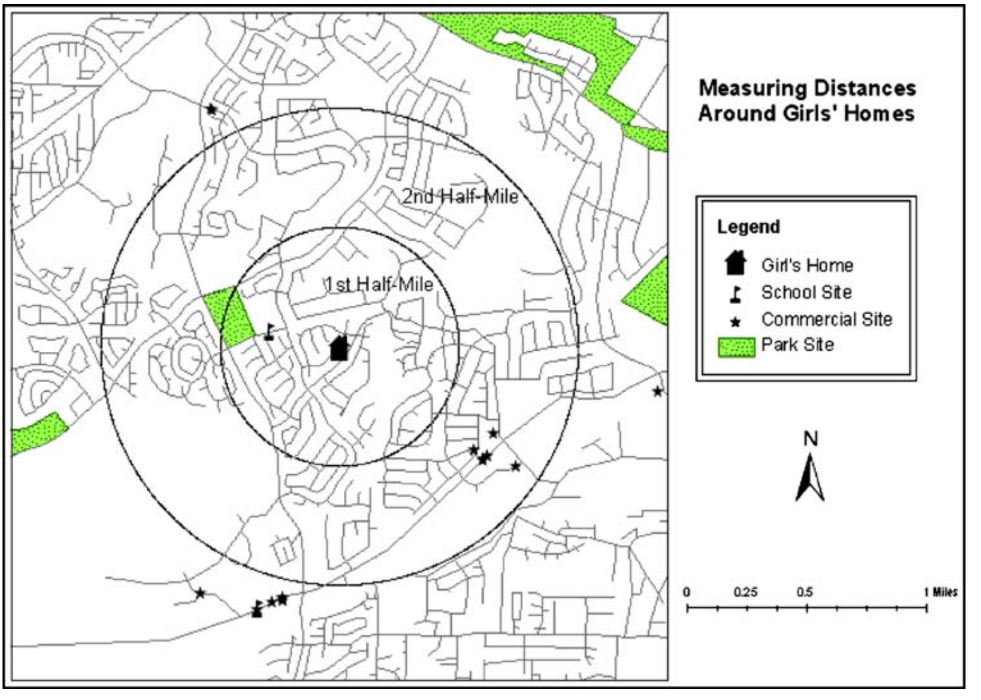

FIGURE 1. Measuring distances around girls' homes.

Family Transportation In the self-administered questionnaire, girls responded to the question, "During a typical week, how often has a member of your household provided transportation to a place where you can do physical activities or play sports?" The five possible responses ranged in frequency from "none" of the time to

TABLE 1 Explanation of objectively measured facilities and participation in community teams/classes

		Sources for objective measures		
Perceived facility	Relevant classes or teams	Schools	Parks	Commercial
Basketball courts	Basketball	X	X	
Golf course	Golf		X	X
Martial arts studio	Martial arts			X
Playing field	Baseball	X	X	
	Field hockey			
	Lacrosse			
	Soccer			
Running track	Track and field	X	X	
Skating rink	Figure skating	X	X	
	Ice hockey			
Swimming pool	Swimming	X	X	X
Tennis courts	Tennis	X	X	X
Dance/gymnastics club	Cheerleading/dance			X
	Gymnastics			
	Dance			

"everyday." We converted these responses into a scale ranging from 0 to 4, with the frequency of transport increasing with the values of the responses.

Other Covariates We created a neighborhood socioeconomic index, described in detail elsewhere,[21] using neighborhood-level U.S. census data. We standardized three different census block-group level indicators from the census: the percentage of households above the poverty line, the percentage of employed persons in the labor force over 16 years of age, and the percentage of persons over the age of 25 years with more than a high school diploma (Cronbach's alpha=0.88). We then combined these three factors into an index and interpolated for the circular area delimited by a 1-mile radius around each girl's geocoded residence.

Also, to control for potential differences in physical activity by race/ethnicity, girls were asked to report on the self-administered questionnaire whether they were Hispanic and how they identified themselves racially: white, black or African American, Asian, Native Hawaiian or other Pacific Islander, American Indian, or Alaska native, or some other group. For these analyses, the girls were classified as Hispanic, non-Hispanic white, non-Hispanic black/African American, and non-Hispanic other.

Analyses

First, we used chi-squared tests to see whether the proportion of girls who perceived easy access to each type of facility differed by how close their nearest facility was located. Next, we ran separate multilevel logistic regression models to predict perceived access to each type of facility using the number of objectively measured facilities within the two half-mile concentric circles around the girls' homes, an indicator for participation in relevant community classes or teams, and the frequency of family transportation, while controlling for girl's race, neighborhood socioeconomic status, and population density as fixed effects. Because the TAAG data itself has a hierarchical structure in which girls (level 1 units) are nested within schools, and schools (level 2 units) are nested within study sites, we treated school and site as random effects.

Subsequently, we analyzed the relationship of non-school MW-MVPA to both self-reported access and to the objectively measured number of each type of facility within the first two half-mile concentric circles around each girl's home. At the girl-level, we modeled perceived access to facilities, objective facility counts, neighborhood socioeconomic status, population density, and race as fixed effects. School and site were treated as random.

As objective facilities were many times located together within parks and schools and were thus correlated with each other, we decided to first run individual models for each type of facility. However, we also examined a final model using the total number of perceived facility types and the total number of objectively measured facilities within a half mile of the girls' homes to predict total weekly MW-MVPA during after school hours and on weekends.

Because the first-level residuals were not normally distributed, we used log-transformed versions of our dependent variables to run our final analyses with Proc Mixed in SAS 9.0. Thus, our parameter estimates are in terms of percent changes in our dependent variables per unit change in our covariates. To make our results more easily interpretable, we also calculated the magnitude of this change for the "average girl" by multiplying the estimate by the mean number of minutes of non-school MW-MVPA.

RESULTS

Perceived Access and Objectively Measured Presence of Facilities

The facilities to which girls most commonly report easy access were playing fields (70%), swimming pools (65%), and basketball courts (60%) (Table 2). However, for almost all types of facilities, the nearest one for the majority of girls was located beyond the 1-mile radius at some unknown distance. Basketball courts and playing fields were an exception. More than half the girls had one of those two types of facilities within a half mile of their homes. For eight of nine facility types, the percentage of girls reporting easy access was highest when their nearest objectively measured facility was located within a half mile of their homes, and with increasing distance, reported perception declined. Even so, for basketball courts, swimming pools, and gymnastics/dance clubs, distance made no difference in perception. That is, regardless of how close by their nearest facility was located, girls perceived them at a similar rate.

The logistic regressions supported the hypothesis that perception and the number and proximity of objectively measured facilities were associated (Table 3). With the exception of the two types of facilities that were exclusively commercial (e.g., martial arts studios and dance/gymnastics clubs), the number of facilities within the first half mile strongly predicted whether the girls would perceive them to be easily accessible. While each additional basketball court increased the odds of perceiving easy access to one by 30%, each additional running track made a girl over two times more likely to perceive one as accessible. Although the size of the effect was slightly smaller within the second half mile, this relationship between objective facility measures and perception persisted at this distance for four of nine of the different types. For example, a girl with one swimming pool within the first half mile and another within the second half mile, would be roughly three and a half times more likely to perceive this facility to be easily accessible than a girl with no swimming pools at all within a mile of her home.

TABLE 2 Percentage of girls who report easy access to facilities by objectively measured distance to their nearest facility

	Percentage of girls who report easy access to each recreational facility			
	All girls	When their nearest facility is within...		
Type of facility	(N=1,367) %	<0.5 mile % (N)	0.5–1.0 mile % (N)	>1.0 mile % (N)
Basketball courts	60	62 (736)	58 (409)	58 (222)
Golf course	26***	42 (114)	38 (207)	21 (1,046)
Martial arts studio	21*	25 (134)	25 (258)	20 (975)
Playing field	70**	72 (806)	67 (384)	63 (177)
Running track	46***	58 (121)	50 (222)	43 (1,024)
Skating rink	37***	72 (115)	58 (80)	32 (1,172)
Swimming pool	65	70 (154)	66 (198)	64 (1,015)
Tennis courts	46***	58 (391)	40 (418)	42 (558)
Dance/gymnastics club	32	32 (138)	31 (243)	33 (986)

* $p|<0.10$, **$|p|<0.05$, ***$|p|<0.01$ for Chi Square of differences in the proportion of girls who perceive facilities by objectively measured distance

TABLE 3 Predicting the perception of easy access to individual types of facilities

	Predictors of facility perception: odds ratio (95% CI)			
	Number of facilities			
Type of facility perceived	≤0.5 mile	0.5–1.0 mile	Team or class	Family transport
Basketball court	1.30 (1.01, 1.68)**	1.02 (0.77, 1.36)	1.94 (1.50, 2.51)***	1.33 (1.20, 1.47)***
Golf course	1.95 (1.25, 3.05)***	1.62 (1.15, 2.28)***	3.57 (2.25, 5.66)***	1.21 (1.07, 1.36)***
Martial arts studio	1.15 (0.74, 1.79)	1.22 (0.87, 1.70)	3.71 (2.39, 5.75)***	1.11 (0.98, 1.26)*
Playing field	1.46 (1.11, 1.92)***	1.44 (1.05, 1.98)**	1.59 (1.23, 2.05)***	1.37 (1.22, 1.52)***
Running track	2.10 (1.37, 3.21)***	1.43 (1.04, 1.95)**	2.00 (1.39, 2.89)***	1.33 (1.20, 1.48)***
Skating rink	1.87 (1.09, 3.20)**	0.77 (0.45, 1.32)	1.97 (1.28, 3.04)***	1.20 (1.08, 1.34)***
Swimming pool	2.05 (1.33, 3.15)***	1.48 (1.04, 2.11)**	1.64 (1.28, 2.11)***	1.32 (1.19, 1.47)***
Tennis court	2.07 (1.60, 2.69)***	1.00 (0.78, 1.27)	2.20 (1.57, 3.09)***	1.21 (1.09, 1.34)***
Dance/gymnastics club	0.94 (0.62, 1.42)	0.84 (0.62, 1.15)	3.66 (2.85, 4.68)***	1.21 (1.08, 1.35)***

Each row displays results for an individual model. All models control for the population density and SES of girls' neighborhoods and girls' race/ethnicity as fixed effects. School and site are treated as random.

*$|p|<0.10$, **$|p|<0.05$, ***$|p|<0.01$ for log odds estimates from individual logistic regressions for each type of facility perceived

Participation in facility-specific community classes or teams and the frequency with which family members provided transportation to sites for recreation strongly predicted the perception of each facility. Both of these coefficients in all nine of the logistic regression models proved to be positively associated with greater odds of perceiving facilities to be easily accessible. Depending on the type of facility, these odds ranged anywhere from 59% for playing a field-related sport to 371% for girls taking a martial arts class. Moreover, these same odds increased in 11–37% increments with each unit increase in the frequency of family-provided transportation.

Associations Between Physical Activity and Facilities

On average, the girls accumulated 704 non-school MW-MVPA minutes (SD=480) per week (range 59–5,842). The separate mixed models showed that most objectively measured facilities had no relationship with physical activity (Table 4). Basketball courts, however, were an important exception. After controlling for perception and other covariates, each additional court within the first half mile was associated with 3% more non-school MW-MVPA; this amounts to approximately 21 additional non-school MW-MVPA minutes per week for the average girl. Moreover, the number of courts within the second half mile was also related to higher levels of physical activity. Each additional court between a half-mile and a mile of the girls' homes translated to a 3% increase or an average of 19 more minutes of nonschool MW-MVPA for girls per week.

In contrast to the objective facility measures, the perceived measures in the separate mixed models were associated with greater non-school MW-MVPA for two thirds of the facilities—basketball courts, golf courses, playing fields, running tracks, swimming pools, tennis courts, and dance/gymnastics studios. The magnitude of these relationships varied quite a bit. For example, perceiving easy

TABLE 4 Separate mixed models predicting total minutes of nonschool MW-MVPA per week

	Estimate (min/wk for avg girl)		
		Number of facilities	
Type of facility	Perception of easy access	≤0.5 mile	0.5–1.0 mile
Basketball court	0.10 (68.1)***	0.03 (21.2)*	0.03 (18.5)**
Golf course	0.14 (96.7)***	−0.01 (−5.7)	0.00 (−3.25)
Martial arts studio	0.02 (13.6)	−0.02 (−12.7)	−0.01 (−6.2)
Playing field	0.10 (69.4)***	0.01 (4.4)	0.01 (8.7)
Running track	0.13 (93.5)***	0.01 (7.5)	0.02 (12.4)
Skating rink	0.01 (8.5)	−0.02 (−16.6)	−0.00 (−1.58)
Swimming pool	0.12 (85.8)***	−0.01 (−4.8)	0.01 (6.7)
Dance/gymnastics club	0.06 (43.6)*	0.01 (6.3)	−0.03 (−24.4)

Each row displays results for a separate model. All models control for the population density and SES of girls' neighborhoods and girl's race/ethnicity as fixed effects; school and site are treated as random. Because our dependent variables were log-transformed, estimates are expressed in terms of percent difference (in decimal form) in the dependent variable per unit change in each covariate. To translate these estimates back into their original units, we calculated the "difference for the avg girl" by multiplying the "estimate" by the average minutes per week of nonschool MW-MVPA: 704.

*$|p|<0.10$, **$|p|<0.05$, ***$|p|<0.01$ for estimates from individual mixed model regressions for each type of facility

access to a dance/gymnastics club upped non-school MW-MVPA by 6%, an average of 44 MET- minutes per week, while the perception of a golf course nearby translated into a 14% gain, roughly 97 additional minutes/week of non-school MW-MVPA.

The final model reinforced our findings in the separate mixed models (Table 5). The total number of objectively measured facilities within a mile of girls' homes proved to have no relationship with the amount of physical activity in which the girls engaged. However, the more types of facilities girls perceived accessible, the higher their levels of MW-MVPA. Each additional type of facility perceived yielded 3% more non-school MW-MVPA—approximately 22 additional minutes per week for the average girl. Even so, this model only explained roughly 1% more than the intercept-only model.

COMMENT

For most types of facilities, it was both the number and proximity of objectively measured facilities that predicted girls' perceptions, not the facilities' simple presence or absence. For this reason, existing studies of adults, which examine perceived and objective facility measures primarily by using kappa statistics and cross tabulations, may not be able to detect a relationship.[7–9]

Even so, not all facilities seem to be equally salient to adolescent girls. For example, the percentage of girls reporting having easy access to a dance/gymnastics studio club did not vary by distance to the nearest facility; nor did the number of these facilities predict the girls' perception of them. This indicates that dance/gymnastics facilities are equally attractive to girls regardless of their number and/or proximity.

Objective measures of basketball courts behaved differently than all the other objective facility measures in terms of their association with physical activity. Two key factors support this trend. First, more girls had a basketball court within a 1-mile radius than any other recreational destination. Second, basketball seems to be

TABLE 5 Combined model predicting total minutes of nonschool MW-MVPA per week

Variable	Estimate	For avg girl min/wk	Probability
Intercept	536.84	–	0.00
Number of facility types perceived	0.03	22.23	0.00
Number of objectively measured facilities within 1 mile	0.00	2.45	0.26
Standardized socioeconomic index	−0.01	−5.68	0.76
Population density	0.00	0.00	0.80
Race/ethnicity			
Hispanic	−0.13	−90.42	0.01
Non-Hispanic African American	−0.09	−63.91	0.09
Other non-Hispanic	−0.16	−111.25	0.00
Non-Hispanic white	0.00	0.00	.

School and site are treated as random. Because our dependent variables were log-transformed, "estimates" are expressed in terms of percent difference (in decimal form) in the dependent variable per unit change in each covariate. To translate these estimates back into their original units, we calculated the "difference for the avg girl" by multiplying the "estimate" by the average minutes per week of nonschool MW-MVPA: 704.

particularly attractive to active girls. The TAAG Community Agency Survey, a study designed to assess agency capacity to provide physical activity programs for girls in potential TAAG schools, found that basketball programs at community centers were the most commonly offered and the most popular among girls.[22]

Unlike previous studies, which also identify a link between perceived measures of facilities and physical activity in adolescents,[1,23,24] this study demonstrates that the higher levels of nonschool MW-MVPA associated with greater perception of recreational resources are independent of the objective presence of these same facilities. Given this finding, the public health advocates should find ways to improve the perception of recreational sites in the community.

In light of the fact that girls at five out of six TAAG sites most often used transportation by car to get to their after-school activities[22] and that 69% of all trips made by children aged 5 to 15 are by private vehicle,[25] it is not surprising that family transportation is one of the principal mechanisms through which girls perceive their environment. Thus, public officials would do well to not only promote recreational programs and opportunities, but also to organize transportation for young people or organize more school-based opportunities for girls to be active.

Limitations

Our analyses might not have considered some individual neighborhood facilities that were available to girls. For example, swimming pools located within health clubs or YMCAs were not included, as we did not have staffing to inventory individual facilities available within commercial sites. This is particularly problematic where weather and/or crime potentially interfere with outdoor activities. It may be too cold or too dangerous for girls to go swimming at the outdoor pool in the park nearby, so parents may encourage their daughters to go the YMCA or the health club where they are members.

Furthermore, our audits of neighborhood facilities took place in one particular moment in time. Businesses close, and park and school facilities are added or removed, making it difficult to say if our counts reflected the exact number of facilities of each type available during the actual time that the girls' activity was measured.

In addition, our study does not capture the detail of where facilities are located within recreational sites like parks and schools. This may have the effect of making facilities seem closer or farther away than they actually are. For example, a playing field located on the far side of a large regional park may not be as perceptible to a neighborhood girl as the pool across the street from her home, even if both facilities are located within the same park.

Moreover, easy access may mean different things to different people. One girl may feel that a facility has to be within a block of her home to be "accessible," while another may think a facility in a neighboring town is equally easy to get to. Given this variation, it may not be appropriate to compare these perception variables to objective measures at discrete distances, and yet, even if the perception variables had specified distance—i.e., "Is there a _____ within a half mile from your home?"—studies have shown that people rarely accurately perceive distance.[26,27] Furthermore, we did not have information about other factors that might influence the girls' perceptions of their surroundings like their tenure in their place of residence, their nativity, and the extensiveness of their social networks.

Using accelerometers to record physical activity also has limitations. For example, with the uniaxial monitor used in this study, we could not properly register biking or roller-skating, and the girls were instructed to remove the monitor for any water activities.

Although no universally accepted analog to the *R* squared has been developed to date for mixed models, a formula developed by Snijders and Bosker[28] indicates that our final model only explains about 5% of the variation in nonschool MW-MVPA. This calculation does not adjust for the number of parameters in the model, however, and may consequently underestimate the proportion of variance explained.

CONCLUSIONS

Because it is the number and proximity of objectively measured facilities that are most directly related to adolescent girls perceiving them, future studies should incorporate both of these dimensions in their analyses. Given that our study is cross-sectional, we cannot determine whether higher levels of physical activity result in heightened perceptions of easy access or whether heightened perception of easy access to recreational resources yield higher levels of physical activity among adolescents. Nevertheless, a reasonable test would be to raise the profile of existing parks, schools, and commercial facilities that support physical activity and to examine whether this results in more active residents.

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