

Physical Activity Resource Attributes and Obesity in Low-Income African Americans

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ABSTRACT *More than two thirds of Americans are overweight or obese, and African Americans are particularly vulnerable to obesity when compared to Caucasians. Ecological models of health suggest that lower individual and environmental socioeconomic status and the built environment may be related to health attitudes and behaviors that contribute to obesity. This cross-sectional study measured the direct associations of neighborhood physical activity resource attributes with body mass index (BMI) and body fat among low-income 216 African Americans (Mean (M) age= 43.5 years, 63.9% female) residing in 12 public housing developments. The Physical Activity Resource Assessment instrument measured accessibility, incivilities, and the quality of features and amenities of each physical activity resource within an 800-m radius around each housing development. Sidewalk connectivity was measured using the Pedestrian Environment Data Scan instrument. Ecological multivariate regression models analyzed the associations between the built environment attributes and resident BMI and body fat at the neighborhood level. Sidewalk connectivity was associated with BMI ($M=31.3 \text{ kg/m}^2$; $p<0.05$). Sidewalk connectivity and resource accessibility were associated with body fat percentage ($M=34.8\%$, $p<0.05$). Physical activity resource attributes and neighborhood sidewalk connectivity were related to BMI and body fat among low-income African Americans living in housing developments.*

KEYWORDS *Obesity, Built environment, Physical activity resources (PARs), BMI, Public housing, African Americans*

INTRODUCTION

As obesity prevalence reaches epidemic proportions,¹ health promoters and researchers have begun to explore environmental influences on obesity.² Obesity continues to be more prevalent among individuals with lower socioeconomic status (SES),³ and the health of American racial minorities is lower than the general population, even after adjusting for SES.⁴ Recent studies and ecological models of health behavior suggest that environmental factors may be important to facilitate health behaviors^{2,5-7} and improve health outcomes.⁸

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Ecological models of health incorporate intra- and extra-individual influences that may influence individual behaviors at multiple levels^{6,9} and provide researchers with innovative opportunities for health intervention.¹⁰ Intra-individual influences include factors like genetics, gender, and race or ethnicity. Extra-individual influences include environmental factors like physical activity resources (PARs), sidewalks, and trails. In particular, an obesogenic environment encourages excessive caloric consumption and physical inactivity¹¹ and includes macro-, exo-, meso-, and micro-environmental dimensions.^{5,6,12} The micro-environments are the settings where individuals interact and include homes, work, parks, and schools.⁶ Earlier studies have examined these settings and revealed associations between them and obesity.^{8,13}

Neighborhood SES has also been associated with obesity prevalence among residents.¹⁴ Residents from lower SES neighborhoods display higher obesity prevalence as compared to residents of higher SES neighborhoods¹⁵ and often contain lower-quality built environments leading to poor health behaviors and outcomes.^{16–18} Lower-SES neighborhoods may also have a decreased number of PARs or low PAR *density*.^{19,20} Lower PAR density has been associated with physical inactivity²¹ and thus may contribute to higher obesity prevalence and higher body mass indexes (BMIs) in low-income neighborhoods.⁸

Neighborhood safety and esthetic appeal also have been associated with obesity prevalence.⁸ For example, neighborhoods with many *incivilities* may influence residents' perceptions and health behaviors related to obesity.²² An incivility reflects unsociable behavior and is manifest as an environmental attribute that would deter PAR use. Incivilities include vandalism, litter, unattended dogs, auditory annoyances, and other factors. PAR *amenities* are additional resource conveniences (e.g., bathrooms, picnic tables, lighting), whereas *features* are facilities used for primarily physical activity (e.g., exercise stations, swimming pool, soccer field).²³ When compared to quantity, the quality of amenities and features has been a better predictor of health outcomes like obesity.⁸ Furthermore, Hoehner et al. found that urban adults, who perceived their neighborhood to have more attractive features, were more likely to engage in recommended recreational physical activity, suggesting a link between neighborhood resource quality and residents' BMI.²⁴

Accessibility, a measure of whether a PAR is free or pay for use, has been shown to be a significant determinant of obesity prevalence rates, especially for low-SES neighborhood residents.⁸ Estabrooks et al. found that low- and medium- SES neighborhoods had significantly fewer free-for-use resources than did high-SES neighborhoods.¹⁹ Particularly for low-SES neighborhoods where residents are typically classified as low-income, decreased accessibility to PARs could hinder PAR use and contribute to an obesogenic environment. Although previous literature suggests that low-SES neighborhoods have fewer accessible PARs, it is uncertain how this relationship affects BMI among residents.

Another important built environment feature and predictor of health behaviors is *sidewalk connectivity*. Sidewalk connectivity is the total number of connections of one sidewalk to other sidewalks on each side of a street segment and suggests a designated pathway for pedestrians to follow in traversing areas of the street primarily designated for vehicles.²⁵ A street segment can be defined as a road or path located between the intersections of two or more streets. Street segment features, like sidewalk connectivity, have been associated with higher amounts of physical activity for local neighborhood residents^{21,26} which could, in turn, be associated with BMI among residents. In addition, sidewalk connectivity can also provide increased

access to a PAR. Because leisure time and transportation resources are often limited for low-income populations, connected sidewalks can provide a more efficient, feasible, and safe means of travel to PARs, saving time and providing additional opportunities for physical activity. Furthermore, higher PAR accessibility⁷ and street-connected PARs²⁷ have been associated with higher levels of physical activity suggesting a possible link between sidewalk connectivity and other health outcomes, like BMI.

Earlier studies propose that neighborhood PARs and their attributes and the built environment are important determinants of health behaviors that contribute to obesity.^{8,28} Heinrich and her colleagues found significant relationships in the built environment and BMI, specifically for street connectivity, resource accessibility, amenity prevalence, and quality.⁸ Although several studies have associated aspects of the built environment with physical activity, these linkages to the health outcome of BMI have not been well defined. The purpose of this study was to measure direct associations of PAR attributes (density, accessibility, incivilities, feature, and amenity quality) and sidewalk connectivity with BMI and body fat in low-income African Americans residing in public housing developments. We hypothesized that neighborhoods containing more accessible PARs with lower incivilities, higher-quality features and amenities, and increased sidewalk connectivity would be associated with lower BMIs and body fat percentages among residents.

METHOD

Design

Both aggregate neighborhood-level and individual-level cross-sectional data were collected in the Healthful Options Using Streets and Transportation in Our Neighborhoods (HOUSTON) Project, conducted in a large southern metropolitan city.

Sample

Neighborhoods. Our neighborhood sample consisted of 12 housing developments in Houston, TX that were mapped using geographic information systems (GIS) technology in the spring of 2005. The residents of the housing developments were predominantly African American and tended to have a lower educational attainment and incomes.²⁹ Residents qualified for residence in public housing by meeting income eligibility limits set by Office of Housing and Urban Development as percentages of the local area median income.^{28,30} For the purpose of measuring exposure to environmental determinants of overweight and obesity, neighborhoods for the 12 housing developments were each defined using GIS technology as the area within an 800-m radius surrounding the housing development. Defining neighborhoods as this region captures all areas to which a resident may be exposed to on a daily basis both on foot and vehicle.³¹ Selected neighborhoods did not overlap geographically, so that PAR and street segment features might not influence residents of another neighborhood.

Participants. The resident sample included African American housing development residents who were 18 years of age or older, ambulatory and English literate as determined by a questionnaire. Houston housing development residents were predominantly African American (78%), and housing developments had an average

of 800 residents.³⁰ For each housing development, management staff and the research team partnered to recruit an on-site assistant to help recruit and retain residents for the study. On site assistants were paid for the recruitment of participants at their development, and participants were paid for the completion of study procedures. Before participating in the project, all prescreened participants signed an informed consent approved by the University of Houston's Institutional Review Board. Residents were recruited via flyers, an on-site assistant, and resident management prior to assessment day.

Measures

Neighborhoods. Each PAR was counted and assessed using the Physical Activity Resource Assessment instrument (PARA; publicly available at <http://www.hhp.uh/undo/>).²³ The PARA has demonstrated good interrater reliability ($\kappa \geq 0.77$) in previous urban neighborhood assessments.^{8,23} The PARA was used to categorize each resource into one of seven types (fitness club, sport facility, community center, school, park, church, trail) or a combination and assign measures of accessibility (e.g., free = accessible, pay = not accessible). Twelve incivilities were rated using an operational classification on a four-point scale (e.g., 0 = none, 1 = some, 2 = medium, 3 = excessive) and included examples like unattended dogs, litter, and no grass. The quality of PAR features designed for physical activity (i.e., exercise stations, swimming pool, etc.) and amenities (e.g., bathrooms, picnic tables, lighting) were objectively rated using operational definitions on a three-point scale (i.e., 1 = poor, 2 = mediocre, and 3 = good).²³ Sidewalk connectivity was measured for all 12 neighborhoods using the Pedestrian Environmental Data Scan.²⁵

Participants. In order to objectively assess overweight and obesity, BMI and body fat percentage were measured for each participant. Trained research assistants conducted the following measurements for each participant: height, using a portable stadiometer (Seca 225 Hite Mobile Measuring Device; North Bend, WA, USA), and weight and body fat percentage, using a bioimpedance monitor with scales (TBF-310 and TBF-300; Tanita Corporation, Chicago of America, Arlington Heights, IL, USA). Individual BMI was calculated using the ratio of weight to height to indicate overweight (25–29.9 kg/m²) and obesity (≥ 30 kg/m²). Obesity prevalence was described as a percentage for each housing development.

Procedures

Neighborhoods. PARs were identified via an internet search, vehicle windshield survey, and GIS data match for the area within an 800-m radius around each housing development. Physical address and map location were then determined for each PAR. Each PAR was counted for the neighborhood density calculation (number of PARs within 800-m radius around the housing development) and assessed. Using GIS data, each neighborhood street segment was located, and sidewalk connectivity was measured for every segment within each 800-m radius.

Participants. The HOUSTON project director and team members visited each of the 12 housing developments several times to recruit and assess volunteer residents. Each participant was provided a complimentary physical assessment and summary

of his or her measured BMI, blood pressure, and resting heart rate and completed an interviewer-administered health questionnaire.

Statistical Analysis

Our initial sample included 219 participants. BMI measurement was refused for six, resulting in 213 complete cases for analyses. Descriptive and inferential analyses were performed using SPSS version 16.0 (SPSS, Inc, Chicago, IL, USA.)

To determine the relationship among environmental factors and BMI, two types of models were considered for the analyses: hierarchical and ecological. To determine which model was more appropriate, preliminary analyses were performed. Because of the lack of variance in neighborhood resident BMI and body fat among housing developments, intraclass correlation coefficients were unable to be calculated, suggesting that ecological analyses were more appropriate. In addition, one-way analysis of variance was conducted using housing development ($N=12$) as the independent variable with BMI as the dependent variable. Means did not vary by housing development ($F(1, 11)=1.2, p=0.81$), suggesting that BMI did not vary as a function of housing development membership. Results suggested that ecological analyses were more appropriate.

Ecological analyses have been used to assess the effect of the built environment on health outcomes at the population level.^{8,23} Ecological analyses aggregate the variables within each neighborhood to the neighborhood level ($N=12$). Thus, analyses reflect the relationship between the aggregated individual weight status variables for each housing development and the aggregated environmental variables in each housing development neighborhood. All independent variables (PAR density, accessibility, incivilities, feature and amenity quality, and sidewalk connectivity) were initially entered into a regression model with BMI as the outcome. Tests for required regression assumptions were conducted, and all criteria were met.

Factors were systematically eliminated using the backward method to create the model that accounted for the most variance. Earlier built environment studies have used the backward method as it is most appropriate for independent variables that may demonstrate multicollinearity, capitalizing on their shared predictive power in studies of obesity prevalence and other population health outcomes.^{8,27}

RESULTS

Demographics, BMIs, Overweight, and Obesity Prevalence

All of our participants were African American residents and qualified for residence in low-income public housing based on Houston Housing Authority guidelines.²⁹ Participants' ages ranged from 18 to 86 years with a mean age of 43.4 (standard deviation (SD)=17.12). Most (63.8%, $N=139$) of the participants were female (participant characteristics are presented in Table 1).

The average BMI for all participants was 31.3 kg/m² (SD=8.7) with 47.1% ($N=101$) of the participants having a BMI of 30 kg/m² or higher and classified as obese. Combined percentages of overweight and obesity were 73% ($N=157$) across all of the housing developments.

TABLE 1 Housing development residents demographics, body fat percentages, and BMIs

ID	Sample	Age (SD)	% Female	Body fat % (SD)	BMI (SD)	% Obese	% Overweight
1	23	42 (3.1)	78.3	35.4 (2.8)	32.6 (2.0)	56.5	17.4
2	25	35 (2.6)	52.0	30.9 (2.9)	29.5 (1.4)	44.0	28.0
3	22	35 (2.4)	72.7	34.4 (2.3)	30.4 (1.7)	50.0	22.7
4	26	50 (2.4)	61.5	34.3 (2.5)	30.5 (1.9)	46.2	19.2
5	8	38 (5.1)	87.5	39.8 (4.3)	31.8 (2.4)	50.0	37.5
6	19	37 (3.8)	73.7	35.1 (3.5)	31.4 (2.4)	47.4	21.1
7	9	72 (2.2)	33.3	28.9 (3.8)	29.4 (1.5)	33.3	22.2
8	14	71 (1.6)	42.9	34.9 (3.5)	31.9 (2.6)	50.0	21.4
9	18	40 (3.2)	55.6	37.1 (3.1)	34.4 (2.8)	55.6	27.8
10	14	49 (3.7)	64.3	41.2 (2.8)	33.9 (2.3)	57.1	28.6
11	12	50 (3.5)	75.0	34.1 (2.8)	28.6 (1.8)	25.0	41.7
12	26	32 (2.7)	69.2	34.2 (2.8)	31.2 (1.6)	50.0	23.1
Total/range		18-84					
Mean (SD)	216	43.5 (17.1)	63.8	34.8 (12.9)	31.3 (8.7)	47.1	25.9

Level of analysis: neighborhood (N=12). Standard deviations are in parentheses

Physical Activity Resources and Sidewalk Connectivity

A total of 105 resources were identified and assessed in the 12 neighborhoods. PAR density for each housing development ranged from 2 to 18 ($M=8.8$, $SD=5.5$) with four neighborhoods containing five or fewer PARs and one neighborhood containing 18 PARs. Most (89%) of the resources were accessible (no cost for use). Although one neighborhood had only 25% accessible PARs, all other neighborhoods contained 75% or more PARs that were accessible. Mean incivilities per resource ranged from 0.3 to 9.5 with a mean of 5.9 ($SD=2.8$) per PAR. For both features and amenities that were found, mean ratings were 2.2 ($SD=0.3$), and the number of neighborhood sidewalk connections per segment ranged from 1.7 to 5.0 ($M=2.8$, $SD=0.9$; neighborhood characteristics are presented in Table 2).

Bivariate Associations of Neighborhood Factors with BMI and Body Fat

Bivariate analyses were conducted for all environmental variables with BMI and body fat. Both BMI ($r=0.610$, $p<0.05$) and body fat percentage ($r=0.745$, $p<0.01$) were significantly positively associated with sidewalk connectivity. No other bivariable correlations were significant.

Multivariate Model Predicting Neighborhood BMI and Body Fat Percentage

Multivariate models are presented in Tables 3 and 4. Each model was tested accounting for gender and age. Thirty-seven percent of the variance in average neighborhood BMI was accounted for by sidewalk connectivity ($F(1, 10)=5.9$, $p=0.035$; see Table 3). PAR accessibility and sidewalk connectivity positively predicted body fat percentage ($F(2, 9)=8.4$, $p=0.009$) accounting for 65% of the variance. No other PAR attributes were significant predictors of BMI or body fat percentage.

DISCUSSION

We hypothesized that neighborhoods with less PAR density, accessibility, feature and amenity quality, sidewalk connectivity, and more incivilities would have residents with higher BMIs and body fat percentages. Our hypothesis was not confirmed for any of these PAR attributes, except accessibility, although sidewalk connectivity was positively associated with higher BMIs and body fat for residents. Consistent with previous reports,^{23,27} women residing in these neighborhoods had higher BMIs than men.

Although unexpected, our findings were unique as we found that higher neighborhood sidewalk connectivity predicted *higher* BMIs and body fat for housing development residents. Higher PAR accessibility also predicted higher body fat percentages, but no other PAR attribute was significantly associated with BMI or body fat. A similar study found that higher PAR feature ratings predicted lower BMIs in African American housing development residents,⁸ but our findings differed considerably. Although sidewalk connectivity was associated with BMIs and body fat, these correlations were positive, suggesting other unexamined, yet important, relationships between neighborhood characteristics and body composition may exist.

Seventy-five percent of our housing developments were located in zip codes where the most common locations for crimes were sidewalks or streets.³² With such a high percentage of crimes taking place on neighborhood streets and sidewalks,

TABLE 2 Physical activity resource attributes and segment connectivity by housing development

ID	Density	% Accessible	Total neighborhood incivilities	Average incivilities/resource	Average feature quality ^a	Average amenity quality ^b	Sidewalk Connectivity
1	6	100	33	5.5	2.3	2.8	2.6
2	3	100	28	9.3	2.1	2.0	1.7
3	8	100	58	7.3	2.1	2.3	3.4
4	18	94	119	6.6	2.4	2.0	2.6
5	17	88	39	2.3	2.0	2.1	3.2
6	8	75	29	3.6	1.8	1.8	1.7
7	4	25	1	0.3	1.7	2.0	2.3
8	2	100	19	9.5	2.7	2.2	3.0
9	5	100	30	6.0	2.4	2.2	3.2
10	14	86	108	7.7	2.5	2.6	5.0
11	13	100	62	4.8	2.2	2.2	2.4
12	7	100	52	7.4	2.3	2.1	2.3
Total	105		578				
Mean (SD)	8.8 (5.5)	89 (21.7)		5.9 (2.8)	2.2 (0.3)	2.2 (0.3)	2.8 (0.9)

Level of analysis: neighborhood (N=12). Standard deviations are in parentheses

^aAverage feature quality was indicated by operational definitions of available features used for physical activity rated on a three-point scale of 1 "poor", 2 "mediocre", or 3 "good"

^bAverage amenity quality was indicated by operational definitions of available amenities rated on a three-point scale of 1 "poor", 2 "mediocre", or 3 "good"

TABLE 3 Ecological multivariate linear regression coefficients for neighborhood BMI

Variable	β	Beta	<i>t</i> test	Sig
Sidewalk connectivity	1.208	0.610	2.435	0.035
Constant	27.947		19.414	0.000

$$R^2=0.372, F(1, 10)=5.928, p=0.035$$

unsafe communities could be discouraging residents to use sidewalks or travel to existing PARs, regardless of existence or quality. Unsafe neighborhoods can discourage physical activity,^{12,33} potentially contributing to higher BMIs for a population who may have fewer leisure time opportunities and fewer available transportation resources when compared to higher SES populations. Furthermore, each neighborhood had an average of almost six incivilities per PAR, suggesting that, regardless of high PAR accessibility and sidewalk connectivity, there are several reasons to *not* visit a PAR or use highly connected sidewalks.

Our sample was also unique in that both neighborhood and individual SES were lower for all 12 housing developments, potentially suggesting a restricted range. Because of the lack of SES variability among neighborhoods and residents, these built environment associations may be unique to our population. A strength of these data is that the potentially confounding factor of individual choice of residence is removed, as public housing residents typically have little choice as to their residential assignment. Future studies could include analyses of higher-SES neighborhoods and other ethnicities in order to generalize to broader populations; however, then the factor of choice of residence must be considered.

Data were collected using direct and detailed, reliable and established environmental measurement instruments and protocols. The PARA has been well established in earlier studies.^{23,27} We assessed *every* street segment within each neighborhood, creating one of the most comprehensive data sets available to investigate the pedestrian environment. BMI and body fat were directly measured (vs. self-report), helping to reduce error due to self-reporting biases.

Limitations and Recommendations. This study was cross-sectional in nature, and future studies are needed to incorporate a temporal relationship and also account for other individual variables (e.g., perceived safety, crime rates, psychological factors) that could affect health behaviors and outcomes.

Although our study did not aim to measure this, future studies are needed to objectively measure physical activity at each neighborhood PAR and sidewalk. Future research should also address how various attributes and sidewalk features

TABLE 4 Ecological multivariate linear regression coefficients for neighborhood body fat percentage

Variable	β	Beta	<i>t</i> test	Sig
Accessibility	0.48	0.312	1.574	0.150
Sidewalk connectivity	2.655	0.706	3.560	0.006
Constant	23.386		7.178	0.000

$$R^2=0.652, F(2,9)=8.415, p=0.009$$

affect PAR use and access and the specific mechanisms of how these factors relate to neighborhood residents' BMI and body fat. Additional environmental variables to be measured include neighborhood residents' perceptions of the PAR attributes and sidewalk connectivity. Positive perceptions of environmental features have been associated with increased health outcomes like more physical activity and lower rates of obesity.³⁴ Future studies could include these perception variables and compare perceived vs. actual neighborhood attributes in order to develop a more comprehensive environmental analysis. Results should only be applied to low-income, Southern, urban housing development populations and not to the general public.

Implications. In summary, these data add to earlier findings, suggesting that built environment attributes can affect BMI and body fat using direct environmental measurement. Although sidewalk connectivity and PAR accessibility predicted higher BMIs and body fat, these data do not necessarily suggest that built environment is not associated with lower BMIs and improved health outcomes. Additional neighborhood characteristics like neighborhood perceived safety and crime rates should be considered when conducting built environment studies in low SES neighborhoods. Our findings suggest that, regardless of increased PAR accessibility and sidewalk connectivity, other important neighborhood factors could be affecting residents' health attitudes and behaviors. The link between the environment and obesity is complex and significant. More research is desperately needed for this underserved population in order to investigate and understand additional neighborhood factors that can contribute to obesity. Community leaders must consider the association between the built environment and obesity in low SES areas when passing and/or enforcing public policies (e.g., increasing police surveillance, sidewalk and park maintenance) in order to treat and prevent obesity in this highly vulnerable population, and an evidence base must be developed to guide these decisions.

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