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SUBJECTIVE NEIGHBORHOOD ASSESSMENT AND PHYSICAL INACTIVITY: AN EXAMINATION OF NEIGHBORHOOD-LEVEL VARIANCE

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Abstract

Research suggests a linkage between perceptions of neighborhood quality and the likelihood of engaging in leisure-time physical activity. Often in these studies, intra-neighborhood variance is viewed as something to be controlled for statistically. However, we hypothesized that intra-neighborhood variance in perceptions of neighborhood quality may be contextually relevant. We examined the relationship between intra-neighborhood variance of subjective neighborhood quality and neighborhood-level reported physical inactivity across 48 neighborhoods within a medium-sized city, Texas City, Texas using survey data from 2,706 residents collected between 2004 and 2006.

Neighborhoods where the aggregated perception of neighborhood quality was poor also had a larger proportion of residents reporting being physically inactive. However, higher degrees of disagreement among residents within neighborhoods about their neighborhood quality was significantly associated with a lower proportion of residents reporting being physically inactive ($p=0.001$). Our results suggest that intra-neighborhood variability may be contextually relevant in studies seeking to better understand the relationship between neighborhood quality and behaviors sensitive to neighborhood environments, like physical activity.

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Conflict of Interest

The authors declare there is no conflict of interest.

Introduction

Physical inactivity is a significant modifiable risk factor for developing numerous chronic illnesses, decreased quality of life, and premature mortality. (Blair and Brodney, 1999; Lee et al., 2012; Physical Activity Guidelines Advisory Committee, 2008) Beyond individual behaviors, attitudes, and attributes related to physical activity, urban environmental factors are widely understood to be key determinants of physical inactivity, particularly at the neighborhood level. (Molnar et al., 2004; Moudon et al., 2007) Neighborhood ecology can be measured using two different approaches: the subjective experiences of the neighborhood's residents or the objective observations of a researcher external to the neighborhood environment. (Giles-Corti and Donovan, 2002; Hoehner et al., 2005; Kamphuis et al., 2010; Martinez et al., 2002; Millstein et al., 2013; Sallis et al., 2015; Weden et al., 2008; Wilhelm et al., 2009) Subjective neighborhood environmental assessments, often, are reported perceptions of neighborhood environment using one of a number of validated instruments, including the Neighborhood Environment Walkability Scale (NEWS) and the Perceived Neighborhood Scale (PNS). (Martinez et al., 2002; Saelens et al., 2003) These measures can be contrasted with more objectively measured assessments of neighborhood environment (such as researcher, rather than resident, observations collected by using validated instruments, windshield surveys, etc.), examples of which include the Physical Activity Resource Assessment and the increasingly referenced WalkScore®. (Carr et al., 2011; Lee et al., 2005)

Neighborhood-level environmental assessments, whether objective or subjective, often treat neighborhoods as defined geographic space composed of relatively homogenous groups of individuals and represented by a measure of central tendency (e.g., the mean or median of responses). (Mujahid et al., 2007; Weden et al., 2008) It is common practice to utilize aggregated (e.g., mean or median) measures of perceived neighborhood quality as an indicator of neighborhood context in neighborhood health studies. (Kim et al., 2010) This approach assumes that individuals within neighborhoods are more similar to each other as compared to individuals living in other neighborhoods. Thus, researchers have increasingly employed multilevel or hierarchical modeling techniques to control for intra-neighborhood heterogeneity. (Diez-Roux, 2000; Raudenbush and Bryk, 2002)

However, testing the accuracy of these aggregated measures is not commonplace. (O'Brien, 1990) Further, the aggregated measures of centrality (e.g., mean or median) account for one dimension of aggregated perceptions of neighborhood quality, that of central tendency. This method of measuring neighborhood context assumes that two neighborhoods with the same aggregated measure are the same. In reality, this may not be the case, as it ignores the variability around the central tendency. Previous work has posited that a measure of variability rather than central tendency may be a better way to describe neighborhoods along some dimensions. (Coulton et al., 1996) Such a measure would be a quantifiable method of measuring consensus within a neighborhood. The authors noted that neighborhoods may differ in the degree to which residents agree, and that this difference (i.e., the degree of within-neighborhood consensus) may be a better indicator of neighborhood context than the aggregate measure.

Consider, for example, a neighborhood where the population has been generally stable and consists of very similar individuals (e.g., a relatively homogeneous neighborhood). Consider a second neighborhood with the same aggregated measure of perceived neighborhood quality as the first neighborhood, but where the residents are more disparate in terms of income, race/ethnicity, age, and other important variables. A neighborhood actively undergoing gentrification have such a property. Accounting for the degree of variability within neighborhoods in the perceived quality, in addition to the aggregated measure of central tendency (e.g., mean) of the perceived quality would add additional context that may be important in determining health behaviors, including physical inactivity. A review of the literature demonstrated that the utility of measuring variability as well as centrality of aggregated perceived neighborhood quality, and its relationship with neighborhood levels of physical inactivity, has not been adequately explored.

We sought to explore the hypothesis that neighborhoods vary in terms of physical inactivity (a behavior that is determined in part by perceptions of neighborhood quality) both on differences in aggregated perception of neighborhood quality, as well as on the variability of these perceptions within neighborhoods. Do neighborhoods where the agreement among residents' perceptions about the quality of their environment is higher promote physical activity more than in neighborhoods where there is greater disagreement in perceived neighborhood quality? We propose that, in a given community, the degree of intra-neighborhood homogeneity is not consistent across each neighborhood, and that this difference may be worth examination. In other words, the extent to which neighbors within a given neighborhood disagree about the quality of their neighborhood may be an important correlate in relationship to physical inactivity.

We explore this phenomenon by examining the relationship between aggregated neighborhood-level agreement in self-reported subjective environmental assessments and the proportion of residents in a neighborhood who report engaging in no leisure-time physical activity at the neighborhood level. In this study, we sought to examine this dimension of neighborhood agreement on perceived neighborhood quality and its relationship to health behaviors (specifically reporting no leisure-time physical activity over the past week). Previous research demonstrates that neighborhoods where residents reported more negative subjective assessments of neighborhood quality were less likely to have residents reporting engaging in physical activity. (Humpel et al., 2002; Saelens et al., 2003) We hypothesize that neighborhoods where there is more agreement in terms of perceived neighborhood quality will have less extreme proportions of residents reporting physical inactivity than in neighborhoods with less agreement (see figure 1), as neighborhoods with more variability include a more diverse, and likely less extreme, mix of perceptions of neighborhood quality. If confirmed, such a result could begin to explain, at least partially, findings in the literature that show a relatively weak association between perceived neighborhood quality and physical inactivity. (Ding et al., 2011)

Methods

This study was conducted to examine this hypothesis in a medium-sized urban community with a racially and socioeconomically diverse population. Data for this study are from the

Texas City Stress and Health Study (TCSHS). (Cutchin, 2007; Peek et al., 2009; Peek et al., 2010) This urban population-based study aimed to evaluate the sources of sociobiological stress associated with living near environmental hazards (petrochemical refineries in particular). The TCSHS collected survey data and biological samples from a random sample of adults (ages 18 and older) living in Texas City, Texas, between 2004 and 2006. Texas City is a city southeast of Houston with a population of approximately 35,000 at time of study. This data set is particularly valuable in that study participants represent diverse age groups, income and education levels, and racial and ethnic groups (including both native born and non-native born Hispanic populations). For this study, we utilized survey responses from 2,706 residents of Texas City. Additional details about the TCSHS are presented elsewhere. (Peek et al., 2009; Peek et al., 2010)

Neighborhood boundary definition

Many neighborhood-level studies utilize census-defined boundaries (e.g., census tracts, zip code tabulation areas, etc.) as proxies to delineate neighborhood boundaries. However, some researchers have demonstrated the limitations of using such boundaries. (Cummins et al., 2007; Cutchin et al., 2011; Diez-Roux and Mair, 2010) Recognizing these limitations, Cutchin and colleagues defined a set of neighborhoods in Texas City using an innovative estimation method, which incorporated both social and spatial processes into determining neighborhood boundaries. (Cutchin et al., 2011) This divided Texas City into the 48 neighborhoods used in this study (figure 2).

Dependent variable

Our dependent variable is the percentage of respondents in a given neighborhood who reported engaging in no physical activity in the last week. This variable was created using two physical activity questions from the TCSHS survey, which were adapted from physical activity questions used by the Centers for Disease Control and Prevention's 2005 Behavioral Risk Factor Surveillance Survey (BRFSS). (Centers for Disease Control and Prevention, 2005) This variable has demonstrated good validity (ICC=0.69) and reliability (kappa = 0.40) in discriminating respondents into physical activity categories of active, insufficient, and inactive. (Brown et al., 2004; Evenson et al., 2003) The first asked respondents about their engaging in vigorous physical activities of at least 10 minutes over the past 7 days, with responses being never, seldom (1–2 days/week), sometimes (3–4 days/week), or often (5–7 days/week); the second asked a similar question, but focused on moderate physical activity. These two variables were used to create our physical inactivity variable, where 1 was equal to not engaging in any vigorous or moderate activity and 0 was equal to engaging in some form of physical activity over the past 7 days. A neighborhood-level value was computed by calculating the percentage of respondents in each neighborhood reporting engaging in no physical activity over the past 7 days.

Predictor and control variables

The Perceived Neighborhood Scale (quality) was used to measure perceived neighborhood quality, where higher scores indicated higher degrees of perceived neighborhood quality. (Cutchin et al., 2011; Martinez et al., 2002) For our analyses, two neighborhood-level aggregate measures of perceived neighborhood quality were calculated. First, the median

quality score was calculated for each neighborhood. The median was chosen, as it is more robust to the influence of outliers than the mean, while still being a measure of central tendency. Second, to determine variability of quality scores, the median absolute deviation of quality within each neighborhood was calculated. This measure is robust to outliers, as is the median, and is calculated by taking the absolute value of the difference between each value in a given neighborhood and the median for that neighborhood, and computing the median of these absolute values. (Leys et al., 2013; Rousseeuw and Croux, 1993)

To illustrate the relationship between median and median absolute deviation of quality and physical inactivity within each neighborhood, neighborhoods were grouped into four categories based on their median and median absolute deviation of quality values. Those neighborhoods with a median quality scores lower than the median of all neighborhood median quality scores and a median absolute deviation lower than the median of all neighborhood median absolute deviations, were grouped into a perceived neighborhood quality category called “low quality, high agreement.” Following this strategy, three other categories were constructed: “Low quality, low agreement,” “High quality, low agreement,” and “High quality, high agreement.”

As the neighborhood is the level of analysis for this study, neighborhood-level control variables were included in our multivariate analysis. These control variables included neighborhood mean age (in years), percent of respondents who were female, percent of respondents who reported belonging to underrepresented racial or ethnic groups, percent of respondents who reported annual household incomes below \$25,000, percent of respondents reporting having graduated high school, and the mean percentage of lifetime spent living at the respondent’s current address.

Analyses

Analyses were conducted using Stata version 14.2. (StataCorp, 2016) The mean, median, and interquartile range for each of these neighborhood-level predictor and control variables were computed, yielding a median value (and interquartile range) of neighborhood means or percentages. Within each of the 4 categories of perceived neighborhood quality, we drew a boxplot of the neighborhood-level percentages of physical inactivity, and reported the median neighborhood level percentage of inactivity. We examined the differences in percentage of respondents reporting no physical activity between each of the four categories of neighborhoods using one-way analysis of variance (ANOVA) with Bonferroni corrections to account for multiple comparisons. Linear regression models provided estimates of the associations of percentage of neighborhood respondents reporting being physically inactive and neighborhood-level quality scores. Three linear regression equations were estimated. The first regressed percentage of respondents reporting no physical activity on the median quality score. Second, the neighborhood-level demographic control variables were introduced into the model. Third, each neighborhood’s median absolute deviation of quality scores was introduced. Standardized regression coefficients were estimated using the LISTCOEF command (Long and Freese, 2014), as these estimates provide a means to compare the magnitude of each parameter estimate on a common scale. Each model was

evaluated for evidence of heteroskedastic residuals or collinearity among the independent variables, and no evidence for either was found.

Results

We aggregated responses from the 2,706 survey participants in the Texas City Stress and Health Study by the 48 neighborhoods developed by Cutchin et al. (Cutchin et al., 2011). Respondents were a heterogeneous population in terms of age (median 47 years (IQR: 35–60)), sex (58.4% female), and race/ethnicity (35.6% white, non-Hispanic, 12.5% Black, non-Hispanic, and 51.93% Hispanic). There was a median of 56 respondents per neighborhood (IQR: 35–73). Table 1 presents the univariate analyses of these neighborhood-level measures. The median neighborhood-level reported physical inactivity was 51.7%. Of note is that the neighborhoods were relatively diverse in terms proportions of residents within each neighborhood belonging to underrepresented racial and ethnic groups, and other socioeconomic indicators. Table 2 presents the median of the neighborhood-level percentage of physical inactivity within each perceived neighborhood quality category; and Figure 3 provides a box plot of this neighborhood-level measure for each of the 4 categories. Overall, the highest median proportion of physical inactivity was among those neighborhoods that reported low quality scores and had higher levels of disagreement on those scores (57.9%). Conversely, the lowest median proportion of reported physical inactivity was among those neighborhoods with high quality scores, but high degrees of disagreement on quality scores (48.6%). Results from the analysis of variance approached statistical significance ($p=0.065$), but were not statistically significant (likely due to a lack of statistical power), so therefore we cannot assume them to be different from one another.

Results from the three linear regression models provide further evidence to support the importance of considering variability in addition to measures of centrality in neighborhood-level studies. Model 1 demonstrated a significant relationship between increased neighborhood-level median quality score and decreased proportion of physically inactive respondents ($p=0.001$), which became statistically insignificant after inclusion of neighborhood-level socio-demographics in the model (model 2). When variability of quality scores (measured as median absolute deviation) was introduced into the model, both mean quality score ($p=0.047$) and median absolute deviation quality score ($p=0.001$) were significant. Our results indicated that, for model 3, the relative effect size of the relationship with decreased percentage of respondents reporting being physically inactive is greater for median absolute deviation quality scores than for median quality scores.

Discussion

The results of this study suggest that intra-neighborhood variance in quality scores is significantly associated with the proportion of respondents reporting being physically inactive, even when controlling for the median quality scores and demographic factors (such as neighborhood-level socio-economic composition and length of residence). As reported in table 2 and figure 3, the unadjusted differences between higher and lower median quality score for a given neighborhood, higher and lower median absolute deviation for quality score for a given neighborhood and the percentage of residents reporting physical inactivity

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were not statistically different across our four categories for neighborhoods, contrary to our initial hypothesis. However, as reported in table 3, our regression modelling predicted that low agreement in perceived neighborhood quality scores (i.e., higher median absolute deviation or greater disagreement) was significantly associated with a lower percentage of residents reporting physical inactivity even after accounting for several covariates. As variability or disagreement in subjective evaluation of the neighborhood's quality increased in this sample, the predicted proportion of physically inactive residents within the neighborhood decreased. While this prediction may be due to unobserved differences in neighborhood composition or other socio-environmental factors, our results suggest that further investigation is warranted into the relationship between neighborhood-level physical inactivity and intra-neighborhood variance in perceived neighborhood quality. Variability within neighborhoods may potentially serve as an important predictor of aggregate level physical inactivity.

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Previous studies have focused, largely, on between group variability. By focusing on aggregate measures only, a study is assuming that this aggregate measure is shared by all within a given neighborhood. (Diez Roux, 2004) As this assumption may not reflect reality, a large amount of information and context for these neighborhood analyses may have been unaccounted for. By including intra-neighborhood variation as a variable in this analysis, we found that the amount of agreement within a neighborhood about the perceived quality of the neighborhood varied across neighborhoods of similar aggregated quality measure, and that this variability predicted rates of physical inactivity. Including a measure of intra-neighborhood variability, rather than trying to control for it, may provide important information for classifying neighborhoods, thereby reducing the likelihood of misclassification and the introduction of information bias.

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There are important implications from our findings. First, we observed in our sample findings that, in general, perception of poor neighborhood quality is positively correlated with rates of physical inactivity, confirming findings of previous work. (Gomez et al., 2004; Hoehner et al., 2005) However, findings from this study suggest that not all neighborhoods with similar aggregate perceived neighborhood quality are the same and that the level of agreement within a neighborhood may be an important construct to include in addition to the aggregate measure of quality. Adding a measure of variability may provide additional context regarding how neighborhood residents perceive their neighborhood beyond what is provided by simple aggregation measures (such as the mean), yielding more precise classification of neighborhoods into analytical groups.

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For example, examining variability in addition to centrality would help to compare areas with relatively stable populations against areas that might be undergoing gentrification or experiencing other active shifts in the demographic make-up of the neighborhood. With an influx of more affluent and, potentially, more active residents, the mean or median level of perceived neighborhood quality may shift in a favorable direction. However, the level of disagreement would also increase, as more tenured residents may have a different perception of their neighborhood compared to more recent residents. Including only the measure of centrality would not account for this discrepancy within the neighborhood and may lead to

erroneous conclusions about the relationship between perception of neighborhood quality and physical inactivity.

There are a number of limitations to this study. The data are drawn from respondents living in a limited geographic area. While the area is diverse in terms of key demographic characteristics, further study is needed in a more geographically diverse sample before conclusions can be validated. Controlling for objective measures of the neighborhood environment are also needed, as both subjective and objective measures are key determinants of physical activity. (Bailey et al., 2014) This would also allow us to observe whether subjective measures and their variability jointly or separately impact outcomes, given the objective measures. Further, additional variables not accounted for at the individual level when constructing our neighborhood-level dataset may have introduced bias into our findings. For example, health status, including self-reported health status and disability, is associated with level of physical activity, and these data were not available in our neighborhood-level dataset. (Galan et al., 2013)

The findings from this study suggest that examining both aggregated measures of subjective assessments of the neighborhood environment, as well as the variance of this assessment within a given neighborhood, are both related to proportions of neighborhood residents reporting physical inactivity. Thus, the relative heterogeneity of perceived neighborhood quality within neighborhoods may be an important dimension in the relationship between perceived neighborhood quality and population-level physical inactivity. In this sample, the relative strength of the association between intra-neighborhood variance of subjective neighborhood assessment and neighborhood-level physical inactivity was greater than the strength of the association between neighborhood-level centralized subjective assessment scores and physical inactivity. As physical inactivity is a major modifiable risk factor in preventing the development of major threats to health and quality of life, further examination of this relationship is warranted. Application of this methodology to other health behaviors and health outcomes related to perceived neighborhood quality is also recommended.

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Highlights

- Neighborhood perceptions of neighborhood quality predict physical inactivity
- Degree of agreement about quality within neighborhoods may provide needed context
- Variability in agreement within neighborhoods predicted physical inactivity
- This dimension of neighborhood-level variables warrants further examination

Figure 1.
Hypothesized Relationship between Perception of Neighborhood Quality, Agreement, and
Reported Physical Inactivity, Texas City, Texas, 2004–2006

Figure 2.
Map of Texas City Neighborhoods, Texas City, Texas, 2004–2006

Figure 3.
Median Proportion of Neighborhood Residents Reporting Physical Inactivity by
Neighborhood Median Quality Score and Agreement amongst Residents, Texas City, Texas,
2004–2006

Table 1

Descriptive Characteristics of 48 Neighborhoods, Texas City, Texas, 2004–2006

Variable	Median	IQR
Median Neighborhood % Inactive *	51.7%	47.0% – 60.1%
Median Neighborhood Mean Age (years)	49.5	46.6 – 51.9
Median Neighborhood % Female	58.7%	51.9% – 65.7%
Median Neighborhood % Minority	36.6%	24.1% – 50.0%
Median Neighborhood % Income below \$25,000	19.1%	7.1% – 37.2%
Median Neighborhood % High School Graduate	64.0%	52.7% – 76.3%
Median Neighborhood % Life Spent in Neighborhood	56.3%	39.8% – 73.7%
Median Perceived Neighborhood Score	82.5	71.3 – 86.0
Median Absolute Deviation Perceived Neighborhood Score	10.5	8 – 13

*-Physical inactivity is defined as reporting not engaging in at least 10 minutes of moderate or vigorous physical activity over the last week

Table 2

Proportion of Neighborhood Residents Reporting Physical Inactivity^{*} by Neighborhood Median Quality Score and Agreement among Residents, Texas City, Texas, 2004–2006

Group	% Inactive
Low Quality, Low Agreement	57.9%
Low Quality, High Agreement	55.6%
High Quality, High Agreement	51.5%
High Quality, Low Agreement	48.6%

Analysis of Variance: $p = 0.065$

^{*} - Physical inactivity is defined as reporting not engaging in at least 10 minutes of moderate or vigorous physical activity over the last week

Table 3

Modeled Estimates (*standardized betas*) of relationship between Median Neighborhood Quality, Agreement of Neighborhood Quality (Median Absolute Deviation), and Proportion of Neighborhood Reported as Being Physically Inactive*, Texas City, Texas, 2004–2006

Variable	Model 1 ^a		Model 2 ^b		Model 3 ^c	
	β	p-value	β	p-value	β	p-value
Median Quality Score	-0.458	0.001	-0.072	0.649	-0.308	0.047
MAD Quality Score ^I					-0.506	0.001
Mean Age (years)			0.334	0.057	0.213	0.166
% Female			0.310	0.050	0.215	0.119
% Minority			-0.220	0.313	-0.118	0.535
% Income below \$25k			0.159	0.422	0.297	0.095
% High School Graduate			-0.217	0.372	-0.137	0.516
Mean % of Life Spent in Neighborhood			-0.020	0.901	-0.135	0.355

* - Physical inactivity is defined as reporting not engaging in at least 10 minutes of moderate or vigorous physical activity over the last week

^I - Median absolute deviation of median Perceived Neighborhood Scale (PNS) score;

^a - controlling for only Median PNS;

^b - adding in neighborhood-level control variables;

^c - full model including Median Absolute Deviation (MAD) PNS

Statistically significant relationships are bolded

Note: no evidence of heteroskedastic residuals or collinearity in any of the three models