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How are neighborhood characteristics associated with mental and physical functioning among older adults with radiographic knee osteoarthritis?

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Abstract

Objective.—This study examined how neighborhood characteristics were associated with health outcomes among older adults with osteoarthritis.

Methods.—We examined in multilevel, cross-sectional and longitudinal analyses if four neighborhood characteristics were a) associated with depressive symptoms and reported knee impact scores and b) interacted with race / ethnicity among older adults with radiographic knee osteoarthritis (n=656 for cross-sectional analyses and n=434 for longitudinal analyses). Data came from the Johnston County Osteoarthritis Project, a prospective cohort study in North Carolina designed to examine risk factors for osteoarthritis.

Results.—Although few longitudinal associations were found, cross-sectional results suggested that greater perceived neighborhood social cohesion (B= −0.04, p< 0.001) and perceived neighborhood resources for physical activity and walking (B= −0.03, p< 0.001) were associated with fewer depressive symptoms and that greater perceived neighborhood resources for physical activity and walking were associated with higher (better) knee impact scores (B=0.48, p=0.008). We also observed two significant interactions among neighborhood characteristics and race / ethnicity related to depressive symptoms (p<0.01); for Black adults, greater perceived

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neighborhood resources for physical activity and walking was associated with fewer depressive symptoms (B= −0.03, p<.001), but for White adults, greater perceived neighborhood safety was associated with fewer depressive symptoms (B= −0.04, p=0.003).

Conclusion.—In a sample of older adults with radiographic knee osteoarthritis, neighborhood context matters, but in nuanced ways. Interventions aiming to improve mental and physical functioning of older adults with knee osteoarthritis can look to this study as evidence for the importance of neighborhood characteristics.

Introduction

Arthritis is one of the most common chronic diseases in the US (1), particularly among older adults—the majority of whom report having arthritis (2). There is now growing evidence that aspects of the neighborhood are associated with arthritis outcomes (3–15). Despite the growing body of evidence that neighborhoods influence the health and well-being of individuals with arthritis, several notable gaps in the literature remain.

First, relatively few studies have examined how neighborhood socioeconomic status (SES) affects the mental health of individuals with osteoarthritis (OA). Previous research shows that neighborhood SES is associated with reduced quality of life (8) and depression (16) *among individuals with self-reported arthritis*. However, no studies to our knowledge have examined how neighborhood SES is associated with psychological well-being *among individuals with OA.* This is surprising given the relatively high prevalence of depression and anxiety among individuals with OA (17–19) and research suggesting co-morbid depression and OA are associated with worse outcomes than either condition alone (20).

Second, the majority of studies have focused only on neighborhood SES without investigating how other neighborhood characteristics are associated with OA outcomes, such as neighborhood cohesion—though there are some exceptions (13, 15). Third, few studies have examined how neighborhood SES may interact with individual-level characteristics to influence OA outcomes. For instance, research has found that African Americans have more than double the prevalence of severe knee OA than Whites (21); they are more likely to have significantly worse pain, stiffness, and function (22, 23); and they are less likely to seek or receive joint replacement therapy or pain medication (24–26). Yet, only one previous study to our knowledge has examined interactions among neighborhoods and race by analyzing if neighborhood SES moderates the effects of income and race on reports of arthritis (5). Finally, as is common with research on neighborhoods and health more generally (27), most studies have examined associations among neighborhood-level characteristics and OA outcomes cross-sectionally.

The present study examines if neighborhood context is associated with mental and physical health outcomes among individuals with radiographic knee OA and addresses limitations of previous research by answering the following research questions:

1. Is neighborhood context associated with mental and physical health outcomes?
2. Is neighborhood context associated with health outcomes over time?

3. Does race / ethnicity interact with neighborhood context to influence health outcomes?

To guide our research questions, we used a conceptual model from Diez Roux & Mair (27), which posits that both physical and social neighborhood environments influence health and that their influence likely depends on individual-level characteristics. Based on this model, we 1) selected multiple neighborhood characteristics, including neighborhood poverty, social cohesion, resources for physical activity and walking, and safety, to understand how neighborhood physical and social environments influence health, and 2) examined how race / ethnicity (an important individual-level characteristic for OA research) interacts with neighborhood context to influence health outcomes. We chose to examine both mental and physical health outcomes given the importance of both outcomes for individuals with OA (28).

Materials and Methods

Participants and Procedures

Data for this study come from a population-based prospective cohort of knee and hip OA among African American and White individuals (the Johnston County Osteoarthritis Project "JoCo OA project") (29). Recruitment occurred in Johnston County, North Carolina (NC), which at the time of this study, was classified as a mostly rural county (30). Details on the study design, data collection procedures, and study population are detailed in previous publications (29). In brief, the study was designed to be representative of civilian, non-institutionalized African Americans and Whites over the age of 45 who resided in one of six towns or townships in Johnston County, NC for at least one year, were living in the county at the time of study enrollment, and physically and mentally capable of completing the study protocol. All participants provided informed written consent at the time of recruitment. The study was approved by the Institutional Review Boards of the University of North Carolina Schools of Medicine and Public Health and the Centers for Disease Control and Prevention.

Study Analytic Sample

The analytical sample for this study uses data from two waves of the JoCo OA study: T2 and T3. For convenience, we refer to these time points as baseline and follow-up. Baseline data were collected between 2006–2011 and follow-up data were collected between 2013–2015. For the purposes of this study, we restricted analyses to individuals with radiographic knee OA, defined as a score of 2, 3, or 4 on the Kellgren and Lawrence (KL) grade (9, 31).

Since we hypothesized that neighborhood variables would have the greatest effect on knee OA outcomes (given plausible links between neighborhood variables, exercise, and mobility), we only analyzed data for individuals with radiographic knee OA, rather than individuals with radiographic knee and hip OA or individuals with radiographic hip OA. Among adults with radiographic knee OA at baseline (n=729), cases in which individuals were missing data on any control variables (n=73) were dropped from the sample, yielding a sample size of 656 for cross-sectional analyses. Among adults with radiographic knee OA at follow-up (n=485), cases in which individuals were missing data on any control variables

(n=51) were dropped from the sample, yielding a sample size of 434 for longitudinal analyses.

Measures

A comprehensive list of all measures and how they were coded can be seen in the Appendix (Table A). We measured two outcomes, depressive symptoms and knee impact scores.

Depressive symptoms.—For cross-sectional analyses, we used the Center for Epidemiologic Studies (CES-D) 20-item scale to assess depressive symptoms that occurred in the past week (32). We summed item responses, which ranged from 0 to 3, to create a total score that ranged from 0 (best possible score) to 60 (worst) (Cronbach's alpha in this study = 0.86).

Between baseline and follow-up, the parent study switched depression measures from the CES-D to the Patient-Reported Outcome Measurement Information System Depression (PROMIS-D) scale (33). Thus, for longitudinal analyses, we used the PROMIS-D scale as a measure of depression with the CES-D entered into models as the corresponding measure at baseline. The PROMIS depression scale has shown strong correlations with the CES-D (>0.80) among the general population (34). We used an 8-item short form of the PROMIS-D, in which items were rated on 5-point scale (1=never; 2=rarely; 3=sometimes; 4=often; and 5=always). Higher scores indicating greater severity of depression (35). We summed responses and then converted the raw scores to standardized scores, in line with scoring guidelines (35) (Cronbach's alpha in this study = 0.94).

Reported knee impact scores.—We used three sub-scales (Knee-Related Quality of Life, Function in Daily Living, and Pain) from the Knee Injury and Osteoarthritis Outcome Score (KOOS) to assess the impact of knee OA (36). Because of high observed correlations in these separate sub-scales (>0.85 in this study), we calculated a composite score from the items comprising the sub-scales and named it "knee impact." Response options determine the frequency of problems in the past week and each item is scored 0 to 4. We calculated the mean of the 30 items and transformed scores to a 0–100 scale, with zero representing extreme problems and 100 representing no problems (Cronbach's alpha in this study = 0.98). The KOOS and its sub-scales have been extensively validated among individuals with OA (36), shown to have adequate reliability (37), and used in a number of OA studies (38, 39).

At baseline, items from the KOOS sub-scales were asked without regard to specific knee, whereas at follow-up, items from the KOOS sub-scales were asked of each knee. To make scores comparable in longitudinal analyses and since our objective was not to look at changes in KOOS scores, we took the highest score for each set of knees at follow-up, rather than each knee. Using the same example from above, if an individual scored their left knee to be a 4 and their right knee to be a 0 on the same item, we calculated the score for that set of items to be a 4. We analyzed scores this way on the intuitive assumption that individuals think of their most painful knee when asked to evaluate overall knee functioning. We calculated the mean of the 8 items and transformed scores to a 0–100 scale (Cronbach's alpha in this study for knee impact scores at follow-up = 0.99).

Independent variables.—We measured four neighborhood characteristics as our independent variables: neighborhood poverty (defined as the percentage of households with income below the poverty line within a census block group and compiled from the 2010 U.S. Census), perceived neighborhood social cohesion (using the 5-item measure of Social Cohesion and Trust (40)), perceived neighborhood resources for physical activity and walking (using 11 items from the Walking and Exercise Environment scale (41)), and perceived neighborhood safety (using three items). Cronbach's alphas for the three perceived neighborhood variables ranged from 0.67 to 0.85.

Moderator.—We assessed cross-level interactions among each of the four neighborhood characteristics and race/ethnicity.

Control variables.—Control variables assessed included standard demographic variables as well as health-related variables that we hypothesized could be independently associated with outcomes. Control variables assessed were race / ethnicity (White or Black), education (categorized as less than high school or high school or greater), body mass index (BMI), gender (male or female), age, health insurance status (categorized as health insurance or no health insurance), number of comorbidities (defined using a disease inventory index at baseline and the Charlson Comorbidity Index (42) at follow-up), and physical activity (categorized as inactive, insufficiently active, or sufficiently active using questions from the Behavioral Risk Factor Surveillance System, BRFSS.

Data Analysis

Descriptive statistics.—We first examined distributions of the data, checked for multicollinearity (all Variance Inflation Factor scores were less than 3), and looked at bivariate associations among neighborhood characteristics and health outcomes.

Centering.—Before modeling the data in multilevel models, we created group means for the three perceived neighborhood variables based on average scores within census block groups. We then a) grand mean centered these variables at the neighborhood level, which means we calculated the deviation of each neighborhood's score from the overall mean of each neighborhood variable (labeled as neighborhood estimates of neighborhood effects) and b) group mean centered these variables at the individual level, which means we calculated the deviation of each individual's score from the mean for the individual's cluster (neighborhood census block group in this case) (labeled as individualized estimates of neighborhood effects) (43).

Multilevel models.—After centering, we used multilevel models to examine the associations among neighborhood characteristics and outcomes, adjusting for control variables and modeling the neighborhood variables as fixed effects. We observed that scores for depression were highly positively skewed, in that more individuals had lower CES-D and PROMIS-D scores. Accordingly, we used a multilevel poisson regression to model CES-D and PROMIS-D scores, as has been done in previous research (44).

Longitudinal analyses.—In longitudinal analyses, we used residualized change scores to model change in outcomes, controlling for prior levels of the measured outcome. For instance, when we modeled PROMIS-D scores as the outcome at follow-up, we controlled for CES-D scores measured at baseline.

Interactions.—After conducting separate multilevel models for each outcome cross-sectionally and longitudinally, we added interaction terms for each neighborhood characteristic with race / ethnicity. Given the number of potential interactions, we only probed and graphed interactions that were significant at $p<.01$. Otherwise, we set critical $\alpha = .05$ and used 2-tailed statistical tests. For all analyses, we used SAS version 9.4 survey procedures (SAS Inc., Cary, NC, USA).

Sensitivity Analyses

We conducted two sensitivity analyses for the cross-sectional analyses. First, we used multiple imputation to impute missing data. Using SAS Proc MI, we created 20 multiply-imputed complete data sets, analyzed multilevel results via the SAS Proc MIANALYZE procedure, and determined whether use of multiple imputation produced different results than listwise deletion by comparing the parameter estimates and p-values. Second, we excluded individuals who resided in a census block group with less than 5 other individuals (n=37), since small neighborhood size might bias neighborhood estimates.

Results

Participant Characteristics

At baseline, our sample included adults who were on average 70.0 years old (standard deviation (SD): 9.0) (Table 1). Participants were diverse, with a substantial number of Black participants (34.0%) and individuals without a high school degree (25.5%). Additionally, at baseline, participants reported low CES-D scores (mean: 6.6, SD: 7.4, possible range: 0–60), although 11.7% had scores at or above 16, indicative of moderate or severe depression, and reported high knee impact scores (mean: 77.5, SD: 23.3, possible range: 0–100).

Correlations

At baseline, CES-D scores were associated with all neighborhood variables, except poverty, with correlations ranging from −0.19 to −0.25, all p-values <0.001 (Table 2). Reported knee impact scores were associated with all neighborhood variables, including poverty, and in the expected direction, with correlations ranging from −0.10 to 0.21, all p-values <0.01.

At follow-up none of the neighborhood variables estimated at baseline were significantly associated with PROMIS-D or reported knee impact scores with the exception of perceived neighborhood safety, which was positively associated with reported knee impact scores at follow-up (r=0.11, p=0.02). CES-D scores at baseline and PROMIS-D scores at follow-up were significantly, moderately correlated (r=0.40, p<0.001), while reported knee impact scores at baseline and follow-up were significantly, moderately correlated (r=0.66, p<0.001).

Is Neighborhood Context Associated with Mental and Physical Health Outcomes?

A summary table with results from all main effects can be seen in Table 3. For the individualized estimates and after adjusting for control variables, we found that perceived neighborhood social cohesion (B= −0.04, p< 0.001) and perceived neighborhood resources for physical activity and walking (B= −0.03, p< 0.001) were both associated with CES-D scores in expected directions (Table 4). We found no significant effect of perceived neighborhood safety on CES-D scores. Turning to the neighborhood estimates, we found that perceived neighborhood social cohesion (B= −0.07, p=0.02) was associated with lower CES-D scores, while neighborhood poverty, perceived neighborhood resources for physical activity and walking, and perceived neighborhood safety were not.

Turning to knee impact, for the individualized estimates, we found that perceived neighborhood resources for physical activity and walking was associated with higher (better) reported knee impact scores (B=0.48, p=0.008), but no other effects of perceived neighborhood social cohesion or safety on reported knee impact scores (Table 5). Turning to the neighborhood estimates, we found no significant effects of neighborhood characteristics on knee impact scores.

Is Neighborhood Context Associated with Depressive Symptoms and Knee Impact Over Time?

In longitudinal analyses (Appendix Tables B1 and B2), we found few statistically significant relationships. For PROMIS-D scores, we found no significant main effects for the individualized or neighborhood estimates of the neighborhood variables. For associations among neighborhood estimates and reported knee impact scores, we found that increasing perceived neighborhood social cohesion was unexpectedly associated with lower (worse) reported knee impact scores (B= −1.65, p=0.04), while increasing perceived neighborhood safety was associated with higher (better) reported knee impact scores (B=2.59, p=0.03).

Does Race / Ethnicity Interact with Neighborhood Context?

We observed two significant interactions among the individualized estimates of neighborhood characteristics and race / ethnicity (Figure 1). First, we found that for both Black (B= −0.03, p<.001) and White adults (B= −0.01, p=0.001), greater perceived neighborhood resources for physical activity and walking was associated with lower CES-D scores; however, the effect was stronger for Black vs. White adults (p-value for interaction = 0.004).

Second, we observed an interaction among race, the individualized estimate of perceived neighborhood safety, and CES-D scores (p=0.009). For White adults, greater perceived neighborhood safety was associated with lower CES-D scores (B= −0.04, p=0.003), whereas no association was found for Black adults (B= 0.02, p=0.33).

Sensitivity Analyses

Additional tables with results from all sensitivity analyses are included in the Appendix (Tables C1, C2, D1, D2). Analyzing the data with multiple imputation did not change any conclusions; all significant parameters remained significant and the magnitude of estimates

was similar. Analyzing the data excluding individuals living in census block groups with less than 5 individuals (n=37) also did not change any conclusions. Most main effects, with the exception of two, remained significant.

Discussion

In a sample of older adults with at least one chronic condition (radiographic knee OA), we found that neighborhood context matters, but in nuanced ways. Individualized estimates of neighborhood social cohesion and resources for physical activity and walking appeared to be important for depressive symptoms and knee impact scores, although we found few significant effects over time. We also found neighborhood characteristics to be differentially associated with outcomes for Black or White adults.

In contrast to a previous systematic review that found neighborhood SES to be the strongest and most consistent predictor of health outcomes among older adults compared to other neighborhood characteristics (45), we found no effect of neighborhood poverty on CES-D or knee impact scores. There are three possible reasons why this occurred. First, there was minimal clustering of health outcomes (i.e., CES-D scores and knee impact scores) by census block groups, and this lack of variation may have made it difficult to detect relevant associations between neighborhood poverty (only measured at the census block group level) and health outcomes. Second, using administrative boundaries to capture neighborhood characteristics (census block groups in this case) may not have accurately reflected what individuals think of as their neighborhoods (known as “spatial misclassification”). Finally, we found neighborhood poverty to be significantly correlated with other neighborhood characteristics in bivariate associations, namely social cohesion and perceived safety. Although poverty may have not had a direct effect on depression or knee impact, an indirect effect through other neighborhood characteristics could have occurred.

We also found more consistent effects of the individualized estimates of neighborhood characteristics than the neighborhood estimates of these variables. In other words, individuals who perceived their neighborhoods to be more cohesive or to have more built environment resources—relative to their neighbors’ average scores—had better CES-D scores and/or knee impact scores. It is important to note that individualized estimates of neighborhood variables are not true measures of the “neighborhood” or “contextual neighborhood effects.” Instead, they refer to individual-level perceptions of neighborhood conditions. Since neighborhoods are not necessarily internally homogeneous, it is possible that self-reported assessments of neighborhoods more closely represent individuals’ own neighborhoods, how they interact with them, and how they are exposed to different neighborhood characteristics than area-level aggregated indicators of neighborhood conditions (46). However, it is also likely that our findings resulted from some of the reasons described above (e.g., minimal clustering of health outcomes) and it is plausible that individuals with a particular disposition (i.e., individuals with depressed moods) may have rated their environments as less satisfactory than individuals with a different disposition (i.e., individuals without depressed moods) (46).

In longitudinal analyses, we observed no consistent relationships among neighborhood characteristics and outcomes, which is consistent with previous research (47). Reduced power to observe significant associations longitudinally may explain these findings. Indeed, in longitudinal analyses, our sample size dropped by almost 35% due to participants' withdrawals or deaths. It is also possible that neighborhood characteristics *changed* between baseline and follow-up. Since we did not re-assess these characteristics, our measures of neighborhood environment would have been insensitive to the effects of such changes. Finally, as other researchers have suggested, if neighborhood characteristics remain relatively stable over time, and if individuals have lived extended periods in those neighborhoods, then cross-sectional analyses are meaningful (47). Supporting this interpretation of the current findings, participants reported living at their current address an average of 45 years (SD: 21.34) in measures taken at the beginning of the parent study.

We also observed significant interactions among the neighborhood characteristics themselves and that race / ethnicity moderated the effects of neighborhood characteristics on CES-D and reported knee impact scores. These findings suggest that researchers should look holistically at neighborhoods when evaluating their influence on health (i.e., not examining one neighborhood characteristic, but examining a multitude) and that some individual-level factors may buffer or change the relationships between neighborhoods and health.

It should be noted that associations among neighborhood characteristics and our two outcomes, while significant, were small. However, we believe findings remain worthy of attention for four reasons. First, this study only looked at four neighborhood characteristics and in reality, there are many other neighborhood characteristics that need to be considered before estimating a total effect size for how neighborhoods influence health. Second, there are likely indirect ways through which neighborhoods influence health (e.g., by affecting health behaviors, which then influence health outcomes) that were not measured by the current study. Third, neighborhood physical and social environments likely have aggregate effects on health (e.g., neighborhood safety and built environment can both affect physical activity above and beyond the influence of either one alone). Finally, results from this study could be used to effectively (and cost-effectively) improve health. Indeed, there are innovative low-cost ways to encourage social interaction in neighborhoods (increasing vegetation and common spaces,(48) designing homes with porches or stoops (49)), which might improve social cohesion and small improvements to neighborhood infrastructure (providing lighting or improving sidewalks) can increase physical activity (50) and consequently physical functioning. Thus, our findings, in conjunction with the growing body of literature on neighborhoods and arthritis (3–15) highlight the need for upstream interventions to improve OA outcomes.

Overall, our findings suggest a number of questions for future research, including:

- What is an important and meaningful effect size for how neighborhoods influence health?
- What is the most appropriate way to measure neighborhood characteristics and does that measurement change based on the neighborhood characteristic being measured?

- How can we better model complex relationships between neighborhoods and health?
- How do genetic predispositions and other individual-level characteristics interact with neighborhood characteristics to influence health?

Limitations

Several study limitations should be considered. First, we did not control for individual-level income data, which may have accounted for the observed effects. Second, this study relied on a specific population—older adults in Johnston County, NC, which limits generalizability to other settings and populations. Third, it is also important to note that participants included in these analyses were selected from a prospective cohort study and originally invited to participate between 1991–1997 (baseline of the parent study) or 2003–2004 (for cohort enrichment). By the baseline wave of data collection for this study (2006–2011), many individuals had died. Accordingly, results may not generalize to all community samples of older adults. Fourth, as discussed above, associations among neighborhood characteristics and outcomes, while significant, were modest. Finally, the lack of longitudinal findings reduces the validity of the cross-sectional findings.

Conclusions

In this sample of older adults with radiographic knee OA, we found that neighborhood context affected health outcomes in nuanced, yet important ways. Interventions aiming to improve mental and physical functioning of older adults with radiographic knee OA can look to this study as evidence for the importance of neighborhood characteristics.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Significance and Innovations

- Few studies of neighborhoods and osteoarthritis have focused on mental health outcomes, examined multiple neighborhood characteristics simultaneously, analyzed associations longitudinally, and assessed cross-level interactions.
- This study examined how four neighborhood characteristics were associated with depressive symptoms and knee impact scores among adults with knee osteoarthritis and used appropriate and novel methods (e.g., multilevel models, longitudinal analyses, multiple imputation, cross-level interactions) to examine associations.
- This study found perceived neighborhood context to be associated with depressive symptoms and knee impact scores in expected directions among individuals with knee osteoarthritis.
- This study also found that associations among neighborhood characteristics and health outcomes were different for White adults with knee osteoarthritis compared to Black adults with knee osteoarthritis.

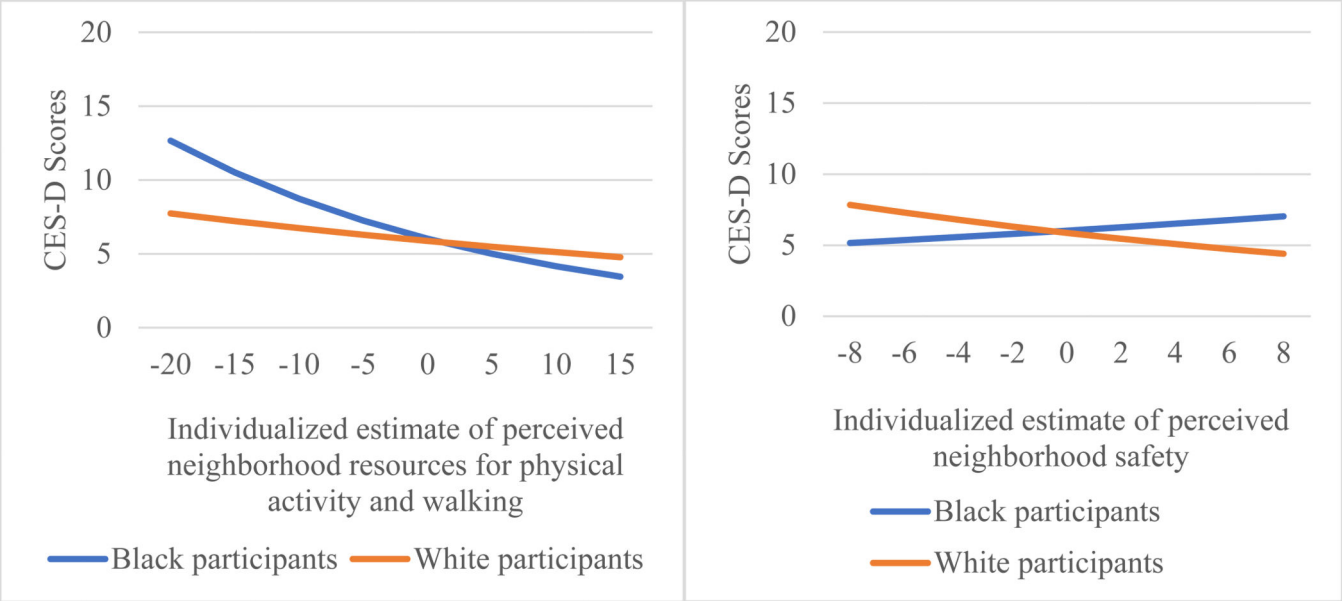

Figure 1.

Interactions among race, neighborhood context, and CES-D scores among adults with radiographic knee OA, n=656, from the Johnston County Osteoarthritis Project, Johnston County, North Carolina, 2006–2011

Note: the slopes for both Black participants and White participants are significant at $p<.05$, but the slope is stronger for Black participants.

Note: only the slope for White participants is significant at $p<0.05$.

Table 1.

Participant characteristics of adults with radiographic knee OA, from the Johnston County Osteoarthritis Project, Johnston County, North Carolina, 2006–2011 (n=656) and 2013–2015 (n=434)

	Baseline, 2006–2011	**Follow-up, 2013–2015**
Characteristic	**N (%) or mean (SD)**	**N (%) or mean (SD)**
Age, years	70.0 (9.0)	72.5 (7.8)
Gender		
Male	215 (32.8)	148 (34.1)
Female	441 (67.2)	286 (65.9)
Race		
White	433 (66.0)	288 (66.4)
Black	223 (34.0)	146 (33.6)
Education		
High school or greater	489 (74.5)	367 (84.6)
Less than high school	167 (25.5)	67 (15.4)
Health insurance		
No	27 (4.1)	27 (6.2)
Yes	629 (95.9)	407 (93.8)
BMI	33.1 (7.9)	32.0 (6.9)
Number of comorbidities, assessed using a disease inventory	1.9 (1.3)	--
Number of comorbidities, assessed using the Charlson Comorbidity Index	--	4.0 (1.8)
Neighborhood poverty (range 0–44)	17.2 (10.7)	17.2 (11.2)
Perceived neighborhood social cohesion (range 5–25)	18.9 (3.6)	19.1 (3.5)
Perceived neighborhood resources for physical activity and walking (range 11–55),	35.5 (6.1)	36.2 (6.0)
Perceived neighborhood safety (range 3–15)	11.1 (2.2)	11.1 (2.2)
Physical activity		
Inactive	225 (34.3)	356 (59.0)
Insufficiently active	234 (35.7)	125 (28.8)
Sufficiently active	197 (30.0)	53 (12.2)
CES-D scores (range 0–60)	6.5 (7.4)	--
PROMIS-D scores (range 8–40)	--	10.7 (4.5)
Reported knee impact scores (range 0–100)	75.6 (23.3)	70.0 (25.9)

Table 2.

Correlations among neighborhood characteristics, physical activity, and health outcomes, among adults with radiographic knee OA, from the Johnston County Osteoarthritis Project, Johnston County, North Carolina, 2006–2011 (n=656) and 2013–2015 (n=434)

	Neighborhood poverty	Perceived neighborhood social cohesion	Perceived neighborhood resources for physical activity and walking	Perceived neighborhood safety	CES-D scores (baseline)	PROMIS-D scores (follow-up)	Reported knee impact scores (baseline)	Reported knee impact scores (follow-up)
Neighborhood poverty	--	**−0.21*****	0.03	**−0.23*****	0.05	−0.06	**−0.10****	−0.08
Perceived neighborhood social cohesion		--	**0.27*****	**0.53*****	**−0.23*****	−0.08	**0.15*****	0.01
Perceived neighborhood resources for physical activity and walking			--	**0.36*****	**−0.19*****	0.00	**0.18*****	0.08
Perceived neighborhood safety				--	**−0.25*****	−0.06	**0.21*****	**0.11***
CES-D scores (baseline)					--	**0.40*****	**−0.40*****	**−0.34*****
PROMIS-D scores (follow-up)						--	**−0.25*****	**−0.35*****
Reported knee impact scores (baseline)							--	**0.66*****
Reported knee impact scores (follow-up)								--

Boldface denotes significance at $p < 0.05$

* $p < .05$

** $p < .01$

*** $p < .001$

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Table 3.

Summary of results, using data from the Johnston County Osteoarthritis Project, Johnston County, North Carolina, 2006–2011 and 2013–2015

Neighborhood characteristics	Cross-sectional results		Longitudinal results	
	CES-D scores at baseline	Knee impact scores at baseline	CES-D scores at follow-up	Knee impact scores at follow-up
Individualized estimates				
Perceived neighborhood social cohesion	↓			
Perceived neighborhood resources for physical activity and walking	↓	↑		
Perceived neighborhood safety				
Neighborhood estimates				
Neighborhood poverty				
Perceived neighborhood social cohesion	↓			↓
Perceived neighborhood resources for physical activity and walking				
Perceived neighborhood safety				↑

Note: Arrows indicate how to interpret effects. For instance, an arrow facing downwards indicates that there was a negative association between the independent variable and outcome for the specified cell. For instance, the arrow in the upper left quadrant indicates that there was a significant negative association between perceived neighborhood social cohesion and CES-D scores. In other words, greater perceived neighborhood social cohesion was associated with lower CES-D scores, or less depressive symptoms (the expected direction).
Note: Red arrows indicate findings contrary to expectations.

Table 4.

Effects of neighborhood variables on CES-D scores among individuals with radiographic knee OA, n=656, from the Johnston County Osteoarthritis Project, Johnston County, North Carolina, 2006–2011

	Model 1 [a,b]		**Model 2** [a,b]	
Variable	**Regression Coefficient (SE)**	**p-value**	**Regression Coefficient (SE)**	**p-value**
Intercept	**1.78 (0.05)**	**p<0.001**	**1.76 (0.05)**	**p<.001**
Individualized estimates				
Perceived neighborhood social cohesion	**−0.04 (0.01)**	**p<0.001**	**−0.04 (0.01)**	**p<0.001**
Perceived neighborhood resources for physical activity and walking	**−0.02 (0)**	**p<0.001**	**−0.03 (0)**	**p<0.001**
Perceived neighborhood safety	−0.02 (0.01)	p=0.10	−0.02 (0.01)	p=0.10
Neighborhood estimates				
Neighborhood poverty			−0.01 (0.01)	p=0.34
Perceived neighborhood social cohesion			**−0.07 (0.03)**	**p=0.02**
Perceived neighborhood access to physical activity and walking resources			0 (0.01)	p=0.99
Perceived neighborhood safety			0.04 (0.05)	p=0.46

Note: Boldface denotes a significant effect at p<0.05

[a]Results are adjusted for sex, race, age, BMI, education, health insurance status, number of comorbidities, and physical activity

[b]Results were estimated using a poisson multilevel model.

Table 5.

Effects of neighborhood variables on reported knee impact scores among individuals with radiographic knee OA, n=656, from the Johnston County Osteoarthritis Project, Johnston County, North Carolina, 2006–2011

	Model 1 [a,b]		Model 2 [a,b]	
Variable	**Regression Coefficient (SE)**	**p-value**	**Regression Coefficient (SE)**	**p-value**
Intercept	**75.63 (0.81)**	**p<0.01**	**75.63 (0.8)**	**p<.001**
Individualized estimates				
Perceived neighborhood social cohesion	−0.11 (0.29)	p=0.71	−0.1 (0.29)	p=0.74
Perceived neighborhood resources for physical activity and walking	**0.47 (0.18)**	**p=0.008**	**0.48 (0.18)**	**p=0.008**
Perceived neighborhood safety	0.94 (0.51)	p=0.07	0.91 (0.51)	p=0.07
Neighborhood estimates				
Neighborhood poverty			−0.11 (0.1)	p=0.27
Perceived neighborhood social cohesion			1.26 (0.77)	p=0.10
Perceived neighborhood access to physical activity and walking resources			0.41 (0.25)	p=0.11
Perceived neighborhood safety			−1.9 (1.3)	p=0.15

Note: Boldface denotes a significant effect at p<0.05

[a]Results are adjusted for sex, race, age, BMI, education, health insurance status, number of comorbidities, and physical activity