

# Perceived Built Environment and Physical Activity in U.S. Women by Sprawl and Region

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**Background:** A number of studies have demonstrated relationships between the perceived built environment and physical activity among adults. However, little is known about whether these associations differ by U.S. region and level of urban sprawl.

**Purpose:** To examine associations between the perceived built environment and physical activity in U.S. women by region and urban sprawl.

**Methods:** Nurses' Health Study II participants (N=68,968) completed four perceived neighborhood environment survey items in 2005. Logistic regression was used to estimate associations with meeting physical activity recommendations, adjusting for demographic and weight-status variables, and stratifying by region and sprawl. Data analyses were completed in 2011.

**Results:** Perceived proximity to shops/stores was positively associated with physical activity across regions and levels of sprawl (ORs=1.21-1.46). Perceived access to recreation facilities was also a positive physical activity correlate in most region-sprawl strata, with strongest relationships found in the West (ORs=1.31-1.70). Perceived crime and presence of sidewalks did not show statistically significant associations with physical activity in most region-sprawl strata, although ORs for perceived crime showed a consistent pattern of negative associations (ORs=0.60-0.95). A higher number of positive environmental attributes was associated with a greater odds of meeting physical activity recommendations.

**Conclusions:** Findings indicate that perceived proximity to shops/stores and access to recreation facilities are important correlates of physical activity for women, irrespective of region or sprawl.

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## Introduction

Physical inactivity continues to be a challenging public health threat both in the U.S. and internationally. As reinforced in an authoritative U.S. report,<sup>1</sup> there is convincing evidence that active adults have lower rates of all-cause mortality, coronary heart disease, high blood pressure, stroke, type 2 diabetes, metabolic syndrome, colon and breast cancers, and depression. Despite the health benefits of regular physical activity, accelerometer data from the National Health and Nutrition Examination Survey<sup>2</sup> indicated that only 3.5% of adults,

aged 20-59 years, were sufficiently active. Further, women in the U.S. appear to be less active than men.

Over the past 10-15 years, studies<sup>3-9</sup> within the public health, transportation, and urban planning disciplines have demonstrated that certain attributes of the built (human-made) environment are related to participation in various forms of physical activity. Research has shown that both objective built environment measures (e.g., using GIS technologies) and perceived measures, using individuals' self-report about their neighborhood, are positively related to physical activity. This research area is still emerging, with further development and empirical testing of conceptual models warranted.

Few studies have examined potential moderating effects of urban versus suburban versus rural context and geographic location (e.g., U.S. region) on these relationships. A small body of literature<sup>10-12</sup> suggests that relationships between the built environment and physical activity may vary by urban-suburban-rural context. One study<sup>10</sup> found positive associations between the age of homes and physical activity among residents of urban and suburban U.S. counties, but not among adults in

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rural areas. In one recent study,<sup>11</sup> investigators found that urbanicity moderated the relationship between street density and walking, bicycling, and jogging among young adults, with associations found only in low-urbanicity areas. In another study,<sup>12</sup> urbanicity moderated the effects of perceived neighborhood barriers on physical activity. Additionally, there is empirical support that physical activity levels are generally higher in more-urban areas and in certain U.S. regions.<sup>13,14</sup> However, although researchers in one study<sup>13</sup> found differences in physical activity across urban and rural areas in the South and West (in different directions for each region), they did not find urban–rural differences in the Northeast and Midwest.

The aim of the present study was to test associations between the perceived built environment and physical activity among U.S. women and examine, in particular, whether associations differ by levels of urban sprawl (e.g., low, medium, high) and geographic region. Urban sprawl, defined as areas characterized by lower residential density, separation of residential and commercial land uses, lack of activity centers, and poor connectivity of road networks, has been shown to be negatively associated with walking.<sup>5,15</sup> However, potential moderating effects of urban sprawl, along with the moderating effects of geographic region, on relationships between individual perceptions of the built environment and physical activity, have not been explored. The current study's primary hypothesis was that associations between the perceived built environment and physical activity would be stronger in less-sprawling areas but would not differ across regions.

Further work is needed to explore the potential moderating effects of region and urban–suburban–rural context on relationships between the built environment and physical activity. Relationships found in one U.S. region may not generalize to others, and differences across regions may not be the same in different contexts. However, in most built environment studies, researchers have derived samples from a particular city, state, or region, an approach that makes assessments of potential moderating effects challenging. Cohort studies, such as the Nurses' Health Study II (NHSII), provide an opportunity to examine relationships between the built environment and physical activity among a large sample from diverse geographic areas.

## Methods

### Participants

The NHSII is a prospective cohort study initiated in 1989 with 116,671 female registered nurses from 14 states. In 2005, participants lived in all 50 states with 91% in the original states. The

cohort is followed with biennial questionnaires. The 68,968 women in this cross-sectional analysis, aged 40–59 years, consisted of respondents to the 2005 survey who answered four questions on perceived neighborhood environment, had complete data for physical activity, were able to walk, and lived in a county with an urban sprawl value.

### Physical Activity

Women were asked to report the average amount of time they spent per week on each of the following physical activities over the past year: walking (for exercise or walking to work); jogging (>10 minutes/mile); running ( $\leq 10$  minutes/mile); and bicycling (including stationary cycling). The 2-year reproducibility and validity (comparison with 7-day diaries) of the physical activity items have been demonstrated.<sup>16</sup> For each activity, the midpoint for each of 10 response categories, which range from 0 to  $\geq 11$  hours/week, was used to estimate duration (e.g., category of 2–3 hours coded as 150 minutes).

Participants were also asked to report their usual walking pace outdoors (<2 mph, 2–2.9 mph, 3–3.9 mph,  $\geq 4$  mph). Consistent with Ainsworth's compendium and previous NHSII approaches, a MET value was assigned to each type of activity.<sup>17,18</sup> MET-minutes/week from walking were calculated based on walking pace. Two binary physical activity outcomes were created indicating whether women were meeting the current recommendation of 500 MET-minutes/week of moderate-to-vigorous physical activity—either via walking only or a combination of walking, jogging, running, and bicycling.<sup>1</sup>

### Perceived Environment

Four perceived neighborhood environment items were selected from the seven core items in the Physical Activity Neighborhood Environment Survey (PANES).<sup>19</sup> Test–retest reliability of these four PANES items has been demonstrated (intraclass correlation coefficients=0.55–0.77).<sup>19</sup> Also, in a recent multinational study,<sup>20</sup> investigators found that five of the seven items showed associations with meeting physical activity guidelines (ORs=1.2–1.5), indicating their construct validity.

Four of these five items were included in the NHSII survey. Items were modified from a Likert-type scale to a yes/no format: (1) "Shops, stores, and markets are within easy walking distance of my home" (perceived proximity to shops/stores); (2) "My neighborhood has free or low-cost recreation facilities, such as parks, walking trails, bike paths, recreation centers, playgrounds, public swimming pools, etc." (perceived access to recreation facilities); (3) "There are sidewalks on most of the streets in my neighborhood" (perceived presence of sidewalks); and (4) "The crime rate in my neighborhood makes it unsafe to go on walks at night" (perceived crime). In addition to examining relationships between each perceived environment variable and physical activity, an index was created summing the number of positive neighborhood perceptions from among four items (range=0–4). The crime item was reverse coded so that a "no" response was considered positive.

### Confounders and Stratifying Variables

The following variables considered as potential confounders were obtained from the 2005 NHSII survey or the most recent questionnaire available: age; race; Hispanic ethnicity; husband's education; marital status; having children; smoking status; history of

clinician-diagnosed heart disease, diabetes, or cancers; BMI; self-reported depression; feeling more relaxed indoors; and disliking going out alone.

County-level urban sprawl and U.S. Census-defined region (Northeast, Midwest, South, and West) were considered as potential moderators of the relationships between perceived neighborhood environment and outcomes.<sup>21</sup> Both variables were linked to participants' county of residence in 2005. The sprawl index, a composite of six variables related to residential density and street accessibility<sup>5</sup> has shown associations with obesity<sup>5,12,22</sup> and physical activity.<sup>5,23</sup> Tertiles of urban sprawl were created: low ( $\geq 111.30$ ); medium (100.00–111.29); and high (62.55–99.99). The original sprawl index was not created for nonmetropolitan counties or counties in smaller metropolitan areas.<sup>5,22</sup> Therefore, 11,373 participants missing a sprawl value were not included in the analytic sample.

## Statistical Analysis

Multivariable logistic regression was used to estimate associations between each perceived environment variable and physical activity (expressed as ORs with 95% CIs). Unadjusted and age-adjusted models were first estimated. Confounding was evaluated by entering each covariate into the model one variable at a time and assessing effects on the ORs. Adjusted models controlled for age, race, ethnicity, BMI categories, and husband's education. Logistic regression models were estimated for the full analytic sample and were then stratified by both county sprawl and region. Prior to this modeling, statistical interactions among sprawl, region, and perceived environmental variables were explored. Statistically significant interactions were found for three environmental variables (perceived proximity to shops/stores, presence of sidewalks, and access to recreation facilities;  $p < 0.05$ ).

To assess possible dose-response effects, models were estimated for the perceived environment index using dummy variables that compared 1, 2, 3, and 4 favorable perceptions to none (referent category). These models were stratified by sprawl and region separately. All statistical analyses were performed in 2011 with SAS, version 9, for UNIX. The present study was approved by the IRBs at the Brigham and Women's Hospital and Purdue University.

## Results

The mean age ( $\pm$ SD) of participants in 2005 was  $50.4 \pm 4.6$  years (Appendix A, available online at [www.ajpmonline.org](http://www.ajpmonline.org), for other demographic and health-related characteristics). Participants reported an average of  $366.5 \pm 519.0$  MET-minutes/week of walking (median=180) and  $613.8 \pm 1004.4$  MET-minutes/week of walking, jogging, running, and bicycling (median=246). Twenty-four percent met current physical activity recommendations based on walking, whereas 36% met recommendations based on four activities.

### Perceived Environment by Demographic, Health-Related, and Contextual Factors

The overall proportions of women who reported perceived crime, proximity to shops/stores, presence of sidewalks, and access to recreation facilities are shown in

Appendix A (available online at [www.ajpmonline.org](http://www.ajpmonline.org)). Compared to whites, a higher percentage of blacks and Asians reported perceived crime and had positive reports for shops/stores, sidewalks, and recreation facilities. Similar differences were seen between Hispanic and non-Hispanic women.

A higher percentage of women who lived in low-sprawl counties reported that crime made it unsafe to walk at night, and that there were stores, sidewalks, and recreation facilities, compared to women living in medium- or high-sprawl counties. The highest percentages of women reporting access to shops/stores and recreation facilities and sidewalks were found in the West, whereas the lowest were generally found in the South. Nine percent of women in the West reported crime, whereas approximately 5% of Midwest and Northeast women had this perception.

### Adjusted Associations with Physical Activity

Estimates from unadjusted (data not shown) and age-adjusted models were the same. Perceived proximity to shops/stores, presence of sidewalks, and access to recreation facilities were positively associated with meeting physical activity recommendations via walking in all models (Table 1). Perceived crime was inversely associated with meeting recommendations. Age-adjusted associations were attenuated in fully adjusted models. Overall, associations between perceived environment variables and meeting recommendations via walking, jogging, running, and bicycling were similar to those found for walking only.

### Associations with Physical Activity by Sprawl and Region

The associations between perceived crime and physical activity differed by region and sprawl (Figure 1). Overall, for both physical activity outcomes, a greater number of inverse associations were found for women who lived in low- and medium-sprawl counties (ORs=0.60–0.76). In the Northeast and South there was little variation in associations by sprawl, particularly for walking.

As shown in Figure 1, perceived proximity to shops/stores showed a consistent pattern of positive associations with physical activity across regions and sprawl (ORs=1.21–1.46). Associations between perceived presence of sidewalks and physical activity were similar across sprawl strata for women in the Midwest and similar across levels of sprawl in the South except for low sprawl (Figure 1). Among women from low-sprawl counties in the West, perceived presence of sidewalks had a significant inverse association with walking (OR=0.86 [95% CI=0.75, 0.97]). Perceived access to recreation facilities was positively associated with both physical activity outcomes in the majority of sprawl-region strata (Figure 1).

**Table 1.** Associations between perceptions of neighborhood environment and meeting physical activity recommendations (N=68,968)

	Walk ≥ 500 MET-min/wk (n of cases=16,813)		Walk-jog-run-bike ≥ 500 MET-min/wk (n of cases=24,972)			
	Age-adjusted	Multivariable Model 1	Multivariable Model 2	Age-adjusted	Multivariable Model 1	Multivariable Model 2
Crime; unsafe to walk at night	0.70 (0.65, 0.76)	0.80 (0.74, 0.86)	0.77 (0.71, 0.83)	0.73 (0.68, 0.78)	0.84 (0.78, 0.90)	0.81 (0.75, 0.86)
Shops/stores easy walking distance	1.44 (1.39, 1.50)	1.41 (1.36, 1.47)	1.33 (1.27, 1.38)	1.46 (1.41, 1.51)	1.42 (1.37, 1.48)	1.33 (1.28, 1.38)
Sidewalks on most streets	1.21 (1.17, 1.26)	1.22 (1.17, 1.26)	1.06 (1.02, 1.11)	1.22 (1.18, 1.26)	1.22 (1.18, 1.26)	1.05 (1.02, 1.09)
Free or low-cost recreation facilities	1.43 (1.37, 1.48)	1.32 (1.27, 1.38)	1.22 (1.17, 1.27)	1.49 (1.44, 1.54)	1.38 (1.33, 1.43)	1.27 (1.23, 1.32)

Note: Values are OR (95% CI). Multivariable Model 1 controlled for age, race, ethnicity, BMI categories, and husband's education. Multivariable Model 2 additionally controlled for the other perceived environmental variables. Meeting physical activity recommendation ≥500 MET-min/week.

For women in the Midwest, a significant positive association between recreation facilities and meeting recommendations was found for all levels of sprawl (ORs=1.19–1.34). The strongest associations for recreation facilities were found for women in high-sprawl counties in the West (ORs=1.56 and 1.70).

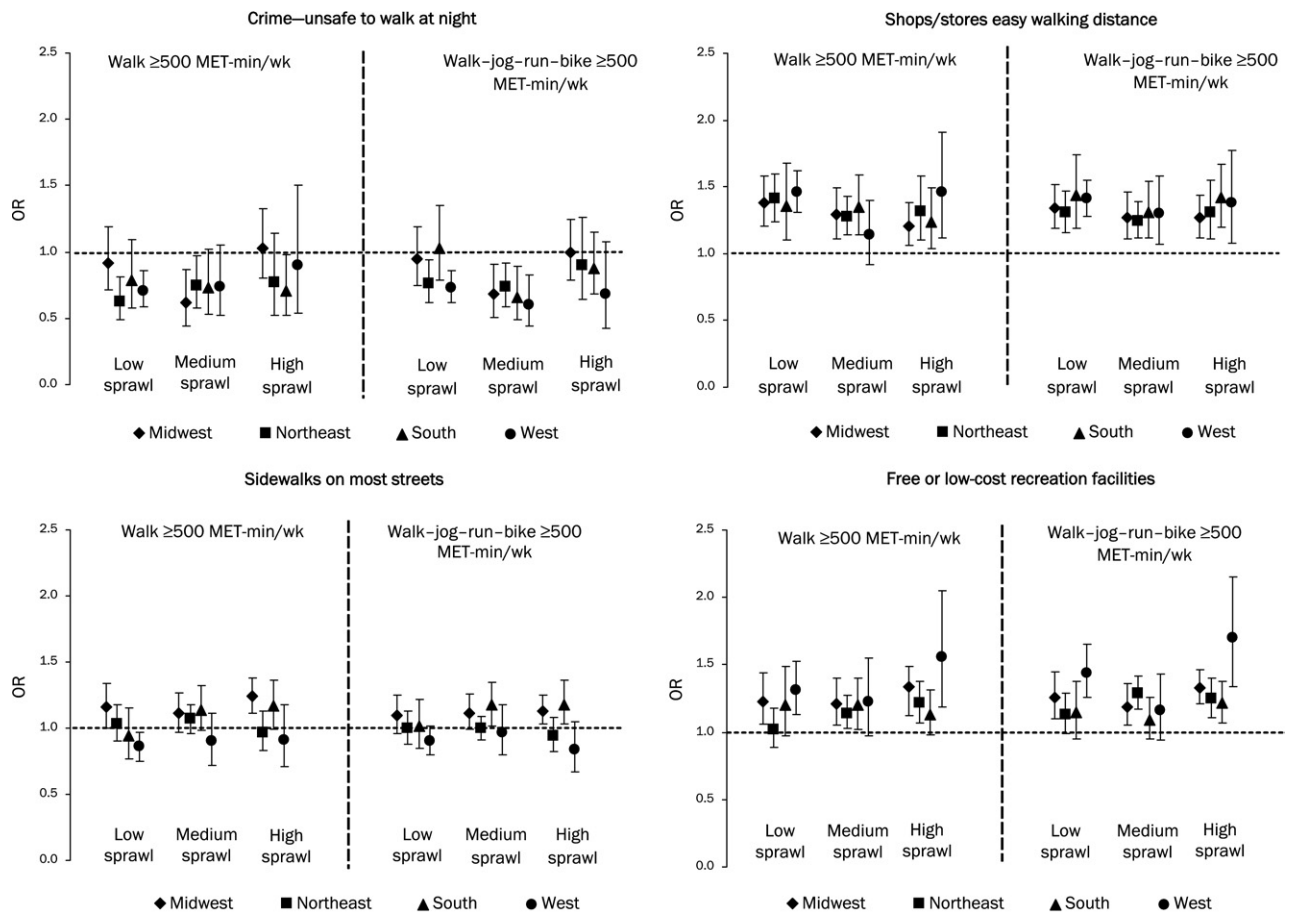
### Clusters of Neighborhood Environment Perceptions and Physical Activity

In nonstratified models, two to four positive perceptions of the neighborhood environment (versus none) were positively associated with meeting physical activity recommendations (Appendix B, available online at [www.ajpmonline.org](http://www.ajpmonline.org)). The magnitude of these associations was greater with a higher number of positive perceptions. In models stratified by sprawl, two positive perceptions versus none was positively associated with both physical activity outcomes only in high-sprawl (less-compact) counties (ORs=1.46 and 1.62). In models stratified by region, two and three positive perceptions showed significant associations with physical activity only in the South and West. Overall, in models stratified by sprawl and by region, four positive perceptions showed significant associations with physical activity. The most common exception to this finding was for women living in low-sprawl counties and in the Northeast.

### Discussion

Among a large sample of U.S. women, perceived proximity to shops/stores and access to recreation facilities were consistently associated with meeting physical activity recommendations across regions and levels of sprawl. Perceived crime was negatively associated with physical activity in most region–sprawl strata, although not significant in the majority of cases. A significant positive relationship between sidewalks and physical activity was found for women in the Midwest and South ( $p<0.05$ ). However, in general, this relationship was not seen in the Northeast and West. There was also evidence of cumulative effects of perceived environment attributes, with a higher number of positive perceptions associated with a greater odds of meeting activity recommendations.

Despite varying by level of sprawl, significant negative associations between perceived crime and physical activity were seen for women in all regions ( $p<0.05$ ). A recent 11-country study using the same perceived crime measure did not find an association with meeting physical activity guidelines.<sup>20</sup> Other studies in the U.S.,<sup>4,24</sup> Australia,<sup>25</sup> and a meta-analysis,<sup>26</sup> also did not find significant associations between perceived crime and physical activity. In New York City, Baltimore, and a North Carolina county, investigators<sup>27</sup> found a negative association be-



**Figure 1.** Associations between perceived built environment variables and meeting physical activity recommendations  
 Note: Results (ORs and 95% CIs) are stratified by urban sprawl and U.S. region.

tween perceived neighborhood violence and physical activity. These inconsistent findings may be due to differences in measures of perceived crime (or safety) or physical activity, or study populations. In a Boston study of racial and ethnic minorities,<sup>28</sup> researchers found an inverse association between perceived safety at night and pedometer steps among women, but found no associations for perceived safety during the day or for men.

Perceived proximity to shops/stores showed consistent positive associations with physical activity. The magnitude of the association in nonstratified models was similar to the value in a recent meta-analysis (OR=1.30).<sup>26</sup> Results from both overall and stratified models were also consistent with a recent multinational study,<sup>20</sup> which found that perceived nearby shops was associated with an OR=1.29 for meeting physical activity guidelines. Other U.S. studies in northern California,<sup>29</sup> and St. Louis MO, and Savannah GA,<sup>24</sup> also found that perceived access to stores was positively associated with physical activity.

There was also a consistent pattern of positive associations between perceived access to recreation facilities and meeting activity recommendations, irrespective of region

or sprawl. In all regions, the magnitude of associations tended to be higher among women in counties with high sprawl. These findings are slightly stronger than the findings from the multinational study<sup>20</sup> that used a similar item. Other U.S. studies<sup>4,24,30</sup> have also reported positive associations for perceived access to physical activity facilities, as did a recent meta-analysis,<sup>26</sup> and an Australian investigation<sup>25</sup> that focused on perceived access to outdoor facilities and using neighborhood streets for recreational physical activity.

Overall, there was limited evidence of a positive relationship between perceived presence of sidewalks and physical activity in the present study, contrary to findings from several U.S. and international studies.<sup>4,20,26</sup> However, one U.S. study<sup>24</sup> did not find associations between perceived availability of sidewalks and meeting recommendations via recreational or transportation physical activity among adults in St. Louis and Savannah.

This may be one of the first studies to examine differences in associations between the perceived built environment and physical activity by region and levels of sprawl. For perceived proximity to shops/stores and ac-

cess to recreation facilities, associations with physical activity were consistent across regions and levels of sprawl, with the exception that the strongest association for recreation facilities was found among women from higher-sprawl counties in the West.

Patterns of associations for perceived crime and sidewalks across sprawl and region were less clear. For instance, sidewalks showed positive associations in the Midwest and South, generally null findings in the Northeast, and some negative associations in the West. Overall, findings from the current study strengthen previous evidence indicating that accessible destinations and physical activity facilities are important correlates of physical activity. Findings also indicate that for many U.S. women with a demographic profile similar to the current sample, feeling unsafe about walking at night is negatively related to physical activity.

The present study employed an approach to assess the dose response or clustering effects of favorable environmental perceptions on physical activity.<sup>20</sup> Overall, findings were consistent with a recent study,<sup>20</sup> although a smaller number of positive perceptions (2 versus 4) were required to show a significant association with physical activity and the magnitude of associations was slightly greater. Also, the current study showed that the relationships between multiple positive environmental perceptions and meeting guidelines varied by sprawl and region. Significant associations were found for two or more positive attributes only among women from less-compact counties and in the South and West ( $p < 0.05$ ). These findings suggest that interventions should target multiple environmental perceptions to increase the likelihood of effecting change in physical activity.

The present study has several limitations. NHSII participants are primarily Caucasian, fairly well educated, and health conscious. Therefore, the results may not be generalizable to more diverse, less-educated U.S. women. Although the reliability<sup>19,31</sup> and validity<sup>20</sup> of the environmental items has been demonstrated, they have not been validated against objective measures. The biases inherent in assessing physical activity via self-report are well established.<sup>32</sup> Additionally, using the midpoint of a range to estimate duration may lead to over- or under-estimates. The NHSII walking question does not distinguish between recreational and utilitarian walking. Therefore, differences in associations for these two forms of walking could not be assessed. Also, as shown in a recent study using accelerometer data, it cannot be assumed that physical activity occurred near women's homes.<sup>33</sup> Stronger associations may be found if women were surveyed about activity proximal to home.

Another limitation is that husband's education was assessed 6 years before the perceived environment and

physical activity variables were collected. Finally, the cross-sectional design precludes causal inferences about the effects of perceived environment on physical activity. Study strengths include the large, geographically diverse sample that allowed for the examination of associations across regions and levels of sprawl and use of an existing cohort, which provided access to extensive data on covariates.

The findings demonstrate that perceived environmental factors such as access to shops/stores and recreational facilities are associated with meeting physical activity recommendations among women, regardless of geographic region or level of sprawl. These results bolster previous findings among adults and indicate that these perceived environmental factors should be considered when designing physical activity intervention strategies.

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## Appendix

### Supplementary data

Supplementary data associated with this article can be found, in the online version, at [doi:10.1016/j.amepre.2011.07.023](https://doi.org/10.1016/j.amepre.2011.07.023).