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The impact of neighborhood on physical activity in the Jackson Heart Study☆

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Abstract

Physical inactivity is an independent risk factor for many diseases. Most research has focused on individual-level factors for physical activity (PA), but evidence suggests that neighborhood is also important. We examined baseline data collected between 2000 and 2004 from 5236 participants in the Jackson Heart Study to determine the effects of neighborhood on 2 types of PA: Active Living (AL), and Sports and Exercise (Sport) in an all-African American cohort. Participants were georeferenced and data from individual baseline questionnaires and US Census were analyzed using descriptive, bivariate, and multilevel models. In both types of PA, neighborhood factors had an independent and additive effect on AL and Sport. Living in an urban ($p = 0.003$) or neighborhood with a higher percentage of residents with less than a high school education ($p < 0.001$) was inversely associated with AL. There was an inverse interaction effect between individual and lower neighborhood education ($p = 0.01$), as well as between age and urban neighborhoods ($p = 0.02$) on AL. Individual level education (OR = 1.30) and per capita income (OR = 1.07) increased the odds of moderate-to-high sports. Future studies should focus on what contextual aspects of urban or less educated neighborhoods are influential in determining PA, as well as longitudinal multilevel analyses of neighborhood effects on PA.

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1. Introduction

Insufficient physical activity (PA) is an independent risk factor for cardiovascular disease (CVD), many cancers, premature death, and other chronic diseases (Ford et al., 2012). Differences in the type, amount, and frequency of activity may be a factor in the persistent health disparities that occur based on socioeconomic status (SES), race and ethnicity, sex, and geographic location. Limited attention has been given to measures of moderate activity, sports, and physical activity acquired during activities of daily life, or global, self-reported activity obtained from surveillance methods (Whitt-Glover et al., 2007).

Approximately 25% of American adults report inadequate leisure-time activity, and <21% of adults meet the federal physical activity guidelines for aerobic and muscle-strengthening activities during leisure-time activity (CDC, 2014), in spite of effective individually focused interventions aimed at increasing PA. Mississippi ranks first in the percentage of adults with no leisure-time activity (CDC, 2015b) and continues to have much higher age-adjusted CVD mortality rates compared to the U.S. among both whites (282.7; U.S. 217.6) and African Americans (353.2; U.S. 283.1) using 2012–2014 data (CDC, 2015a). Neighborhood context including the physical and social dimension of where a person lives, plays an influential role in determining individual health behaviors (Turrell et al., 2010; Wen and Zhang, 2009). Studies focusing on the relationship between neighborhood and PA in a large all-African American cohort are scarce (Hannon et al., 2012; Lee et al., 2012; Miles et al., 2008; Siceloff et al., 2014), and most are limited to walking behavior (Miles et al., 2008) or sports only (Diez Roux et al., 2007).

Using data from the Jackson Heart Study (JHS), we examined influences on two types of PA (Active Living and Sports & Exercise) with a primary interest in determining neighborhood impact using multilevel modeling and a socioecological framework in a large sample of southern African Americans. We expected independent association of neighborhood contextual variables with PA after controlling for individual-level predictors.

2. Methods

The JHS is the largest single-site, all-African American epidemiologic prospective study of CVD ever conducted in the U.S. The JHS recruited and examined 5301 African Americans from three counties (Hinds, Madison, and Rankin) in the Jackson, MS metropolitan area. Baseline data collection occurred between 2000 and 2004 with subsequent follow-up visits approximately every fourth year ending in 2013; for the current study only baseline data is included. Details of the study design, methods, and data collection protocols have been published elsewhere (Fuqua et al., 2005; Payne et al., 2005; Robinson et al., 2010; Taylor, 2005). Participants were 35–84 years old (younger and older participants were included as part of the family sample) and completed a home interview and baseline clinic visit (Fuqua et al., 2005). Participants responded to detailed interviews by trained interviewers. Institutional review board approval was received from Jackson State University, Tougaloo College, and the University of Mississippi Medical Center.

A cross-sectional, social epidemiological approach using a socioecological framework was used for this study (Institute of Medicine, 2002). The socioecological model incorporates factors from a variety of levels, including self, relationships, community, and the broader environment. The individual-level socioecological analytic data used for this study were collected during the home induction interview and first clinic examination. The neighborhood-level data from the 2000 U.S. Census was used as a proxy for the outer most level of influence of social, economic, and environmental conditions of the framework. Census tract was used to represent neighborhood, similar to other studies (Hickson et al., 2011; Krieger et al., 2003; Mujahid et al., 2008). Analyses were conducted using multi-level modeling to account for individual and neighborhood contributions to variance components, as well as clustering of nested data (Hearst et al., 2012; Sund et al., 2010).

2.1. Outcome variables

The two individual-level PA outcomes for this study were Active Living and Sports & Exercise (Sports). The JHS Physical Activity Form (JPAC), an interviewer-administered instrument with 30 items in 4 separate PA domains (active living; work; sports; and home and family life) (Dubbert et al., 2005), was modified from Atherosclerosis Risk in Communities measures and the Kaiser Physical Activity Survey (KPAS) (Ainsworth et al., 2000). Only Active Living and Sports were used in this analysis because they were hypothesized to be most influenced by neighborhood variables. The Active Living score is calculated using response from seven items to assess usual PA participation gained during daily living with questions about walking or bicycling to and from work, school, or errands; walking or bicycling for 15 min or more during leisure; and time spent watching television during the week (Dubbert et al., 2005). A scoring algorithm for the instrument is provided for the JPAC and was used to calculate individual Active Living scores, which ranged from 1 (no AL) to 4.75 (highest AL). The Sports domain measures up to three of the most commonly performed sports or exercise activities with the duration and intensity of each for the previous year. Again, the JPAC scoring algorithm was used with scores ranging from 1 (no Sports) to 5 (highest calculated as intensity × frequency × duration). Both outcome variables produce a rank order scale measure; forms are available at https://www.jacksonheartstudy.org/. Two-week test-retest reliability and validity using accelerometers and pedometers were previously established for the Active Living and Sports instruments (Smitherman et al., 2009).

2.2. Independent variables

2.2.1. Individual variables—Individual-level variables, the first level of the socioecological framework, included age, sex, education, per capita income (total family income divided by number of people supported), and wealth (cars, home ownership, liquid assets). Education was a standardized ordinal measure of years of education completed. Indicators of wealth were categorical and included: total number of cars that participants had access to (0–≥2), home ownership (Own/Pay Mortgage, dichotomized with other categories coded no), and liquid assets collapsed into four categories (refused, $0–9999; $10,000–49,999; $50,000–99,999; $100,000 or above).

2.2.2. Neighborhood variables—Neighborhood-level variables comprise the next level in the socioecological framework. Using geocoded residential address data for each JHS participant (Robinson et al., 2010), individual participants' residential addresses were geocoded and aggregated to the census tract, and merged with data from the 2000 U.S. Census (U.S. Census-Bureau, 2003). Median neighborhood income; neighborhood education (continuous variable % of residents with <HS education); neighborhood segregation (continuous variable % African Americans per neighborhood); and location type (rural or urban) were included. Census 2000 defined Urbanized Area and Urban Cluster block groups were classified as urban; all other block groups were considered rural (Barron, 2002). Since tracts are comprised of multiple block groups, some tracts had both urban and rural areas; if a larger percentage of the tract was comprised of urban block groups, it was classified as urban. The percentage of African Americans per neighborhood was used as a proxy for racial residential segregation.

Neighborhood safety, a proxy for crime, was assessed using an individual-level proxy from JHS participant self-report of neighborhood stress related to perceived safety ("Over the past 12 months, how much stress did you experience related to living in your neighborhood? This would include crime, traffic, events affecting your personal safety, etc.") with four potential response categories of not stressful to very stressful. For analysis, responses were collapsed to create a dichotomous variable of any level of perceived stress versus no stress. Individual neighborhood safety stress responses were aggregated to compute a measure of mean neighborhood stress for each tract similar to methods used in other studies (Wen et al., 2003); this aggregated score was used at the neighborhood level.

2.3. Analytic approach

Statistical analyses were conducted using SPSS 19 (IBM, 2012) for descriptive and bivariate analyses prior to using HLM 6 (Raudenbush et al., 2004) for hierarchical multi-level modeling. Because the distribution of Sports activity scores was zero-inflated, we dichotomized Sports into none or low sports activity versus moderate or high sports activity to facilitate fitting statistical models. Restricted maximum likelihood estimates were obtained for the model parameters for the continuous outcome Active Living. Restricted PQL (penalized quasi-likelihood) approach was used to estimate the parameters for the dichotomized Sports activity. Following exclusions for missing outcome data at the individual level (Active Living = 18; Sports & Exercise = 217), the sample used for all analyses included 5236 participants. The range of missing data on the remaining variables was low (0−33). In addition to tests of statistical significance, effect size estimates were reported as slopes (standard errors) for continuous outcomes and odds ratios (95% confidence intervals) for dichotomized sports and exercise outcomes.

A four-step modeling strategy was used for analysis of each PA outcome. For both outcomes, the same individual and neighborhood variables were tested but based on results and fit of each successive model for each outcome, several variables were removed as described below. Initially, a simple model (Model 1) was fit that included no individual or neighborhood variables but used random intercepts to capture the variability between neighborhoods in a single variance component. Model 2 included only census tract neighborhood variables (% <HS & urban categorization) as fixed effects but including random intercepts, nesting Model 1. Model 3 was a random coefficient model that included a full set of individual predictors (education, age, sex, perceived stress, per-capita income & wealth) as previously defined but no census tract neighborhood variables. For Model 3, the predictors were first assumed random; however, variance components were not considered significant and the final model assumed all individual level predictors were fixed. At the individual level, wealth and per capita income were not significant predictors of Active Living and were removed from the final interpretation model. At the neighborhood level, percent African American, median income, and the aggregated stress related to neighborhood safety variables were dropped from further analyses after failing to reach statistical significance in Model 2. That is, Model 3 is a parsimonious model based on removing non-significant predictors. The final model, Model 4, included the remaining individual- (education, age, sex, stress, per capita income, & wealth) and neighborhood-level variables (urban & education). Although successive models (Models 2, 3 and sub-models of 3) were used in model building, we report only Model 1 which determined the feasibility and need for a multi-level model, and Model 4, the final multi-level model as most appropriate for interpretation.

In the final model (Model 4), interactions between individual level factors and census tract neighborhood factors were investigated through the fixed effects. Interactions that remained in the model were age, sex, perceived stress and education at the individual level with urban/rural classification and percentage of residents with less than high school education at the neighborhood level. For AL, including interactions of urban and neighborhood education and per capita income and wealth affected model convergence and were removed, leaving all other interactions intact. For Sports, all individual and neighborhood interactions were modeled. We considered all tests, including interactions, significant if $p < 0.05$.

3. Results

Table 1 summarizes demographic characteristics of the sample and neighborhood tracts. There was a higher percentage of women (63.4%), the mean age was 55 years, and most had at least a high school education (81.5%), owned their home or were paying a mortgage (84%), had access to one or more vehicles (92.8%), and nearly a third could access between $10,000 and $49,000 if they needed money quickly (29.9%).

The neighborhood sample included 102 of the 104 possible U.S. Census tracts in the JHS area with geocoded participants' addresses linked to the tract (Table 1). Almost half of the tracts had at least 25 participants; 21 tracts had <10 participants ($\mu = 51$; SD 75.7).

The bivariate relationships between individual characteristics and each PA outcome were examined as a preliminary step prior to multilevel model building (Table 2). Age, sex, education, liquid assets, access to a car, home ownership, and per capita income were related to both measured domains of PA. Stress regarding neighborhood safety and wealth were related to Active Living but not to Sports. Active Living and Sports were moderately correlated with each other.

At the neighborhood level, stress was negatively correlated with median income ($r = -0.55$) and positively correlated with African American race ($r = 0.60$). In addition, median income was negatively correlated with race ($r = -0.70$). We did not find a correlation between urbanicity and education, stress, median income or race. Education (% <HS) was positively correlated with stress ($r = 0.59$) and race ($r = 0.73$) but relatively negatively correlated with median income ($r = -0.67$). As these entered the multivariate models, their collinearity became a factor and, thus, the final model did not include these as indicators.

3.1. Multilevel analyses

3.1.1. Active living physical activity—Active Living PA varied significantly among the various census tracts in Model 1 ($\beta = 2.11$, SE = 0.02, $p < 0.001$) and we estimated that approximately 4% of the variance in mean Active Living scores is explained by belonging to a different neighborhood; however, a significant proportion of the variance remained unexplained. Neighborhood variables explained a large proportion of the variation in mean Active Living, indicating that 75% of the neighborhood variation could be explained by two neighborhood variables: the percentage of people with less than a high school education or urban neighborhood.

Following analyses of the individual and neighborhood associations in Model 2 and 3, the final model included rural/urban classification and neighborhood education (Table 3, Model 4). Fitting a more complex model did not produce a significant improvement in variance explained, so education, which had been allowed to vary in previous models, was fixed in the final step. There was a significant interaction between urban neighborhood and neighborhood education (% <HS education) on Active Living. The final model explained 79% of the variance in Active Living. Based on our fitted model, someone living in an urban neighborhood would be expected to have a lower Active Living score compared to those in a rural neighborhood, for example. Neighborhood education was also inversely associated with Active Living scores, holding all other variables constant. Cross-level interactions between *individual* education and *neighborhood* education and between age and living in an urban area were significant, moderating the amount of Active Living reported. For each one year of additional individual education, Active Living increased slightly ($\beta = 0.07$, N.S.). However, when living in neighborhoods with a higher percentage of residents who had less than a high school education, the influence of individual education was moderated and further decreased ($\beta = -0.003$; $p = 0.01$).

Fig. 1 visually represents the cross-level association on Active Living using data from both levels (individual & neighborhood education) for all neighborhoods represented as single regression lines, one for each of the two categories of neighborhoods based on residents' educational attainment. Since it was determined during modeling that neighborhoods varied in Active Living (between neighborhood influence), we also modeled individual neighborhoods (Fig. 2) using a random sample of neighborhoods based on individual education and the interaction of individual and neighborhood education. In neighborhoods with higher education, as individual education increased, Active Living score increases were greater compared to individuals with similar education living in neighborhoods with lower education. As individual education increased, in more educated neighborhoods (i.e., those with the lowest & <HS education), the outcome was generally stronger than in less educated (i.e., neighborhoods with the highest & <HS education) (Fig. 2). The results indicate the individual neighborhood variability in the association of education on the outcome. Fig. 3 indicates differences in Active Living by individual education in urban versus rural neighborhoods.

3.1.2. Sports and exercise physical activity—Sports PA also revealed significant variation among the census tract-defined neighborhoods (Model 1; Odds Ratio [OR] = 0.82, 95% Confidence Interval [CI] 0.74, 0.91). Models 2 and 3 included the same variables used in the Active Living analyses.

The full model (Table 3, Model 4) explained nearly all of the variance for the odds of participating in Sports PA among neighborhoods. Cross-level interaction between education (% <HS) and urban type neighborhood and all individual variables were modeled, as well as the intercept to determine the main effects for each. Unit-specific results with robust standard errors are reported; population-averages were similar. The odds of participating in moderate or high sports activity versus lower sports was about 16% lower across all neighborhoods (OR = 0.84; 95% CI 0.66, 1.06). With each unit increase in individual education, the odds of participating in moderate or high sports increased by 30% (OR = 1.30; 95% CI 1.14, 1.47). Cross-level interactions with neighborhood variables did not further change the strength or direction of this relationship. With increasing age, the odds of Sports declined about 18% per year (OR = 0.82; 95% CI 0.69, 0.97). Individual wealth was associated with increased odds of participating in Sports. With a one unit increase in wealth, the odds of participating in moderate to high Sports were increased by 27% (OR = 1.27; 95% CI 1.09, 1.47).

4. Discussion

This study demonstrates that neighborhoods have an independent influence on two measures of PA. Rural neighborhoods had more Active Living PA compared with urban, and individual participant educational level had somewhat different results depending on the neighborhood education level. Our findings of an independent association of neighborhood on Active Living and Sports PA confirm those of other studies of neighborhood influences (Mujahid et al., 2007; Piro et al., 2006; Riva et al., 2009) with neighborhood accounting for 3.8% of the variance in Active Living PA scores, similar to other studies (Boone-Heinonen et al., 2011; Logstein et al., 2013).

Our findings show a similar association of individual-level variables with PA to those found in other studies (Bopp et al., 2006; Mendes de Leon et al., 2009). However, our primary focus was on the contextual neighborhood factors influencing PA. When the individual variables were nested in the neighborhoods and analyzed simultaneously, differences emerged and many of the significant associations at the individual level disappeared. Individual level variable main effects were not associated independently with Active Living. This suggests that the neighborhood that one lives in has an important effect on Active

Living, i.e., walking or biking for transport. We found that living in an urban setting was inversely associated with AL. In urban areas of Jackson, MS, there are few or poor sidewalks and few biking paths, suggesting that built environmental features may be important. A similar finding was observed in a study of walking among a multi-ethnic, low-income, urban sample (Caspi et al., 2013).

In contrast, for Sports, main effects of individual education and the wealth measure were associated, while age had an inverse association even when neighborhood variables were included. In Model 2 (neighborhood variables only), segregation and urban type were significantly inversely associated with Sports; however, in the full model, that association was attenuated and was non-significant. Thus, for Sports, it indicates that while neighborhood factors may be important, Sport PA is less influenced by the neighborhood of residence as people have the option to participate elsewhere. Individual SES has been associated with PA in other studies (Crespo et al., 2000; National Center for Health Statistics, 2011); however, the SES association in the JHS depended on the PA domain and the dimension of SES used. Importantly, unlike most other studies that have used composite or one individual measure of education, income, or occupation, our analyses included measures of wealth (home & car ownership; liquid assets). Wealth measures were independently associated with Sports PA, perhaps reflecting financial security, less need to focus on making ends meet, and more time for Sports, but were not significantly associated with Active Living. Differences in association or lack of an association may also be explained by having access to a car. If one has access to a car, they may be less inclined to walk or bike for errands.

Neighborhood education and urban type neighborhood were the only neighborhood-level variables with an association with PA in this study. However, the association was attenuated and was not significant for Sports in the final model. A lack of neighborhood effect on Sports may be because participation in sports activities can occur both within and outside a person's neighborhood of residence and not strongly tied to areas around where someone lives. Only about 41% of the enrolled participants reported any sports or exercise (Dubbert et al., 2010) and the most common was vigorous walking (61%, data not shown). A common place in the Jackson area to walk is in one of several indoor malls where residents may perceive that they are safer, can socialize, and are protected from temperature extremes. For Active Living, there were significant cross level influences for the interaction of individual and neighborhood level of education. This supports the hypothesis that neighborhood and individual factors act synergistically to moderate their influence on outcomes and highlights the benefit of simultaneously modeling individual and neighborhood variables. As illustrated in Fig. 1, education is positively associated with active living so that increasing individual education could potentially increase active living scores similar to other reports (CDC, 1996; Gauvin, 2010). However, the interaction of education within the context of neighborhood attenuates the effect of education so that the improvements from the individual contribution are somewhat subsumed by the neighborhood with higher educational attainment. This could be a consequence of higher neighborhood education resulting in more resources for participation in active living through improvements in the built environment, social awareness, and opportunity (Gauvin, 2010). Findings of a contextual neighborhood effect add to what is known; associations have been demonstrated in some studies but not in others

(Bauman et al., 2012; Boone-Heinonen et al., 2011). We believe this is an important finding that could act as a catalyst of support for more shared resources between affluent, well-educated neighborhoods and those with less opportunity. As a sensitivity analysis, Fig. 2 illustrates that this is not attributable to a statistical anomaly but, rather, appears to remain consistent across neighborhoods.

For this study, we measured perceived stress of the neighborhood as an individual-level variable, using it as a proxy for neighborhood stress related to safety. We also aggregated individual responses for each tract to form a mean neighborhood stress score, recognizing the potential for ecological fallacy. To minimize ecological bias, we included the variable on the individual and neighborhood levels as previously suggested (Wakefield, 2008). In this study, individual-level stress was positively associated with both domains of PA but the association disappeared in the full multilevel model, while the aggregated neighborhood stress measure was not associated with either type of PA. Crime and safety have been inconsistently associated with PA in other studies. Our results may reflect that the measure we utilized was not a good proxy for crime of the neighborhood. Accurate crime data were not available at the tract level, limiting our ability to assess the association of neighborhood crime and safety with other measures.

In this study, we found no association of racial segregation with either outcome. We used percentage of African Americans per census tract to represent neighborhood segregation and its association with PA. Using a similar definition, a higher proportion of white residents at the neighborhood level was associated with walking in older adults (Shelton et al., 2009). It is possible that the spatial neighborhood segregation measure is not an important predictor of PA or that there was not enough variation among neighborhoods. By design, recruitment focused on neighborhoods with high concentrations of African Americans. The percentage in this study ranged from 1% to 100% with a median of 43%.

Individual income was associated with Sports PA but not Active Living. Thus, we anticipated that neighborhood income might affect PA. Neighborhood median income was not associated with either domain of PA. This lack of association with Active Living is consistent with a study conducted in the Netherlands that examined the odds of no recreational walking by five income categories (Kamphuis et al., 2009). Including measures of PA from multiple studies, the majority of studies included in a recent systematic review found no association with neighborhood SES (Schule and Bolte, 2015), while Gidlow et al. (2006) noted that education tends to be a stronger predictor of PA compared to income. This would be consistent with our findings as neighborhood education and not median neighborhood income was important in predicting PA in this sample. However, neighborhood socioeconomic disadvantage has shown a strong, graded relationship with lower PA especially among African Americans in other studies (Boone-Heinonen et al., 2011).

There are several limitations to this study. This is a cross-sectional design and a secondary analysis of existing data. As such, we were limited in some of the variables that we might have included. For example, self-efficacy and social support for exercise, and more specific questions about perception of crime in the neighborhood directed at PA might have helped explain more of the variance in different types of PA. Additional limitations were that racial comparisons cannot be made and the findings are not generalizable to others or different regions of the U.S. The definition of "neighborhood" was determined by the researchers and did not necessarily reflect what residents might consider their neighborhood. Using residential address to represent place does not capture fully the multiple places in which people live and interact, such as work or church.

The strengths of this study were that it examined different types of PA in a large cohort study with a sample size adequate for multi-level analyses and a wide range of SES measures, especially education; most studies of African Americans have a higher percentage of lower SES participation. This study provides a comprehensive analysis of associations of multi-level socioecological determinants on different types of leisure and transport PA performed by African Americans.

Our findings indicate that both individual- and neighborhood-level variables are important in determining Active Living and Sports PA in African Americans. The salient neighborhood factors for this sample were urban type and education levels of the neighborhood. Further studies are needed to determine specific neighborhoods to target for future interventions to increase PA of all types; the association of built environmental features such as presence and condition of sidewalks and access to parks which may influence both AL and Sports; the influence of crime and social disorder rather than a proxy measure of stress on activity in the neighborhood; and the impact of neighborhood on the rate of change in activity over time.

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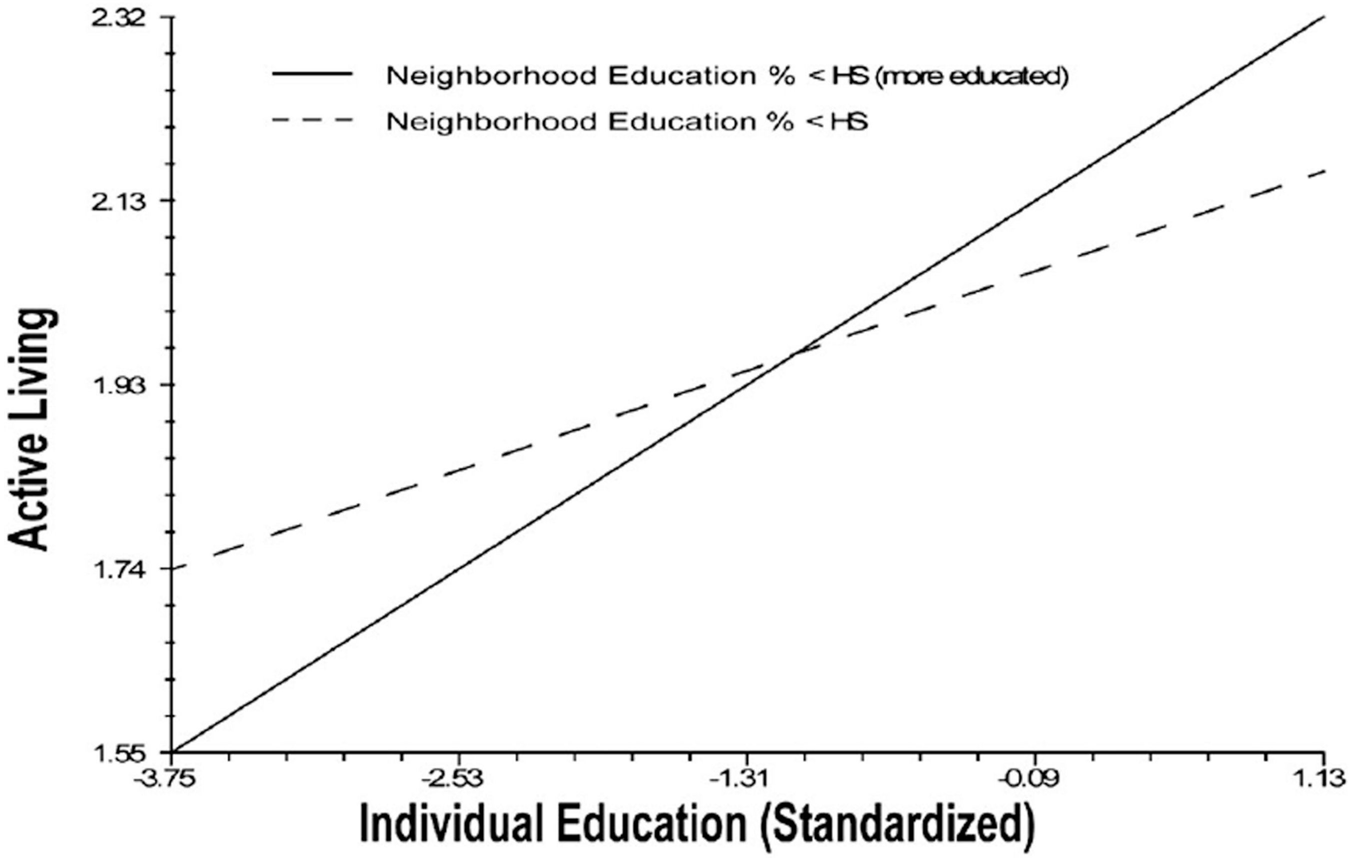

Fig. 1.
Active Living as a function of individual and neighborhood education in the Jackson Heart Study at baseline, 2000–2004, Jackson, MS. Note: Neighborhood education was divided into two categories at 50%.

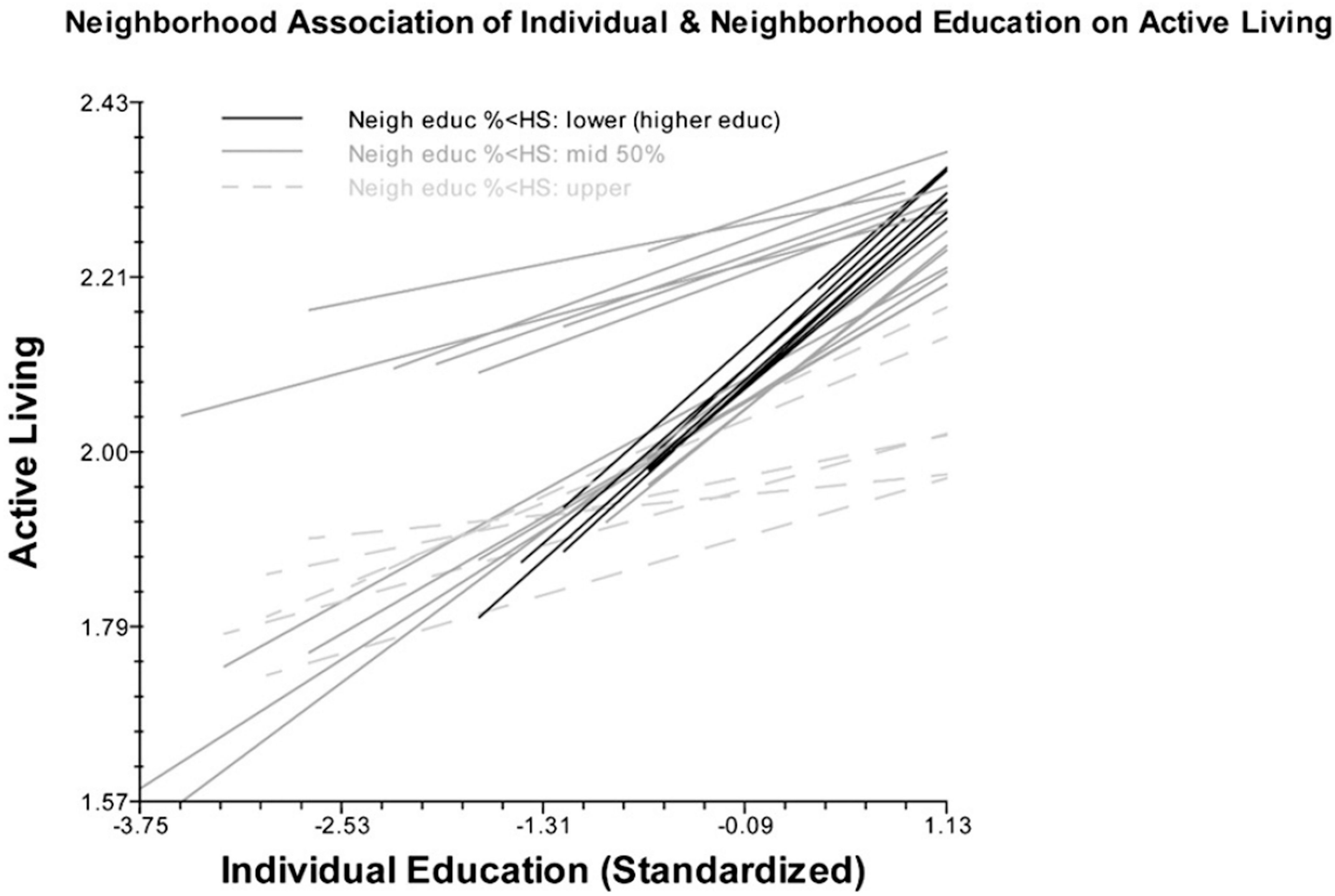

Fig. 2.

Active Living among randomly selected neighborhoods by individual and neighborhood education in the Jackson Heart Study at baseline, 2000–2004, Jackson, MS. Note: Neighborhood education was divided into three categories at the 25th, 50th, and 75th percentiles.

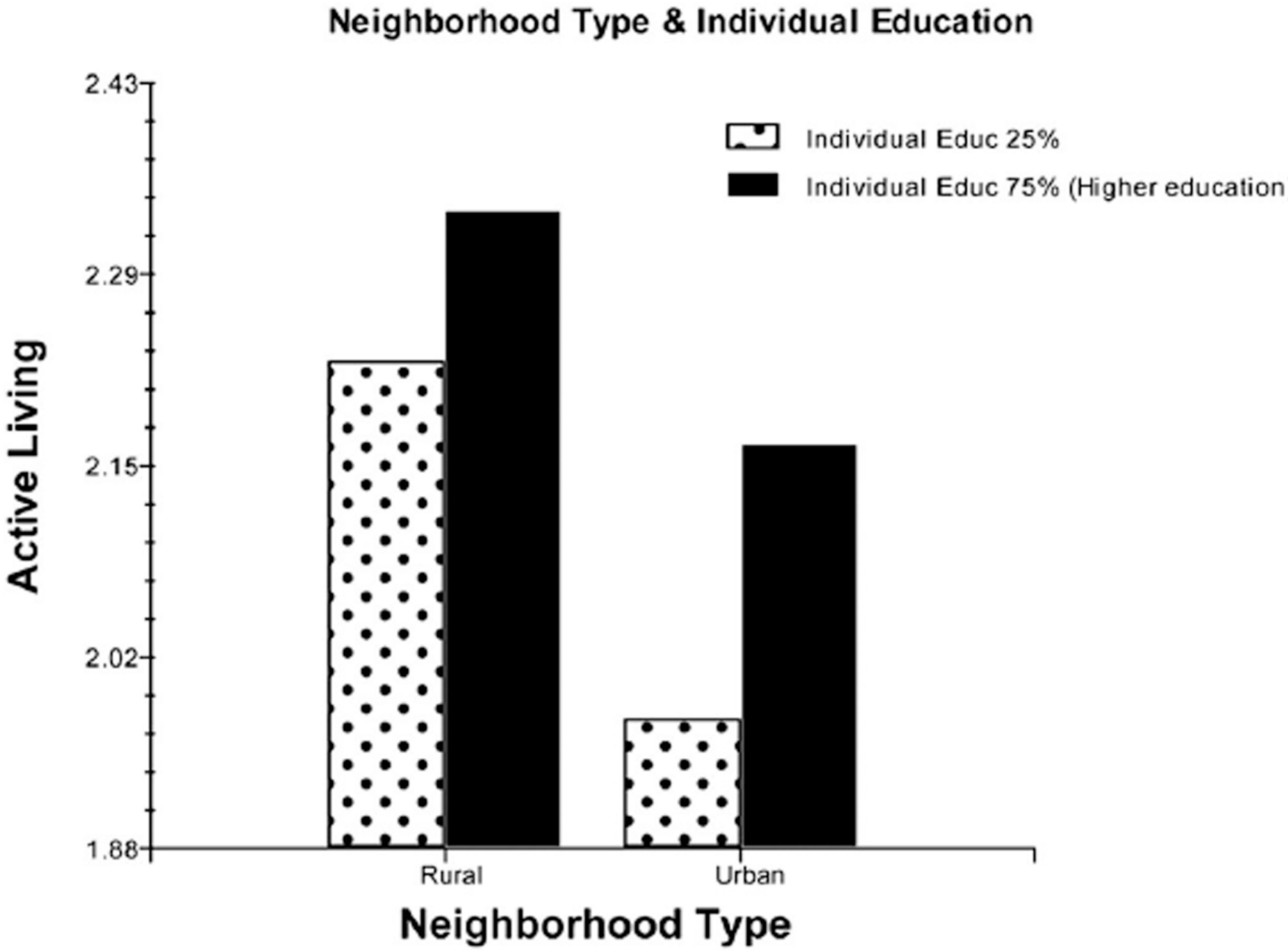

Fig. 3.
Association of neighborhood type and individual education on Active Living in the Jackson Heart Study at baseline, 2000–2004, Jackson, MS. Note: The 25th and 75th percentiles were used to categorize individual education.

Table 1

Demographic characteristics of Jackson Heart Study participants and neighborhoods at baseline, 2000–2004, Jackson, MS.

	Analysis population (N = 5236)	
Individual level (range)	**Mean (SD)**	***n* (%)**
Age (21–95)	54.9 (12.8)	
Missing		1 (0.02)
Sex		
Male		1916 (36.6)
Female		3319 (63.4)
Missing		1 (0.02)
Education[a]		
<High school		967 (18.5)
High school/GED/vocational school/some college		2198 (42)
College degree or higher		2047 (39.1)
Missing		19 (0.36)
Per capita income (0–100,000 or more)	$15,682 ($15,188)	
Missing		33 (0.6)
Home		
Own or buying		4397 (84)
Renting or other		839 (16)
Missing		
Car access		
0		377 (7.2)
1		1851 (35.4)
2		3008 (57.4)
Missing		0
Liquid assets ($)		
0–9999		1252 (23.9)
10,000–49,999		1560 (29.8)
50,000–99,999		738 (14.2)
100,000 or more		873 (16.7)
Don't know or refused		788 (15)
Missing		25 (0.48)
Wealth Score[b] (range 0–7)	4.28 (1.73)	
Missing		25 (0.5)
Stress related to safety		
Not stressful		3858 (73.7)
Mildly stressful		787 (15)
Moderately stressful		330 (6.3)

	Analysis population (*N* = 5236)	
Individual level (range)	**Mean (SD)**	***n* (%)**
Very stressful		234 (4.5)
Missing		27 (0.52)
Active Living scores (1 [none]–4.75)	2.08 (0.80)	
Missing		18 (0.3)
Sports & Exercise scores (1.25 [none]–5)	3.25 (0.73)	
None or low		2747 (52.5)
Moderate or high		2272 (43.4)
Missing		217 (4.1)
US Census tract level (range)	*n* = 102	
% African American (1–100%)		49.9 (35)
Stress of neighborhood (0–1.07)		0.33 (0.27)
Median income ($10,507–$118,192)		$39,346 ($20,120)
Urban		84 (82.4)
Education[c] (% population with <HS) (range 1.29%–57.14%)		
≤8.61		26
8.62–20.88		25
20.89–32.41		26
32.42–53.73		25

[a]GED = General Educational Development test; AD= associate degree.

[b]Wealth Score = own or buying a home + number of cars + liquid assets in categories.

[c]Neighborhood education classification reflects the percentage of the residents 25 years and older in that census tract had less than a high school education.

Table 2

Bivariate Spearman rho correlations among individual variables in the Jackson Heart Study, 2000–2004, Jackson, MS.

	Age	Male	Education	Income	Assets	Car	Home	Wealth	Stress	Sport
AL	− 0.17**	0.03*	0.19**	0.07**	0.06**	0.06**	0.03*	0.07**	0.05**	0.36**
Age		− 0.05**	− 0.28**	0.07	0.03*	− 0.08**	0.19**	0.03*	− 0.03*	− 0.15**
Male			− 0.02	0.07**	0.12**	0.21**	0.01	0.16**	− 0.05**	0.04**
Education				0.40**	0.30**	0.23**	0.12**	0.33**	− 0.03	0.21**
Income					0.58**	0.24**	0.17**	0.55**	− 0.09**	0.15**
Assets						0.32**	0.22**	0.90**	− 0.09**	0.13**
Car							0.32**	0.64**	− 0.11**	0.07**
Home								0.46**	− 0.06**	0.03*
Wealth									− 0.11**	0.13
Stress										0.02

Note: AL: Active Living; Sex: represented as Male; Assets: Liquid Assets; Home: Own or Buying a Home; Wealth: Composite score consisting of home ownership, liquid assets, and access to a car; Stress: individual stress of living in the neighborhood because of crime and safety.

* $p < 0.05$,

** $p < 0.001$, 2 tailed.

Table 3

Final multilevel estimates with cross-level interactions for Active Living, and Sports & Exercise physical activity in the Jackson Heart Study, 2000–2004, Jackson, MS.

	Active Living		**Sports & Exercise**
	β (SE)	**p-Value**	**Odds ratio (95% CI)**
Intercept	2.24 (0.07)	<0.001	0.84 (0.66, 1.06)
Urban	− 0.23 (0.08)	0.003	0.84 (0.66, 1.08)
Ed.: % <HS	− 0.01 (0.001)	<0.001	1.00 (0.99, 1.00)
Education (standardized)	0.07 (0.07)	0.29	1.30 (1.14, 1.47)
Urban	0.06 (0.07)	0.39	1.09 (0.93, 1.27)
Ed.: % <HS	− 0.003 (0.001)	0.01	1.00 (0.99, 1.00)
Age (standardized)	− 0.01 (0.03)	0.76	0.82 (0.69, 0.97)
Urban	− 0.07 (0.03)	0.02	1.00 (0.83, 1.19)
Ed.: % <HS	0.0005 (0.0001)	0.64	1.00 (1.00, 1.01)
Male	0.06 (0.06)	0.29	1.20 (0.88, 1.65)
Urban	− 0.02 (0.06)	0.75	0.98 (0.70, 1.35)
Ed.: % <HS	0.001 (0.001)	0.35	0.99 (0.99, 1.00)
Stress (dichotomized)	0.04 (0.06)	0.53	1.41 (0.96, 2.07)
Urban	0.07 (0.06)	0.29	0.85 (0.57, 1.26)
Ed.: % <HS	0.002 (0.001)	0.09	1.00 (0.99, 1.01)
Per capita income (standardized)	0.01 (0.01)	0.26	1.07 (0.88, 1.32)
Urban			1.09 (0.88, 1.34)
Ed.: % <HS			1.00 (0.99, 1.00)
Wealth (standardized)	0.01 (0.01)	0.38	1.27 (1.09, 1.47)
Urban			0.86 (0.73, 1.00)
Ed.: % <HS			1.00 (0.99, 1.00)
Variance components			
μ_0	0.005 (p = 0.02)		0.008 (p = 0.09)
σ^2	0.599		

Notes: Model 4 – adds individual and neighborhood variables and cross-level interactions as indicated during model specification. Results indicate final estimates of fixed effects with robust standard errors.