The Association Between Neighborhood Characteristics and Body Size and Physical Activity in the California Teachers Study Cohort

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Objectives. We considered interactions between physical activity and body mass index (BMI) and neighborhood factors.

Methods. We used recursive partitioning to identify predictors of low recreational physical activity (<2.5 hours/week) and overweight and obesity (BMI≥25.0 kg/m²) among 118 315 women in the California Teachers Study. Neighborhood characteristics were based on 2000 US Census data and Reference US business listings.

Results. Low physical activity and being overweight or obese were associated with individual sociodemographic characteristics, including race/ethnicity and age. Among White women aged 36 to 75 years, living in neighborhoods with more household crowding was associated with a higher probability of low physical activity (54% vs 45% to 51%). In less crowded neighborhoods where more people worked outside the home, the existence of fewer neighborhood amenities was associated with a higher probability of low physical activity (51% vs 46%). Among non–African American middle-aged women, living in neighborhoods with a lower socioeconomic status was associated with a higher probability of being overweight or obese (46% to 59% vs 38% in high–socioeconomic status neighborhoods).

Conclusions. Associations between physical activity, overweight and obesity, and the built environment varied by sociodemographic characteristics in this educated population. (*Am J Public Health.* 2012;102:689–697. doi:10.2105/AJPH.2011.300150)

The prevalence of overweight and obesity has reached epidemic levels in the United States. The most recent national prevalence data report that 68% of US adults are overweight or obese.[1] This prevalence poses a significant public health problem given that obesity is a risk factor for many chronic conditions and certain cancers.[1–3] Because of the health benefits of physical activity in preventing and treating overweight and obesity, increasing physical activity has become a public health priority.[4]

With these high levels of overweight and obesity in the United States,[1] researchers have begun to search for neighborhood factors, including the built environment, that may influence physical activity and overweight or obesity. The built environment comprises the physical attributes of a person's surroundings, including the existence and condition of sidewalks and walking trails for walking and other types of recreation, the spatial configuration of street networks, the availability of health-promoting resources, and the number of walkable destinations. The research to date suggests that elements of the built environment influence physical activity and levels of overweight or obesity.[5–7] Most studies, however, have focused on relatively specific geographic areas (e.g., a given city or county), have not assessed the influence of the built environment across different sociodemographic groups, and have not considered interactions between individual and neighborhood factors.

We aimed to determine the association between measures of the built environment and physical activity levels and body mass index (BMI, defined as weight in kg divided by height in m^2) across geographically and sociodemographically diverse neighborhoods. We applied recursive partitioning, a tree-based classification method, to identify both independent associations and interactions between these variables in a large, established cohort of California women.

METHODS

The California Teachers Study (CTS) is a prospective study of 133 479 women who were active or retired California teachers or administrators at the time the cohort was established in 1995 to 1996.[8] Women joined the cohort by completing a self-administered questionnaire that assessed a wide range of lifestyle characteristics and exposures (including physical activity during the past 3 years) as well as personal and family medical history (including height and weight).

Geocoding

The current study was based on 118 315 CTS participants who resided in California at the time of the baseline survey and for whom residential address could be geocoded to a census block group. Residential addresses at study entry were geocoded through a variety of efforts described previously.[9] Briefly, batch geocoding was performed by Geographic Data Technology GDT (Geographic Data Technologies, Lebanon, NH). We then made extensive efforts to manually geocode addresses that could not be geocoded by the batch method. Together, these approaches resulted in assigning 95% of California baseline residences to a latitude and longitude and 98% to a US Census block group.

Outcome Data

Information on physical activity and BMI was obtained from responses to the baseline questionnaire. Women were asked about their physical activity levels over the previous 3 years, including the average number of hours per week and the number of months per year that they performed strenuous (e.g., swimming laps, aerobics, running, basketball, cycling on hills) and moderate (e.g., brisk walking, golf, volleyball, cycling on level streets) exercise activities or sports. The average hours per week and months per year of moderate and strenuous physical activity were summed and categorized into either meeting (≥2.5 hours per week, henceforth referred to as high), or not meeting (<2.5 hours per week, henceforth referred to as low), the physical activity recommendations of the American Cancer Society.[3] Long-term metrics of these physical activity measures have been associated with cancer risk and mortality in this cohort.[10–12] We excluded women from the physical activity analysis for whom physical activity data were missing (n=948).

Weight (lb) and height (ft, in) as self-reported at baseline were used to calculate BMI, which was then categorized as normal weight (<25.0 kg/m^2) and overweight or obese (≥25.0 kg/m^2).[2] We excluded from the BMI analysis women with missing (n=5290) or extreme (<16.0 or >54.8 kg/m^2; n=61) BMI values.

Sociodemographic Characteristics

Age at baseline was calculated from self-reported birth date and the date the questionnaire was completed. Self-reported race/ethnicity was categorized as non-Hispanic White (henceforth referred to as White), African American or Black, Hispanic, Asian or Pacific Islander, and other or not reported. All public school teachers and administrators have at least a college education; therefore, education as a measure of individual socioeconomic status (SES) is not useful within this cohort. However, individual SES for these women is partially determined by spousal income as well as other factors that are reflected in the diversity of neighborhoods in which they live.[9] Thus, we used 2000 US Census data to characterize neighborhood urbanization and SES at the block group according to the address of residence at baseline.[9] The degree of urbanization was categorized into 5 groups: urban, suburban, city, small town, and rural.[9] This SES metric incorporates population measures of average neighborhood education, income, and occupation, as described elsewhere,[9] and was categorized into quartiles based on the distribution of the block groups across the state.

Built Environment Measures

We derived measures of neighborhood housing and commuting characteristics from 2000 US Census data. Neighborhood density was characterized at the block group level by several measures: population density (number of people/m^2), household crowding (percentage of occupied households with 1 or more persons/room), percentage of total housing units that are not single family dwellings, and percentage of total housing units that are housing structures with more than 10 units. Population-based commuting characteristics were summarized in the following manner: means of transportation (% of individuals in the block group who traveled to work via car or motorcycle, public transportation, walking or bicycle, other means, or worked at home) and typical travel time to work (% of individuals in the block group who traveled <30, 30–44, 45–59, or ≥60 min/d to work).

We obtained information on street connectivity, which was calculated at the US Census tract level, from the Rand Center for Population Health and Health Disparities.[13] In addition to median area and median length of street blocks, the α and γ ratios were used to characterize the directness of links and density of connections in neighborhoods such that high values of these ratios (i.e., close to 1.0) indicated a pedestrian-friendly area with many short links and intersections and few dead ends.[13] These measures have been shown to be predictive of health behaviors and outcomes in previous studies.[5,14–17]

We derived information on neighborhood amenities from ReferenceUSA business listing data for 2002.[18] Businesses of interest for the study were downloaded from the complete database, and their addresses were geocoded to a latitude and longitude by using ArcView GIS software (Esri, Redlands, CA). The number of businesses within a 400- or 1600-meter buffer around a participant's residence was determined as amenities because these distances have been associated with physical activity and BMI.[14,19–21] We selected and categorized businesses on the basis of a priori hypotheses regarding the influence such amenities might have on neighborhood walkability and BMI[14,22,23] as follows: social capital (museums, historical sites, and similar institutions; theaters; and performing arts and spectator sports); recreation facilities (golf courses and country clubs, skiing facilities, marinas, fitness and recreational sports centers, bowling centers, and other amusement and recreation industries); beer, wine, and liquor stores; retail stores; gasoline stations; convenience stores; restaurants and eating places; specialty food stores; bars; parking lots and garages; and supermarkets and other grocery stores. Additionally, composite measures were created of desirable amenities (the number of social capital amenities and recreation facilities), undesirable amenities (the number of beer, wine, and liquor stores; gasoline stations; and convenience stores), and total destinations. Total destinations has been shown to be a reliable indicator of walkability.[24]

Statistical Analysis

We used recursive partitioning,[25–27] conducted by using the RPART routine in the R statistical software program,[26] to identify mutually exclusive subgroups of participants that varied with regard to the outcomes of interest (BMI and physical activity). Recursive partitioning is a nonparametric regression method that uses the current data set to find the decision tree with the lowest average misclassification rate for classifying future observations. The terminal nodes of the tree partition the participants into subgroups according to a set of explanatory variables. Starting with the original data set, recursive partitioning splits each node by examining each variable and selecting 1 binary split across the members in that node based on a variable that maximizes the purity in the outcome. This process is repeated until further partitioning is not possible. Because the final tree over-fits the data, 10-fold cross-validation is used to prune the tree.[27] Finally, the "one-standard error" heuristic is used to find the simplest tree with a cross-validated error estimate no more than one standard error larger than the best tree.[27] Recursive partitioning can detect multiway interactions and handle highly correlated variables; however, this method is less well-known and is not as powerful as parametric methods when the form of the underlying model is parametric and correctly specified.

We performed separate analyses for dichotomized outcomes of BMI and physical activity. We submitted 49 explanatory variables into the recursive partitioning procedure, including age group, race/ethnicity, neighborhood urbanization, SES, population density, 3 measures of housing density, 4 street connectivity measures, 9 measures of population commuting characteristics, and 22 specific and 6 composite neighborhood amenities within both 400 and 1600 meters of the residence. Because the results were similar for the neighborhood amenities variables regardless of buffer size, we only presented the results that assessed the 1600-meter buffer.

We used logistic regression models for low physical activity and overweight or obesity to estimate the adjusted odds ratios for categorical variables that represented each subgroup (terminal node) from the recursive partitioning analyses. Odds ratios were adjusted for age and BMI in the analyses of physical activity or age and physical activity in the analyses of BMI.

RESULTS

Most of the women included in these analyses were aged 46 to 75 years, were White, and had a normal BMI (Table 1). Nearly half of the participants engaged in moderate or strenuous physical activity for at least 2.5 hours per week, on average, in the 3 years before joining the cohort. Most participants lived in neighborhoods that were suburban, in the upper 2 quartiles of SES, had little or no household crowding, and were composed predominantly of single family homes. The participants' neighborhoods tended to have relatively low average street connectivity (α ratio = 0.15; γ ratio = 0.43) and a high average percentage of residents commuting to work by car or motorcycle. The most common neighborhood services within 1600 meters of the participants' homes were restaurants and eating establishments (mean number = 32.6), followed by retail stores (mean number = 14.7), social capital facilities (mean number = 5.2), and supermarkets and grocery stores (mean number = 4.9).

The built environment characteristics of the participants' residences varied by neighborhood SES (Table 2). Compared with the lower SES neighborhoods, the highest SES neighborhoods were more likely to be suburban and to have lower population density, less household crowding, and a higher proportion of single-family homes. Block sizes were somewhat smaller in high-SES neighborhoods, and the percentage of the population that worked at

TABLE 1—Demographic and Neighborhood Characteristics at Recruitment Among Study Participants: California Teachers Study, 1995–1996

Age, y, no. (%)	
≤35	13 919 (11.8)
36–45	22 155 (18.7)
46–75	72 468 (61.2)
≥76	9773 (8.3)
Race/Ethnicity, no. (%)	
White (non-Hispanic)	102 135 (86.3)
Hispanic	5089 (4.3)
Asian/Pacific Islander	4321 (3.7)
African American	3179 (2.7)
Other or not reported	3591 (3.0)
BMI, no. (%)	
Normal, < 25.0	69 103 (58.4)
Overweight, 25.0–29.9	28 140 (23.8)
Obese, ≥30.0	15 782 (13.3)
Unknown	5290 (4.5)
Recent moderate or strenuous physical activity, no. (%)	
Low activity, < 2.5 h/wk	58 973 (49.8)
High activity, ≥2.5 h/wk	58 394 (49.4)
Unknown	948 (0.8)
Area of residence, no. (%)	
Rural	14 151 (12.0)
Small town	4075 (3.4)
City	21 783 (18.4)
Suburban	65 593 (55.4)
Urban	12 262 (10.4)
Unknown	451 (0.4)
Neighborhood SES quartile,[a] no. (%)	
1st, low	4821 (4.1)
2nd	19 799 (16.7)
3rd	38 615 (32.5)
4th, high	54 591 (46.1)
Unknown	489 (0.4)
Population density quartile,[a] no. (%)	
0.00–0.86 people/1000 m^2	29 589 (25.0)
0.87–1.91 people/1000 m^2	29 569 (25.0)
1.92–2.98 people/1000 m^2	29 581 (25.0)
2.99–66.76 people/1000 m^2	29 575 (25.0)
Unknown	1 (< 0.1)
Housing density,[a] %, mean ±SD	
Crowding: occupied households with ≥1 person/room	6.9 ±8.8
Nonsingle family housing units	22.6 ±25.2
Housing structures with ≥10 units	10.0 ±16.2
Commuting characteristics,[a] %, mean ±SD	
Car/motorcycle	89.0 ±8.3
Public transportation	3.0 ±5.2
Walking or bicycle	2.5 ±4.1

Continued

home was lower in low-SES neighborhoods. Proximity to neighborhood amenities modestly differed by neighborhood SES.

Predictors of Physical Activity

The recursive partitioning analysis of physical activity identified 7 subgroups of women with variable probabilities of low physical activity (Table 3). Women aged 76 years or older (node 1) and Hispanic, African American, and Asian/Pacific Islander women younger than 76 years (node 2) had the highest probabilities of low physical activity (66% and 60%, respectively), whereas White women and those of other or not reported race/ethnicity aged 35 years or younger (node 3) were the most active, with only a 40% probability of low physical activity. Among the majority of women, those who were aged 36 to 75 years and of White or other or not reported race/ethnicity, physical activity level varied by aspects of the built environment. Among these women, those who lived in neighborhoods with more household crowding (node 4) were slightly more likely to have low physical activity levels (54%) than were women in neighborhoods with less household crowding (nodes 5, 6, and 7 who had a probability of low physical activity ranging from 45% to 51%). In less crowded neighborhoods that also had a higher percentage of people who worked at home, women with more desirable amenities (node 7) were 5% less likely to have low levels of physical activity (probability = 46%) than were women who lived in neighborhoods with fewer of these types of destinations (node 6; probability = 51%).

Even after adjustment for age and BMI, older women (≥76 years) and women of Hispanic, African American, and Asian/Pacific Islander race/ethnicity who were younger than 76 years were at least 2 times more likely to engage in low levels of physical activity than were young (≤35 years) White women (Table 3). Compared with young White women, White women aged 36 to 75 years who lived in neighborhoods with more household crowding or in neighborhoods with less crowding but fewer desirable amenities were at least 1.5-fold more likely to be less physically active. Further adjustment of these models for neighborhood SES did not change these results (data not shown).

TABLE 1—*Continued*

Other means	0.6 ±1.1
Working at home	4.9 ±3.8
<30 min	62.7 ±14.3
30–44 min	19.5 ±8.6
45–59 min	8.1 ±5.4
≥60 min	9.7 ±6.8
Street connectivity,[b] mean ±SD	
γ: ratio of streets/possible intersections	0.43 ±0.05
α: ratio of loops/possible loops	0.15 ±0.07
Median area of street blocks, sq ft	480 878 ±1 221 385
Median length of street blocks, ft	2843 ±1564
No. of specific neighborhood amenities within 1600 m from address, mean ±SD	
Social capital	5.2 ±9.2
Beer, wine, and liquor stores	2.5 ±3.3
Recreation facilities	3.9 ±4.0
Retail stores	14.7 ±18.0
Gasoline stations	2.5 ±2.5
Convenience stores	1.3 ±1.6
Restaurants and eating places	32.6 ±46.0
Specialty food stores	3.5 ±5.9
Bars	1.9 ±5.4
Parking lots and garages	<1 ±0.3
Supermarkets and other grocery stores	4.9 ±8.6
Desirable amenities[c]	9.1 ±12.2
Undesirable amenities[d]	6.3 ±6.1
Total destinations	73.1 ±95.2

Note. BMI = body mass index, defined as weight in kg divided by height in m^2; SES = socioeconomic status. The sample size was n = 118 315.
[a]Based on 2000 US Census block group data.
[b]Based on 2000 US Census tract data.
[c]Desirable amenities included social capital (museums, historical sites, and similar institutions; theaters; associations; performing arts; spectator sports) and recreation (golf courses and country clubs, skiing facilities, marinas, fitness and recreational sports centers, bowling centers, and other amusement and recreation industries).
[d]Undesirable amenities included beer, wine, and liquor stores; gasoline stations; and convenience stores.

Predictors of Overweight and Obesity

Our recursive partitioning analyses for BMI identified 5 subgroups of women with variable probabilities of being overweight or obese (Table 4). Overall, the lowest probability of being overweight (33%) was observed among the youngest (≤45 years) and oldest (≥76 years) women (node 1). Only among middle-aged (46–75 years) women were neighborhood SES and race/ethnicity associated with various probabilities of being overweight. In high-SES neighborhoods, African American women (node 3) had a substantially higher probability (58%) of being overweight than did women of all other race/ethnicities (node 2; probability = 38%). In lower SES neighborhoods, African American and Hispanic women and women of other or not reported race/ethnicity (node 5) had higher probabilities of being overweight (59%) than did White and Asian/Pacific Islander women (node 4; probability = 46%). After adjustment for age and physical activity, African American women in all SES neighborhoods and Hispanic women in the lower 3 quartiles of neighborhood SES had more than a 2.4-fold increased odds of being overweight compared with younger or older women.

DISCUSSION

In this population of highly educated women living throughout the geographically

TABLE 2—Built Environment Characteristics by Quartile of Neighborhood Socioeconomic Status (SES): California Teachers Study, 1995–1996

Characteristic	SES		P^a
	Low, 1st to 3rd Quartiles (n = 63 235)	High, 4th Quartile (n = 54 591)	
Area of residence, no. (%)			< .001
Rural	11 952 (18.9)	2194 (4.0)	
Small Town	3779 (6.0)	296 (0.5)	
City	14 086 (22.3)	7686 (14.1)	
Suburban	25 824 (40.8)	39 747 (72.8)	
Urban	7594 (12.0)	4668 (8.6)	
Population density quartiles,[b] no. (%)			< .001
0.00000–0.00086 people/m^2	16 906 (26.7)	12 423 (22.8)	
0.00087–0.00191 people/m^2	12 090 (19.1)	17 383 (31.8)	
0.00192–0.00298 people/m^2	15481 (24.5)	14 034 (25.7)	
0.00299–0.06676 people/m^2	18 758 (29.7)	10 751 (19.7)	
Housing density,[b] %, mean ±SD			
Crowding: occupied households with ≥ 1 person/room	10.3 (10.4)	3.0 (3.5)	< .001
Nonsingle family housing units	27.2 (25.6)	17.3 (23.6)	< .001
Housing structures with ≥ 10 units	10.9 (16.7)	8.9 (16.3)	< .001
Street connectivity,[c] mean (SD)			< .001
γ: ratio of streets/possible intersections	0.44 (0.05)	0.42 (0.05)	< .001
α: ratio of loops/possible loops	0.16 (0.07)	0.13 (0.07)	< .001
Median area of street blocks, sq ft	577 427 (1 539 695)	366 702 (667 541)	< .001
Median length of street blocks, ft	2944.4 (1913.4)	2720.6 (991.9)	< .001
Commuting characteristics,[a] %, mean (SD)			< .001
Car/motorcycle	89.6 (8.2)	88.4 (8.4)	< .001
Public transportation	3.0 (5.2)	2.9 (5.0)	.193
Walking or bicycle	2.9 (4.4)	2.1 (3.8)	< .001
Other means	0.7 (1.2)	0.5 (0.9)	< .001
Working at home	3.9 (3.4)	6.0 (4.0)	< .001
< 30 min	63.9 (14.4)	61.4 (14.0)	< .001
30–44 min	18.6 (8.7)	20.6 (8.4)	< .001
45–59 min	7.6 (5.3)	8.6 (5.5)	< .001
≥ 60 min	9.9 (7.3)	9.5 (6.3)	< .001
No. of specific neighborhood amenities within 1600 m from address, mean (SD)			
Social capital	4.8 (8.4)	5.8 (9.9)	< .001
Beer, wine, and liquor stores	2.7 (3.5)	2.2 (3.1)	< .001
Recreation facilities	3.6 (3.8)	4.2 (4.3)	< .001
Retail stores	14.3 (17.6)	15.2 (18.4)	< .001
Gasoline stations	2.7 (2.6)	2.3 (2.4)	< .001
Convenience stores	1.6 (1.7)	1.0 (1.3)	< .001
Restaurants and eating places	33.0 (46.3)	32.1 (45.5)	< .001
Specialty food stores	3.7 (6.2)	3.3 (5.6)	< .001
Bars	2.1 (5.6)	1.6 (5.2)	< .001
Parking lots and garages	< 0.1 (0.2)	0.1 (0.3)	< .001
Supermarkets and other grocery stores	5.8 (9.3)	4.0 (7.5)	< .001
Desirable amenities[d]	8.4 (11.4)	10.0 (13.0)	< .001
Undesirable amenities[e]	7.1 (6.4)	5.5 (5.6)	< .001
Total destinations	74.4 (96.2)	71.8 (94.2)	< .001

Note. SES = socioeconomic status.
[a]T-tests and χ^2 statistics were used, where appropriate, to test for differences by SES categories.
[b]Based on 2000 US Census block group data.
[c]Based on 2000 US Census tract data.
[d]Desirable amenities included social capital (museums, historical sites, and similar institutions; theaters; associations; performing arts; spectator sports) and recreation (golf courses and country clubs, skiing facilities, marinas, fitness and recreational sports centers, bowling centers, and other amusement and recreation industries).
[e]Undesirable amenities included beer, wine, and liquor stores; gasoline stations; and convenience stores.

TABLE 3—Probability of Low Physical Activity and Logistic Regression Modeling of the Risk Subgroups Identified From Recursive Partitioning: California Teachers Study, 1995–1996

Age, Years	Race/Ethnicity	Crowding[a]	Work at Home[b]	Desirable Amenities[c]	Terminal Node	No.	Probability of Low Physical Activity (95% CI)	OR	AOR[d]
≥76					1	9491	0.66 (0.65, 0.67)	2.99	2.95
<76	Hispanic, African American, and API				2	12 235	0.60 (0.59, 0.61)	2.29	2.16
≤35	White and other				3	11 494	0.40 (0.39, 0.40)	1.00	1.00
36–75	White and other	≥8%			4	19 344	0.54 (0.53, 0.55)	1.80	1.65
		<8%	≥3.9%		5	40 277	0.45 (0.45, 0.45)	1.25	1.21
			<3.9%	<11.5	6	19 666	0.51 (0.51, 0.52)	1.61	1.51
				≥11.5	7	4860	0.46 (0.45, 0.47)	1.31	1.25

Note. AOR = adjusted odds ratio; API = Asian and Pacific Islander; CI = confidence interval; OR = odds ratio. Low physical activity is defined as moderate or strenuous physical activity of < 2.5 h/wk.
[a]Percentage of housing units with 1 or more occupants per room.
[b]Percentage who worked at home.
[c]Desirable amenities included social capital (museums, historical sites, and similar institutions; theaters; associations; performing arts; and spectator sports) and recreation (golf courses and country clubs, skiing facilities, marinas, fitness and recreational sports centers, bowling centers, and other amusement and recreation industries).
[d]Adjusted for age and body mass index (continuous).

diverse state of California, we found that a few elements of the built environment, including household crowding, commuting characteristics, and proximity to desirable neighborhood amenities, were associated with meeting physical activity recommendations, but only among White women. We did not find any specific measures of the built environment to be associated with overweight or obesity. Physical activity was also associated with age and race/ethnicity, and overweight or obesity was related to age, race/ethnicity, and neighborhood SES. Our analysis is unique in its application of recursive partitioning to identify interactive effects among individual and neighborhood predictors of physical activity and overweight and obesity. Most previous studies of these associations did not fully explore the potential interactions between sociodemographic variables and characteristics of the built environment, although characteristics of the built environment are strongly related to neighborhood racial/ethnic composition and SES.[6,7,28–32]

Previous studies have suggested that physical activity, primarily in the form of walking, is related to the built environment, with increasing activity levels associated with greater residential density, land-use mix, street connectivity, and access to recreational areas.[5,15,16,19,33–35] The associations between our measure of recreational moderate or strenuous physical activity and the built environment were limited to middle-aged White women and were not as strong as findings from previous studies of walking, likely because of the differing physical activity measure. Among middle-aged White women, however, our finding of greater physical activity among those who lived in neighborhoods with more desirable amenities is consistent with several previous studies that considered more global measures of physical activity. These previous studies found greater levels of physical activity among people living near recreational resources such as parks, schools, and sports facilities.[28,36–38] Household crowding and neighborhood commuting characteristics were also related to physical activity in our population. We found that women who lived in neighborhoods with more household crowding were less likely to meet physical activity recommendations. Our findings suggest that neighborhood attributes that facilitate recreational physical activity may differ from neighborhood attributes that favor walking for transportation.[5] Furthermore, because the distributions of our household crowding and commuting variables varied strongly by neighborhood SES and because physical inactivity is associated with lower SES,[15,39,40] these associations could

TABLE 4—Probability of Being Overweight or Obese and Logistic Regression Modeling of the Risk Subgroups Identified From Recursive Partitioning: California Teachers Study, 1995–1996

Age, Years	Neighborhood SES	Race/Ethnicity	Terminal Node	No.	Probability of Overweight or Obese (95% CI)	OR	AOR[a]
≤45 or ≥76			1	43 495	0.33 (0.32, 0.33)	1.00	1.00
46–75	Highest quartile	African American	3	772	0.58 (0.54, 0.61)	2.80	2.47
		White, Hispanic API, and other	2	34 737	0.38 (0.37, 0.38)	1.25	1.18
	Lower 3 quartiles	White and API	4	30 549	0.46 (0.46, 0.47)	1.79	1.64
		Hispanic African American, and other	5	3411	0.59 (0.58, 0.61)	3.03	2.68

Note. AOR = adjusted odds ratio; API = Asian and Pacific Islander; BMI = body mass index; OR = odds ratio; SES = socioeconomic status. Overweight or obese defined as BMI ≥ 25 kg/m^2.
[a]Adjusted for age and physical activity.

also have been due to some residual SES-related effect, particularly individual-level SES.

Our recursive partitioning results indicate that the relationship between neighborhood SES and overweight or obesity is not uniform across racial/ethnic groups. Specifically, the probability of being overweight or obese was highest for African American women, regardless of neighborhood SES, whereas for women of other race/ethnicities, living in lower SES neighborhoods was associated with a higher probability of being overweight or obese. Although the lack of association between overweight and obesity and the built environment measures in our study differs from previous studies that found a lower prevalence of overweight and obesity associated with increased neighborhood walkability[6,7,17,19,33–35,41,42] and to a lesser degree with neighborhood accessibility to food establishments that offer healthy food options,[7] research on the built environment and body size and physical activity suggests that these associations may vary by sociodemographic characteristics. It has been hypothesized that people living in low-SES neighborhoods may be more influenced by the built environment because of transportation constraints or limited opportunities for mobility[7,43]; however, there are few consistent data to support this notion,[44] perhaps because of the mediating influence of race/ethnicity, which is often not considered. In a population-based study in Atlanta, Georgia, elements of the built environment were related to walking behavior and obesity among White men but were not as evident among African Americans and women.[45] In the same Atlanta study population, built environment features considered to enhance walkability were associated with lower rates of overweight among White, highly educated men, but relationships were opposite among women, non-White men, and less-educated men.[15] Similarly, a recent analysis of national prevalence data reported that low neighborhood SES was associated with higher BMI among Hispanics and non-Hispanic Whites, but not among African Americans.[46] By contrast, a recent study of predominantly low-income, Mexican-born Hispanics living in Texas revealed that higher SES was associated with greater BMI[47]; others have reported a similar positive association among Hispanics living in predominantly immigrant neighborhoods.[46]

The associations found in this population of educated professional women, although internally valid, may not be generalizable to other populations. Nearly half of CTS respondents reported meeting the American Cancer Society guidelines for physical activity, compared with only about one third of non-Hispanic White respondents to the 2005 National Health and Nutrition Examination Survey,[40] and the prevalence of overweight and obesity among our study participants was considerably lower (37%) than were national (69%)[48] or Californian (47%)[8] prevalence data. However, the relationships between the sociodemographic variables and physical activity and overweight and obesity found in our study are consistent with those found in other studies. In the present study, older women, regardless of race/ethnicity, and younger African American, Asian/Pacific Islander, and Hispanic women had the highest probabilities of not meeting physical activity recommendations, which is consistent with well-documented lower levels of physical activity among minority women and older women.[49,50] Similarly, our findings for overweight and obesity are consistent with national prevalence data indicating that the rates of overweight and obesity increase with age[1,51] and are higher among non-White populations and in lower SES areas.[6,50,52–54]

Similar to most studies on this topic, this analysis was limited to cross-sectional data; therefore, the effects of the built environment cannot be distinguished from associations resulting from the self-selection of individuals to live in neighborhoods with certain attributes. We had no subjective measurements of the built environment (e.g., how safe it feels, how one uses their environment), which are likely to affect behavior as well.[14] Contrary to most previous studies, which generally focused on relatively small (and usually urban) geographic areas, our study included women from a broad geographic area with a diversity of social and built environments. We were able to consider a large number of established and objectively measured elements of the built environment that were not subject to recall bias. Finally, our study sample provided a unique opportunity to evaluate neighborhood SES among a cohort of women who were relatively homogeneous with respect to education, which is one measure of individual SES.

Our findings suggest that the associations between physical activity and overweight and obesity and the built environment vary by sociodemographic characteristics and highlight the importance of considering these interactions in future research. We found that characteristics of the built environment were related to physical activity among White women. In addition, whereas neighborhood SES influenced the probability of being overweight or obese for most women, this was not the case for African American women. This is important given that the obesity epidemic in the United States disproportionately affects socioeconomically disadvantaged and minority populations. The relationship between neighborhood SES and overweight and obesity, despite relative homogeneity in education in this cohort, highlights the importance of SES and underscores the need for improving our understanding of the contextual factors associated with neighborhood SES. ■

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Contributors

D. Goldberg led the analyses. S. Hurley, S.L. Gomez, D.O. Nelson, P. Reynolds, L. Bernstein, and P.L. Horn-Ross interpreted the data and assisted with drafting the article. T.H.M. Keegan originated the study and led the writing.

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Human Participant Protection

Cancer Prevention Institute of California (CPIC) institutional review board approval was received for this study.

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