HHS Public Access
Author manuscript
Prev Med. Author manuscript; available in PMC 2022 April 25.

Published in final edited form as:
Prev Med. 2019 June ; 123: 242–249. doi:10.1016/j.ypmed.2019.03.039.

Perceived and objective characteristics of the neighborhood environment are associated with accelerometer-measured sedentary time and physical activity, the CARDIA Study

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Abstract

We investigated cross-sectional and longitudinal associations of neighborhood environment characteristics with accelerometer-measured sedentary time (SED), light-intensity physical activity (LPA), and moderate-to-vigorous intensity physical activity (MVPA). Participants were 2,120 men and women in the year 20 (2005–2006) and year 30 CARDIA exams (2015–2016). Year 20 neighborhood characteristics included neighborhood cohesion, resources for physical activity, poverty, and racial residential segregation. Physical activity was measured by accelerometer at

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Conflicts of Interest:
None

years 20 and 30. Multivariable linear regression models examined associations of standardized neighborhood measures at year 20 with SED, LPA, and MVPA assessed that year, and with 10-year changes in SED, LPA, and MVPA. Cross-sectionally, a one standard deviation (SD) increase in cohesion was associated with 4.06 less SED min/day (95% CI: −7.98, − 0.15), and 4.46 more LPA min/day (95% CI: 0.88, 8.03). Each one SD increase in resources was associated with 1.19 more MVPA min/day (95% CI: 0.06, 2.31). A one SD increase in poverty was associated with 11.18 less SED min/day (95% CI: −21.16, −1.18) and 10.60 more LPA min/day (95% CI: 1.79, 19.41) among black men. No neighborhood characteristic was associated with 10-year changes in physical activity in the full sample; however, a one SD increase in cohesion was associated with a 10-year decrease of 25.44 SED min/day (95% CI: −46.73, −4.14) and an increase of 19.0 LPA min/day (95% CI: 1.89, 36.10) in black men. Characteristics of the neighborhood environment are associated with accelerometer-measured physical activity. Differences were observed by race and sex, with more robust findings observed in black men.

Keywords

neighborhood; cohesion; resources; poverty; segregation; physical activity; sedentary time; accelerometer

Introduction:

Growing evidence suggests that features of the neighborhood environment are associated with health outcomes and may contribute to health disparities. Four broad domains of neighborhood attributes identified as important for health outcomes include residential segregation by race/ethnicity, socioeconomic position, characteristics of the physical neighborhood environment, and characteristics of the social neighborhood environment (see conceptual framework by Diez Roux and Mair).[1] For example, higher levels of racial segregation are associated with increased cardiovascular disease risk and obesity,[2–6] with differences in associations observed by race and sex. Higher rates of premature mortality have been observed among individuals living in neighborhoods with greater poverty.[7,8] Evidence also suggests that aspects of the neighborhood physical and social environment, such as access to recreational resources and greater neighborhood cohesion, are associated with a reduced risk of obesity and cardiovascular disease.[9–11]

There are many hypothesized mechanisms through which the neighborhood environment is thought to influence health, including mediation by health behaviors, such as physical activity. Over the last 20 years there has been increased interest in studying the role of the neighborhood environment on physical activity levels across the lifespan.[12] However, to date, much of the research in this area has focused on moderate-to-vigorous intensity physical activity (MVPA),[13–18] and the existing evidence examining associations of the neighborhood environment with sedentary time (SED) and light-intensity physical activity (LPA) is scarce and inconsistent. Given the growing body of evidence linking high SED and low LPA with adverse health outcomes,[19–22] it is important to examine whether the neighborhood environment plays a role in encouraging individuals to engage in these behaviors. Furthermore, the majority of studies to date examining associations of the neighborhood environment with higher-intensity physical activities have focused on self-reported, leisure-time MVPA, which is prone to bias[23] and gives an incomplete characterization of physical activity patterns as it does not include occupational, household, or transportation MVPA.[13] Additionally, the majority of studies examining the neighborhood environment with physical activity are limited by cross-sectional study designs. There is a need for research using longitudinal designs relating neighborhood characteristics to changes in health indicators over time.[1]

The Coronary Artery Risk Development in Young Adults (CARDIA) study provides an opportunity to address these gaps in knowledge by examining associations of characteristics of the neighborhood environment with accelerometer-based SED, LPA, and MVPA, assessed longitudinally. The objectives of this study are to examine the associations between self-reported neighborhood cohesion and neighborhood resources and objectively measured neighborhood poverty and racial residential segregation, assessed in 2005–06 (year 20), with accelerometer-based SED, LPA, and MVPA, assessed in 2005–06 (year 20) and 2015–16 (year 30). We hypothesized that low levels of neighborhood cohesion, fewer neighborhood resources for physical activity, high levels of neighborhood poverty, and greater racial segregation are associated with higher SED, and lower LPA and MVPA, as well as a greater rate of change over 10-years, with SED increasing and LPA and MVPA decreasing. Given the known differences by race and sex in neighborhood environment characteristics and physical activity patterns, we also examined in exploratory analyses whether the associations between measures of the neighborhood environment and accelerometer-based SED, LPA, and MVPA differed by the four represented race and sex groups.

Methods:

Study Participants:

CARDIA is an ongoing cohort study of 5,115 black and white men and women, 18–30 years of age, who were recruited to complete an in-person clinical exam in 1985–86 (year 0) in Birmingham, AL; Minneapolis, MN; Chicago, IL; or Oakland, CA. Additional in-person clinic exams were held approximately every 2–5 years, including a 2005–06 (year 20) and 2015–16 (year 30) exam, with 72% and 71% surviving participant retention, respectively. For the present study, participants were included in the analyses if they had complete data on the neighborhood variables of interest and valid accelerometer wear time (≥4 days with ≥10 hours per day, by convention) at the year 20 exam (N=2,242). Participants were excluded if they were missing data on covariates of interest (N=118), or had unreasonably high values for MVPA (>12 hours/day, N=4), for a final analytic sample of 2,120. Of these participants, 892 also had accelerometer data at the year 30 exam, and were included in longitudinal analyses. The smaller sample with accelerometer data at year 30 was due in part to a shortened data collection period (due to funding mechanism) that began mid-way through the year 30 exam. Participants who had accelerometer data at both exams had higher levels of education and income, where less likely to smoke, had greater accelerometer wear time, reported higher levels of neighborhood cohesion and lived in areas of lower poverty as compared to those who only wore an accelerometer at the year 20 exam (see Supplemental Table 1).

Exposure Variables – Perceived and Objective Measures of the Neighborhood Environment:

Perceived Measures: Neighborhood cohesion was assessed by asking how strongly participants agreed or disagreed with the following statements related to their neighborhood: (1) people around here are willing to help their neighbors, (2) this is a close-knit neighborhood, (3) people in this neighborhood can be trusted, (4) people in this neighborhood generally don't get along with each other, and (5) people in this neighborhood do not share the same values.[24] Response options were strongly agree, agree, neutral, disagree, and strongly disagree with a possible score range of 1–5 for each item. Items 1–3 were reverse coded so higher scores indicate stronger neighborhood cohesion, and all items were summed, with an overall score range of 5–25. Neighborhood cohesion was modeled continuously and in tertiles based on the sampling distribution (score ranges 5–16, 17–19, and 20–25).

Neighborhood resources were assessed by asking questions related to physical activity resources located in the participant's neighborhood, or within a 10–15 minute walk from their home, including (1) exercise facility, (2) park, (3) sidewalks, (4) walking and/or bike paths, and (5) public transportation including subway, bus, or trolley stop.[25] An affirmative response was given a score of 1, a negative response 0. Responses were summed for a possible score range of 0–5. Neighborhood resources was modeled continuously, and also in four categories based on the sampling distribution (scores 0–2, 3, 4, and 5).

Objective Measures: Participant addresses at year 20 were converted to state-county-census tract Federal Information Processing Standard (FIPS) codes. State and county FIPS codes were used to determine each census tract using 2000 U.S. Census data. Using these data, we defined neighborhood poverty as the percent of the population in the census tract living below the U.S. defined poverty threshold. Poverty was modeled continuously, and also in tertiles based on the sampling distribution (score ranges 0.0%–4.5%, 4.6%–11.1%, and 11.2%–67.4%).

Census tract-level racial composition was linked to geocoded home addresses at the year 20 exam using the 2000 U.S. Census data. Within-group racial residential segregation was measured separately for blacks and whites using the Getis-Ord Local Statistic (G_i^*).[26] The G_i^* statistic is a spatial autocorrelation measure that returns a Z-score for each neighborhood, indicating the extent to which racial/ethnic composition in the focal tract and neighboring tracts differs from the mean racial composition of the larger unit (metropolitan area or county) surrounding the tract. Higher positive Z-scores indicate higher racial/ethnic segregation or clustering, scores close to 0 indicate racial integration, and lower negative scores suggest lower racial/ethnic representation, in comparison to the racial composition of the larger unit. Segregation was modeled continuously and categorized into three groups: as high ($G_i^*>1.96$), medium (G_i^* 0–1.96), and low ($G_i^*<0$).

Outcome Variables - Accelerometer Measures:

Sedentary, LPA, and MVPA were assessed using a waist-worn ActiGraph 7164 and Actigraph wGT3X-BT+ for 7 consecutive working and non-working days during CARDIA years 20 and 30, respectively. Given that different types of monitors were used at the two exams, we developed and applied a calibration factor to the wGT3X-BT values to allow for data harmonization.[27] Weekly summary sedentary behavior and physical activity estimates were averaged for all participants with valid wear (≥ 4 days, ≥ 10 hours/day).[28] Total and average accelerometer counts per day were calculated using summed counts detected over wear periods and time (i.e., minutes) spent in different intensity levels using Feedson cut-point threshold values.[28–30] SED was defined as ≤ 100 counts per minute (cpm), LPA as 101– 1951 cpm, and MVPA as 1952+ cpm.[30] Data are presented as minutes/day, averaged over the number of valid days. Changes in physical activity levels were calculated as year 30 minus year 20, with a positive change value reflects an increase in the physical activity of interest over time.

Covariates:

Study covariates from the year 20 exam include field center and self-reported age, sex, race (black/white), years of education completed, employment status (yes/no), marital status, and annual family income. Smoking status was categorized as never, former, or current. Alcohol consumption was calculated in milliliters per day using self-reported intake of wine, beer, and hard liquor. Depressive symptoms were assessed using the 20-item Center for Epidemiologic Studies Depression Scale, and modeled as a dichotomous variable using a cutpoint of 16, with scores equal to this or higher indicating clinically significant depressive symptoms.[31]

Statistical Analyses:

Linear regression models were used to examine the cross-sectional and longitudinal associations between neighborhood cohesion, resources, poverty and racial segregation measured at year 20 with accelerometer estimated SED, LPA, and MVPA assessed at year 20, and change in accelerometer measures from year 20 to year 30 (separate models for each exposure and each outcome). Each exposure was modeled as a continuous and categorical variable; for continuous models, variables were standardized by dividing by the mean score to enhance comparability between measures. Results did not materially differ when modeling the exposure variables continuously or categorically; therefore, all models presented use continuous exposure variables. Each outcome variable was modeled continuously, as an absolute value (minutes/day) while adjusting for total wear time, and also as a percentage of total wear time. Results were similar, and therefore for ease of interpretation data are presented using absolute values. MVPA was log transformed to address skewness; the findings did not materially differ, therefore results with original data are presented. Model 1 adjusted for year 20 center, age, race, sex, education, employment status, marital status, family income, and total accelerometer wear time. Model 2 additionally adjusted for smoking status, alcohol consumption, and depressive symptoms as these factors may lie on the causal pathway between neighborhood characteristics and physical activity. The models examining change in accelerometer measures from year 20 to year 30 were also adjusted for the baseline physical activity of interest (e.g. model examining 10-year change in MVPA was adjusted for year 20 MVPA). In sensitivity analyses we examined MVPA as a dichotomous variable (meeting physical activity guidelines vs. not). We also examined the associations between neighborhood factors and physical activity after excluding those who reported moving residences between the year 20 and 30 examinations. In exploratory analyses we examined interactions by race and sex by including cross-product terms in the models; stratified results were reported when significant.

Results:

As seen in Table 1, neighborhood cohesion was significantly higher in white men and women compared to black men and women. Neighborhood resources for physical activity was highest in black men, followed by black women, and white men and women. The percent of the neighborhood living below the poverty level was higher among black men and women compared to white men and women. Black men and women also lived in areas with higher levels of racial residential segregation compared to whites. Greater levels of neighborhood poverty and racial residential segregation were positively associated with physical activity quartile (see Supplemental Table 2, $p_{trend} \leq 0.002$ for both).

Spearman correlations between the neighborhood environmental measures are shown in Supplemental Table 3. Self-reported neighborhood cohesion was inversely correlated with poverty (ρ=−0.25) and segregation (ρ=−0.23), while self-reported neighborhood resources was positively correlated with poverty (ρ=0.09) and segregation (ρ=0.20). The two self-reported measures (cohesion and resources) were not correlated, while the two objectively measured characteristics (poverty and racial segregation) were highly correlated (ρ=0.64) (all p<0.001).

In cross-sectional analyses, each one standard deviation (SD) increase in the neighborhood cohesion score (3.5 units) was associated with 4.1 less SED minutes/day (95% CI: −8.0, −0.2, p=0.042) and 4.5 more LPA minutes/day (95% CI: 0.9, 8.0, p=0.015) after adjustment for potential confounders (Model 1) as well as smoking, alcohol, and depressive symptoms (Model 2; see Table 2). A one SD increase in the neighborhood resources score (1.4 units) was associated with 1.2 more MVPA minutes/day (95% CI: 0.1, 2.3, p=0.039). While not statistically significant, each one SD increase in neighborhood resources for physical activity was associated with higher odds of meeting the aerobic physical activity guidelines (OR = 1.11, 95% CI: 1.00–1.23, p=0.051). In exploratory analyses, there was a significant interaction between neighborhood poverty and race/sex group (p=0.04). Among black men, a one SD increase in neighborhood poverty, indicating higher levels of poverty, was associated with 11.2 less SED minutes/day (95% CI: −21.2, −1.2, p=0.029) and 10.6 more LPA minutes/day (95% CI: 1.8, 19.4, p=0.019; see Table 2).

In longitudinal analyses, there were no significant associations between neighborhood characteristics at year 20 with 10-year changes in accelerometer-based physical activity (see Table 4). Results also did not materially differ when excluding those who moved residences between the year 20 and year 30 examinations (data not shown). There was a significant interaction between neighborhood cohesion and race/sex group (p=0.03). Among black men, a one SD increase in neighborhood cohesion was associated with a 10-year decrease of 25.4 SED minutes/day (95% CI: −46.7, −4.1, p=0.020), and an increase of 19.0 LPA minutes/day (95% CI: 1.9, 36.1, p=0.030); see Table 5).

Discussion:

We examined the associations of neighborhood environmental characteristics with accelerometer-based SED, LPA, and MVPA in a large cohort of middle-aged black and white adults. In cross-sectional analyses, we found that greater levels of self-reported neighborhood cohesion were associated with lower SED and higher LPA, and greater levels of self-reported neighborhood resources for physical activity were associated with higher MVPA after adjustment for potential confounders, including smoking, alcohol consumption, and depressive symptoms. Higher levels of neighborhood poverty were associated with lower SED and higher LPA in black men only. In longitudinal analyses, no significant associations were observed between the neighborhood environmental measures with change in SED or physical activity from year 20 to year 30 in the full study sample. However, higher levels of neighborhood cohesion were associated with a decrease in SED and an increase in LPA among black men.

This is one of the first studies to identify associations between neighborhood cohesion and accelerometer-based SED and LPA. Our findings are contrary to those by Strong and colleagues, who reported no associations between neighborhood cohesion and SED among middle-aged black men and women in Texas.[32] However, the authors used self-reported television viewing as a surrogate for SED, which is a poor reflection of total sitting time.[33] While others have not specifically examined the relation of neighborhood cohesion with LPA (self-report or accelerometer-based), a study of older adults found that higher levels of neighborhood cohesion were associated with more neighborhood walking or strolling (implying slower walking), thus capturing LPA.[34] In the present study, neighborhood cohesion was not associated with MVPA or odds of meeting physical activity guidelines, in contrast to other studies using self-reported leisure-time MVPA.[17,18,35] However, the methodological differences between the present study (accelerometer-based MVPA) and others (self-reported leisure-time MVPA) may explain the disparate findings. It appears that higher levels of neighborhood connectedness may serve to reinforce engagement in health promoting LPA while deterring sedentary behaviors.

Also in cross-sectional analyses, higher perceived levels of neighborhood resources were associated with greater MVPA and odds of meeting the aerobic physical activity guidelines. Availability and proximity to recreation facilities, assessed both subjectively and objectively, has consistently been associated with higher self-reported physical activity among adults.[13,36–38] For example, a national study of U.S. adults (18 to 65+ years) found that perceived access to exercise facilities, parks, sidewalks, and walking trails was positively associated with self-reported physical activity.[36] The current paper contributes to the existing literature by providing further support that features of the built environment are related to accelerometer-based MVPA.

Interestingly, we also found that higher levels of neighborhood poverty were associated with lower levels of SED and higher LPA among black men. Others have also reported positive associations between neighborhood poverty and lower-intensity physical activities.[16,34,39] For example, using data from the NIH-AARP Diet and Health Study, Xiao and colleagues found that neighborhood socioeconomic deprivation was associated with less recreational exercise, but more time spent in non-exercise physical activities, such as walking for transportation among older adults.[16] Individuals living in higher poverty areas are more likely to socialize on the street or walk to visit with neighbors, and are also less likely to have a motor vehicle for transportation,[40] which could explain why higher levels of poverty were associated with less SED and more LPA. It is unclear why this association was only observed in black men; however, the percentage of white men and women living in high poverty neighborhoods was small, and therefore we may not have been adequately powered to detect associations among white participants. Findings should be interpreted with caution, given the exploratory nature of the race/sex stratified analyses.

Little is known about whether aspects of the neighborhood environment are associated with change in physical activity over time. In the full sample, we did not observe an association between neighborhood characteristics at baseline (year 20) with change in accelerometer-measured SED, LPA, or MVPA over 10-years. It is possible that the significant associations observed in cross-sectional analyses were the result of reverse causality or same source bias, where the outcome affects the perception or report of the neighborhood attribute. For example, individuals who engage in more MVPA may be more aware of the resources for physical activity in their neighborhood. Differential attrition may also explain why longitudinal associations were not significant, as participants who wore an accelerometer at both the year 20 and 30 exams differed from those who only wore an accelerometer at year 20.

In stratified analyses by race and sex group, greater levels of neighborhood cohesion were associated with less adverse changes in SED and LPA over 10-years in black men only. Others have also reported differences in the associations between neighborhood cohesion and self-reported physical activity by race, with stronger associations observed in non-Hispanic white adults than in non-Hispanic black adults.[18,35] Additional research is needed to confirm the race/sex differences observed in this present study, and to explore potential mechanisms.

Our study makes a novel contribution by examining how neighborhood characteristics are associated with lower intensity physical activities (SED and LPA), which are emerging risk factors for adverse health outcomes.[19–22] The use of accelerometers to assess physical activity is a notable strength, as accelerometers are less prone to bias than self-reported methods.[23] Additionally, inclusion of both perceived and objective measures of the neighborhood environment allowed for a more comprehensive examination of the neighborhood characteristics that may influence physical activity. Finally, we were able to examine differences by race and sex group, and identified several associations that were stronger among black men compared to other groups.

While accelerometer assessment of physical activity is a strength of this paper, this also prevented us from having contextual information about the types of physical activities people engaged in and location of physical activity. Additionally, although census information at the tract level has been commonly used in prior studies as a proxy for neighborhood, there is debate about whether or not this is the most appropriate way to define neighborhood boundaries.[41] There is a body of research which emphasizes the use of self-report or GIS procedures to define neighborhood delimitations.[42] While we defined neighborhood poverty and racial residential segregation using census information, perceived measures of the neighborhood environment were also included, which allowed individuals to self-define their neighborhood. It is also possible that certain unmeasured factors, such as mobility limiting diseases, changes in neighborhood characteristics over time, length of time residing in neighborhood, or personal characteristics like optimism may obscure associations between the neighborhood environment and physical activity. Notably, while we examined associations between neighborhood characteristics and physical activity domains separately, it is possible that neighborhood measures used in this study may lie on the same causal pathway or interact with one another. Future studies are needed to explore how characteristics of the neighborhood environment interact when examining relationships with physical activity patterns or health outcomes. . Finally, the magnitude of the associations were relatively small in the full study sample; therefore, the clinical implications of study findings are unclear.

In conclusion, higher perceived levels of neighborhood cohesion and resources for physical activity were associated with more favorable accelerometer-measured SED and physical activity patterns in cross-sectional analyses. Neighborhood characteristics were not related to 10-year change in physical activity in the full study sample. Several differences by race and sex were identified, with more robust associations observed in black men. Interventions aimed at improving neighborhood cohesion and resources, such as providing opportunities for community activities,[43] adopting community policing strategies to improve safety, and developing or maintaining parks, green spaces, and sidewalks,[13] may lead to beneficial changes in physical activity patterns.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgements:

The Coronary Artery Risk Development in Young Adults Study (CARDIA) is conducted and supported by the National Heart, Lung, and Blood Institute (NHLBI) in collaboration with the University of Alabama at Birmingham (HHSN268201800005I & HHSN268201800007I), Northwestern University (HHSN268201800003I), University of Minnesota (HHSN268201800006I), and Kaiser Foundation Research Institute (HHSN268201800004I).Accelerometer data collection was supported by grants R01 HL078972 and R56 HL125423 from the NHLBI. This manuscript has been reviewed by CARDIA for scientific content. The authors thank the investigators, the staff, and the participants of the CARDIA study for their valuable contributions.

Abbreviations:

SED	sedentary time
LPA	light-intensity physical activity
MVPA	moderate-to-vigorous intensity physical activity

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Highlights

- Neighborhood cohesion associated with less sedentary and more light activity
- Neighborhood resources associated with more moderate-to-vigorous activity
- Differences observed by race and sex with more robust findings in black men

Table 1:

Participant Characteristics, stratified by race and sex group, the CARDIA Study, 2005–2006 (N=2120)

Characteristics	Black Men N=325	Black Women N=539	White Men N=577	White Women N=679
Age, years	44.6 ± 3.6	44.4 ± 3.8	45.7 ± 3.3	45.9 ± 3.4
Education, years	14.0 ± 2.3	14.3 ± 2.2	15.9 ± 2.7	16.0 ± 2.4
Unemployed, n(%)	47 (14.5)	86 (16.0)	38 (6.6)	59 (8.7)
Annual family income, n(%)				
<$50,000	129 (39.7)	271 (50.3)	105 (18.2)	153 (22.5)
$50,000-$99,999	115 (35.4)	188 (34.9)	207 (35.9)	238 (35.1)
≥$100,000	81 (24.9)	80 (14.8)	265 (45.9)	288 (42.4)
Smoking status, n(%)				
Current	81 (24.9)	100 (18.6)	73 (12.7)	79 (11.6)
Former	44 (13.5)	87 (16.1)	111 (19.2)	201 (29.6)
Never	200 (61.5)	352 (65.3)	393 (68.1)	399 (58.8)
Alcohol consumption, ml/day	2.4 (16.7)	0.0 (4.9)	7.5 (23.9)	4.8 (14.3)
CES-D Score ≥ 16	58 (17.9)	106 (19.7)	61 (10.6)	94 (13.8)
Neighborhood environment measures				
Cohesion score[a]	16.7 ± 3.5	16.7 ± 3.6	18.3 ± 3.3	18.7 ± 3.3
Resources score[b]	3.9 ± 1.2	3.7 ± 1.3	3.4 ± 1.5	3.4 ± 1.5
Poverty[c]	15.7 ± 12.7	15.9 ± 12.4	7.3 ± 7.5	7.7 ± 7.4
Racial Segregation[d]	2.1 ± 2.7	2.3 ± 2.9	−0.4 ± 1.8	−0.2 ± 1.9
Accelerometer measured activity, min/day[e]				
Total wear time	909.7 ± 111.0	868.6 ± 90.9	889.6 ± 76.9	883.4 ± 74.6
Sedentary	484.7 ± 113.8	473.7 ± 102.0	510.7 ± 97.0	483.5 ± 96.4
LPA	379.2 ± 99.2	369.9 ± 81.9	337.0 ± 86.0	365.2 ± 78.4
MVPA	36.3 (33.3)	19.4 (21.3)	38.3 (31.3)	30.8 (30.0)

Abbreviations: LPA = light-intensity physical activity; MVPA: moderate-to-vigorous intensity physical activity

Data presented as mean ± SD or median (IQR) unless otherwise specified. P-value testing for differences by race and sex group using chi-square test, one-way ANOVA, or Kruskal Wallis test, as appropriate, all p<0.001.

[a] Higher scores indicate more self-reported neighborhood cohesion, score range 5–25.

[b] Higher scores indicate more self-reported resources for physical activity, score range 0–5.

[c] Percent living below the U.S. defined poverty threshold.

[d] Assessed using the G_i* statistic, with higher positive scores indicating higher racial/ethnic segregation, scores close to 0 indicating racial integration, and lower negative scores indicating lower racial/ethnic representation.

[e] Freedson cut point thresholds defined sedentary time in counts/minute as <100, LPA as 100–1951, and MVPA as ≥1952.

Table 2:

Cross-sectional associations of neighborhood environment measures (independent variable) and accelerometer-based activity minutes/day (dependent variable), the CARDIA Study, 2005–2006 (N=2120)

	Self-reported Neighborhood Cohesion		Self-reported Neighborhood Resources		Objectively Measured Neighborhood Poverty		Objectively Measured Racial Segregation	
	Beta (95% CI)	**p-value**	**Beta (95% CI)**	**p-value**	**Beta (95% CI)**	**p-value**	**Beta (95% CI)**	**p-value**
Sedentary								
Model 1	−4.23 (−8.12, −0.33)	**0.034**	−1.37 (−5.30, 2.57)	0.496	−2.73 (−6.89, 1.43)	0.198	−1.21 (−5.54, 3.12)	0.583
Model 2	−4.06 (−7.98, −0.15)	**0.042**	−1.58 (−5.50, 2.35)	0.431	−2.19 (−6.36, 1.98)	0.304	−0.79 (−5.12, 3.54)	0.720
LPA								
Model 1	4.62 (1.07, 8.18)	**0.011**	0.22 (−3.37, 3.81)	0.903	1.66 (−2.14, 5.45)	0.392	1.16 (−2.79, 5.12)	0.564
Model 2	4.46 (0.88, 8.03)	**0.015**	0.39 (−3.20, 3.98)	0.831	1.26 (−2.55, 5.08)	0.516	0.85 (−3.11, 4.81)	0.675
MVPA								
Model 1	−0.40 (−1.52, 0.72)	0.488	1.14 (0.01, 2.27)	**0.047**	1.07 (−0.12, 2.27)	0.078	−0.05 (−1.20, 1.30)	0.938
Model 2	−0.39 (−1.52, 0.73)	0.493	1.19 (0.06, 2.31)	**0.039**	0.93 (−0.27, 2.13)	0.130	−0.06 (−1.30, 1.89)	0.930

Models expressed per 1 SD of neighborhood cohesion (3.5 units), neighborhood resources (1.4 units), neighborhood poverty (10.6%), or racial segregation (2.6 units). Model 1 adjusted for center, age, race, sex, education, employment status, and family income. Model 2 additionally adjusted for smoking status, alcohol consumption, and depressive symptoms.

Table 3:

Cross-sectional associations of objectively measured neighborhood poverty (independent variable) with accelerometer-based activity minutes/day (dependent variable), stratified by race and sex group, the CARDIA Study, 2005–2006 (N=2120)

	Black Men (N=325)		Black Women (N=539)		White Men (N=577)		White Women (N=679)	
	Beta (95% CI)	p-value	Beta (95% CI)	p-value	Beta (95% CI)	p-value	Beta (95% CI)	p-value
Sedentary								
Model 1	−12.51 (22.62, −2.40)	**0.016**	0.17 (−6.16, 6.50)	0.958	−1.64 (−12.12, 8.85)	0.759	5.63 (−3.35, 14.62)	0.219
Model 2	−11.18 (−21.16, −1.18)	**0.029**	0.12 (−6.25, 6.49)	0.971	−1.01 (−11.6, 9.6)	0.852	4.54 (−4.54, 13.62)	0.326
LPA								
Model 1	11.67 (2.75, 20.60)	**0.011**	−0.57 (−6.37, 5.24)	0.847	2.11 (−7.45, 11.66)	0.752	−7.75 (−16.14, 0.65)	0.070
Model 2	10.60 (1.79, 19.41)	**0.019**	−0.53 (−6.37, 5.31)	0.858	1.76 (−7.87, 11.40)	0.720	−6.75 (−15.22, 1.73)	0.119
MVPA								
Model 1	0.83 (−3.06, 4.73)	0.674	0.40 (−1.06, 1.86)	0.589	−0.47 (−3.42, 2.47)	0.753	2.11 (−0.23, 4.45)	0.077
Model 2	0.57 (−3.32, 4.46)	0.774	0.41 (−1.06, 1.89)	0.581	−0.76 (−3.74, 2.23)	0.619	2.20 (−0.17, 4.58)	0.069

Models expressed per 1 SD of neighborhood poverty (10.6%). Model 1 adjusted for center, age, education, employment status, and family income. Model 2 additionally adjusted for smoking status, alcohol consumption, and depressive symptoms.

Table 4:

Associations of neighborhood environment measures (independent variable) with 10-year changes in accelerometer-based activity minutes/day (dependent variable), the CARDIA Study, 2005–2016 (N=892)

	Self-reported Neighborhood Cohesion		Self-reported Neighborhood Resources		Objectively Measured Neighborhood Poverty		Objectively Measured Racial Segregation	
	Beta (95% CI)	**p-value**	**Beta (95% CI)**	**p-value**	**Beta (95% CI)**	**p-value**	**Beta (95% CI)**	**p-value**
ΔSedentary								
Model 1	−4.49 (−9.91, 0.94)	0.105	4.85 (−0.65, 10.35)	0.084	−3.77 (−9.97, 2.43)	0.233	−4.78 (−10.95, 1.39)	0.128
Model 2	−4.54 (−10.00, 0.91)	0.102	4.88 (−0.66, 10.41)	0.084	−3.32 (−9.54, 2.90)	0.295	−4.16 (−10.36, 2.04)	0.188
ΔALPA								
Model 1	3.19 (−1.76, 8.15)	0.207	−2.34 (−7.38, 2.69)	0.361	3.66 (−2.01, 9.32)	0.205	5.45 (−0.18, 11.08)	0.058
Model 2	3.15 (−1.81, 8.12)	0.213	−2.24 (−7.31, 2.82)	0.385	3.12 (−2.56, 8.79)	0.281	4.80 (−0.85, 10.46)	0.096
ΔAMVPA								
Model 1	0.60 (−0.86, 2.05)	0.421	0.59 (−0.89, 2.06)	0.436	−0.95 (−2.61, 0.71)	0.262	0.08 (−1.57, 1.74)	0.921
Model 2	0.59 (−0.88, 2.05)	0.432	0.50 (−0.99, 1.99)	0.508	−0.87 (−2.54, 0.80)	0.309	0.18 (−1.49, 1.84)	0.834

Models expressed per 1 SD of neighborhood cohesion (3.5 units), neighborhood resources (1.4 units), neighborhood poverty (10.6%), or racial segregation (2.6 units). Change in accelerometer-based activity calculated as year 30 minus year 20. Model 1 adjusted for baseline (year 20) center, age, race, sex, education, employment status, family income, the baseline activity of interest (i.e. Δsedentary model adjusted for baseline sedentary time), and 10-year change in total accelerometer wear time. Model 2 additionally adjusted for smoking status, alcohol consumption, and depressive symptoms.

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Table 5:

Associations of self-reported neighborhood cohesion (independent variable) with 10-year changes in accelerometer-based activity minutes/day (dependent variable), by race and sex group, the CARDIA Study, 2005–2016 (N=892)

	Black Men (N=107)		**Black Women (N=220)**		**White Men (N=222)**		**White Women (N=343)**	
	Beta (95% CI)	**p-value**	**Beta (95% CI)**	**p-value**	**Beta (95% CI)**	**p-value**	**Beta (95% CI)**	**p-value**
ΔSedentary								
Model1	−26.91 (−47.75, −6.06)	**0.012**	−2.82 (−13.93, 8.30)	0.618	−4.92 (−15.36, 5.52)	0.354	2.08 (−6.21, 10.37)	0.622
Model 2	−25.44 (−46.73, −4.14	**0.020**	−2.76 (−14.10, 8.57)	0.631	−6.18 (−16.63, 4.27)	0.245	1.67 (−6.69, 10.03)	0.695
ΔLPA								
Model 1	20.72 (3.68, 37.75)	**0.018**	−0.46 (−10.47, 9.54)	0.927	3.65 (−6.12, 13.42)	0.463	−0.63 (−8.69, 7.43)	0.878
Model 2	19.00 (1.89, 36.10)	**0.030**	0.30 (−9.88, 10.48)	0.953	4.80 (−4.96, 14.55)	0.334	−0.21 (−8.35, 7.93)	0.960
ΔMVPA								
Model 1	4.91 (−1.27, 11.10)	0.118	1.08 (−1.23, 3.43)	0.363	0.34 (−2.79, 3.47)	0.830	−0.69 (−2.92, 1.54)	0.542
Model 2	5.33 (−1.01, 11.66)	0.098	1.21 (−1.20, 3.62)	0.323	0.10 (−3.07, 3.27)	0.949	−0.70 (−2.94, 1.53)	0.535

Models expressed per 1 SD of neighborhood cohesion (3.5 units). Change in accelerometer-based activity calculated as year 30 minus year 20. Model 1 adjusted for baseline (year 20) center, age, education, employment status, family income, the baseline activity of interest (i.e. Δsedentary model adjusted for baseline sedentary time), and 10-year change in total accelerometer wear time. Model 2 additionally adjusted for smoking status, alcohol consumption, and depressive symptoms.