Published in final edited form as:
Ann Epidemiol. 2015 February ; 25(2): 107–112. doi:10.1016/j.annepidem.2014.11.019.

Does territoriality modify the relationship between perceived neighborhood challenges and physical activity? A multilevel analysis

Vicki Johnson-Lawrence, PhD,
University of Michigan-Flint

Amy J. Schulz, PhD,
University of Michigan

Shannon N. Zenk, RN, PhD,
University of Illinois at Chicago

Barbara A. Israel, DrPH, and
University of Michigan

Zachary Rowe
Friends of Parkside, Detroit, Michigan

Abstract

Background—Individuals who perceive more neighborhood challenges are less physically active. Territoriality, an observable positive marker of social presence and defensible space in the neighborhood, may influence the association between neighborhood challenges and physical activity. We hypothesized that greater territoriality would reduce the negative effects of neighborhood challenges on physical activity levels.

Methods—Data were collected by the Healthy Environments Partnership in an urban Midwestern city. Multilevel regressions were employed to test associations in a sample of 696 White, Black, and Hispanic adults aged 25+.

Results—Territoriality moderated associations between residents' perceptions of neighborhood challenges and physical activity. Contrary to our hypothesis, individuals who perceived more neighborhood challenges and lived in areas with more territoriality markers (e.g. buildings with decorations, buildings with security signage, neighborhood watch signs) were less physically active than other respondents. ($b = -2.41$, $SE = 0.84$, $p < 0.01$).

Conclusions—Our findings suggest that associations between perceived neighborhood challenges and physical activity are shaped by the context in which the individual lives. Our study

Corresponding Author: Vicki Johnson-Lawrence, 3124 William S White Building, Department of Public Health and Health Sciences, University of Michigan-Flint, 303 E Kearsley St, Flint, MI 48502, Phone: 810-762-3172, vickij@umich.edu.

provides empirical evidence that individual perceptions and observed neighborhood characteristics are joint contributors to physical activity, and suggest the need for continued research to characterize the complexity of individual and contextual factors that contribute to physical activity.

Keywords

Territoriality; neighborhoods; physical activity

The health benefits of regular physical activity (PA) among adults are well established, including reduced likelihood of obesity (1), heart disease (1), and mood disorders (2). Adult PA is influenced by individual preferences, interpersonal interactions, and the environmental context in which individuals live (3–7). Socioecologic models highlight the interrelationships between multilevel determinants of PA, including both contextual (e.g. features of the neighborhood environment) and individual factors (e.g. perceptions of the environment) (6) (8–17).

A significant body of literature has examined associations between individuals' perceptions of their neighborhood environments and PA. Several studies have reported inverse associations between perceptions of neighborhood challenges- both physical and social- and PA (18). Perceptions of neighborhood physical challenges, including poor housing (19), sidewalk condition (20), vacant lots (15, 21, 22), heavy traffic (21, 23, 24), and lack of safety (22, 25–27) have been associated with less PA. Perceived social challenges in the neighborhood, including the presence of gang activity, prostitution, loitering, drug dealing, vandalism, adults fighting, along with crime such as robbery and theft (28), have also been found to be inversely associated with PA (25). One recent qualitative study suggests that neighborhood residents and institutions may construct socially determined "territories of concern" with observable markers that influence resident reactions to perceptions of challenges in the neighborhood (29).

Studies also suggest that well-maintained observable neighborhood features, including maintenance of sidewalks, are positively associated with PA ((30, 31) (31, 32)), and poorer observed neighborhood aesthetics have been associated with lower PA (21). Other commonly used observable measures of the environment, such as physical disorder (28) or incivilities (33), have been negatively associated with PA (30, 34). Another contextual feature that has been previously theorized to positively correlate with health is territoriality (33). Territoriality has been defined as a signal of social investment and organization (or territorial functioning (35)), and demarcates defensible space within the neighborhood (33, 35, 36). Territoriality measures consists of physical markers of resident social presence and defensible space, identified by features erected by residents such as fences, gardens, or signage (36). Primarily examined to date in relation to crime outcomes, territoriality has been associated with reduced perceptions of crime and improved safety in the neighborhood (35). As a result, some researchers have proposed that territoriality may be positively associated with PA (37). However, empirical evidence on how territoriality is associated with PA is sparse. We identified only one study that examined associations between territoriality and PA in which territoriality was conceptualized to have protective effects

against crime and adverse community events. In that study, the authors reported a null direct association between territoriality and PA among a sample of pregnant women (38). We propose that it is also possible that those living in neighborhoods with greater territoriality may feel more comfortable engaging in PA in the neighborhood even when they perceive challenges, such as vacant housing, littering, or gang activity.

In this study, we examine the independent and joint relationships of perceptions of neighborhood challenges and observed territoriality with PA. We had three hypotheses: (1) more perceived neighborhood challenges are associated with lower PA, (2) greater observed territoriality is positively associated with PA; and (3) residents who perceive more neighborhood challenges and live in neighborhoods with higher levels of observable territoriality will be more physically active compared to those with lower levels of territoriality.

Methods

Data sources and study population

Data for this study were drawn from the Healthy Environments Partnership (HEP) 2002–2003 community survey and systematic observation of study neighborhoods and from the 2000 U.S. Census, as described below. The University of Michigan Institutional Review Board for Protection of Human Subjects approved the study in 2001.

The survey sample is a two-stage equal probability sample of occupied households, with the goal of obtaining 1000 completed interviews among non-Hispanic Black, non-Hispanic White, and Hispanic adults aged 25 or older, with the extensive details of the survey sampling procedures and derived analytic weights described in detail elsewhere (39). Households were selected to represent similar distributions of socio-economic status (SES) across racial/ethnic groups in three Detroit communities--the Northwest, Southwest, and Eastside of Detroit--from March 2002 to March 2003. Households were nested within census blocks (n=146) and census block groups (n=68); census blocks and census block groups, in turn, were nested within these three communities. Neighborhoods were defined as the residential census blocks where at least one HEP survey participant lived (n=146) and the surrounding blocks that shared at least one common border with the residential blocks (referred to as “rook” neighbors) (39, 40). For these analyses, each “neighborhood” includes the study block and its rook neighbors. Face-to-face interviews were completed with 919 participants, with a response rate of 75% of households that were determined to have an eligible respondent and 55% of households with known or potential respondents (39).

Measures

Physical activity (PA)—The outcome for these analyses is PA, assessed by asking how many days and the amount of time an individual reported walking, moderate-intensity activities (such as yard work or chores that cause 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. These measures were drawn from the Behavioral Risk Factor Surveillance

Survey (41). Based on Ainsworth's compendium of activities (42) and the International Physical Activity Questionnaire (42, 43), an average metabolic equivalent of task (MET) weighting score was derived for each category (walking, moderate, or vigorous) of PA. "MET minutes" reflect the amount of activity and the associated energy requirements in a single measure. These values are multiples of the resting metabolic rate, and a MET minute is computed by multiplying the MET score of an activity by the minutes of time the activity is performed (42). For walking, the weighting score was 3.3 METs, for moderate intensity activities the weighting score was 4.0 METs, and for vigorous activities the weighting score was 8.0 METs. MET minutes of each intensity level of activity were calculated for each participant as the product of the MET weighting score, the number of days active at that intensity, and the number of minutes per day active at the intensity. The total number of MET minutes of activity was calculated for each individual as the sum of their MET minutes for walking, moderate intensity, and vigorous intensity activities per week and scaled by the standard deviation. Our analysis included participants for whom data were available on frequency and duration of PA. This measure has been used in previous analyses of the HEP data (14, 31).

Perceived neighborhood challenges—Perceived neighborhood challenges assessed in this study (see Table 1) were identified from previous literature as indicators of physical and social disorder (9, 44). Perceived challenges related to the neighborhood physical environment consisted of seven items on a 5-point agree-disagree scale ranging from 1=strongly agree to 5=strongly disagree. Perceived challenges related to the neighborhood social environment were captured through six items rated on a 5-point scale, ranging from 1=never to 5=always for the extent to which each was a problem in their neighborhood. Items from both scales were recoded such that higher scores were representative of more neighborhood challenges. The mean of the 13 items across the physical and social aspects of the environment was calculated and used to represent an overall measure of perceived neighborhood challenges. Higher scores corresponded to more neighborhood challenges.

Observed territoriality—Territoriality was captured using the Neighborhood Observation Checklist (NOC) (45), a systematic social observation data collection instrument. The NOC assessed aspects of the social and built environments for each neighborhood, including condition of homes and businesses, vacant lots, streets and sidewalks, traffic patterns, and parks and recreational facilities (39, 46). Trained observers collected data during a 15-week period in the summer and early fall of 2003 (39, 46) on each neighborhood. Territoriality was conceptualized as characteristics of the neighborhood environment that reflect social presence or defensible space, following the literature (33). Our measure was constructed from the indicators shown in Table 2. Our initial step was to calculate the proportion of block faces within each neighborhood with each territoriality marker. Our final measure reflects the average of those nine proportions for each neighborhood, with higher territoriality scores indicative of a greater number of territoriality markers within the neighborhood.

Covariates—Preliminary analyses of these data have identified a number of correlates of PA in this sample, and they are included here. Individual level covariates included age (in

years), length of residence in the neighborhood (in years), gender, education (less than high school diploma or high school diploma or more), poverty to income ratio (PIR < 1 or PIR ≥ 1), labor force participation (currently in the labor force or not in the labor force), car ownership status (yes or no), home ownership status (yes or no), marital status (married or not 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 self-reported race/ethnicity (non-Hispanic white, Latino, or non-Hispanic black) were included in analyses.

At the census block group level, models accounted for neighborhood poverty, which was defined as the proportion of households with incomes below the poverty line, and was based on 2000 census data.

Data Analysis

All analyses were performed in HLM 7.0. Multiple imputation using IVEware (47) was performed to account for missing data in the analyses, as well as to account for the sampling design in analyses (48). Weights were created to ensure appropriate representation of racial and ethnic groups across socioeconomic statuses in the sample, and were applied to adjust for probabilities of selection within strata and to match the sample to Census 2000 population distributions of the study communities as well (39). Details of the multiple imputation process and survey methodology have been reported elsewhere (39). 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 test the hypotheses. All continuous measures at the individual level were group mean centered to allow for unbiased estimation of cross-level interactions (49), and both neighborhood (census block) and census block group level measures were grand mean centered. Fixed effects at the individual, block, and block group levels were estimated in the analyses. Main effects and a product-term interaction effect of observed territoriality and perceived neighborhood challenges models of PA were tested and evaluated at α=0.05. 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

The analytic sample included 696 individuals nested in 137 census blocks and 68 census block groups. Among 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, and were included in analyses. Chi-square and t tests suggested respondents who were not chair or bed bound but had missing data (n=152) were comparable to the analytic sample (n=696) on all demographic measures.

Descriptive characteristics of the analytic sample are shown in Table 3, including sample frequencies, weighted proportions, means, and standard errors for census block group, neighborhood, and person level variables. Among the 68 census block groups, on average, 32.2% of the households had incomes below the federal poverty level (standard error (SE) = 11.7%). Across the 137 neighborhoods, the mean proportion of block faces within each neighborhood with territorial markers was 0.21 (SE = 0.06). Within the census blocks, racial/ethnic and socioeconomic characteristics were relatively homogenous, but varied significantly across census blocks and block groups because they were intentionally sampled to represent various communities in Detroit as of 2000 (39).

For the 696 respondents, the mean age was 45.4 (SE = 0.88) years; the majority was female (52.1%); and most had at least a high school diploma (67%). Most of the respondents lived above the poverty line based on household size and income (PIR ≥ 1, 66.3%). Respondents tended to be in the labor force (69.6%) and own a car (70.0%); about half of the sample reported that they owned their homes (49.4%). A majority of participants reported their race as non-Hispanic black (56.9%), and about a quarter indicated that they were currently married (28.6%). The mean standardized amount of PA was 1.36 (SE = 0.04) MET minutes per week. The mean perceived neighborhood challenges score was 2.92 (SE = 0.05). Calculation of the intraclass correlation for PA within the sample indicated the neighborhood (level 2) variance to be 6.5% and the block group (level 3) variance to be 3.2%.

Weighted multilevel regression modeling results

Regression analyses (Table 4) showed non-significant associations of both perceived neighborhood challenges (Model 1: b = 0.01, SE = 0.05, p = 0.81) and territoriality (Model 2: b=−0.15, SE=0.77, p=0.84) with PA in models adjusted for demographic and other covariates. Results of Model 3, which included both measures, indicated similar non-significant associations between neighborhood challenges (b = 0.04, SE = 0.68, p = 0.54) and territoriality (b=−0.15, SE=0.77, p=0.84) with PA, adjusted for demographic and other covariates.

A significant negative interaction was found between territoriality and perceived neighborhood challenges with PA (Model 4: b = −2.41, SE = 0.84, p < 0.01). At any given level of perceived neighborhood challenges, residents of neighborhoods with higher levels of territoriality were less physically active compared to those with lower levels of territoriality. Further, those individuals who perceived more neighborhood challenges and lived in areas with more territoriality markers (e.g. buildings with decorations, buildings with security signage, neighborhood watch signs) were less physically active than other respondents. We interpreted the interaction with territoriality presented at lowest and highest quintiles for respondents who, on average, reported that they strongly agreed (many challenges) or strongly disagreed (few challenges) about their perceived neighborhood challenges, in relation to a standardized measure of PA. While reporting many (compared to few) challenges was associated with lower PA in the sample, the decline in PA was greater, at 2.74 standardized MET minutes, for those who lived in neighborhoods with more

territoriality (highest quintile) than the 1.19 standardized MET minute decrease in PA for those who lived in neighborhoods with territoriality scores in the lowest quintile.

Discussion

We hypothesized higher observed territoriality in the neighborhood environment would be positively associated with PA and would buffer the negative effects of perceived neighborhood challenges on PA. Contrary to our hypothesis, we found that territoriality seemed to amplify the negative association between perceived neighborhood challenges and PA. Residents who reported higher levels of neighborhood challenges and who resided in neighborhoods with high levels of territorial markers reported lower levels of PA compared to those living in neighborhoods with lower levels of territoriality. Thus, rather than making residents feel more comfortable engaging in outdoor PA due to the claiming of space and investment, it is possible that territoriality markers reflect heightened crime and other challenges (e.g., vacant housing, loitering) to which residents may respond by creating territorial markers. Specifically, previous work suggests that territoriality markers that indicate defensible space (e.g. bars on windows) have been associated with increased perceptions of crime intensity that possibly reflect reactions to past problems (35). As a result, some markers of territoriality may reflect past crime, exacerbate negative perceptions of the neighborhood, and result in lower PA.

This work contributes to the extremely sparse research on the associations between territoriality and PA. The limited work in this area resulted in our comparison to the two other studies we identified on this topic. Laraia and colleagues examined observed neighborhood features and physical activity among pregnant women, but found no statistically significant bivariate associations between territoriality and physical activity and therefore did not perform regression analyses (38). Further, our study evaluates the impact of territoriality, as a marker of territorial functioning and defensible space, which has been hypothesized to reduce crime and improve perceived safety in previous literature (33, 35), on the association between resident perceptions of neighborhood challenges and PA. We expected that greater territoriality would represent greater resident social presence that would make individuals more comfortable engaging in PA in the face of challenges related to the neighborhood social and physical environments. One of the previous studies undertaken by several of the co-authors of this study examined the association between territoriality and physical activity (13), which also used data from the 2002 wave of the HEP survey and found significant interactions of territoriality with reach- a measure of connectivity to other areas of the city- in relation to PA (13). The authors suggested that areas with high reach and high territoriality may have had lower levels of resident physical activity due to residents' need to claim space from non-community members (e.g. to minimize perceived threats to their safety) (13). One potential interpretation of the findings reported here then is that territorial markers are indicative of residents' response to social challenges in the neighborhood. This would be consistent with the finding that, holding perceived neighborhood challenges constant, residents of neighborhoods with higher levels of territoriality reported lower levels of PA compared to those in neighborhoods with lower territoriality.

Strengths of our study include that it is one of few to directly assess the role of territoriality in PA. Further, the data allowed for distinctions between resident perceptions and observed indicators of neighborhood conditions in relation to PA. Limitations of our study include that the data were cross-sectional in nature, limiting our ability to distinguish the temporality of the associations observed. PA was self-reported in these analyses, and could represent overestimates among sample participants; however, the level of PA among the sample was relatively low, which may limit the generalizability of the study findings (particularly to more physically active samples). In addition, the internal consistency of scale measures based on systematic observational data in previous studies has been found to vary, ranging from moderately to highly reliable (9, 50). Our ability to assess territoriality in the models, with moderate reliability, remains a strength of our analyses. Finally, the dimensions of the neighborhood reflected in our measure of territoriality captured both measures of territoriality of residents (e.g., resident installed fencing or gardens) and indicators of maintenance for otherwise unclaimed space (e.g. vacant lots with gardens). Future work is warranted to investigate in relation to other correlates of PA. This future work could employ multiple mediator and moderated mediator models to address the role of social relationships and social support at the individual level among neighborhood residents as explanatory factors on the pathway by which territoriality influences PA.

Conclusions

Residents who report perceptions of more neighborhood challenges and who reside in neighborhoods with more compared to fewer indicators of territoriality, report lower levels of PA. Our findings are consistent with previous literature that suggest an effect of the neighborhood environment on individual health behaviors, but also show that people respond to their environments in ways that influence the behavior of others, thus creating a reciprocal effect. Residents living in neighborhoods with many challenges--including high crime and less safety--may react to their environment by erecting new territorial markers that can influence the actions and preferences of other neighborhood residents. Our study provides empirical evidence that individuals perceptions and observable neighborhood characteristics are joint contributors to PA, and suggest the need for continued research to characterize the complexity of individual and contextual factors that contribute to PA.

Acknowledgments

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.

Funding: The study and analysis were supported by the National Institute of Environmental Health Sciences (NIEHS) (R01ES10936, R01ES014234), and The Aetna Foundation. The Aetna Foundation 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 NIEHS, or The Aetna Foundation, its directors, officers, or staff.

References

1. Roger VL, Go AS, Lloyd-Jones DM, Benjamin EJ, Berry JD, Borden WB, et al. Executive Summary: Heart Disease and Stroke Statistics-2012 Update A Report From the American Heart Association. Circulation. 2012 Jan 3; 125(1):188–97. [PubMed: 22215894]
2. Strawbridge WJ, Deleger S, Roberts RE, Kaplan GA. Physical activity reduces the risk of subsequent depression for older adults. Am J Epidemiol. 2002; 156:6.
3. Blanchard CM, McGannon KR, Spence JC, Rhodes RE, Nehl E, Baker F, et al. Social ecological correlates of physical activity in normal weight, overweight, and obese individuals. International Journal of Obesity. 2005 Jun; 29(6):720–6. [PubMed: 15795751]
4. Sallis, JF.; Kerr, J. Physical activity and the built environment. 2006.
5. Sallis, JE.; Cervero, RB.; Ascher, W.; Henderson, KA.; Kraft, MK.; Kerr, J. Annual review of public health. Annual Review of Public Health. Vol. 27. Palo Alto: Annual Reviews; 2006. An ecological approach to creating active living communities; p. 297-322.
6. Sallis, JF.; Owen, N.; Fisher, EB. Ecological models of health behavior. In: Glanz, K.; Rimer, B.; Viswanath, K., editors. Health Behavior and Health Education: Theory, Research, and Practice. 4. San Francisco, CA: Josey-Bass; 2008.
7. Papas MA, Alberg AJ, Ewing R, Helzlsouer KJ, Gary TL, Klassen AC. The built environment and obesity. Epidemiologic Reviews 2007. 2007; 29:129–43.
8. Li FZ, Fisher KJ, Bauman A, Ory MG, Chodzko-Zajko W, Harmer P, et al. Neighborhood influences on physical activity in middle-aged and older adults: A multilevel perspective. Journal of Aging and Physical Activity. 2005 Jan; 13(1):87–114. [PubMed: 15677838]
9. Sampson RJ, Raudenbush SW. Seeing disorder: neighborhood stigma and the social contruction of “broken windows”. Social Psychology Quarterly. 2004; 67(4):319–42.
10. Schulz AJ, Zenk SN, Israel BA, Mentz G, Stokes C, Galea S. Do neighborhood economic characteristics, racial composition, and residential stability predict perceptions of stress associated with the physical and social environment? Findings from a multilevel analysis in Detroit. Journal of urban health: bulletin of the New York Academy of Medicine. 2008 Sep; 85(5):642–61. Epub 2008/05/16. eng. [PubMed: 18481182]
11. Cummins S, Curtis S, Diez-Roux AV, Macintyre S. Understanding and representing ‘place’ in health research: A relational approach. Social Science & Medicine. 2007 Nov; 65(9):1825–38. [PubMed: 17706331]
12. Macintyre S, Ellaway A, Cummins S. Place effects on health: how can we conceptualise, operationalise and measure them? Social Science & Medicine. 2002 Jul; 55(1):125–39. [PubMed: 12137182]
13. Schulz AJ, Mentz G, Johnson-Lawrence V, Zenk SN, Israel B, Wineman J, et al. Independent and joint associations between multiple measures of the built and social environment and physical activity in a muti-ethnic urban community. Journal of Urban Health. 2013; 90(5):872–87. [PubMed: 23435574]
14. Wineman, JD.; Marans, RW.; Schulz, AJ.; Van der Westhuizen, D.; Mentz, G.; Max, P., editors. Neighborhood design and health: characteristics of the built environment and health-related outcomes for residents of Detroit neighborhoods; Eighth International Space Syntax Symposium; Santiago de Chile: PUC; 2012.
15. Carlson JA, Sallis JF, Conway TL, Saelens BE, Frank LD, Kerr J, et al. Interactions between psychosocial and built environment factors in explaining older adults’ physical activity. Preventive Medicine. 2012 Jan; 54(1):68–73. English. [PubMed: 22027402]
16. Frank LD, Saelens BE, Powell KE, Chapman JE. Stepping towards causation: Do built environments or neighborhood and travel preferences explain physical activity, driving, and obesity? Social Science & Medicine. 2007 Nov; 65(9):1898–914. [PubMed: 17644231]
17. Johnson-Lawrence, V.; Schulz, A.; Zenk, SN.; Israel, B.; Rowe, Z.; Wineman, J., et al. Joint effects of residential density and neighborhood participation in association with physical activity among a multiethnic sample of urban adults. Accepted for Publication

18. Steptoe A, Feldman PJ. Neighborhood problems as sources of chronic stress: development of a measure of neighborhood problems, adna associations with socioeconomic status and health. Annals of Behavioral Medicine. 2001; 23(3):144–85.
19. Droomers M, Schrijvers CTM, Machenbach JP. Educational level and decreases in leisure time physical activity: predictors from the longitudinal GLOBE study. Journal of Epidemiology and Community Health. 2001; 55:562–8. [PubMed: 11449013]
20. Hosler AS, Gallant MP, Riley-Jacome M, Rajulu DT. Relationship between objectively measured walkability and exercise walking among adults with diabetes. Journal of Environmental Public Health. 2014
21. Hoehner CM, Ramirez LKB, Elliott MB, Handy SL, Brownson RC. Perceived and objective environmental measures and physical activity among urban adults. American Journal of Preventive Medicine. 2005 Feb; 28(2):105–16. [PubMed: 15694518]
22. Frank LD, Engelke P. Multiple impacts of the built environment on public health: Walkable places and the exposure to air pollution. Int Reg Sci Rev. 2005 Apr; 28(2):193–216. English.
23. King AC, Castro C, Wilcox S, Eyler AA, Sallis JF, Brownson RC. Personal and environmental factors associated with physical inactivity among different racial-ethic groups of US middle-aged and older-aged women. Health psychology: official journal of the Division of Health Psychology, American Psychological Association. 2000; 19:354–64.
24. Troped PJ, Saunders RP, Pate RR, Reininger B, Ureda JR, Thompson SJ. Associations between self-reported and objective physical environmental factors and use of a community rail-trail. Preventive Medicine. 2001 Feb; 32(2):191–200. [PubMed: 11162346]
25. Mendes de Leon CF, Cagney KA, Bienias JL, Barnes LL, Skarupski KA, Scherr PA, et al. Neighborhood Social Cohesion and Disorder in Relation to Walking in Community-Dwelling Older Adults A Multilevel Analysis. J Aging Health. 2009 Feb; 21(1):155–71. English. [PubMed: 19144973]
26. Li FZ, Fisher KJ, Brownson RC, Bosworth M. Multilevel modelling of built environment characteristics related to neighbourhood walking activity in older adults. Journal of Epidemiology and Community Health. 2005 Jul; 59(7):558–64. [PubMed: 15965138]
27. Suminski RR, Poston WSC, Petosa RL, Stevens E, Katzenmoyer LM. Features of the neighborhood environment and walking by US adults. American Journal of Preventive Medicine. 2005 Feb; 28(2):149–55. [PubMed: 15710269]
28. Sampson RJ, Raudenbush SW. Systematic social observation of public spaces: A new look at disorder in urban neighborhoods. American Journal of Sociology. 1999 Nov; 105(3):603–51.
29. Benediktsson MO. Territories of concern: vacant housing and perceived disorder on three suburban blocks. City & Community. 2014; 13(3):191–213.
30. Kwarteng JL, Schulz AJ, Mentz GB, Zenk SN, Opperman AA. Associations between observed neighborhood characteristics and physical activity: findings from a multiethnic urban community. Journal of Public Health. 2013; 36(3):358–67. [PubMed: 24159053]
31. Wineman JD, Marans RW, Schulz AJ, van der Westhuizen DL, Mentz GB, Max P. Designing Healthy Neighborhoods: Contributions of the built environment to physical activity in Detroit. Journal of Planning Education and Research. 2014; 34(2):181–90.
32. Schaefer-McDaniel N, Caughy MO, O'Campo P, Gearey W. Examining methodological details of neighbourhood observations and the relationship to health: a literature review. Soc Sci Med. 2010 Jan; 70(2):277–92. Epub 2009/11/04. eng. [PubMed: 19883966]
33. Caughy MO, O'Campo P, Patterson J. A brief observational measure for urban neighborhoods. Health and Place. 2001; 7:225–36. [PubMed: 11439257]
34. King D. Neighborhood and individual factors in older adults: results from the neighborhood and senior health study. J Aging Phys Act. 2008; 16(2):144–70. [PubMed: 18483439]
35. Perkins DD, Meeks JW, Taylor RB. THE PHYSICAL-ENVIRONMENT OF STREET BLOCKS AND RESIDENT PERCEPTIONS OF CRIME AND DISORDER - IMPLICATIONS FOR THEORY AND MEASUREMENT. Journal of Environmental Psychology. 1992 Mar; 12(1):21–34. English.

36. Taylor RB, Gottfredson SD, Brower S. BLOCK CRIME AND FEAR - DEFENSIBLE SPACE, LOCAL SOCIAL TIES, AND TERRITORIAL FUNCTIONING. J Res Crime Delinq. 1984; 21(4):303–31. English.
37. McNeill LH, Kreuter MW, Subramanian SV. Social Environment and Physical activity: A review of concepts and evidence. Social Science & Medicine. 2006 Aug; 63(4):1011–22. [PubMed: 16650513]
38. Laraia B, Messer L, Evenson K, Kaufman JS. Neighborhood factors associated with physical activity and adequacy of weight gain during pregnancy. Journal of urban health: bulletin of the New York Academy of Medicine. 2007 Nov; 84(6):793–806. Epub 2007/08/22. eng. [PubMed: 17710552]
39. Schulz AJ, Kannan S, Dvonch JT, Israel BA, Allen A, James SA, et al. Social and Physical Environments and Disparities in Risk for Cardiovascular Disease: The Healthy Environments Partnership Conceptual Model. Environmental Health Perspectives. 2005; 113(12):1817–25. [PubMed: 16330371]
40. Lee, J.; Wong, DW. Wiley. Statistical analysis with ArcView GIS. New York: 2001.
41. BRFSS 2000 Survey Data and Documentation [Internet]. 2000. [cited June 2012]. Available from: http://www.cdc.gov/brfss/annual_data/annual_2000.htm
42. Ainsworth BE, Haskell WL, Whitt MC, Irwin ML, Swartz AM, Strath SJ, et al. Compendium of Physical Activities: an update of activity codes and MET intensities. Medicine and Science in Sports and Exercise. 2000 Sep; 32(9):S498–S516. [PubMed: 10993420]
43. Craig CL, Marshall AL, Sjostrom M, Bauman AE, Booth ML, Ainsworth BE, et al. International physical activity questionnaire: 12-country reliability and validity. Medicine and Science in Sports and Exercise. 2003 Aug; 35(8):1381–95. English. [PubMed: 12900694]
44. Franzini L, Caughy MOB, Nettles SM, O'Campo P. Perceptions of disorder: Contributions of neighborhood characteristics to subjective perceptions of disorder. Journal of Environmental Psychology. 2008; 28(1):83–93.
45. Zenk SN, Schulz AJ, Mentz G, House JS, Gravlee CC, Miranda PY, et al. Inter-rater and test-retest reliability: methods and results for the neighborhood observational checklist. Health Place. 2007 Jun; 13(2):452–65. Epub 2006/07/01. eng. [PubMed: 16809060]
46. Zenk SN, Schulz AJ, Israel BA, James SA, Bao S, Wilson ML. Neighborhood racial composition, neighborhood poverty, and the spatial accessibility of supermarkets in metropolitan Detroit. Am J Public Health. 2005 Apr; 95(4):660–7. Epub 2005/03/31. eng. [PubMed: 15798127]
47. Raghunathan, T.; Solenberger, P.; Hoewyk, J. IVEware: Imputation and Variance Estimation Software. Survey Research Center, Insitute for Social Research, University of Michigan; 2002.
48. Rubin, D. Multiple imputation for nonresponse in surveys. New York: J Wiley and Sons; 1987.
49. Hofmann DA, Gavin MB. Centering decisions in hierarchical linear models: Implications for research in organizations. Journal of Management. 1998; 24(5):623–41.
50. Brownson RC, Hoehner CM, Day K, Forsyth A, Sallis JF. Measuring the built environment for physical activity: state of the science. Am J Prev Med. 2009 Apr; 36(4 Suppl):S99–123. e12. Epub 2009/04/16. eng. [PubMed: 19285216]

Table 1

Perceived Neighborhood Challenges

		Mean (SD)
Physical environment	Houses in my neighborhood are generally well maintained.*	2.54 (1.36)
	There is heavy car or truck traffic in my neighborhood.	3.97 (1.34)
	My neighborhood has a lot of vacant lots or vacant houses.	3.48 (1.55)
	There is air pollution like diesel from trucks or pollution from factories or incinerators in my neighborhood.	2.89 (1.55)
	Streets, sidewalks and vacant lots in my neighborhood are kept clean of litter and dumping.*	2.88 (1.50)
	There is a lot of loud noise from cars, motorcycles, music, neighbors, or airplanes in my neighborhood.	3.57 (1.44)
	There is contaminated land in my neighborhood.	2.51 (1.53)
Social environment	Gang activity in your neighborhood.	2.17 (1.23)
	Drug dealings or drug dealers	3.02 (1.37)
	Gunfire or shootings in your neighborhood.	2.85 (1.21)
	Prostitutes or cars driving through looking for prostitutes	2.44 (1.43)
	People loitering or hanging around on the street.	2.90 (1.41)
	Theft, vandalism, or arson in your neighborhood.	2.53 (1.22)

*All positively worded items were reverse coded such that higher scale scores were representative of greater frequency of neighborhood challenges.

Table 2

Observed Territoriality Indicators

	Mean (SD)
More than 50% of the buildings within the neighborhood had decorations	0.28 (0.19)
More than 50% of buildings within the rook had security markers (e.g., bars on windows)	0.37 (0.20)
Presence of vacant lots with gardens	0.02 (0.02)
Presence of vacant lots with furniture	0.02 (0.03)
Presence of vacant lots in good condition	0.24 (0.14)
Presence of neighborhood watch signs	0.11 (0.10)
Presence of security signs	0.74 (0.27)
No trespassing signs	0.13 (0.09)
No dumping signs	0.01 (0.02)

Table 3

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

			Weighted Measures		
Characteristic	**N**	**%**	**Mean**	**SE**	**Range**
Block Group Level					
Percent of Households in Poverty	68		32.15	11.70	7.78–63.11
Neighborhood/Rook Level					
Territoriality	137		0.21	0.06	0.09–0.42
Person Level					
Age (years)	696		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 HS Diploma	223	32.95			
Poverty Income Ratio Less than 1	237	33.72			
In the Labor Force	470	69.61			
Owns 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 Challenges Score	696		2.91	0.04	1–5

SE=Standard error

Table 4

Perceived Neighborhood Challenges, Observed Territoriality, and Physical Activity Weighted Multilevel Linear Regression Model Results (n=696)

	Model 1 b (SE)	Model 2 b (SE)	Model 3 b (SE)	Model 4 b (SE)
Intercept	1.43 (0.18)**	1.42 (0.18)**	1.43 (0.18)**	1.42 (0.18)**
Neighborhood Challenges	0.01 (0.05)		0.04 (0.68)	0.03 (0.06)
Territoriality		−0.15 (0.77)	−0.15 (0.77)	−0.19 (0.76)
Territoriality* Neighborhood Challenges				−2.41 (0.84)**
Residual Error (σ^2)	0.05	0.04	0.05	0.05
Person Level Variation (τ_π)	0.74	0.74	0.74	0.74
Neighborhood Level Variation (τ_β)	0.04	0.04	0.04	0.04

** p<0.01

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.