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Neighborhood walkability, neighborhood social health, and self-selection among U.S. adults

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ABSTRACT

Objectives: Neighborhood walkability is favorably related to multiple physical health outcomes, but associations with social health are less clear. Present analyses examined how neighborhood walkability was related to neighborhood social health and explored the potential confounding role of neighborhood self-selection.

Methods: Cross-sectional data were analyzed for 1745 adults, ages 20–66, recruited from two US regions. We created a walkability index around each participant's home (1 km street network buffer) based on residential density, street intersection density, mixed land use, and retail floor area ratio. Neighborhood social health outcomes included reported social interactions with neighbors and sense of community. Two mixed model regressions were conducted for each outcome, with and without adjusting for walkability-related reasons for moving to the neighborhood (self-selection). Covariates included sex, age, socioeconomic status, white/nonwhite race/ethnicity, marital status, and time living in the neighborhood.

Results: Neighborhood walkability was positively related to social interactions with neighbors, both without ($b = 0.13$, $p < .001$) and with adjustment for self-selection ($b = 0.09$, $p = .008$). Neighborhood walkability was positively associated with sense of community, but only before adjusting for self-selection ($b = 0.02$, $p = .009$).

Conclusion: Neighborhood walkability may promote specific aspects of neighborhood social health, which together are beneficial for physical and mental health. These findings provide additional impetus for enhancing walkability of US communities.

1. Introduction

Neighborhoods are complex and multifaceted phenomena, with diverse physical (built and natural) and social environment attributes. There is substantial literature on the links between neighborhood built environment attributes (e.g., walkability, park and green space access, streetscape design) and health outcomes (Riggs, 2012; Sallis et al., 2012). Greater walkability, as generally characterized by higher residential density, proximal non-residential destinations (i.e., mixed land use), and other features that promote active behaviors like walking for leisure or transportation, is a commonly studied built environment construct (Fonseca et al., 2022; McCormack and Shiell, 2011; Smith et al., 2017). There is substantial evidence of positive associations of walkability and its components with physical activity (Barnett et al., 2017; Ding and Gebel, 2012; Kärmeniemi et al., 2018), physical health (Bird et al., 2018; Chandrabose et al., 2019; Kerr et al., 2012; Malambo et al., 2016; Rachele et al., 2019), and mental health (Moore et al., 2018; Núñez-González et al., 2020). Neighborhood social environment attributes (e.g., social cohesion, socio-economic disadvantage, safety from crime) have also been linked to health outcomes such as obesity (Carrillo-Álvarez, Kawachi and Riera-Romaní, 2019; Mohammed et al., 2019) and physical activity (Foster and Giles-Corti, 2008; Quinn et al.,

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2019).

Walkability can facilitate more walking in one's neighborhood (Frank and Pivo 1994; Owen et al., 2004; Saelens et al., 2003; Howell et al., 2017; Sallis et al., 2016), which may increase opportunities for residents to interact, thereby fostering a sense of community. Social interactions and sense of community are dimensions of neighborhood social cohesion (Wilkinson, 2007). Social cohesion broadly reflects the extent of connectedness and solidarity at the community level and is distinct from interpersonal (between individuals) constructs such as social support (Kawachi and Berkman, 2015). Hypothesized associations between walkability and social interactions within neighborhoods and sense of community may be a key pathway by which walkability promotes health.

Theoretical frameworks from public health and urban planning support links between the built environment and neighborhood (or community) social health. In public health, built and social environments are considered intermediate (meso-level) determinants of health, shaped by fundamental (macro-level) factors including the natural environment, macrosocial factors (e.g., policies), and social inequities (e.g., unequal distribution of wealth) (Northridge et al., 2003). These built and social environment factors are expected to influence one another as well as individual (micro-level) determinants of health, such as psychological stressors, health behaviors, and interpersonal factors (e.g., social support).

An urban planning framework posits the built environment influences sense of community via instrumental and symbolic mechanisms (Moustafa, 2009). Through the instrumental pathway, the built environment provides the physical context for behaviors that people consider culturally appropriate (i.e., based on values, norms, lifestyle) and communicates cues for the intended uses of specific settings such as social interactions and behaviors. The symbolic pathway suggests the built environment influences perceptions about the social environment and the cultural/social characteristics of individuals and groups in those settings, thereby contributing to perceptions of community homogeneity, community functioning, and community competence.

Though there is a substantial international literature on the relation between walkability and individuals' perceptions of their neighborhood social environments, results are mixed (French et al., 2014; Leyden, 2003; Mouratidis, 2018; van den Berg et al., 2017; Wood et al., 2010). As examples, du Toit et al. (2007) reported GIS-based walkability was associated with "sense of community," but not other social health variables; Hanibuchi et al. (2012) found no association between any walkability and social capital variables; Zhu et al. (2020) reported the objective WalkScore walkability measure was related to "social support", but only before a move to a new neighborhood; and both van den Berg et al. (2022) and Jun and Hur (2015) found only perceived walkability showed an association with social health variables. The purpose of the present study was to add evidence to prior inconclusive results on the topic of walkability and social health.

Although some studies of associations between walkability and social health accounted for resident socio-demographic characteristics and housing tenure, one variable rarely accounted for was residential self-selection. Residential self-selection refers to people selecting neighborhoods based on pre-existing preferences, attitudes, and other unmeasured characteristics (Hedman and Van Ham, 2012). The theoretical basis for including self-selection in analyses is that it helps account for the distinction between people's underlying preferences and their actual choice of a residential location. These are different phenomena, and both are known to shape travel patterns (Frank et al., 2007). Not controlling for self-selection assumes someone's chosen residential environment represents their underlying preferences. This is arguably a flawed premise because evidence shows many people do not reside in the environments they may prefer. Mokhtarian and Cao (2008) and Levine and &Frank (2007) documented many people are forced to trade-off what they may prefer for other considerations. For example, walkable neighborhoods may be under-supplied due to zoning laws (Frank et al., 2007), housing in a preferred environment may not be affordable, or they may prioritize quality schools over the built environment.

A methodological concern is self-selection may be related to both neighborhood characteristics (e.g., walkability) and health outcomes (e.g., physical activity, social health), and is therefore a potential confounder that can bias associations of the built environment with outcomes. One analytic approach that has been used to control for this bias is to adjust for self-reported measures of residential attitudes or preferences (Mokhtarian and Cao 2008; Boone-Heinonen et al., 2011). There are multiple approaches for measuring residential self-selection (Handy et al., 2005). The scale used in the present study is considered a "direct" measure of self-selection attitudes or preferences, a category that can include perceptions about a neighborhood's accessibility to destinations, physical activity options, safety, socializing, and attractiveness, among other characteristics (Handy et al., 2005). Applying adjustments for self-selection can aid interpretation such that, if an association between a neighborhood environment factor and an outcome (such as physical activity or social health) remains significant even after controlling for self-selection, this provides support for a potential causal relationship (Boone-Heinonen et al., 2011; Mokhtarian and Cao, 2008).

Individuals may choose to reside in walkable neighborhoods if they have a preference for built environments with easy access to places that facilitate interactions among neighbors (Brookfield, 2017; Frank et al., 2007; Hong et al., 2018). Thus, a preference for easy and safe access to places (e.g., shopping areas, parks and greenspace) to interact with others could help explain the relation between walkability and community social health as shown in a study with older adults (Hong et al., 2018). We found two published studies that evaluated self-selection as a confounder in associations of walkability and social health. In the first, Kim and Kaplan (2004) compared residents of a walkable new-urbanist community and a nearby low-walkable suburban community. They examined differences in sense of community, and after adjusting for a single-item "sense of community" neighborhood selection indicator, differences between neighborhoods in sense of community remained. The second paper was a previous publication from the current study that found a composite measure of one dimension of social cohesion (i.e., 5 items related to having close-knit, helpful, trusted neighbors who get along and share values) was higher in adults living in higher-income neighborhoods but was not related to walkability, and results were similar with and without adjusting for self-selection (Sallis et al., 2009). However, the previous analysis did not examine how specific components of social cohesion (i.e., interactions with neighbors and sense of community) may be independently associated with walkability, controlling for self-selection. Examining these components separately may provide a better understanding of the unique and complex pathways by which walkability may influence health.

Present analyses were used to advance the literature on walkability and neighborhood social health in two ways. First, self-selection was examined as a confounder of the associations. Second, a widely used GIS-based measure of walkability was examined, because prior analyses with objective measures have had mixed results, as noted above. Using data from over 1700 participants in two metropolitan areas of the United States comprised of neighborhoods representing a range of income and walkability levels, the present study examined associations of an objectively-measured neighborhood walkability index around each participant's home with self-reported social interactions with neighbors and sense of community within their neighborhoods. Separate models tested whether residential self-selection, based on self-reported "easy access to places" as a walkability-related reason for moving to one's current neighborhood, confounded associations between objective walkability and the neighborhood social health measures.

2. Methods

2.1. Study design

The Neighborhood Quality of Life Study (NQLS) was a cross-sectional observational study designed to examine associations of neighborhood environments with physical activity and other health indicators (Sallis et al., 2009). The study was conducted during 2001–2005 in two metropolitan regions (Seattle/King County, WA and Maryland counties around Baltimore and Washington, DC), chosen because of (a) the completeness of existing geographic information systems (GIS) databases, (b) the consistency in land use data across the metropolitan areas, and (c) substantial variability in walkability across neighborhoods. Studying Seattle and Baltimore regions, being on opposite sides of the United States, also enhanced generalizability. The study design was to identify neighborhoods (clusters of census block groups) that met definitions for a 2 by 2 matrix of high/low walkability by high/low median household income. The resulting four "quadrants" were comprised of 32 neighborhoods (16 in Seattle and 16 in Baltimore regions). Geographic distribution of neighborhoods was maximized within each of the quadrants in each region to the greatest extent possible (e.g., clusters of block groups that defined neighborhoods were spread throughout each region). Adult participants were recruited from the identified neighborhoods. Samples from both regions were combined for present analyses. The study was approved by the Institutional Review Board at San Diego State University (vIBB Protocol #2179), and participants gave written informed consent.

2.2. Neighborhood selection

As described in detail elsewhere (Frank et al., 2010), national census data were used to determine median household income for block groups, and a walkability index was constructed for each block group so that block group-level GIS measures could be aggregated to characterize the walkability of pre-defined neighborhoods. Component variables for the walkability index were net residential density, mixed land use, street connectivity, and retail floor area ratio. Due to a lack of available data, sidewalks, intersection characteristics and traffic calming were not included in the walkability index. The four GIS components were standardized within each region) and summed to calculate the index used to characterize the walkability of defined neighborhoods in each region (see Frank et al., 2010 for details).

This walkability index was validated through comparisons with census data, showing cities scoring higher on this index had significantly less driving and more walking to work (Frank et al., 2010). "High" walkability was defined by the top four deciles, while "low" walkability was defined by the bottom four deciles on the index within each region.

Using census-based median household income data, neighborhoods that averaged under $15,000 and over $150,000 were excluded to reduce outlier areas on either extreme. The remaining neighborhoods were split into deciles with the lower three representing low-income, and the higher three representing high-income neighborhoods. The middle-income areas were omitted to create greater separation between the higher- and lower-income neighborhoods.

2.3. Participant recruitment and assessment procedures

Participants in each region were recruited in consecutive years, first in the Seattle region (2002–2003), then in the Baltimore region (2003–2005). Recruitment and initial assessment within region were conducted in all neighborhood quadrants simultaneously across a 12-month period to avoid confounding by season. Six months after participants' initial assessment, they repeated a subset of physical activity measures (to sample behavior in a different season) and several new survey measures, including the community social health outcomes examined in this paper.

Contact information for recruiting participants was purchased from a marketing company, with household records in each neighborhood selected from the lists via computer randomization. Letters were sent introducing the project to the heads of households, followed by a telephone call. Eligible participants were between 20 and 65 years old, not living in a group residence (nursing home or dormitory), able to answer a survey in English, and having no illness or injury that impaired their ability to walk. A total of 8504 eligible residents were contacted by phone, with a 26% study participation rate (participants/eligible contacts), resulting in N = 2199 participants in the full study sample. The retention rate for those completing the 6-month survey was 79%, resulting in N = 1745 participants in the analysis sample examined here.

2.4. Participant-level GIS walkability index

Rather than using the neighborhood-level walkability scores described above (Frank et al., 2010), a more precise indicator of walkability around each participant's home address was used in the statistical analyses. The participant-level walkability index was computed using the same four GIS components contained in the neighborhood-level index (Saelens et al., 2012). Using ArcGIS, a 1-km street network buffer around each participant's home address was identified to construct the four GIS components of the walkability index: 1) net residential density (number of residential housing units relative to the amount of residential land within the buffer); 2) land-use mix (the evenness of distribution of floor space area dedicated to residential, entertainment (including restaurants), and retail mixed land uses); 3) retail FAR (floor-to-land area ratio for retail/commercial uses relative to the total land area dedicated to retail/commercial within the buffer); and 4) intersection density indicating connectivity of the street network (number of intersections per land area).

Each participant's walkability index for the 1-km buffer around their home residence was computed as the weighted sum of region-standardized component scores using the following expression:

Walkability Index (1-km buffer around home) = (2 x z-intersection density) + (z-net residential density) + (z-retail floor area ratio) + (z-land use mix)

2.5. Neighborhood social interaction and sense of community

Social interaction was assessed with a scale constructed from 9 survey items about the number of days in the last month participants had various interactions with their neighbors: waved, said hello, stopped and talked, gone to a neighbor's house to socialize, had a neighbor over to socialize, gone somewhere with a neighbor, asked for help, sought advice, and borrowed things/exchanged favors. Participant responses on each of these items ranged between 0 and 31 days. The *Social Interaction* scale was computed by averaging responses across the 9 items to reflect the mean number of days per month that participants reported engaging in these interactions with neighbors. This measure was developed by the study's investigators, drawing on concepts previously published (Chapman and Frank, 2004; Parker, 2001) and showed a high test-retest correlation of r = 0.79 in a different sample (Forsyth et al., 2009).

Sense of community was assessed by a scale computed as the mean of responses to 3 survey questions: willingness to work with others to improve the neighborhood, neighborhood provides a sense of community, and it's easy to make friends in the neighborhood. Responses were rated on a 5-point Likert scale from "strongly disagree" (1) to "strongly agree" (5). These questions were taken from a 6-item scale developed for SMARTRAQ (Chapman and Frank, 2004) and used by Wood and colleagues (Wood et al., 2010). Test-retest correlation for this measure was r = 0.81 in a different sample (Forsyth et al., 2009).

2.6. Walkability-related neighborhood self-selection

To control for walkability-related self-selection into one's current neighborhood, survey items adapted from the SMARTRAQ study (Chapman and Frank, 2004; Frank et al., 2007) were included to assess reasons for moving to one's current residence. Principal components analysis conducted with data from the current study supported computation of a 3-item scale of walkability-related reasons for moving that reflected "importance of easy access to places." Items included in the scale were: desire for nearby shops and services, ease of walking, and closeness to public transportation. The walkability-related self-selection measure is particularly well-suited to the present study whose primary independent variable is walkability, because of the conceptual consonance. By contrast, using a self-selection scale based on aesthetics would not be expected to adjust for a walkability preference. The scale was computed as the mean of responses on a 5-point Likert scale from "not at all important" (1) to "very important" (5). This scale showed good internal consistency with Cronbach alpha = .76 in the present sample. Test-retest reliability for the walkability preference subscale was acceptable, at $r = 0.71$ in a different sample (Forsyth et al., 2009).

2.7. Study design and socio-demographic covariates

Participant sex, age, education, race/ethnicity, marital/partner status, and length of residence at current address (in months) were assessed in the first survey and included as covariates in the statistical models. Education, race/ethnicity, and marital status were recoded and analyzed as binary variables: college graduate or not, non-Hispanic white or Hispanic/nonwhite, and married/living with a partner or not, respectively, as reported elsewhere (Sallis et al., 2009). Two study design factors also were included as covariates: region where participants lived (Seattle/King County, WA or Baltimore/Maryland counties/Washington, DC area) and census-based neighborhood income category (high or low median household income – see Methods: Study Design and Neighborhood Selection sections). The high/low walkability study design factor was not included as a covariate because the walkability index was used as the primary exposure variable.

2.8. Statistical analyses

Data were analyzed using IBM SPSS Statistics for Windows, version 26 (IBM Corp., Armonk, N.Y., USA). Distributional characteristics of all measures were examined to ensure there were no improbable outliers or excessive skewness. Descriptive statistics (means, standard deviations or frequencies, percents) were generated for the study design and socio-demographic covariates, walkability index, neighborhood self-selection scale, and the two neighborhood social health outcomes (social interactions and sense of community scales).

To examine associations between the GIS walkability index and the two neighborhood social health outcomes, the SPSS MIXED procedure was used. Because study participants were recruited from neighborhoods defined *a priori* as falling into one of four high/low walkability-by-income quadrants, participant clustering within neighborhoods was adjusted for as a random effect. Covariates entered as fixed effects included two study design factors (region and high/low neighborhood income) and six socio-demographic variables (participant's sex, age, education, race/ethnicity, marital status, and length of time at current residence).

Two mixed models were run for each neighborhood social health scale: once *without* adjusting for the neighborhood self-selection scale, and once *with* the neighborhood self-selection scale added as a fixed effect. In each of these four models, Cohen's f^2 effect size for the walkability index was computed using methods described for multilevel mixed models (Lorah, 2018, p. 5). Cohen's f^2 can be interpreted here as the proportion of variance independently explained by the objective walkability index relative to the proportion of unexplained outcome variance.

3. Results

3.1. Descriptive statistics

Table 1 provides descriptive statistics for all measures, including the neighborhood social health outcomes, the walkability predictors, and the covariates adjusted for in all statistical models. Socio-demographically, the analysis sample of 1745 adults had an average age of 46 years old and were primarily white/non-Hispanic (74%). Just under half were female, and nearly two-thirds of participants had a college degree and were married or living with a partner. Average length of time participants had lived at their current residence was just over 10 years. Per the study design, roughly half of participants were recruited from high- and low-income neighborhoods and from each geographic region.

The neighborhood social health measures indicated participants averaged social interactions with neighbors on almost 5 days per month and averaged just above mid-point agreement (3.6) on the sense of community scale. The objective walkability index averaged close to zero, as was expected for a scale computed with z-scores. The neighborhood self-selection scale averaged the mid-point (3.1) for importance of walkability-related reasons for moving to one's neighborhood.

3.2. Associations of walkability with neighborhood social health outcomes

Tables 2 and 3 present the mixed-model results showing associations of the social health outcomes with the walkability measures and covariates. In the models adjusted for covariates, but not adjusted for neighborhood self-selection (i.e., "easy access to places" scale), the walkability index was significantly associated with both higher social interactions $p < .001$) and sense of community ($p = .009$).

Table 1
Descriptives for measures examined (n = 1745).

	Mean (SD) or %
Neighborhood Social Health Outcomes	
Social Interaction scale (maximum possible = 31 days) [a]	4.76 (3.72)
Sense of Community scale (mean score) [b]	3.64 (0.75)
Independent Variables	
Walkability Index (sum of GIS-based component z-scores)	−0.15 (3.08)
Self-Selection Scale: Walkability-related reasons for moving to the neighborhood ("Easy Access to Places" mean score) [c]	3.10 (1.13)
Study Design Covariates	
Region (% in Seattle/King County)	58.6%
Neighborhood Income (% high median household income, census-based)	53.4%
Socio-demographics Covariates	
Age (yrs)	46.0 (10.5)
Sex (% female)	48.3%
Education (% with a college degree)	67.3%
Race/Ethnicity (% non-white or Hispanic)	24.4%
Marital Status (% married or living with partner)	64.5%
Length of time at current residence (months)	122.6 (110.4)

[a] Higher scores represent higher average frequency (number of days) of 9 types of interactions with neighbors in the last month (e.g., waving at, saying hello, socializing with, etc. – see Methods).

[b] Higher scores represent higher sense of community. Respondents reported how strongly they agreed with 3 statements about their willingness to work with others, personal sense of community, and the ease of making friends (1 = strongly disagree to 5 = strongly agree).

[c] Higher scores represent higher self-rated importance of walkability-related reasons for deciding to move to one's current neighborhood. Items in the "Easy Access to Places" scale (i.e., ease of walking, nearby shops and services, and closeness to public transportation) were rated on a 5-point scale (1 = not at all important to 5 = very important).

Table 2
Neighborhood Social Interaction in relation to Walkability. Mixed-model results *without* and *with* adjustment for walkability-related self-selection to the neighborhood.

	Model Without Adjusting for Walkability-related Self-Selection to Neighborhood			Model With Adjustment for Walkability-related Self-Selection to Neighborhood		
Variable	Estimate (error)	95% CI	Sig.	Estimate (error)	95% CI	Sig.
Walkability Index [a]	0.13 (0.03)	0.07–0.19	<0.001	0.09 (0.03)	(0.02, 0.16)	0.008
Walkability-related Self-Seletion Scale [b]	–	–	–	0.26 (0.09)	(0.11, 0.44)	0.001
Covariates adjusted for in all models:						
Region (Seattle/King County) (Ref: Baltimore/Maryland)	−1.39 (0.19)	(-1.77, −1.01)	<0.001	−1.37 (0.20)	(-1.77, −0.97)	<0.001
Income (Low) (Ref: High)	−0.55 (0.19)	(-0.94, −0.16)	0.007	−0.50 (0.20)	(-0.91, −0.08)	0.020
Sex (Male) (Ref: Female)	−0.57 (0.22)	(-0.92, −0.22)	0.001	−0.47 (0.18)	(-0.82, −0.12)	0.008
Age	−0.57 (0.18)	(-0.01, 0.03)	0.322	0.01 (0.01)	(-0.01, 0.03)	0.555
Education (No Degree) (Ref: College Degree)	−0.30 (0.20)	(-0.69, 0.08)	0.124	−0.29 (0.20)	(-0.68, 0.09)	0.135
Ethnicity (Non-White) (Ref: White)	−0.57 (0.22)	(-1.00, −0.15)	0.009	−0.67 (0.22)	(-1.11, −0.24)	0.002
Marital Status (Unmarried) (Ref: Married/partner)	−0.46 (0.19)	(-0.83, −0.08)	0.019	−0.45 (0.19)	(-0.82, −0.07)	0.021
Time at current address	0.00 (0.00)	(-0.00, 0.00)	0.586	0.00 (0.00)	(-0.00, 0.00)	0.372

Note: Reference group for dichotomous variables is noted in parentheses.
[a] Cohen $f^2 = 0.$ 0.012 for Walkability Index in model without adjustment for walkability-related self-selection scale.Cohen $f^2 = 0.$ 0.005 for Walkability Index in model with adjustment for walkability-related self-selection scale.
[b] Self-selection scale of walkability-related reasons for moving to the neighborhood reflected “Easy Access to Places” (ease of walking, nearby shops and services, closeness to public transportation).

Table 3
Sense of Community in relation to Walkability. Mixed-model results *without* and *with* adjustment for walkability-related self-selection to the neighborhood.

	Model Without Adjusting for Walkability-related Self-Selection to Neighborhood			Model With Adjustment for Walkability-related Self-Selection to Neighborhood		
Variable	Estimate (error)	95% CI	Sig.	Estimate (error)	95% CI	Sig.
Walkability Index [a]	0.02 (0.01)	(0.01, 0.03)	0.009	0.01 (0.01)	(-0.01, 0.02)	0.518
Walkability-related Self-Seletion Scale [b]	–	–	–	0.10 (0.02)	(0.07, 0.14)	<0.001
Covariates adjusted for in all models:						
Region (Seattle/King County) (Ref: Baltimore/Maryland)	−0.15 (0.05)	(-0.25, −0.05)	0.004	−0.14 (0.05)	(-0.24, −0.04)	0.007
Income (Low) (Ref: High)	−0.22 (0.05)	(-0.32, −0.12)	<0.001	−0.20 (0.05)	(-0.30, −0.10)	<0.001
Sex (Male) (Ref: Female)	−0.07 (0.04)	(-0.14, −0.00)	0.049	−0.04 (0.04)	(-0.10, 0.02)	0.325
Age	0.01 (0.00)	(0.00, 0.01)	0.001	0.01 (0.00)	(0.00, 0.01)	0.007
Education (No Degree) (Ref: College Degree)	−0.12 (0.04)	(-0.20, −0.04)	0.002	−0.12 (0.04)	(-0.19, −0.04)	0.003
Ethnicity (Non-White) (Ref: White)	0.05 (0.04)	(-0.03, 0.14)	0.236	0.02 (0.04)	(-0.07, 0.11)	0.673
Marital Status (Unmarried) (Ref: Married/partner)	−0.20 (0.04)	(-0.27, −0.12)	<0.001	−0.19 (0.04)	(-0.27, −0.12)	<0.001
Time at current address	−0.00 (0.00)	(-0.00, 0.00)	0.344	0.00 (0.00)	(-0.00, 0.00)	0.815

Note: Reference group for dichotomous variables is noted in parentheses.
[a] Cohen $f^2 = 0.008$ for Walkability Index in model without adjustment for walkability-related self-selection scale.Cohen $f^2 = 0.001$ for Walkability Index in model with adjustment for walkability-related self-selection scale.
[b] Self-selection scale of walkability-related reasons for moving to the neighborhood reflected “Easy Access to Places” (ease of walking, nearby shops and services, closeness to public transportation).

When adjusted for neighborhood self-selection, the walkability index remained significantly associated with higher social interaction (p = .008) but was no longer associated with sense of community (p = .518). The neighborhood self-selection scale was significantly associated with both social interaction (p = .001), and sense of community (p < .001). Cohen effect size for the independent association of walkability with the two neighborhood social health outcomes was very small in all four models.

Regarding the covariates, social interaction was significantly ($p <$ .05) higher in the Baltimore/Maryland than Seattle/King County region, in higher-income than lower-income neighborhoods, in females than males, in non-Hispanic whites than nonwhites, and in those married/with partner than unmarried. Sense of community was significantly ($p <$ .05) higher in the Baltimore/Maryland than Seattle/King County region, in higher-income than lower-income neighborhoods, in females than males (not significant if neighborhood self-selection was controlled), in older individuals, in those with a college degree than less educated, and in those married/with partner than unmarried.

4. Discussion

Present findings supported the hypothesis that living in a walkable neighborhood is positively associated with social interactions with neighbors and sense of community. In a large sample of adults recruited from geographically and socio-demographically diverse neighborhoods in two US regions, a GIS-based walkability index around each participant's home was related to more social interactions with neighbors and greater sense of community in analyses unadjusted for self-selection into neighborhoods with easy access to places. Both of these social health outcomes are considered components of social cohesion.

Our findings are consistent with some prior studies that examined associations of built environment factors with community social health variables. For example, several studies found positive associations of walkability with some aspect of social interactions (Leyden, 2003; Mouratidis, 2018; van den Berg et al., 2017; Zhu et al., 2020), but another study found no association (du Toit et al., 2007). Jun and Hur (2015) and van den Berg et al. (2022) reported measures similar to our social interaction variable were related to perceived walkability but not to objectively-assessed walkability. Regarding associations of walkability and sense of community, three prior studies reported significant and positive associations (du Toit et al., 2007; French et al., 2014; Wood et al., 2010), but Wood et al. (2010) found inconsistent associations with various walkability components, and French et al. (2014) reported a negative association with residential density. However, our findings contrast with a previous report from this same study that found GIS-based walkability category (i.e., high vs low) was not associated with a composite measure of social cohesion (Sallis et al., 2009). The present analysis examined specific dimensions of social cohesion, and we believe this focus allows for a better understanding of the specific pathways by which the built environment may influence health.

Links between walkability and neighborhood social health could be due to the environment affording more opportunities to meet and get to know neighbors. Findings that walking and/or bicycling behaviors were related to various neighborhood social health outcomes (Wood et al., 2010; French et al., 2014; van den Berg et al., 2017) provide indirect evidence that more walking in walkable neighborhoods is a likely mechanism for seeing, talking with, and perhaps getting to know and build trust in neighbors. Alternatively, the self-selection hypothesis is that people with a propensity for social engagement may seek out neighborhoods that have the potential to provide more of such social opportunities, which happen to be walkable neighborhoods. A third interpretation is that a combination of environmental and individual mechanisms could be operating, which is consistent with findings from the present study. The walkability-related self-selection measure, based on a preference for "easy access to places," was positively related to both social interaction and sense of community, which could indicate many people were able to fulfill their preference for access to places where they could meet people in their selected neighborhoods.

When models were adjusted for self-selection, neighborhood walkability remained related to social interactions but not sense of community. This finding was not consistent with the Kim and Kaplan (2004) report that adjusting for "sense of community" as a self-selection variable did not eliminate the difference in the sense of community outcome when comparing communities that differed in walkability. In the present study, the non-significant association between walkability and sense of community when adjusting for self-selection suggests people who value nearby places to socialize may make an effort to build a sense of community independent of the neighborhood's walkability. Further, our scale on the importance of "easy access to places" could indirectly indicate the importance of having nearby institutions that reflect shared values in a community (e.g., commercial, religious, cultural, or educational institutions), which could promote a sense of community regardless of the walkability of the surrounding built environment.

One interpretation of the significant association between walkability and social interactions with neighbors, even after adjustment for self-selection, is neighborhood design that facilitates meeting neighbors on the street is an important pre-condition for interactions with neighbors, regardless of pre-existing preferences for access to places. Zhu et al. (2020) reported complex associations among walkability, social interaction variables, and self-selection, roughly consistent with findings of the present study. Thus, it is possible neighborhood design has a causal effect on promoting interactions with neighbors, and this should be examined further with prospective studies and evaluations of natural experiments. Low-walkable neighborhoods where people drive in and out of the neighborhood, and where there is an absence of gathering places, could prevent people who have a predisposition to interact with neighbors from doing so. Happenstance or spontaneous encounters are likely in walkable areas, where people repeatedly see the same neighbors, creating a sense of familiarity. It is also possible that walkable neighborhoods are more likely to be used to host organized community programs (e.g., business or cultural events) because commercial destinations and institutional venues provide opportunities for such gatherings to occur. Thus, future work is needed to examine the role of community programming and events, independent of walkability, in neighborhood social health.

4.1. Study strengths and limitations

Strengths included controlling for self-selection based on ease of access to places where neighbors might be likely to encounter each other, when assessing associations of walkability with social interaction and sense of community. The study employed a large sample with geographic and sociodemographic diversity, standardized outcome measures that were evaluated for test-retest reliability, and an objective GIS-based index of walkability around each participant's residence. Although associations of walkability with social interactions and sense of community were statistically significant in 3 of 4 models tested, all the effect sizes were low. Thus, the results should not be over-interpreted.

The cross-sectional design was an important limitation on interpretation of results, so prospective studies are recommended to examine whether changes to neighborhood walkability are associated with increases in interactions with neighbors and sense of community, among those with and without pre-existing preferences for walkability and close connections with neighbors. The data were collected in the early 2000's, but GIS and survey data were closely aligned in time. Though neighborhoods are likely to have changed since these data were collected, it is unlikely the associations have changed substantially, though we cannot confirm this expectation.

Social capital and community social health are complex constructs with several components (Kawachi and Berkman, 2015), but the current study only examined the components of social interaction and sense of community. Though there are many conceptualizations and measures of self-selection (Handy et al., 2005), the present measure was designed to be conceptually relevant and aligned to the key study variable of walkability. The "easy access to places" subscale of a longer self-selection measure did not explicitly refer to a desire to interact more with people in the neighborhood and has been interpreted previously as a preference for walkable mixed-use neighborhoods (Sallis et al., 2009). Thus, development of a more comprehensive self-selection measure could help advance research. Another limitation in use of self-selection as a covariate is based on an assumption that participants had a range of options in choosing their residential neighborhoods. However, previous research documented that residential location choice is more constrained among lower-income participants (Levine and Frank, 2007) which, by design, made up about half of participants in the present study.

5. Conclusions

Current analyses indicated neighborhood walkability was positively associated with interactions with neighbors and sense of community, though the latter association was fully explained by self-selection of the current neighborhood based on "easy access to places." Walkable neighborhoods with destinations, but also public realm in the form of hardscape, greenspace, and community events can provide favorable environmental conditions that make unplanned and repeated interactions with neighbors likely. These can be considered fundamental environmental features that support the formation of social cohesion. It is important to understand not only the physical health but also the mental and social health implications of living in environments that support social interactions and sense of community.

Geolocation information

This study was conducted in Seattle/King County, WA and parts of five counties in Maryland around Baltimore, MD and Washington, DC.

Data availability

Data will be made available on request.

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