Published in final edited form as:

Health Educ Behav. 2015 August ; 42(4): 510–517. doi:10.1177/1090198114564500.

Joint Associations of Residential Density and Neighborhood Involvement With Physical Activity Among a Multiethnic Sample of Urban Adults

Vicki Johnson-Lawrence, MS, PhD¹, Amy J. Schulz, PhD², Shannon N. Zenk, PhD³, Barbara A. Israel, DrPH², Jean Wineman, PhD⁴, Robert W. Marans, PhD⁴, Zachary Rowe, PhD⁵

¹University of Michigan–Flint, MI, USA

²University of Michigan School of Public Health, Ann Arbor, MI, USA

³University of Illinois at Chicago, IL, USA

⁴University of Michigan, Ann Arbor, MI, USA

⁵Friends of Parkside, Detroit, MI, USA

Abstract

Regular physical activity is associated with improvements in overall health. Although resident involvement in neighborhood social activities is positively associated with physical activity, neighborhood design features, including residential density, have varied associations with physical activity. Using data from a multiethnic sample of 696 adults in Detroit, Michigan, multilevel models were used to examine joint effects of residential density and resident involvement in neighborhood activities in relation to physical activity. We found a marginally significant negative interaction of higher residential density and resident neighborhood involvement. Higher residential density was negatively associated with physical activity, and resident neighborhood involvement was positively associated with physical activity. Our findings suggest that future work incorporate additional neighborhood and individual-level characteristics to understand the complexity of the association between the neighborhood environment, resident social engagement in the neighborhood, and physical activity.

Keywords

neighborhoods; neighborhood involvement; physical activity; residential density; social epidemiology; social participation

Current research supports the importance of physical activity (PA) for better health. Regular participation in PA is associated with decreased risk of cardiovascular disease, depression, and all-cause mortality (Haskell et al., 2007; Savelle et al., 2010; Teychenne, Ball, & Salmon,

Reprints and permissions: sagepub.com/journalsPermissions.nav

Corresponding Author: Vicki Johnson-Lawrence, Department of Public Health and Health Sciences, University of Michigan–Flint, 3143 William S White Building, 303 E Kearsley Street, Flint, MI 48502, USA. vickij@umich.edu.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

2008; Zhao, Ford, Li, & Mokdad, 2008). However, recent evidence suggests that only 48.8% of adults in the United States meet Healthy People 2010 guidelines for PA (Centers for Disease Control and Prevention, 2008). Ecological models of health behavior have been increasingly applied to an understanding of PA behaviors. These theoretical models emphasize the role of environmental contexts, as well as social and psychological influences, on health-related behaviors, providing a framework for explicit consideration of multiple levels of influence on health-related behaviors. Key assumptions of ecological models include the principle that health-related behaviors (e.g., PA) occur within particular settings characterized by physical, social, organizational, and other features; and that these features interact across levels of an ecological model to shape specific health-related behaviors (Barker, 1968; Blanchard et al., 2005; Glass & McAtee, 2006; Lewin & Cartwright, 1951; McNeill, Kreuter, & Subramanian, 2006; Owen, Humpel, Leslie, Bauman, & Sallis, 2004; Saelens & Handy, 2008; J. E. Sallis et al., 2006; J. F. Sallis & Kerr, 2006; J. F. Sallis, Owen, & Fisher, 2008).

Consistent with ecological models of health behavior, a growing body of evidence indicates associations between both neighborhood social characteristics and characteristics of the built environment (Boone-Heinonen et al., 2011) with PA (Centers for Disease Control and Prevention, 2008; Haskell et al., 2007). Relatively few of these studies have examined the joint effects of physical and social environmental characteristics as they interact across levels of an ecological model (e.g., the joint effects of the built environment in conjunction with individual or interpersonal characteristics). Understanding multilevel correlates of PA, across levels of influence, is an important step needed to guide the development of more effective interventions to promote PA (J. F. Sallis et al., 2008).

In the analysis presented here, we build on the ecological theoretical model to examine characteristics of the built environments in which individuals reside, in conjunction with their level of engagement within their neighborhood social environments, to understand their joint associations with PA. Specifically, we examine whether associations between residential density (as an indicator of the built environment) and PA may be modified based on residents' involvement with local organizations, as an indicator of social engagement. We test these associations in a multiethnic sample of adults from a Midwestern U.S. city. Below we review the literature on residential density, neighborhood involvement, and PA.

Residential Density and Physical Activity

Ecological models emphasize associations between characteristics of the built environment and health-related behaviors such as PA. There is some empirical evidence to support these associations, although the evidence base is mixed. Neighborhood design factors, including residential density, are the focus of considerable research (Oakes, Forsyth, & Schmitz, 2007; Papas et al., 2007; Saelens, Sallis, Black, & Chen, 2003). More dense neighborhoods often have more diverse land uses and closer destinations to which to walk or bike (Saelens & Handy, 2008). Higher residential density has been positively associated with PA for utilitarian purposes (e.g., shopping; Forsyth, Oakes, Lee, & Schmitz, 2009; Oakes et al., 2007), but fewer studies have identified positive associations with overall PA (Forsyth et al., 2009; Forsyth, Oakes, Schmitz, & Hearst, 2007; Oakes et al., 2007) or with moderate to

vigorous PA (Saelens et al., 2012) for nonutilitarian purposes. In fact, there is some evidence suggesting residential density is inversely associated with PA for nonutilitarian (Forsyth et al., 2009; Saelens & Handy, 2008; J. E. Sallis et al., 2006) or leisure (Chaudhury, Mahmood, Michael, Campo, & Hay, 2012; Forsyth et al., 2007; Forsyth et al., 2009) purposes. Nonetheless, overall or moderate-to-vigorous PA represent engagement in a health-promoting behavior (PA) with long-term beneficial public health outcomes (Forsyth, Hearst, Oakes, & Schmitz, 2008). Furthermore, studies by Wineman et al. (2012) and Schulz et al. (2013) found that the association between residential density and PA may be jointly determined by other neighborhood features, including, for example, measures of physical deterioration, street condition, and presence of a park or playground in good condition. Such indicators may reflect resident involvement, which may, in turn, enhance any positive effects of density.

Resident Neighborhood Involvement and Physical Activity

Participation in neighborhood organizations has been linked to higher levels of PA among adults (Greiner, Li, Kawachi, Hunt, & Ahluwalia, 2004). Participation in neighborhood organizations may cross cut levels of an ecological model. In addition to reflecting individual characteristics, participation in neighborhood organizations may enhance social relationships through contact with neighbors (as an interpersonal level characteristic), and/or shape neighborhood social environments through engagement of individuals with neighborhood organizations. In neighborhoods where residents are supportive of PA, such social relationships may provide opportunities to be physically active together (thereby reinforcing PA as a social norm) and maintain accountability for each other in their PA practices (Carlson et al., 2012). Other research, however, has shown associations between social relationships and health demoting behaviors, which may be attributable to (subjective) social norms that discourage PA (Christakis & Fowler, 2007, 2012). While normative practices across social connections may vary, one's sense of connectedness to, and socialization with, friends and neighbors has been reported to be positively associated with reported leisurely walking (Wood, Frank, & Giles-Corti, 2010) and overall PA (Hystad & Carpiano, 2012), and negatively associated with physical inactivity (Oakes, 2004).

Joint Effects of Residential Density and Neighborhood Involvement on PA

As noted above, ecological models of PA emphasize the likelihood of joint effects across multiple levels, including physical or built environment characteristics (e.g., density) as well as social characteristics (e.g., neighborhood engagement). It is possible that neighborhood involvement may enhance positive effects of density on PA through social support for PA, or overcome challenges more common among denser neighborhoods (e.g., greater traffic or crime) by strengthening social ties in the neighborhood and thus making individuals more comfortable and active in their neighborhoods. We identified only one study, by Greiner et al., that examined the relationship between involvement in local social and civic activities to address community problems and PA across high and low-density neighborhoods among adults living in a rural area (Greiner et al., 2004). They found positive associations between involvement and PA, positive associations between residential density and involvement, but no interaction of involvement and density with PA. Collective community efforts are used to

protect and improve communities, both urban and rural alike. However, the degree to which collective community efforts and residential density impact a community may vary by urbanicity (potentially, e.g., because of differing levels of need for these forms of community organization). Additional research to assess the consistency of this finding across populations and contexts is warranted.

Our study addresses the paucity of work on cross-level influences on PA. We examine the joint associations of residential density and involvement in neighborhood activities with PA among a multiethnic sample of adults from a Midwestern U.S. city. We hypothesize that residents of denser neighborhoods who are involved in neighborhood activities will be more physically active than residents living in other contexts. Understanding these dynamics can help to identify whether interventions that promote community involvement can be used as tools to promote healthier behaviors across heterogeneous neighborhood contexts.

Method

Study Sample

Data for this study were drawn from the Healthy Environments Partnership (HEP) Community Survey (2002–2003) and from 2000 U.S. Census data. The University of Michigan Institutional Review Board for Protection of Human Subjects approved the study in 2001. The HEP survey sample is a stratified, two-stage probability sample of occupied housing units (households). The sample was designed to obtain 1,000 completed interviews with persons 25+ years of age in each of three study areas: northwest, southwest, and eastside Detroit. Households were selected to attain approximately equal representation across racial/ethnic groups and socioeconomic position in order to allow for comparisons across racial and ethnic and socioeconomic status within geographic areas (Schulz et al., 2005). The final sample comprised 919 non-Hispanic Black, non-Hispanic White, and Latino adults aged 25 or older. Sample weights were constructed to adjust for differential selection and response rates and to perform analyses with equitable racial/ethnic and poverty distributions (Schulz et al., 2005).

Measures

Physical Activity.—The outcome for these analyses was PA, assessed using items from the Behavioral Risk Factor Surveillance Survey (Centers for Disease Control and Prevention, 2001). Participants were first asked whether they participate in walking, moderate-intensity activities (vacuuming, gardening, or anything else that causes small increases in breathing or heart rate) or vigorous activities (such as fast walking, running, dancing, or participating in strenuous sports) that cause large increases in breathing or heart rate in a usual week for at least 10 minutes at a time. Those who indicated “yes” to any of these items proceeded to answer items asking how many days of the week, and the amount of time each of those days that they participate in the relevant activity. Based on the International Physical Activity Questionnaire guidelines (Ainsworth et al., 2000; Craig et al., 2003), metabolic equivalent of task (MET) minutes of PA per week were calculated for participants for whom data were available on frequency and duration of PA (Wineman et al., 2012) and scaled (divided) by the standard deviation to create a standardized PA score.

Neighborhood Involvement.—Neighborhood involvement was assessed through three questions representing involvement in various types of neighborhood activities over the past 12 months, and included “Have you attended a block club, neighborhood association, or police precinct meeting?” “Have you participated in a neighborhood clean-up or beautification project, crime watch, Angel’s Night, or other neighborhood activity?” and “Have you served on a committee, helped organize meetings, or served in a position of leadership for any local organization such as a block club, church, parent teacher or other school organization, or any other organization?” Possible responses for each question were yes (1) and no (0). Neighborhood involvement was categorized as “any involvement” (1) or “no involvement” (0).

Residential Density.—Residential density was derived from 2000 census data and was calculated as the number of housing units per acre (Wineman et al., 2012). Each respondent was assigned the average residential density for the area within a half mile radius from their residential block (including their own) to account for housing density not only within their own block but for the surrounding blocks as well (Wineman et al., 2012).

Covariates.—Individual-level covariates included in all models were age (years), length of residence in the neighborhood (years), gender, education (less than a high school diploma or high school diploma or more), poverty to income ratio (PIR; $\text{PIR} < 1$ or $\text{PIR} \geq 1$), labor force participation (yes/no), car ownership (yes/no), home ownership status (yes/no), marital status (currently married or not currently married), physical limitations, defined by having difficulty with doing heavy work (e.g., washing walls, shoveling snow), climbing flights of stairs, walking several blocks, or difficulty bathing, and race/ethnicity (non-Hispanic White, Hispanic, or non-Hispanic Black). The socioeconomic measures were categorized to ensure sample sizes within combinations of the covariates were sufficient for parameter estimation. All models accounted for neighborhood poverty, defined as the proportion of households with incomes below the poverty line within each census block group and based on 2000 U.S. Census data.

Data Analysis

All analyses were performed in HLM 7.0. Multiple imputation analyses were performed to account for the missingness across variables in the data. Details of the multiple imputation process and survey methodology have been reported elsewhere (Schulz et al., 2005). The imputations and appropriate weighting procedures were applied in HLM 7.0 to accurately reflect the intended socioeconomic and racial/ ethnic distribution of the study communities.

Weighted multilevel linear regression models of PA were used to examine interaction effects of neighborhood involvement and residential density on PA. The sample included 696 individuals nested in 137 census blocks and 68 census block groups. All continuous measures at the person level were group mean centered to allow for unbiased estimation of cross-level interactions (Hofmann & Gavin, 1998), and both block and block group level measures were grand mean centered. Fixed effects at the individual and block group levels were estimated in the analyses. Main effects and a product– term interaction effect of residential density and neighborhood involvement models of PA were evaluated at $\alpha = .05$.

Model assumptions were tested. Although the PA scores were slightly left skewed, transformation of the data did not result in improved model fit. The untransformed models results are presented to facilitate interpretability of the results.

Results

Descriptive Statistics

A total of 696 participants of the original 919 persons sampled were not chair or bed bound and provided data on the frequency (weekly) and duration (daily) for calculation of their PA level, including the report of any vigorous or moderate PA for 10 minutes or more. Of the 223 individuals excluded, 71 were chair or bed bound, and 152 individuals did not provide information to calculate their PA level. Respondents who provided information to calculate their PA and were physically inactive had calculated MET scores of zero. Chi-square and *t* tests suggested respondents who were not chair or bed bound but had missing data ($n = 152$) were less likely to be involved in neighborhood activities ($p < .01$), but comparable to the analytic sample ($n = 696$) on all other demographic measures (including residential density).

Descriptive characteristics of the analytic sample are shown in Table 1. Across the 137 blocks, the average residential density was 5.29 household units per acre (standard error [*SE*] = 2.61). The average standardized PA score was 1.36 (*SE* = 0.04) MET minutes per week. Approximately half (47.9%) of the sample reported involvement in at least one neighborhood activity. Within the census blocks, racial/ethnic and socioeconomic characteristics were relatively homogenous but varied significantly across census blocks and block groups.

Regression Results

The multilevel linear regression results are shown in Table 2. The findings showed that neighborhood involvement is positively associated with PA (Model 1; $b = 0.17$, *SE* = 0.09, $p = .046$). Greater residential density was associated with less PA (Model 1; $b = -0.03$, *SE* = 0.01, $p = .01$) controlling for all covariates. Our interaction model (Table 2, Model 2) showed a marginally significant negative interaction between higher residential density and involvement (Model 2; $b = -0.04$, *SE* = 0.03, $p = .095$) in relation to PA.

Discussion

The purpose of this study was to examine the joint associations of neighborhood involvement in neighborhood activities and residential density with PA among a multiethnic sample of adults from a Midwestern U.S. city. We found weak (marginally significant) evidence that involvement in neighborhood activities might exacerbate an inverse association between density and PA.

The borderline interactive association between residential density and neighborhood involvement with PA of our study is not surprising, given the previous research findings for these measures. Just one other study of which we are aware examined interactions between neighborhood involvement and population density in relation to PA. Greiner et al. (2004)

report no interactions between neighborhood involvement and population density in relation to PA in their predominantly rural sample.

The sample used by Greiner et al. (2004) differed in setting, sample, and scale of the environmental measurement. These factors may have contributed to the slight differences in findings of our studies—a marginally significant interaction in our study compared with the absence of association in their study. As noted above, Greiner et al. examined these associations in a predominantly rural population-based sample from the Kansas Behavioral Risk Factor Surveillance System, while our study population was drawn from select areas of Detroit. Greiner et al. measured population density at the county level while our analyses were based on the residential household density within a 0.5 mile radius of the block in which the resident lived. The geographic area at which neighborhood factors are measured has been shown to have differential associations with PA, with more localized measures demonstrating stronger associations with PA (Wineman et al., 2012). The implications of differing measures and absolute values of density, as well as other neighborhood features that may interact with density (e.g., land use mix), for understanding joint associations between density, neighborhood involvement and PA warrant further investigation.

Our finding of a positive association between neighborhood involvement and PA is consistent with results in a predominantly rural sample (Greiner et al., 2004) and a sample of Japanese adults (Ueshima et al., 2010). Furthermore, results from a qualitative study among 66 older adults (65+) suggested that individuals who socialized (e.g., socializing with community members or neighbors while on a walk) or participated in formally planned social activities (e.g., walking groups or lunch groups) with others (as forms of peer support) within their neighborhoods also reported walking more for both utilitarian (e.g., shopping) purposes and exercising in general (Chaudhury et al., 2012).

While more dense urban neighborhoods are often thought to increase PA by providing more destinations to which to walk or bike for utilitarian purposes, negative associations between residential density and PA have been reported previously in this sample (Schulz et al., 2013; Wineman et al., 2012) and others (Forsyth et al., 2009). Residential density may increase pedestrian congestion, crime, and traffic concerns and reduce public open space and recreational opportunities, thereby reducing leisure PA (Boyko & Cooper, 2011). These effects may contribute to the negative association between density and PA observed here. It is possible that the negative effects of higher density on leisure PA outweighed the positive effects on utilitarian PA in our sample, producing an overall negative effect on total PA. As observed previously, the negative association between density–PA relationships may also reflect other neighborhood conditions such as street condition or deterioration (Schulz et al., 2013).

Of particular interest for this study, negative effects of residential density on PA may be more pronounced among those who are involved in neighborhood activities because their interactions with neighbors raise awareness of crime, traffic, or other problems associated with higher density neighborhoods, contributing to lower PA in higher density neighborhoods. This suggests caution in promoting PA through neighborhood involvement alone in more dense contexts. Attention may need to be paid to promoting positive social

ties that would enhance the social environment of the neighborhood and outweigh any increased awareness of crime, traffic, and other problems associated with higher density neighborhoods.

Study Limitations

Limitations of our study include the use of cross-sectional data, which limits any causal interpretation of the results. The data are based on information from 2002, which may seem aged, but the associations described are not expected to be dynamic; we expect that these relationships are likely to be stable over time. Our analysis may be biased by model misspecification at both the neighborhood and individual levels of analysis, although we controlled for several factors that were likely to influence our findings at the individual level as well as poverty at the neighborhood level. The neighborhoods (census blocks) were expected to vary in demographic composition, but preliminary analyses that included both racial composition and neighborhood poverty measures suggested racial composition was non-significant and had a minimal effect size, and was therefore not included in the final analyses. Additionally, the socioeconomic measures accounted for in the analyses were analyzed crudely to support model estimation, but may have more nuanced roles in these analyses. We excluded objective and perceived measures of crime and safety from these analyses, given that these may be mediators of the hypothesized relationships examined in this study. Future work can assess the role of these measures in this association.

Additionally, these analyses did not account for informal social interactions between residents, but informal interactions reflect an alternative measure of resident social engagement, and can be examined for their role in these associations in future work. Other demographic measures, such as the presence of children in the household, may influence the hypothesized associations, and should be assessed in future work. We acknowledge that our measure of PA may have resulted in measurement error, based on the limited examples of PA provided to the residents, the exclusion of work-related PA, and reliance on self-reported PA. With the exception of the use of self-reported PA, such errors may have led to the underreporting of PA among the sample respondents. Furthermore, we examined total PA rather than domain-specific PA (utilitarian, leisure), which may have obscured associations. In addition, we understand that individuals are not selected into our study neighborhoods at random, and these patterns may influence the associations shown in our analyses. However, we have controlled for multiple individual level factors that are likely correlated with an individual's likelihood of moving into (or remaining within) our study neighborhoods, and acknowledge this concern as a limitation within our data, as it is with many neighborhood studies. A final note regarding our sample is that our analyses were limited to individuals who did not report being chair or bed bound and provided sufficient information to calculate a measure of PA according to the International Physical Activity Questionnaire guidelines. This decision allowed us to minimize potential confounding effects (likely toward the null) of being restricted to their place of residence (either by choice or by physical limitation) on the combined influences of residential density and neighborhood involvement with PA.

Conclusion

In conclusion, this study empirically examined the joint effects of observed attributes of the neighborhood built environment and measures of the social involvement in the neighborhood

in relation to PA. Our findings are consistent with ecological models in showing both individual and contextual correlates of PA, and suggest that additional correlates need to be incorporated into our models to better characterize the interactive effects of individual and contextual determinants of PA. Future research corroborating our findings of a negative effect of density on PA may suggest the need to address traffic and crime problems that are often associated with higher density areas. This may include traffic calming measures such as speed bumps, narrowed traffic lanes, medians, and flashing crosswalks to improve traffic safety and enhanced community policing, neighborhood watches, and buildings that facilitate natural surveillance to improve crime-related safety (Giles-Corti, Ryan, & Foster, 2012). Moreover, if our findings on joint associations between density and neighborhood involvement are supported in future studies, interventions using community involvement as a strategy to increase PA may need to deliberately strengthen social ties among neighbors to counteract any increased awareness of traffic, crime, and other problems associated with higher density neighborhoods.

Acknowledgment

The Healthy Environments Partnership (HEP; www.hepdetroit.org) is a community-based participatory research partnership affiliated with the Detroit Community-Academic Urban Research Center (www.detroiturc.org). We thank the members of the HEP Steering Committee for their contributions to the work presented here, including representatives from Brightmoor Community Center, Detroit Department of Health and Wellness Promotion, Detroit Hispanic Development Corporation, Friends of Parkside, Henry Ford Health System, Warren Conner Development Coalition, and University of Michigan School of Public Health.

The Aetna Foundation (one of the funding agencies) is a national foundation based in Hartford, Connecticut, that supports projects to promote wellness, health, and access to high-quality health care for everyone. The results presented here are solely the responsibility of the authors and do not necessarily represent the views of National Institute of Environmental Health Sciences, or The Aetna Foundation, its directors, officers, or staff.

Funding

The authors disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: The study and analysis were supported by the National Institute of Environmental Health Sciences (R01ES10936, R01ES014234) and The Aetna Foundation.

References

- Ainsworth BE, Haskell WL, Whitt MC, Irwin ML, Swartz AM, Strath SJ, ...Leon AS (2000). Compendium of physical activities: An update of activity codes and MET intensities. *Medicine and Science in Sports and Exercise*, 32, S498–S516. doi:10.1097/00005768-200009001-00009 [PubMed: 10993420]
- Barker RG (1968). *Ecological psychology* Stanford, CA: Stanford University Press.
- Blanchard CM, McGannon KR, Spence JC, Rhodes RE, Nehl E, Baker F, & Bostwick J (2005). Social ecological correlates of physical activity in normal weight, overweight, and obese individuals. *International Journal of Obesity*, 29, 720–726. doi:10.1038/sj.ijo.0802927 [PubMed: 15795751]
- Boone-Heinonen J, Diez-Roux AV, Kiefe CI, Lewis CE, Guilkey DK, & Gordon-Larsen P (2011). Neighborhood socioeconomic status predictors of physical activity through young to middle adulthood: The CARDIA study. *Social Science & Medicine*, 72, 641–649. doi:10.1016/j.socscimed.2010.12.013 [PubMed: 21316829]
- Boyko CT, & Cooper R (2011). Clarifying and re-conceptualising density. *Progress in Planning*, 76, 1–61.
- Carlson JA, Sallis JF, Conway TL, Saelens BE, Frank LD, Kerr J, ...King AC (2012). Interactions between psychosocial and built environment factors in explaining older adults' physical activity. *Preventive Medicine*, 54, 68–73. doi:10.1016/j.ypmed.2011.10.004 [PubMed: 22027402]

- Centers for Disease Control and Prevention. (2001). Behavioral Risk Factor Surveillance System: Survey questionnaire Atlanta GA: Author.
- Centers for Disease Control and Prevention. (2008). Prevalence of self-reported physically active adults—United States, 2007. *MMWR. Morbidity and Mortality Weekly Report*, 57, 1297–1300. [PubMed: 19052527]
- Chaudhury H, Mahmood A, Michael YL, Campo M, & Hay K (2012). The influence of neighborhood residential density, physical and social environments on older adults' physical activity: An exploratory study in two metropolitan areas. *Journal of Aging Studies*, 26, 35–43.
- Christakis NA, & Fowler JH (2007). The spread of obesity in a large social network over 32 years. *New England Journal of Medicine*, 357, 370–379. doi:10.1056/NEJMsa066082 [PubMed: 17652652]
- Christakis NA, & Fowler JH (2012). Social contagion theory: Examining dynamic social networks and human behavior. *Statistics in Medicine*, 32, 556–577. doi:10.1002/sim.5408 [PubMed: 22711416]
- Craig CL, Marshall AL, Sjostrom M, Bauman AE, Booth LL, Ainsworth BE, ...Oja P (2003). International Physical Activity Questionnaire: 12-Country reliability and validity. *Medicine and Science in Sports and Exercise*, 35, 1381–1395. doi:10.1249/01.mss.0000078924.61453.fb [PubMed: 12900694]
- Forsyth A, Hearst M, Oakes JM, & Schmitz KH (2008). Design and destinations: Factors influencing walking and total physical activity. *Urban Studies*, 45, 1973–1996. doi:10.1177/0042098008093386
- Forsyth A, Oakes JM, Lee B, & Schmitz KH (2009). The built environment, walking, and physical activity: Is the environment more important to some people than others? *Transportation Research Part D—Transport and Environment*, 14(1), 42–49. doi:10.1016/j.trd.2008.10.003
- Forsyth A, Oakes JM, Schmitz KH, & Hearst M (2007). Does residential density increase walking and other physical activity? *Urban Studies*, 44, 679–697. doi:10.1080/00420980601184729
- Giles-Corti B, Ryan K, & Foster S (2012). Increasing density in Australia: Maximising the health benefits and minimising harm (Report to the National Heart Foundation) Melbourne, Victoria, Australia: National Heart Foundation of Australia.
- Glass TA, & McAtee MJ (2006). Behavioral science at the crossroads in public health: Extending horizons, envisioning the future. *Social Science & Medicine*, 62, 1650–1671. [PubMed: 16198467]
- Greiner KA, Li CY, Kawachi I, Hunt DC, & Ahluwalia JS (2004). The relationships of social participation and community ratings to health and health behaviors in areas with high and low population density. *Social Science & Medicine*, 59, 2303–2312. doi:10.1016/j.socscimed.2004.03.023 [PubMed: 15450705]
- Haskell WL, Lee I, Min P, Russell R, Powell KE, Blair SN, ...Bauman A (2007). Physical activity and public health: Updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. *Medicine and Science in Sports and Exercise*, 39, 1423–1434. doi:10.1249/mss.0b013e3180616b27 [PubMed: 17762377]
- Hofmann DA, & Gavin MB (1998). Centering decisions in hierarchical linear models: Implications for research in organizations. *Journal of Management*, 24, 623–641.
- Hystad P, & Carpiano RM (2012). Sense of community belonging and health-behaviour change in Canada. *Journal of Epidemiology and Community Health*, 66, 277–283. doi:10.1136/jech.2009.103556 [PubMed: 20947874]
- Lewin K, & Cartwright D (1951). *Field theory in social sciences* New York, NY: Harper.
- McNeill LH, Kreuter MW, & Subramanian SV (2006). Social environment and physical activity: A review of concepts and evidence. *Social Science & Medicine*, 63, 1011–1022. doi:10.1016/j.socscimed.2006.03.012 [PubMed: 16650513]
- Oakes JM (2004). The (mis)estimation of neighborhood effects: Causal inference for a practicable social epidemiology. *Social Science & Medicine*, 58, 1929–1952. doi:10.1016/j.socscimed.2003.08.004 [PubMed: 15020009]
- Oakes JM, Forsyth A, & Schmitz KH (2007). The effects of neighborhood density and street connectivity on walking behavior: The Twin Cities walking study. *Epidemiologic Perspectives & Innovations: EP+I*, 4, 16. doi:10.1186/17425573-4-16 [PubMed: 18078510]

- Owen N, Humpel N, Leslie E, Bauman A, & Sallis JF (2004). Understanding environmental influences on walking: Review and research agenda. *American Journal of Preventive Medicine*, 27, 67–76. [PubMed: 15212778]
- Papas MA, Alberg AJ, Ewing R, Helzlsouer KJ, Gary TL, & Klassen AC (2007). The built environment and obesity. *Epidemiologic Reviews*, 29, 129–143. doi:10.1093/epirev/mxm009 [PubMed: 17533172]
- Saelens BE, & Handy SL (2008). Built environment correlates of walking: A review. *Medicine and Science in Sports and Exercise*, 40, S550–S566. doi:10.1249/MSS.0b013e31817e67a4 [PubMed: 18562973]
- Saelens BE, Sallis JF, Black JB, & Chen D (2003). Neighborhood-based differences in physical activity: An environment scale evaluation. *American Journal of Public Health*, 93, 1552–1558. doi: 10.2105/ajph.93.9.1552 [PubMed: 12948979]
- Saelens BE, Sallis JF, Frank LD, Cain KL, Conway TL, Chapman JE, ...Kerr J (2012). Neighborhood environment and psychosocial correlates of adults' physical activity. *Medicine and Science in Sports and Exercise*, 44, 637–646. [PubMed: 21946156]
- Sallis JE, Cervero RB, Ascher W, Henderson KA, Kraft MK, & Kerr J (2006). An ecological approach to creating active living communities. *Annual Review of Public Health*, 27, 297–322.
- Sallis JF, & Kerr J (2006). Physical activity and the built environment (President's Council on Fitness and Sports). *Research Digest*, 7, 1–8.
- Sallis JF, Owen N, & Fisher EB (2008). Ecological models of health behavior. In Glanz K, Rimer B, & Viswanath K (Eds.), *Health behavior and health education: Theory, research, and practice* (4th ed., pp. 465–485). San Francisco, CA: Josey-Bass.
- Savela S, Koistinen P, Tilvis RS, Strandberg AY, Pitkala KH, Salomaa VV, ...Strandberg TE (2010). Leisure-time physical activity, cardiovascular risk factors and mortality during a 34-year follow-up in men. *European Journal of Epidemiology*, 25, 619–625. doi:10.1007/s10654010-9483-z [PubMed: 20574657]
- Schulz AJ, Kannan S, Dvorch JT, Israel BA, Allen A, James SA, ...Lepkowski J (2005). Social and physical environments and disparities in risk for cardiovascular disease: The Healthy Environments Partnership conceptual model. *Environmental Health Perspectives*, 113, 1817–1825. doi:10.1289/ehp.7913 [PubMed: 16330371]
- Schulz AJ, Mentz G, Johnson-Lawrence V, Zenk SN, Israel B, Wineman J, ...Max P (2013). Independent and joint associations between multiple measures of the built and social environment and physical activity in a multi-ethnic urban community. *Journal of Urban Health*, 90, 872–887. [PubMed: 23435574]
- Teychenne M, Ball K, & Salmon J (2008). Physical activity and likelihood of depression in adults: A review. *Preventive Medicine*, 46, 397–411. doi:10.1016/j.ypmed.2008.01.009 [PubMed: 18289655]
- Ueshima K, Fujiwara T, Takao S, Suzuki E, Iwase T, Doi H, ...Kawachi I (2010). Does social capital promote physical activity? A population-based study in Japan. *Plos One*, 5(8), e12135. doi: 10.1371/journal.pone.0012135 [PubMed: 20808822]
- Wineman JD, Marans RW, Schulz AJ, Van der Westhuizen D, Mentz G, & Max P (2012, 3). Neighborhood design and health: Characteristics of the built environment and health-related outcomes for residents of Detroit neighborhood Paper presented at the Eighth International Space Syntax Symposium, Santiago de Chile, Chile.
- Wood L, Frank LD, & Giles-Corti B (2010). Sense of community and its relationship with walking and neighborhood design. *Social Science & Medicine*, 70, 1381–1390. doi:10.1016/j.socscimed.2010.01.021 [PubMed: 20189699]
- Zhao G, Ford ES, Li C, & Mokdad AH (2008). Compliance with physical activity recommendations in US adults with diabetes. *Diabetic Medicine*, 25, 221–227. doi:10.1111/j.14645491.2007.02332.x [PubMed: 18201213]

Table 1.
HEP Community Survey Study Sample Characteristics of Physical Activity in 2002 ($n = 696$).

Characteristic	<i>n</i>	Weighted measures		
		%	<i>M</i>	<i>SE</i> <i>Range</i>
Block groups	68			
Percentage of households in poverty		32.15	11.70	7.78–63.11
Blocks	137			
Residential density at half mile radius of the resident's block		5.29	2.61	0.24–14.90
Individuals	696			
Age (years)		45.39	0.88	25–95
Length of residence in neighborhood (years)	696	18.37	0.81	0–76
Female	482	52.07		
Education level: Less than high school diploma	223	32.95		
Poverty income ratio less than 1	237	33.72		
In the labor force	470	69.61		
Owens a car	472	70.01		
Home owner	330	49.41		
Married	188	28.60		
Race/ethnicity				
Latino	133	21.05		
Non-Hispanic White	154	19.29		
Non-Hispanic Black	395	56.87		
Other	14	2.79		
Physical health limitations	696	1.51	0.03	0–5
Physical activity (MET minutes/week)	696	1.38	0.05	0–4.24
Neighborhood involvement (%)	696	47.90		

Note. *SE* = standard error; MET = metabolic equivalent of task.

Table 2.

Weighted Multilevel Linear Models of Residential Density, Neighborhood Involvement, and Physical Activity ($n = 696$).

Measure	Model 1		Model 2	
	<i>b</i> (<i>SE</i>)	<i>p</i>	<i>b</i> (<i>SE</i>)	<i>p</i>
Intercept	1.354 (0.185)	<.001	1.357 (0.185)	<.001
Neighborhood level (Level 2)				
Density	−0.029 (0.011)	.010	−0.013 (0.016)	.413
Individual level (Level 1)				
Neighborhood Involvement	0.171 (0.086)	.046	0.172 (0.086)	.044
Neighborhood involvement * Residential density			−0.044 (0.027)	.095
Residual error (σ^2)	0.738		0.737	
Person-level variation (τ_e)	0.035		0.033	
Neighborhood-level variation (τ_p)	0.045		0.046	

Note. *b* = beta coefficient; *SE* = standard error. Adjusted for age, race, gender, education, poverty income ratio, in the labor force, marital status, car ownership, home ownership, length of neighborhood residence, physical limitations, and block group-level poverty