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Is the Environment Near Home and School Associated with Physical Activity and Adiposity of Urban Preschool Children?

Gina S. Lovasi, Judith S. Jacobson, James W. Quinn, Kathryn M. Neckerman, Maxine N. Ashby-Thompson, and Andrew Rundle

ABSTRACT *Preventing sedentary behavior and adiposity in childhood has become a public health priority. We examined urban social and built environment characteristics as correlates of physical activity and anthropometry among 428 preschool children from low-income families in New York City. We measured the children's height, weight, skinfold thicknesses, physical activity by accelerometer, and covariates. We geocoded home and Head Start center addresses and estimated the following for an area within 0.5 km of those two locations using a detailed geographic database: neighborhood composition, walkability, crime and traffic safety, and aesthetic characteristics. Generalized estimating equations were used to examine the associations of area characteristics with physical activity or adiposity, adjusted for characteristics of the child, mother, and home. Participants were 2–5 years old, 53% female, 83% Hispanic, and 43% either overweight or obese. Of the walkability indicators, land use mix was associated with physical activity (26 more activity counts/minute per standard deviation increase in mixed land use, $p=0.015$) and subway stop density was associated with adiposity (1.2 mm smaller sums of skinfold thicknesses sum per standard deviation increase in subway stop density, $p=0.001$). The pedestrian–auto injury rate, an indicator of traffic safety problems, was associated with physical activity and adiposity (16 fewer activity counts/minute, $p=0.033$, and 1.0 mm greater skinfold thickness per standard deviation increase in pedestrian–auto injuries, $p=0.018$). Children living in areas with more street trees were more physically active and those living in areas with more park access had smaller skinfolds. However, many of the tested associations were not statistically significant and some trends were not in the hypothesized direction. Efforts to enhance walkability, safety, and green spaces in the local environment may be relevant to physical activity and adiposity, and therefore to the health of preschool-aged children from low-income families.*

KEYWORDS *Built environment, Safety, Physical activity, Accelerometer, Overweight, Obesity*

Lovasi, Jacobson, and Rundle are with the Department of Epidemiology, Mailman School of Public Health, Columbia University, New York, NY, USA; Quinn is with the Institute for Social and Economic Research and Policy, Columbia University, New York, NY, USA; Neckerman is with the Center for Health and the Social Sciences, University of Chicago, Chicago, IL, USA; Ashby-Thompson is with the Department of Health and Behavior Studies, Teachers College, Columbia University, New York, NY, USA.

Correspondence: Gina S. Lovasi, 722 W 168th St., 8th Floor, Room 804, New York, NY 10032, USA. (E-mail: gl2225@columbia.edu)

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Strategies to promote childhood physical activity are becoming a public health priority,[1,2] both because an active lifestyle has direct health benefits,[3–6] and because physical activity plays a role in preventing obesity.[7,8] Childhood activity patterns may be particularly important if they persist into adulthood. One proposed strategy involves making structural changes in the environments within which children live,[9] especially in areas where children have the greatest risk of sedentary behavior patterns, obesity, and related chronic diseases.[10]

The characteristics of the environment that influence physical activity and body size may be similar for young children and their parents. A child's body size is strongly correlated with his or her parents' body size,[11,12] and parental weight change predicts childhood weight change.[13,14] Very young children depend on an adult to take them out and bring them home. Thus, the local environment may influence childhood physical activity to the extent that it encourages or discourages parental walking or other activity with the child, or affects parental perceptions of the safety and attractiveness of outdoor play.

In particular, walkable urban form, safety, and aesthetic amenities in the built environment may support physical activity among young children and subsequently help to prevent excess weight and adiposity. Walkable urban form, characterized by high population density, land use mix, and connectivity of streets and transit systems, has been associated with walking for transportation, lower body mass index (BMI) among adults,[15–19] and active commuting to school.[20,21] Those characteristics make walking a practical way to visit neighbors, stores, and other destinations. Transit opportunities (subway stops and bus stops in our study) fit into this concept of walkability because transit and walking are complementary travel modes. Accessibility of transit means that transit stops are near enough to the trip origin and destination to be reached by walking at each end of the trip.[22] Neighborhood safety, which has also been linked with adult physical activity,[23] may be an especially important determinant of activity opportunities for young children.[21,24,25] Safety concerns may be a particularly strong constraint on physical activity at early ages and in disadvantaged urban populations.[26–29] Finally, aesthetic amenities may encourage walking and other physical activity by providing activity venues and pleasant scenery.[30–32] We selected aesthetic characteristics that may signal whether a place is safe and appropriate for young children: high traffic volume, filthy sidewalks, and vacant housing are expected to discourage childhood physical activity, while trees, parks, and playgrounds are expected to encourage active play.

Evaluating the role of the environment in young children's physical activity and adiposity requires reliable and unbiased measures. Young children are not considered to reliably report their own physical activity, and parental reports may be subject to social desirability bias[33] or based on incomplete information.[34] Height and weight alone have been shown to have limited value as indicators of children's adiposity; skinfold thicknesses may be more informative about the health-relevant aspects of body size. Similarly, parental reports of neighborhood characteristics may have limited accuracy. Previous studies of neighborhood characteristics that relied on parental reports have found associations with physical activity, but have not been consistently replicated in studies that use geographic information systems (GIS) data.[20] Although GIS databases can miss important information about the subjective experience of an environment, errors in environment measures based on GIS data are less likely to be correlated with outcome measurement errors than those based on self-report.[35]

We used accelerometer-based physical activity measures, standardized anthropometry, and GIS data on the built environment near home and preschool to investigate associations of environmental characteristics with physical activity and adiposity among preschool children in low-income families in New York City. Our hypothesis was that children who live and attend Head Start in areas with greater walkability (higher population density, more mixed land use, and a higher density of subway and bus stops), better safety (lower homicide rates and fewer pedestrian-auto accidents), and a more favorable balance of unattractive (traffic volume, fewer sidewalks, and vacant homes) and attractive (street trees, parks, and playgrounds) aesthetic features will be more physically active and leaner than other children.

METHODS

Study Population and Setting

New York City Head Start enrollees were recruited to participate in this study between 2003 and 2005.[36,37] Head Start is a preschool program for children of low-income families. Although the study was designed primarily to examine the determinants of asthma prevalence and severity, the data also provide an opportunity to investigate geographic patterns related to childhood physical activity and anthropometry in a vulnerable urban population.

Head Start centers were selected for recruitment based on the neighborhood's childhood asthma burden (approximately 15% prevalence or higher among children entering the public school system);[38] of 50 centers in which we recruited, 41 were represented in the analytic dataset for this paper (Figure 1). A description of the study was presented to parents in both English and Spanish. At the time of study enrollment, the child's guardian (usually mother) provided informed consent and was interviewed. During home visits, conducted approximately 6 months after initial enrollment, the child's height, weight, and skinfold thicknesses were measured and physical activity assessment was initiated.

Physical Activity and Anthropometry Measures

Study staff placed Acti-Watch accelerometers (Philips Respironics, Bend, OR, USA) on the wrist of the nondominant hand of each child, and asked the parents to leave the accelerometer on the child's wrist for the next week.[36] The validity of the Acti-Watch for capturing youth physical activity compares favorably to that of other motion sensors and is rated moderate-to-good for preschool-aged children.[39] Activity counts indicating the intensity of physical activity were recorded for 1-minute epochs. Accelerometer data were then summarized for the entire 6-day period, including an estimation of the mean activity counts per minute during waking hours.

During the home visit, the child was weighed on a portable Seca electronic scale and height was measured using a portable Seca stadiometer (Seca, Hamburg, Germany). Height and weight were used to calculate a BMI z-score based on a comparison with Centers for Disease Control and Prevention (CDC) growth charts for children of the same age and sex.[40] BMI z-scores were categorized into normal weight (<85th percentile), overweight (85th to 94th percentile), and obese (95th percentile and above). Triceps and subscapular skinfolds were measured three times with Lange calipers; the sum of skinfolds was the sum of the means of the three measurements at each of these two sites. The sum of skinfold thicknesses was highly

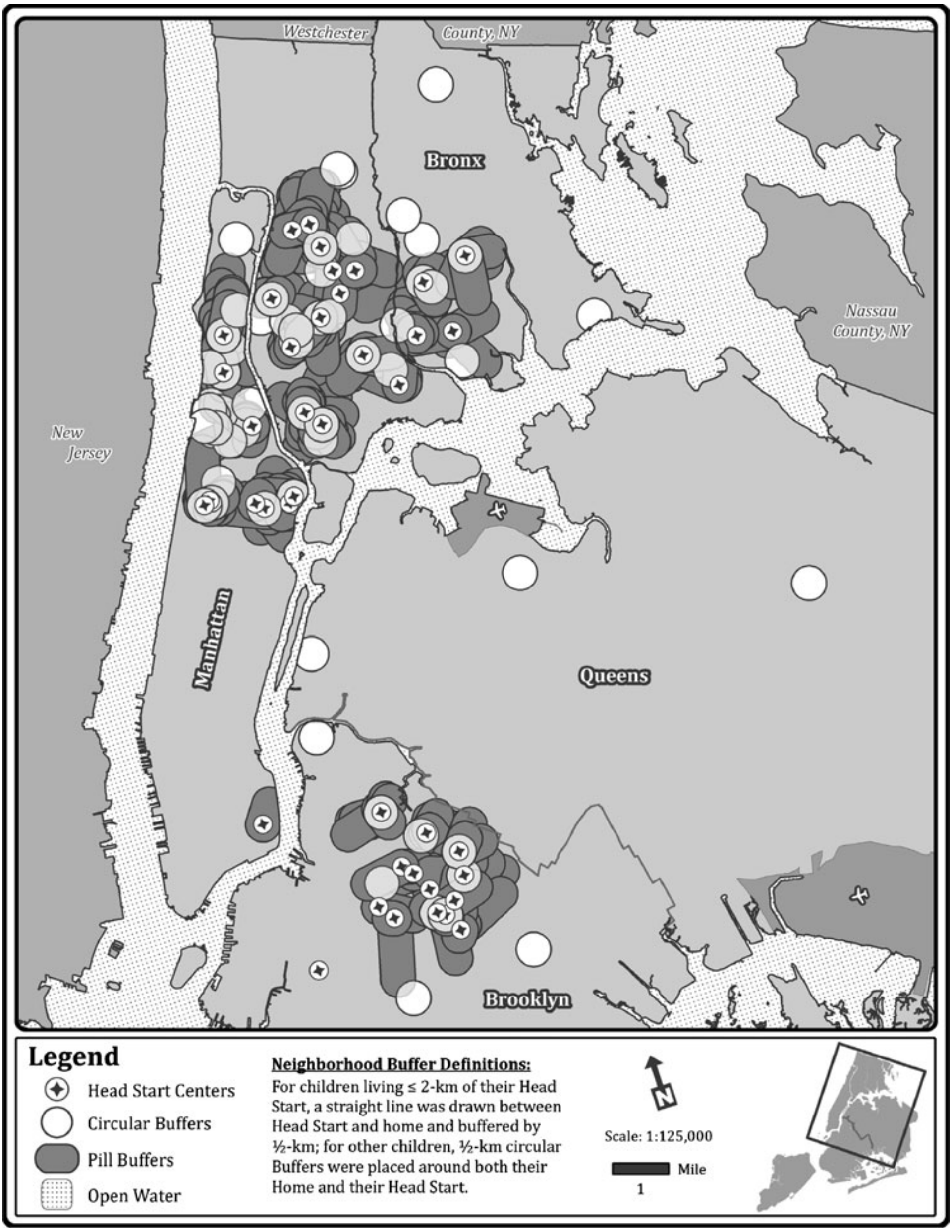

FIGURE 1. Neighborhoods defined as 0.5-km buffers around participant addresses and Head Start centers (N=428). For 381 children living within 2 km of their Head Start center, a pill-shaped buffer was drawn around the straight line between home and preschool; for the remaining 47 children, circular buffers were drawn around both home and preschool.

correlated with tricep and subscapular skinfold thicknesses (r=0.93 and 0.94, respectively), and moderately correlated with BMI z-score (r=0.64).

Physical and Social Environment Measures

Home addresses, collected at the time of the home visit, and Head Start center locations were geocoded using Geosupport, a Windows®-based software package maintained and published by the New York City Department of City Planning's Information Technology Division. Geosupport is the most accurate method for building-level geocoding in New York City. ArcGIS, version 9.3.1, was used for all geospatial analysis (ESRI, Redlands, CA, USA).

To define each child's neighborhood, we drew a straight line between the child's home and Head Start center addresses. For the 381 children (89%) living less than 2 km from their Head Start center, we defined the neighborhood as the area within a 0.5-km buffer around the line (Figure 1). For the 47 children (11%) who lived more than 2 km from their Head Start center, we defined the neighborhood as the circular areas within a 0.5-km buffer around each of the two addresses. All bodies of water were excluded from these neighborhood buffers.

For each buffer, measures of neighborhood composition, walkable urban form, safety, and aesthetic features were constructed. Compositional characteristics (proportion of individuals below the federal poverty line, proportion reporting their race as black, and proportion foreign born) and population density (residents per square kilometer) were estimated using census data from the year 2000, Summary File 3. Proportion below poverty and reporting black race were expected to predict higher adiposity, while percent foreign born was expected to predict lower adiposity, based on national patterns of obesity prevalence[41,42] and the idea that local social norms are important determinants of body size.[43] Data from census block groups within or intersecting the neighborhood buffers were combined using a clipped and area-weighted mean. Population density was also calculated using census block group data. Land use mix was constructed using the parcel-level Primary Land Use Tax Lot Output dataset, available from the Department of City Planning, with a scale of 0 (single land use) to 1 (an even mix of residential and commercial land uses).[44] The densities of subway and bus stops for the years 2007 and 2004, respectively, were calculated using data provided by the New York City Metropolitan Transportation Authority. Intersection density was calculated using the street centerline GIS layer from the New York State Accident Location Information System. These compositional and walkability-related characteristics have been previously linked to adult body size in New York City.[16]

Crime safety was assessed using the average number of homicides per resident. The danger to pedestrians from nearby traffic was estimated using the New York State Department of Transportation data on number of pedestrian–auto injuries. Homicide and pedestrian injury locations for the years 2003–2005 were recorded and geocoded based on the exact incident location or the nearest street intersection, respectively. Daily traffic volume was estimated based on combining US Census Bureau Feature Class Codes with data assembled by TeleAtlas from federal, state, county, and city departments. Project Scorecard data from the Mayor's Office of Operations were used to estimate the proportion of sidewalks rated as "filthy" within New York City Sanitation Sections. Census data were used to estimate the proportion of homes that were vacant. Street tree density was calculated from the City of New York, Parks and Recreation's 2005–2006 Street Tree Census. Park access and playground access were estimated based on the proportion of land area covered, using 2003–2005 data provided by the New York City Department of Parks and Recreation.

Statistical Analysis

General estimating equations with robust variance estimates were used to examine the associations of each neighborhood characteristic with physical activity counts, BMI *z*-score, and skinfold thicknesses. Neighborhood characteristic variables were standardized, such that one unit was equal to 1 standard deviation regardless of the original scale, to facilitate comparisons.

The final models included adjustment for potential confounders using characteristics of the child (age, sex, and race/ethnicity), mother (age, birth outside of the USA, use of Spanish, and employment/student status), and number of rooms in the home as well as neighborhood characteristics; physical activity models also included adjustment for the total number of hours recorded as awake and for season (using a dichotomous variable, defined previously for this population).[36] Season was also used to stratify the sample for subgroup analyses; accompanying p values were based on Wald tests for adding a single interaction term to the main analysis. Participants with missing covariate data (n=23) were excluded. All generalized estimating equation models accounted for the clustering of children within Head Start centers and were run in Stata 10.0 (Stata Corp., College Station, TX, USA).

RESULTS

This study included 428 Head Start enrollees, ages 2–5 years, with interview, accelerometry, and anthropometry data. Approximately half were female and 83% were Hispanic. Most participants lived in Brooklyn, the Bronx, and Northern Manhattan (Figure 1). Based on their BMI z-scores, 22% met the CDC criteria for obesity, and another 21% were overweight (Table 1). For comparison, 10% of the nationally representative National Health and Nutrition Examination Survey study participants in this age group were considered obese by these criteria in the year 2000.[45]

Children living in areas with more poor, black, or foreign-born residents were more physically active and had lower adiposity than children living in other areas (Tables 2 and 3), but only the positive association of percent foreign born with physical activity was statistically significant; for each standard deviation increase in the proportion of residents born outside the USA, children accumulated a mean of 33 more activity counts per minute throughout the 6 days of observation.

Of the neighborhood walkability indicators previously shown to predict adult BMI in New York City,[16,46] only land use mix and subway stop density were associated with activity or adiposity (Tables 2 and 3). An increase of 1 standard deviation in land use mix was associated with 26 more activity counts per minute (Table 2). The other associations between walkability indicators and activity counts had confidence intervals that included zero. The confidence intervals for subway stop density and intersection density had upper bounds of eight and nine activity counts per minute, respectively, for each standard deviation increase in density, apparently precluding strong positive associations. Subway stop density was associated with less adiposity (Table 3) as indicated by a trend toward lower BMI z-scores and statistically significant lower skinfold thicknesses (1.2 mm decrease for each standard deviation increase in subway stop density). In contrast, the coefficients for the associations of bus stop density with adiposity were positive and their confidence intervals precluded a strong association in the expected direction.

Of the safety and aesthetic characteristics selected for their potential relevance to physical activity, pedestrian injuries, street trees, and park access all had statistically significant associations in the expected direction with at least one outcome (Tables 2 and 3). Children living in areas with a higher pedestrian–auto injury rate were less physically active (16 fewer activity counts per minute for each standard deviation increase in pedestrian-auto injuries) and had greater skinfold thicknesses (an

TABLE 1 Demographic and neighborhood characteristics of study participants in a study of preschool-aged children from low-income families in New York City

	Total	Normal (BMI below 85th percentile)	Overweight (BMI 85th to 94th percentile)	Obese (BMI at or above 95th percentile)
	N=428	*N*=242	*N*=92	*N*=94
Child's characteristics				
Age, years	4.0 (0.5)	4.0 (0.5)	3.9 (0.5)	4.0 (0.6)
Sex, % female	53%	54%	47%	54%
Race or nationality, %				
Non-Hispanic black	11%	12%	12%	7%
Mexican	36%	35%	36%	38%
Dominican	23%	21%	26%	24%
Puerto Rican	8%	10%	4%	9%
Mixed or other Hispanic nationalities	16%	16%	15%	18%
Other	6%	7%	7%	3%
Maternal and household characteristics				
Mother's age, years	30 (6)	30 (6)	31 (6)	31 (6)
Mother born in New York City, %	21%	23%	20%	17%
Mother employed/student, %	44%	44%	48%	43%
Mother speaks Spanish at home, %	33%	35%	34%	27%
Rooms in home	3.9 (1.0)	3.9 (1.0)	3.9 (1.1)	3.9 (1.1)
Neighborhood composition				
Proportion below federal poverty line	0.38 (0.07)	0.39 (0.07)	0.38 (0.07)	0.38 (0.07)
Proportion black	0.36 (0.17)	0.38 (0.19)	0.36 (0.16)	0.32 (0.11)
Proportion foreign born	0.31 (0.10)	0.31 (0.11)	0.32 (0.10)	0.32 (0.10)
Walkability indicators				
Population density, thousands of residents/km^2	3.0 (0.9)	3.0 (0.9)	3.0 (0.9)	2.9 (1.0)
Land use mix (theoretical range: 0–1)	0.41 (0.20)	0.39 (0.19)	0.41 (0.20)	0.43 (0.23)
Subway stop density, stops/km^2	1.7 (1.0)	1.7 (1.0)	1.7 (0.9)	1.6 (1.0)
Bus stop density, stops/km^2	39 (11)	38 (11)	39 (10)	39 (12)

TABLE 1 (continued)

	Total	Normal (BMI below 85th percentile)	Overweight (BMI 85th to 94th percentile)	Obese (BMI at or above 95th percentile)
	N=428	*N*=242	*N*=92	*N*=94
Intersection density, count/km^2	69 (10)	68 (10)	70 (10)	69 (10)
Safety and aesthetic characteristics				
Homicides/thousand residents	0.11 (0.05)	0.11 (0.05)	0.11 (0.05)	0.10 (0.04)
Pedestrian-auto injuries/thousand residents	1.4 (0.4)	1.4 (0.4)	1.4 (0.4)	1.4 (0.4)
Traffic volume, thousands of vehicles/day	11 (3)	11 (3)	11 (3)	11 (3)
Proportion of sidewalks rated as filthy	0.014 (0.010)	0.014 (0.010)	0.013 (0.009)	0.014 (0.010)
Proportion vacant housing	0.068 (0.024)	0.069 (0.026)	0.07 (0.02)	0.06 (0.02)
Street tree density, thousands of trees/km^2	0.80 (0.24)	0.81 (0.25)	0.79 (0.24)	0.77 (0.24)
Park access, proportion of land area	0.087 (0.058)	0.088 (0.060)	0.086 (0.057)	0.086 (0.054)
Playground access, proportion of land area	0.017 (0.009)	0.017 (0.009)	0.016 (0.007)	0.017 (0.008)
Child's physical activity and anthropometry				
Mean activity counts/minute	685 (147)	690 (147)	673 (135)	683 (160)
BMI Z-score	0.80 (1.28)	0.0 (1.0)	1.3 (0.2)	2.4 (0.7)
Sum of skinfold thicknesses, mm	17 (6)	14 (3)	17 (4)	24 (8)

TABLE 2 Regression coefficients and 95% confidence intervals for associations between neighborhood characteristics and physical activity counts per minute (by accelerometry) among preschool-aged children from low-income families in New York City, with stratification by season of measurement

	Physical activity counts per minute		
	Total sample $N=428$	Warmer season (May to September) $N=153$	Cooler season (October to April) $N=275$
Neighborhood composition			
Proportion below federal poverty line	19 (−2 to 41)	−9 (−51 to 33)	24 (−8 to 56)
Proportion black	16 (−12 to 43)	29 (−23 to 81)	29 (−11 to 69)
Proportion foreign born	**33 (2 to 63)**	41 (−8 to 90)	40 (0 to 81)
Walkability indicators			
Population density	−9 (−39 to 22)	−15 (−48 to 18)	1 (−49 to 50)
Land use mix	**26 (6 to 46)**	13 (−26 to 51)	**43 (15 to 71)**
Subway stop density	−12 (−32 to 8)	2 (−21 to 25)	−11 (−45 to 23)
Bus stop density	13 (−13 to 39)	18 (−15 to 52)	2 (−29 to 32)
Intersection density	−11 (−30 to 9)	34 (−1 to 69)	**−28 (−54 to −1)**
Safety and aesthetic characteristics			
Homicide rate	4 (−21 to 28)	−11 (−55 to 32)	13 (−19 to 44)
Pedestrian-auto injury rate	**−16 (−30 to −2)**	−14 (−46 to 18)	−16 (−35 to 4)
Traffic volume	15 (−41 to 70)	**119 (21 to 217)**	−49 (−129 to 31)
Proportion of sidewalks rated as filthy	7 (−15 to 29)	37 (−9 to 82)	−5 (−39 to 30)
Proportion vacant housing	−6 (−35 to 23)	4 (−47 to 56)	−24 (−63 to 15)
Street tree density	**24 (1 to 46)**	8 (−33 to 50)	**39 (9 to 69)**
Park access	−11 (−29 to 7)	4 (−18 to 25)	−18 (−49 to 14)
Playground access	12 (−14 to 37)	16 (−22 to 54)	16 (−10 to 42)

Values shown are regression coefficients (95% confidence intervals) for standardized environmental variables (rescaled, standard deviation=1); area characteristics are for neighborhood buffers, drawn as 0.5-km buffers around a line between the child's home and school; all models were adjusted for characteristics of the child (age, sex, and race/ethnicity), mother (age, born outside of the USA, use of Spanish, employed/student status), household (number of rooms), the total number of hours recorded as awake, the time of year, and all of the neighborhood characteristics listed; bold font is used to indicate statistical significance ($p \leq 0.05$).

additional 1.0 mm for each standard deviation increase in pedestrian–auto injuries) than those living in safer neighborhoods. Children living in areas with more street trees were more physically active (24 additional activity counts per minute for each standard deviation increase in street tree density), and those living in areas with more park access had smaller skinfolds (a decrease of 1.0 mm for each standard deviation increase in park access) than those living in areas with fewer trees or less park access. Other safety and aesthetic characteristics considered did not significantly predict physical activity or adiposity in this sample, and in some cases our confidence intervals allowed us to exclude a strong association in the expected direction. In particular, the confidence interval for vacant housing as a predictor of skinfold thicknesses had an upper bound that rounded to zero; while not reaching statistical significance, this casts considerable doubt on the hypothesized positive association.

Because the associations between neighborhood environment characteristics and physical activity may depend on the season of measurement, we conducted a

TABLE 3 Regression coefficients and 95% confidence intervals for associations of neighborhood characteristics with measures of adiposity among preschool-aged children from low-income families in New York City

	Adiposity	
	BMI *z*-score	Sum of skinfolds
Neighborhood composition		
Proportion below federal poverty line	−0.14 (−0.40 to 0.13)	−0.5 (−1.3 to 0.3)
Proportion black	−0.39 (−0.81 to 0.04)	−0.8 (−2.2 to 0.5)
Proportion foreign born	−0.09 (−0.51 to 0.32)	−0.5 (−2.1 to 1.1)
Walkability indicators		
Population density	−0.08 (−0.38 to 0.22)	−0.1 (−1.1 to 1.0)
Land use mix	−0.11 (−0.38 to 0.17)	−1.1 (−2.4 to 0.2)
Subway stop density	−0.16 (−0.33 to 0.01)	**−1.2 (−1.9 to −0.5)**
Bus stop density	0.10 (−0.09 to 0.30)	0.5 (−0.1 to 1.1)
Intersection density	0.05 (−0.12 to 0.22)	−0.5 (−1.3 to 0.3)
Safety and aesthetic characteristics		
Homicide rate	0.04 (−0.19 to 0.26)	−0.6 (−1.3 to 0.1)
Pedestrian-auto injury rate	0.00 (−0.18 to 0.19)	**1.0 (0.2 to 1.7)**
Traffic volume	0.22 (−0.40 to 0.83)	0.0 (−2.8 to 2.8)
Proportion of sidewalks rated as filthy	0.22 (−0.05 to 0.48)	0.3 (−0.7 to 1.3)
Proportion vacant housing	−0.15 (−0.42 to 0.12)	−0.7 (−1.4 to 0.0)
Street tree density	−0.05 (−0.24 to 0.15)	−0.6 (−1.4 to 0.2)
Park access	−0.04 (−0.19 to 0.11)	**−1.0 (−1.9 to −0.1)**
Playground access	0.03 (−0.23 to 0.29)	−0.3 (−1.2 to 0.7)

Values shown are regression coefficients (95% confidence intervals) for standardized environmental variables (rescaled, standard deviation = 1); area characteristics are for neighborhood buffers, drawn as 0.5 km buffers around a line between the child's home and school; all models were adjusted for characteristics of the child (age, sex, and race/ethnicity), mother (age, born outside of the USA, use of Spanish, employed/student status), household (number of rooms), all of the neighborhood characteristics listed, and, for physical activity only, the total number of hours recorded as awake and the time of year; bold font is used to indicate statistical significance ($p \leq 0.05$); $N = 428$

secondary analysis stratified by season of physical activity measurement. The association between land use mix and physical activity remained statistically significant among children whose physical activity was measured during the cooler months of the year (Table 2). In the same winter subgroup, greater street connectivity (higher intersection density) was associated with less physical activity (contrary to our hypothesis). Street tree density was positively associated with physical activity in this subgroup. Among children whose physical activity was measured during the warmer months, higher estimated traffic volume was associated with more activity counts. The only statistically significant interaction observed with season was for street connectivity ($p = 0.020$).

DISCUSSION

Investigations of the environmental correlates of physical activity have recently turned attention to vulnerable subgroups such as young children or the socio-economically disadvantaged.[20,29,47,48] Our study adds to this literature by investigating such associations in a population of young children from low-income families. While previous studies have reported correlations between land use mix,[49,50] subway stop density,[51] safety,[21,24,25,27] vegetation,[30] or parks[31,32] with youth physical activity or adiposity, our results examine these associations in a high-risk urban subgroup with detailed outcome measurement using accelerometry and anthropometry. In this cohort of preschool-age children from low-income families in New York City, several measures of neighborhood composition, walkability, pedestrian safety, and greenness were correlated with physical activity or adiposity. We found that mixed land use, subway stops, pedestrian safety, street trees, and parks all had statistically significant associations with either greater mean activity count or smaller skinfold thicknesses, as hypothesized. However, several of our hypotheses were not supported (e.g., those involving intersection density, physical disorder as indicated by filthy sidewalks and vacant housing), and the confidence intervals around some of the coefficients were narrow enough to exclude a large association in the expected direction.

Characteristics of the neighborhoods in which children live and attend school may influence their opportunities to spend time outdoors and to use active transportation modes, such as walking. Children are more physically active when outdoors than indoors,[52] and children who walk or bike to school are more active than children who travel by other means.[53,54] However, other contexts, such as the indoor home[55] or school environment,[56–58] may also influence physical activity at early ages. The social context, including local norms about body size, is also likely to influence activity and adiposity; indeed, local norms may be responsible for our finding that living in a neighborhood with more immigrants predicts lower adiposity.[42]

As the literature on how environments affect physical activity and adiposity grows, interactions between environment characteristics have been noted. For example, Liu and colleagues reported an association between vegetation and youth body weight that was stronger in more densely populated areas.[59] We explored potential interactions between the neighborhood environment characteristics and season of physical activity measurement. In addition, examining associations within distinct populations and settings, such as our population of young children in a low-income urban environment, can add to a broader understanding of effect modification across the published literature.[29] Analyzing modification of associations by variables such as season or subpopulation may not only help to different findings across studies, but may also inform causal inference. Associations between neighborhood factors and physical activity that are consistent throughout the year may point to self-selection, if the associations are hypothesized to depend on the seasonal presence of barriers such as heat or inclement weather. For example, the presence of street trees might be hypothesized to encourage physical activity by providing shade in the summer; however, we found that the association between street trees and physical activity tended to be stronger in the cooler months, calling this hypothesis into question. Likewise, bias due to self-selection may be particularly strong among adults and advantaged social groups who have greater power to match their environment to their preferences;[60] associations that persist within situations of constrained residential choice may increase our confidence in causal inference.

Strengths and Limitations

Strengths of the present study include the range of built environment measures considered and the novel use of a buffer surrounding two locations (home and school) to characterize an activity space regularly experienced by preschool-aged children. Another strength is the use of outcome assessment methods (accelerometry and anthropometry) that were precise and independent of the geographic measures. Our skinfold-based measure of adiposity may be more sensitive to the influence of the neighborhood environment than the more common BMI *z*-score which was not associated with any of the neighborhood characteristics considered. A final strength is our focus on a vulnerable population: young children from low-income families, most of whom were of Hispanic ethnicity, in an urban setting.

The latter strength is also a limitation. The study participants were not representative of preschool-age children nationwide or even in New York City, and the sample came mainly from neighborhoods with high childhood asthma prevalence. Although robust standard errors were used to account for clustering of children within Head Start centers, we did not assess the Head Start centers themselves. The centers vary in indoor and outdoor space and in the opportunities they provide for physical activity, and those variations may affect children's activity and adiposity.[56] Although we examined interactions between the built environment and season of accelerometry, we had limited power to detect statistically significant effect modification. Finally, given the cross-sectional and observational nature of this research, chance and bias from unmeasured confounders should be considered as alternative explanations for the findings.

CONCLUSIONS

This study contributes to the existing literature on neighborhood characteristics and childhood obesity by (1) introducing a novel way to define local environments that includes the area near both home and school, and (2) testing hypotheses about walkability, safety, and aesthetic characteristics as determinants of physical activity and adiposity in a vulnerable population. We find that some neighborhood environment characteristics may be relevant to physical activity and adiposity among preschool-age children. In particular, mixed land use, subway stops, pedestrian safety, street trees, and parks all had statistically significant associations with either activity counts or skinfold thicknesses in the expected direction; however, the three other walkability indicators and five other safety and aesthetic measures were not associated with any outcome except for associations with activity in the unanticipated direction after stratifying by season. Future investigations with larger samples, more variation in the exposures of interest, or longitudinal study designs have the potential to strengthen the basis for causal inference regarding these associations.

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