Availability of Recreational Resources and Physical Activity in Adults

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Objectives. Using data from a large cohort of adults aged 45 to 84 years-old, we investigated whether availability of recreational resources is related to physical activity levels.

Methods. Data from a multiethnic sample of 2723 adult residents of New York City, NY; Baltimore, Md; and Forsyth County, NC, were linked to data on locations of recreational resources. We measured the availability (density) of resources within 0.5 (0.8 km), 1, 2, and 5 miles of each participant's residence and used binomial regression to investigate associations of density with physical activity.

Results. After adjustment for potential confounders, individuals in the tertile of participants residing in areas with the highest density of resources were more likely to report physical activity during a typical week than were individuals in the lowest tertile. Associations between availability of recreational resources and physical activity levels were not present for the smallest area assessed (0.5 miles) but were present for areas ranging from 1 to 5 miles. These associations were slightly stronger among minority and low-income residents.

Conclusions. Availability of resources may be 1 of several environmental factors that influence individuals' physical activity behaviors. (*Am J Public Health.* 2007;97:493–499. doi:10.2105/AJPH.2006.087734)

The growing attention to obesity as a public health problem has generated interest in how features of residential environments, including the built environment, influence physical activity.[1–3] A parallel body of work has shown that neighborhood socioeconomic characteristics are related to cardiovascular risk, even after control for individual socioeconomic indicators.[4,5] The extent to which these associations are causal and the processes through which neighborhood effects might be mediated remain subjects for research. Availability of physical activity resources is 1 mechanism postulated to explain neighborhood differences in cardiovascular risk.

Past work on residential environments and physical activity has been hampered by limited data on the specific features of residential environments that may be relevant.[6] A growing body of recent work has begun to measure features of the physical environment using survey data as well as objective measures of the location of recreational facilities.[7] The presence of a positive association between objective availability of resources and physical activity would suggest that improving spatial access to resources is an appropriate strategy to increase population levels of activity.

Evidence on whether availability of physical activity resources is an important predictor of physical activity behavior is mixed.[8–22] Although important, existing research has focused largely on simple measures, such as distance to selected facilities or number of facilities within a given area,[8–10,13–19,22] that do not account for the resources offered at a particular location. In addition, these studies have viewed space as discrete areas rather than a continuous field. Questions remain regarding the relevant spatial scale and sensitivity of empirical results to different spatial scales.

Using data from a large, multiethnic cohort of adults aged 45 to 84 years-old, we investigated associations between objective measures of the availability of recreational resources and physical activity. We used geographic information system methods to quantify the density (per area and per population) of physical activity resources weighted by the number and types of activities available at each location. We hypothesized that greater availability of recreational resources would be associated with a greater probability of residents being physically active. Because individual characteristics may result in individuals being more or less dependent on local resources, we also investigated whether any associations observed differed according to individual-level income or race/ethnicity.

In the absence of an a priori theory on how the distance one must travel to access recreational resources affects one's use of those resources, we explored areas ("windows") of different sizes (0.5 miles [0.8 km], 1 mile, 2 miles, and 5 miles) around each person's home. Our a priori assumption was that, within a window of a given size, resources closer to one's residence would have more effect on physical activity than those further from one's residence. Therefore, kernel densities (which assign more weight to resources closer to one's residence than those closer to the boundary of the window) were our primary measure of resource availability. However, in addition, we examined whether results differed when simple densities (which assume equal effects of all resources located within the window) were used. Although the presence of a resource may affect physical activity regardless of the number of people who reside in the area, the presence of a larger population also implies more competition for the resources available. We therefore examined whether our results differed when density of resources was calculated in terms of population or simply in terms of area.

METHODS

Study Sample and Individual-Level Data

The Multi-Ethnic Study of Atherosclerosis (MESA) was a longitudinal study of cardiovascular disease conducted at 6 study sites.[23]

The MESA Neighborhood Study, an ancillary MESA investigation on which the present analyses were based, collected additional information on neighborhood characteristics among participants residing in 3 of the 6 sites: Baltimore, Md; New York City, NY; and Forsyth County, NC. At each of the 3 sites, a sample of more than 1000 participants was selected through a variety of population-based approaches. Only those participants free of clinical cardiovascular disease were eligible. Non-Hispanic White and non-Hispanic Black participants were recruited at all 3 sites; Hispanic participants were recruited only at the New York site. Baseline MESA visits, from which our analyses were derived, took place between July 2000 and September 2002.

A semiquantitative questionnaire adapted from the Cross-Cultural Activity Participation Study[24] was used to collect data on physical activity. In our analyses, we focused on the types of activities that we hypothesized would be linked to density of recreational resources: (1) team sports (e.g., softball, volleyball, basketball, soccer), (2) dual sports (e.g., tennis, racquetball, paddleball), (3) individual activities (e.g., golf, bowling, yoga, tai-chi), and (4) moderate- or heavy-effort conditioning activities (e.g., aerobics, bicycling, running, jogging, rowing, swimming, judo, karate). Participants who reported that they engaged in any of these 4 types of activities during a typical week were categorized as physically active. In some analyses, information on total number of minutes per week spent engaging in these activities was also used.

Data on covariates (age, gender, race/ethnicity, income, and perceived neighborhood violence) were obtained from the baseline MESA examination as well. Race and ethnicity were classified using questions from the US census. Family income was grouped into 3 categories (less than $20 000, $20 000–$49 999, $50 000 or more). Participants rated the extent to which they perceived that violence was a problem in their neighborhood. Participants who reported that they exercised at least once a week were also asked about the frequency with which they exercised within 1 mile of their home. Home addresses for all participants were geocoded.

Data on Recreational Resources

We obtained information on the locations of private and public recreational facilities for all of Forsyth County, 30 zip codes in the city of Baltimore and in Baltimore County, and 30 zip codes in the Manhattan and Bronx boroughs of New York using online yellow page and Internet searches; in addition, we obtained information from departments of city planning and recreation and from geographic information system units. Facilities located on school or church property, trails not located within parks or recreational facilities, and private facilities located in hotels or apartment buildings were not included. Information on whether a facility required a fee for its use was inferred from the type of facility or verified through Web searches and telephone calls. Data were collected between April 2003 and June 2004.

The types of resources available at each facility or park were recorded, and 48 different types of resources were identified. The distribution of these resources by broad types is shown in Table 1. Information on counts (of tracks, roller and ice skating rinks, skate parks, pools, tennis courts, racquetball or squash courts, general sports fields, and baseball, cricket, and football fields) was obtained for some types of resources. By summing the total number of resources (weighted by the count when appropriate), we obtained variables for each point location or park that represented the total number of resources available at that location. In the case of parks, we

TABLE 1—Characteristics of Study Sites: Multi-Ethnic Study of Atherosclerosis, 2003–2004

	Baltimore, Md	Forsyth County, NC	New York City, NY
Total no. of census tracts	276	75	334
Total population	996 617	306 067	1 695 989
Total area, sq mi	241.5	409.6	26.0
Population density per mi^2	4 127	747	65 230
Race/ethnicity, %			
Non-Hispanic White	44.3	66.1	26.3
Non-Hispanic Black	49.6	25.2	24.2
Hispanic	1.8	6.4	43.6
Other	4.2	2.3	5.9
Total no. of nonpark facilities	199	115	185
Total no. of parks[a]	172	70	166
Median acreage of parks (25th–75th percentile)	4.9 (1.2–17.2)	17.5 (8.3–34.9)	1.6 (1.0–4.8)
No. of resources available	758	457	885
Team sports, %[b]	39.2	27.1	27.9
Dual sports, %[c]	4.6	11.6	16.8
Running areas, %[d]	4.1	11.6	2.8
Water activities, %[e]	6.6	7.4	5.1
Tai-chi, pilates, yoga, martial arts, %	15.6	12.0	19.3
Aerobics, cardiovascular equipment, weight training, %	18.7	16.6	21.0
Gymnastics and dancing, %	4.0	4.4	4.1
Skating, skiing, %	1.7	1.1	0.5
Golf, %	3.0	4.6	0.7
Other, %[f]	2.5	3.5	1.8

Note. All data except data on facilities and parks were derived from the 2000 US census.
[a]Parks were defined according to the definitions used by parks and recreation departments at each site. Ornamental parks were not included.
[b]Baseball, football, basketball, and so on.
[c]Tennis, boxing, fencing, and so on.
[d]Tracks and trails.
[e]Pools, beaches, canoeing, and so on.
[f]Bowling, cricket, wall climbing, and so on.

assumed that any resources were evenly distributed in space over the park.

We estimated the density of recreational resources in windows of varying size around each participant's residence. We calculated densities by dividing total number of resources by area of the window. We used kernel estimation[25] in our calculations, so resources located closer to participants' residences were given more weight than those located further from their residences, with the weight approaching 0 at the boundary of the window. The weights followed a bivariate normal (Gaussian) distribution.[25] The density measures thus obtained (henceforth referred to as kernel densities) can be interpreted as the number of resources available per 1000 hectares (1 hectare = 10 000 m^2).

For comparison purposes, we also estimated simple densities by dividing the count of resources by the area of the window without assigning more weight to resources located closer to participants' residences. To obtain resource density estimates adjusted for population density, we divided the resource density value by a population density value for the same window.[26] We estimated population density using block population data and an approach identical to that used for recreational densities. These population-adjusted densities can be interpreted as number of resources per 100 000 population.

When the area for which density was estimated for a given participant fell partly outside the geographic areas for which data were collected, we applied a correction factor according to which we assumed that densities for the unobserved area were identical to those in the observed area. The percentages of participants for whom 80% of the density window was in the study area were 96%, 92%, and 77% for the 1-mile, 2-mile, and 5-mile windows, respectively. We estimated densities separately for team and dual sports, conditioning, and individual activities and then summed them to obtain an overall activity density measure. We also estimated densities separately for facilities with and without use fees.

Statistical Analyses

A total of 2742 MESA neighborhood study participants lived within the geographic areas for which physical activity resource data were collected. Of these individuals, 19 were excluded because they had missing physical activity data, leaving 2723 participants for the analysis. Population-adjusted densities were divided into 3 groups based on tertiles derived from the full sample. We used binomial regression to calculate relative prevalences of physical activity by density categories adjusted according to age, gender, race/ethnicity, and individual-level income.[27] We used stratified analyses and included interaction terms in models to examine effect measure modification (multiplicative interaction).

We assessed associations between density and the amount of activity reported by physically active participants using linear regression analyses in which logged weekly minutes of reported activity was the outcome. We repeated selected analyses using kernel densities unadjusted for population density. We used site-specific tertiles (instead of full-sample tertiles) in these analyses because of the large differences in densities observed across sites when population density was not taken into account. Also, as mentioned, we repeated selected analyses using simple densities. All *P* values reported were derived from 2-tailed tests.

RESULTS

The total number of nonpark facilities and parks was similar in Baltimore and New York City, but both were less common at the North Carolina study site, which was a larger, less densely populated area (Table 1). The most common resources available at all 3 sites were team sports resources (27%–39% of all activities across sites), followed by aerobics/cardiovascular equipment/weight training activities (17%–21%).

Overall, 45% of participants were younger than 65 years, and 46% were men (Table 2). The racial/ethnic composition of the sample was roughly similar to that of the geographic

TABLE 2—Characteristics of Study Participants: Multi-Ethnic Study of Atherosclerosis, 2003–2004

	Baltimore, Md (n = 907)	Forsyth County, NC (n = 911)	New York City, NY (n = 905)
65 y or older, %	48.8	43.4	42.2
Men, %	47.7	46.7	43.4
Race/ethnicity, %			
Non-Hispanic White	49.5	55.7	20.2
Non-Hispanic Black	50.5	44.1	34.3
Hispanic	0.0	0.2	45.3
Household income, $, %			
< 20 000	17.2	11.4	25.0
20 000–49 999	35.8	31.9	43.7
≥ 50 000	43.0	47.3	29.9
Unknown	4.0	9.3	1.4
Reported activity during past week, %			
All activities	42.1	48.6	36.2
Team and dual sports	4.7	4.5	3.8
Individual activities	12.9	18.9	7.5
Conditioning	32.5	38.6	31.5
Reported exercising within 1 mi of home, %[a]	57.7	53.7	79.6
Fee activities,[b] median %	41.9	45.7	41.1

Note. Team and dual sports included baseball, cricket, football, tennis, racquetball, soccer, boxing, basketball, and volleyball; individual activities included golf, skating, bowling, yoga, and tai chi; conditioning activities included swimming, aerobics classes, and weight training.

[a]Participants who reported that they exercised within 1 mile of their home all or at least half of the time. The denominator was physically active participants who exercised outside of their home.

[b]Percentage of total resource density corresponding to resources that required a fee. Calculated only for cases in which the density was above 0 (95% of participants).

area from which each sample was drawn. Moderate- and heavy-effort conditioning activities were the most common activities reported (34.2% of participants overall). Other individual activities (13.1% of participants) and team or dual sports activities (4.3% of participants) were less common. These patterns were consistent across the 3 sites, with the exception of a lower prevalence of individual activities in New York. Of the study participants who reported being physically active outside of their home, a majority (64%) reported that they exercised within 1 mile of their home all or at least half of the time.

Median recreational densities within 1 mile of each participant's home were substantially higher in New York than in the 2 other study areas (data available from authors). Density of recreational resources was positively correlated with population density, with the correlation increasing as the size of the window increased (Spearman correlation coefficients were 0.79, 0.82, 0.86, and 0.89 for the 0.5-, 1-, 2-, and 5-miles windows, respectively). Differences across sites were less pronounced when recreational densities were standardized to population (total activities per 100 000 people 64.3, 117.5, and 80.5 in Maryland, North Carolina, and New York, respectively). At all 3 sites, the highest population-adjusted densities were documented for team and dual sports activities, and the lowest densities were observed for individual activities. Resources provided by facilities requiring a fee represented 40% to 45% of total resources, depending on the site.

Table 3 shows physical activity prevalence ratios (PRs) by sociodemographic characteristics and tertiles of population-adjusted densities. Participants in the tertile with the highest density of resources were significantly more likely to report engaging in physical activities during a typical week than those in the lowest tertile (PR=1.14; 95% confidence interval [CI]=1.03, 1.26). In addition, when analyses were restricted to individuals who reported that they exercised regularly, density of recreational resources within a 1-mile radius was positively associated with the probability of exercising within 1 mile of one's residence all or most of the time (Table 3).

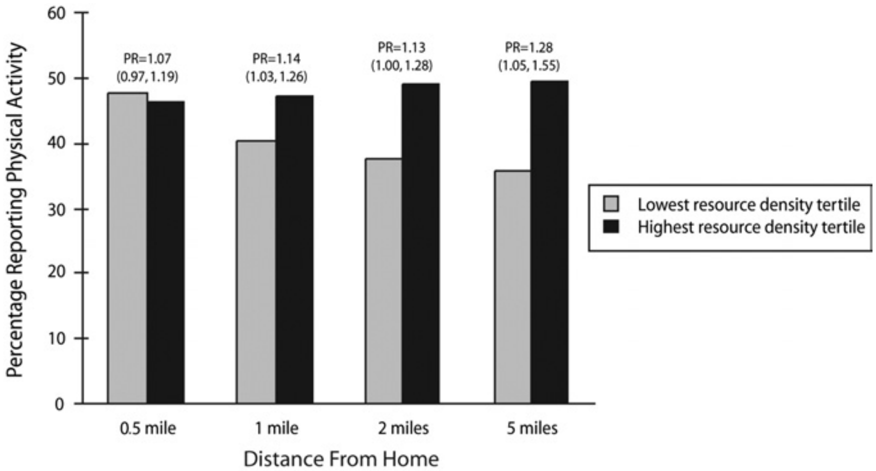
TABLE 3—Prevalence Ratios of Physical Activity, by Individual-Level Characteristics and Resource Densities: Multi-Ethnic Study of Atherosclerosis, 2003–2004

	Prevalence Ratio (95% Confidence Interval)	
	Physically Active[a]	Exercising Within 1 mi of Home[b]
Gender		
Women	0.83 (0.76, 0.91)	1.11 (1.00, 1.23)
Men	1.00	1.00
Age, y		
45–54	1.09 (0.93, 1.26)	0.92 (0.77, 1.10)
55–64	1.07 (0.92, 1.24)	1.05 (0.89, 1.24)
65–74	1.05 (0.91, 1.22)	1.01 (0.86, 1.18)
75–84	1.00	1.00
Race/ethnicity		
Hispanic	0.69 (0.57, 0.84)	0.90 (0.77, 1.06)
Non-Hispanic Black	0.85 (0.77, 0.93)	0.88 (0.79, 0.99)
Non-Hispanic White	1.00	1.00
Household income, $		
< 20 000	0.54 (0.45, 0.65)	1.06 (0.90, 1.25)
20 000–49 999	0.81 (0.73, 0.90)	1.07 (0.95, 1.20)
≥ 50 000	1.00	1.00
Site		
Forsyth County, NC	1.04 (0.94, 1.16)	0.96 (0.83, 1.10)
New York City, NY	1.07 (0.95, 1.21)	1.29 (1.13, 1.47)
Baltimore, Md	1.00	1.00
Perceived neighborhood violence problem		
Yes	0.82 (0.73, 0.92)	1.07 (0.95, 1.19)
No	1.00	1.00
Resource density category[c]		
Highest	1.14 (1.03, 1.26)	1.19 (1.04, 1.35)
Middle	1.06 (0.95, 1.18)	1.20 (1.06, 1.36)
Lowest	1.00	1.00

Note. Models included all variables shown.
[a]Defined as engaging in team or dual sports, or moderate- or heavy-effort conditioning activities at least once a week (see "Methods" for examples of activities in each category).
[b]Refers to probability of exercising within 1 mile of one's residence all or most of the time. Restricted to individuals who reported exercising (walking for exercise, going for a jog or swim, participating in sports or exercise classes, or using training equipment or machines) at least once a week (n = 1702).
[c]Adjusted for population density. Distributions of participants across density tertiles, from lowest to highest, were as follows: 51.0%,16.4%, and 32.6% in North Carolina; 24.4%, 47.3%, and 28.3% in New York; and 24.4%, 36.5%, and 39.1% in Maryland.

Kernel densities and unweighted simple densities were highly correlated (Spearman correlations were 0.96 or 0.97 for the 4 windows), and hence results were similar when unweighted simple densities were used. Density of resources was positively associated with physical activity for windows ranging from 1 mile to 5 mile (Figure 1). With the exception of the 5-mile window, similar results were obtained when resource densities were not adjusted for population density (in comparisons of the lowest and highest site-specific resource tertiles, prevalence ratios were 1.15 [95% CI=1.04, 1.27] for 1 mile, 1.15 [95% CI=1.04, 1.27] for 2 miles, and 1.06 [95% CI=0.96, 1.18] for 5 miles).

When associations between availability of recreational resources and physical activity were investigated separately for nonfee and fee resources, associations appeared to be present only for fee resources (in comparisons of the top and bottom density categories for nonfee and fee resources, respectively, prevalence



Note. Results for the 5-mile window were virtually identical when analyses were restricted to individuals for whom 95% or more of the window was in the study area.
[a]Adjusted for age, gender, race/ethnicity, household income, site, and perceived neighborhood violence; 95% confidence intervals are shown in parentheses.

FIGURE 1—Percentages of participants reporting physical activity and activity prevalence ratios (PR) by resource densities for windows of varying sizes: Multi-Ethnic Study of Atherosclerosis, 2003–2004.

ratios were 0.99 [95% CI=0.89, 1.09] and 1.17 [95% CI=1.05, 1.29] for the 1-mile window and 0.92 [95% CI=0.80, 1.05] and 1.38 [95% CI=1.18, 1.60] for the 5-mile window). Associations between availability of recreational resources and physical activity levels were stronger among low-income than high-income participants and stronger among non-Hispanic Black and Hispanic participants than among non-Hispanic White participants (Table 4), but this heterogeneity of associations was statistically significant ($P<.1$) only for race/ethnicity. Among those reporting activity, only 5-mile densities were positively associated with weekly minutes of activity (adjusted percentage differences in minutes for the top and middle tertiles vs the bottom tertile were 29% [95% CI=−2%, 71%] and 13% [95% CI=−4%, 33%], respectively).

DISCUSSION

In this adult sample, living in an area with a high density of recreational resources for team or dual sports, conditioning activities, and other individual activities was positively associated with participation in these activities (prevalence ratios ranged from 1.14 to 1.28 depending on window size). On the basis of the overall prevalence of activity in the sample (42.3%), these prevalence ratios represent absolute differences of 6 to 12 percentage points in the amount of people reporting physical activity. However, only densities for the 5-mile window were positively associated with the amount of time individuals reported being physically active.

Past work relating objective measures of the availability of recreational resources to physical activity has produced mixed results. In one of the first studies linking spatial accessibility of resources to physical activity, Sallis et al. documented a positive association between density of pay-per-use neighborhood facilities (defined in windows ranging in size from 1 to 5 km) and frequency of exercise among neighborhood residents.[9] Other studies have reported an inverse association between distance to resources such as bikeways or parks and use of these resources or physical activity levels.[8,10,13,21] Giles-Corti and Donovan[11] found only weak

TABLE 4—Adjusted Physical Activity Prevalence Ratios, by Categories of Resource Density Stratified According to Income and Race/Ethnicity: Multi-Ethnic Study of Atherosclerosis, 2003–2004

Area Density and Population Density Category	Full Sample (95%CI)	Participants With Incomes <$35 000 (95%CI)	Participants With Incomes ≥$35 000 (95%CI)	Non-Hispanic Blacks and Hispanics (95%CI)	Non-Hispanic Whites (95%CI)
1 mi					
Highest	1.14 (1.03, 1.26)	1.18 (0.92, 1.52)	1.13 (1.01, 1.26)	1.32 (1.12, 1.56)	1.04 (0.91, 1.19)
Middle	1.06 (0.95, 1.18)	1.14 (0.90, 1.45)	1.07 (0.94, 1.22)	0.98 (0.83, 1.16)	1.14 (0.98, 1.31)
Lowest	1.00	1.00	1.00	1.00	1.00
Interaction P[a]		.700		.001	
2 mi					
Highest	1.13 (1.00, 1.28)	1.37 (1.01, 1.85)	1.12 (0.98, 1.28)	1.32 (1.06, 1.65)	1.04 (0.89, 1.21)
Middle	1.09 (0.97, 1.23)	1.27 (0.99, 1.62)	1.08 (0.94, 1.24)	1.14 (0.95, 1.35)	1.05 (0.90, 1.23)
Lowest	1.00	1.00	1.00	1.00	1.00
Interaction P[a]		.300		.100	
5 mi					
Highest	1.28 (1.05, 1.55)	1.56 (0.97, 2.52)	1.27 (1.02, 1.57)	1.42 (0.99, 2.04)	1.25 (0.99, 1.58)
Middle	1.18 (1.05, 1.32)	1.21 (0.96, 1.54)	1.19 (1.04, 1.37)	1.07 (0.89, 1.28)	1.27 (1.07, 1.50)
Lowest	1.00	1.00	1.00	1.00	1.00
Interaction P[a]		.500		.070	

Note. CI = confidence interval. Models included gender, age (4 categories), survey site, race/ethnicity, and income (3 categories). Stratified models included all variables other than the stratification variable.
[a]Statistical test for heterogeneity of associations across strata.

and nonsignificant associations between access to natural and built facilities and physical activity among 1803 adults in Perth, Australia. Other studies have also documented null or weak associations between objective measures of availability of recreational resources and physical activity.[14,16,18,19]

Our study was unique in that we studied the relationship between a quantitative measure of the availability of specific types of resources (i.e., not simply the presence of facilities) and the probability that people reported physical activity. The use of a quantitative, objective measure (as opposed to participant reports) eliminated the possibility of same-source bias (i.e., physically active participants being more likely to report resources in their local area).

Associations appeared to be stronger among Hispanic and non-Hispanic Black participants than among non-Hispanic White participants, suggesting that certain groups may be more affected by local environmental features. Similar to earlier work by Sallis,[9] there was some evidence in our data that associations between density and physical activity were stronger for pay-per-use activities (or were present only for these activities); however, as a consequence of the limited cost data available, it is difficult to draw conclusions from this finding. The presence of a fee may simply be a proxy for facility quality and attractiveness.

Previous work examining the spatial accessibility of recreational resources has involved the use of measures such as presence of a facility within a given area or distance measure (e.g., distance to nearest park).[8–10,13–16,18,19,22] Giles-Corti and Donovan[11] used a measure based on the gravity model[28]; that is, they estimated distances from each residential location to all facilities within a bounded study area. In contrast, we estimated densities for windows of different sizes. Our approach did not create artificial boundaries implying barriers to movement from one area to the next. However, it did require establishing a window size beyond which the density was assumed to be 0 (just as the gravity model requires defining a boundary beyond which the distance decay parameter is 0).

The kernel density method also assigns within-window weights that decline following a bivariate normal distribution. A priori, we think that this is reasonable given that if space affects resource use, we would expect resources located close to one's residence to have a greater effect on one's physical activity than those located closer to the boundary of the window. Use of the kernel density method was recently proposed in studying the spatial accessibility of primary care services.[26] Our results did not vary substantially when kernel densities or simple densities were used, because of the very high correlations between the measures (all correlations were above 0.95). A limitation of our approach is that we did not account for transportation options and we used Euclidian distances rather than network distances.

There is scant information on how distance affects use of different types of recreational resources. Ideally, one would develop specific hypotheses about the size of the area that is relevant (which may vary for different types of resources) and collect data to test these hypotheses. In the absence of such a priori theory, studies must necessarily be exploratory. Our focus on the 1-mile window was consistent with the fact that the majority of physically active individuals in our sample reported using resources within 1 mile of their home; however, we also tested the sensitivity of our results to window size.

Giles-Corti and Donovan[11] allowed for the possibility that the relationship of distance to facility use differs for different types of facilities by including different distance decay parameters for different facility types in their analysis of Australian data. Unfortunately, we are not aware of any data on how distance affects use of the different types of facilities we investigated in the US context. As additional information becomes available, it will be possible to refine our method by estimating densities for windows of different sizes on the basis of knowledge regarding how far people are willing to travel to use different resources.

Associations between density of resources and physical activity levels were present for windows ranging from 1 to 5 miles. Our data did not allow us to investigate larger windows. The presence of associations even for relatively large windows is compatible with the notion that, in a car-oriented culture, resources spread over relatively large areas may be relevant to behaviors. A limitation of our analyses is that they were based exclusively on home residences and did not include information on availability of resources around work locations. Also, we had limited cost data and no data on quality or attractiveness of facilities.

Another complex issue is whether density of resources should be adjusted for population density. There is little information on how population density affects use of resources. The sites we studied differed substantially in population density and density of resources. We think it is unlikely that the much larger unadjusted densities in New York reflect better access; they may simply reflect the much greater concentration of people and things in space. For this reason, we chose to investigate population-adjusted densities using an approach similar to one recently proposed for the study of accessibility to medical services.[26]

We examined the sensitivity of our results to population adjustment and found that results were similar for all windows except the 5-mile window. In the case of that window, no associations were observed when densities were not adjusted for population. Unadjusted and population-adjusted estimates of resource densities were less correlated for the larger than for the smaller windows. Our results suggest that population adjustment may be necessary to detect effects of availability on physical activity, but more work is needed to understand whether or under what circumstances population density affects use of resources.

Spatial accessibility of physical activity resources appears to be a positive, albeit weak, predictor of activity levels. Improved theory and data on the ways in which distance affects use of different types of resources will allow testing of much more specific hypotheses regarding the relationship between density of resources and physical activity. Intervention studies are also needed to determine whether increased availability increases levels of physical activity. Other characteristics, including quality and attractiveness of resources as well as features of the built environment that facilitate the use of public spaces for walking and exercise, may be as relevant as or more relevant than pure spatial accessibility of resources. ■

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Contributors

A.V. Diez Roux drafted the article and conducted analyses. K.R. Evenson supervised data collection and assisted with the writing of the article. A.P. McGinn assisted with data collection and critically reviewed the article. D.G. Brown provided expertise on accessibility measures and critically reviewed the article. L. Moore assisted with data analyses and critically reviewed the article. S. Brines created geographic information system measures and critically reviewed the article. D.R. Jacobs, Jr, provided expertise on measurement of physical activity and critically reviewed the article.

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Human Participant Protection

The Multi-Ethnic Study of Atherosclerosis was approved by institutional review boards at the study sites. The analyses reported here were also approved by the University of Michigan institutional review board. All participants provided written informed consent.

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