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Association of residential greenness with obesity and physical activity in a US cohort of women

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Abstract

There is evidence of several health benefits associated with neighborhood greenness, but reasons for this are unclear. Studies have found that those who live in greener neighborhoods are more physically active, and have lower rates of obesity. Relatively few studies have attempted to characterize associations between greenness and both obesity and physical activity concurrently, or among women who are at higher risk of developing cancer and for whom physical activity may be important for primary prevention. To address these gaps, we undertook a cross-sectional analysis of data from 50,884 women who enrolled in the Sister Study between 2003 and 2009. This cohort includes women aged 35–74 whose sister had been diagnosed with breast cancer. Residential measures of greenness were determined using the US National Land Cover database. Logistic regression was used to characterize associations between greenness, obesity, and physical activity. Adjustments were made for other possible confounders. Women who lived in areas with the highest tertile of greenness (based on a 500m buffer) had a reduced risk of obesity (body mass index (BMI) ≥ 30) relative to those in the lowest tertile (odds ratio (OR)=0.83, 95% CI=0.79–0.87). We also found that those the upper tertile of greenness were 17% more likely to expend more than 67.1 metabolic equivalent (MET) hours per week when compared to those in the lowest tertile (OR=1.17, 95% CI=1.10–1.23). Beneficial associations between greenness and both obesity and

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physical activity were observed in urban and rural areas, and regionally, stronger associations were observed in the western census region in the US. Mediation analyses indicated that physical activity attenuated the association between greenness and obesity by 32%. Our findings indicate that, amongst US adult women at higher risks of breast cancer, residential proximity to greenness may help mitigate against sedentary behaviors that increase the risk of chronic disease.

Keywords

Greenness; Obesity; Physical Activity; Cross-Sectional Study; Breast Cancer

1.0 Introduction

Obesity is a worldwide pandemic. In 2014, it was estimated that approximately 1.9 billion adults were considered obese (World Health Organization, 2016). The prevalence of obesity in the United States in 2011–2014 was estimated to be 36%, with higher rates among women (38.3%), and women between the ages of 40–59 (42.1%) (Ogden et al., 2015). The public health burden associated with obesity is considerable as excess body mass index (BMI) increases the risk of developing chronic diseases including cancer, heart disease, diabetes, and stroke (World Health Organization, 2016). In 2008, it was estimated that the annual medical costs associated with obesity in the United States was \$147 billion (Ogden et al., 2015). Increased sedentary behaviors both at work and at home are believed to have played a key role in observed trends in the US and other developed countries, with adults spending an estimated 70% or more of their waking hours sitting (Owen et al., 2010).

Traditionally, epidemiological studies of obesity have focused on the role of individual factors such as physical activity, genetic predisposition, diet, and socio-economic status (Trost et al., 2002). Over the past decade, however, findings from a number of studies suggest that some features of the built environment play an important role in reducing sedentary behaviors, and thereby decreasing obesity. The built environment incorporates the building and transportation design of a city, and includes features such as open green spaces, bike ways/sidewalks, shopping centers, business complexes, and residential accommodation (World Health Organization, 2009). Neighborhoods with greater access to grocery stores, increased walkability, and decreased access to fast food have lower rates of obesity (Frank et al., 2007; Saelens et al., 2003). More recently, women who lived in higher population density counties (i.e., lower sprawl) were found to have lower BMI, and higher rates of physical activity than those who lived in lower density counties (Hruby et al., 2016). Greenness, often referred to as green spaces or natural areas, has been evaluated as a deterrent of obesity largely due to the possibility it provides enhanced opportunities for physical activity (James et al., 2015). Epidemiological investigations in children have somewhat consistently reported an inverse association between the amount of green space and BMI (Dunton et al., 2009; Wolch et al., 2011). However, fewer studies have investigated these associations in adults, and the results have been mixed, varying by age, socio-economic status and the methods used to characterize greenspace (Lachowycz and Jones, 2011). Additionally, few studies have evaluated differences in the strength of the association between urban and non-urban areas.

Studies that have investigated associations between greenness and physical activity have also produced equivocal results with positive associations noted in some (Cohen et al., 2007; Coombes et al., 2010; Mytton et al., 2012), but not in others (Maas et al., 2008; Witten et al., 2008). Interpreting the associations between greenness and obesity and physical activity is complicated by the potential modifying role of socio-demographic status as well as urbanicity. Some studies suggest that access to green spaces, which are often free, or at low cost, have larger benefits among those of lower socio-demographic status (Dadvand et al., 2012; de vries et al., 2003; Mitchell and Popham, 2007; Mitchell and Popham, 2008).

While several epidemiological studies have investigated associations between greenspace and obesity and physical activity, few studies have considered both measures. An analysis of 21,832 adults who completed the Danish National Health Interview Survey found that those who lived more than 1 km from green space were less likely to exercise, and more likely to be obese when compared to those who lived less than 300 m (Toftager et al., 2011). In contrast, a survey of 3,883 adults in 85 neighborhoods in Ottawa, Canada found that those who lived in greener neighborhoods were less likely to exercise, and had increased rates of obesity in men while reduced rates in women (Prince et al., 2011). The findings from these two studies may have been influenced by biases introduced by characterizing green spaces using self-reported data (Toftager et al., 2011), or at an ecological (neighborhood) level (Prince et al., 2011).

Exposure measurement error resulting from the characterization of greenness in epidemiological studies, may have contributed to the inconsistent associations with physical activity and obesity. To date, most studies have relied on self-reported measures of greenness, or the Normalized Difference Vegetation Index (NDVI) (James et al., 2015). The NDVI is the most widely used measure of vegetation and is derived using satellite imagery that can describe vegetative density at a high spatial resolution (~30m) worldwide. Although the NDVI is an objective measure of greenness, it is only able to capture the amount of vegetation in a given area and is not capable of providing qualitative information about the usability, or access. For these reasons, some have recommended that epidemiological studies adopt metrics that are better able to differentiate between these features of greenness (James et al., 2015; Lee and Maheswaran, 2011).

Here, we characterized associations between residentially-based measures of greenness and both obesity and physical activity in a national US survey of women at higher risk of developing breast cancer. Our measures of greenness are based on the National Land Cover Database that is better able to differentiate between features of greenness than the NDVI. Further, we explored to what extent socio-demographic status, age and place of residence (i.e., urban, suburban, rural) modified associations between greenness and sedentary behaviours. Lastly, we examined to what extent physical activity mediated associations between greenness and obesity.

2.0 Materials and methods

2.1 Study population

The study population consisted of women in the Sister Study, a U.S. nationwide study designed to evaluate environmental and genetic risk factors of breast cancer (US National Institutes of Environmental Health Sciences, 2017). Approximately fifty thousand initially breast cancer-free women, ages 35–74, who had a sister previously diagnosed with breast cancer, were enrolled in the study between August 2003 and July 2009. Participants were from throughout the US, including Puerto Rico. At baseline, participants completed computer assisted telephone interviews that collected data on demographic characteristics, environmental exposures, lifestyle factors including physical activity, medical history, and other possible risk factors for breast cancer. In addition, participants provided their residential histories and self-reported measures of physical activity during childhood and in the past 12 months.

The main and secondary places of residence at the time of enrollment were collected from the participants and this yielded 53,374 records for the 50,884 enrolled women. These addresses were geocoded to assign residential measures of greenness. An exact address was available for 50,746 (95.1%) of these residences, while the nearest intersection and zip code were used for the remaining 4.6%, and 0.4% of the addresses, respectively. We further restricted assignment of green spaces to those residences ($n=51,990$) that were based in the contiguous US. We further restricted the analysis to a single residential address per participant, using the address given as main place of residence ($n=49,649$). For these residences, participants indicated whether they were in urban, suburban, rural or in a small town. In addition, residential address was linked to census data to obtain the census region, division, and census tract population for each participant (US Census Bureau, 2017).

All participants provided written informed consent. The Sister Study was approved by the Institutional Review Board (IRB) of the National Institute of Environmental Health Sciences, National Institutes of Health, and the Copernicus Group IRB.

2.2 Exposure to greenness

The US National Land Cover Database (NLCD) was used to assign residential measures of greenness. Land cover describes the presence (or absence) of vegetation on the land surface. We downloaded data from the Multi-Resolution Land Characteristics Consortium for 2006, and 2011. The NLCD in these years used a 20-class land-cover classification scheme that has been applied consistently across the US at a resolution of 30 meters based on a decision-tree classification of respective circa 2006 and 2011 Landsat satellite data (Homer et al., 2015). These 20 classes span 8 broader land cover categories have been previously described, and are listed in Appendix Table 1 (Multi-Resolution Land Characteristics Consortium, 2016). Since the primary aim of this research was to describe associations of residential greenness with obesity and physical activity, we created the following exposure metrics and assigned them to the geocoded home addresses of the Sister Study participants:

Number	Exposure metric	Land cover classes (NLCD values in parentheses)
1	<i>Green1</i>	Includes the forest (values:41,42,43), shrubland (52), and herbaceous (71,72, 73) land covers
2	<i>Green2</i>	Includes classes within <i>Green1</i> as well as developed open spaces (21)
3	<i>DHI</i>	Developed high intensity land cover (24)
4	<i>IMP</i>	Percentage of impervious surface

The *Green1* and *Green2* exposure metrics differed by the inclusion of developed open spaces in the latter category. Developed open spaces are areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses and with impervious surfaces accounting for less than 20% of total cover. Developed high intensity areas are where people reside or work in high numbers, such as apartment complexes, row houses and commercial/ industrial development. Impervious surfaces account for 80% to 100% of the total cover. Impervious surfaces (Xian et al., 2011) are mainly artificial structures - such as pavements (roads, sidewalks, driveways and parking lots) that are covered by impenetrable materials such as asphalt, concrete, brick, stone - and rooftops.

For each residential address, we estimated the percentage of the area that described by these four metrics across six different buffer categories (30m, 250m, 500m, 1000m, and 2000m). We have focused our analyses on the 250m and 500m buffer distances to facilitate comparisons to previously published papers that used these distances (Dadvand et al., 2016; McMorris et al., 2015; Villeneuve et al., 2012). Further, these buffers represent areas within an approximate 15 minute walk from participant's place of residence thereby providing a reasonable representation of proximal green space that could be used for recreational purposes. The need to characterize differences in the strength of the association between neighborhood greenness and health outcomes by different distance buffers has been identified as an important research priority (James et al., 2015; Markevych et al., 2017)

2.3 Physical activity and obesity

The Sister Study collected detailed information on physical activity. Women reported participation in sports and exercise, recreational activities and physically active chores for several periods including the past 12 months. The number of metabolic equivalent task (MET) hours per week was determined for the participants using the established guidelines (Ainsworth, 2002). Women were asked to provide information for activities that they participated in at least once a week for at least one month over the last 12 months. For each activity, they then had to report how many months per year, how many days per week, and how many hours per day they engaged in the activity. These data were then used to calculate weekly energy expenditures, in MET-hours, per week. We also constructed a separate metric that represented the MET-Hours expended on recreational activities only. This metric was derived by subtracting the MET-hours spent on physically active chores from the total number of weekly MET-hours. This metric was created so that we could evaluate the impacts of greenness on recreational activities alone, rather than the combined expenditure on recreational and utilitarian activities combined.

Trained examiners took height and weight measurements during a home visit. They used digital self-calibrating scales to estimate participants' weight (lbs), while metal tape measures were used to record height (inches). These measures were rounded off to the nearest pound and quarter inch for weight and height. The measurements were taken three times, without shoes. BMI was calculated and categorized based on the US Centers for Disease Control and Prevention formula (US Centers for Disease Control and Prevention, 2009).

2.4 Other covariates

The enrollment questionnaires collected information on many other factors that could confound or modify associations between residential measures of greenness, and physical activity or obesity. For these analyses, we extracted data related to: cigarette smoking, alcohol use, household income, educational attainment, marital status, race, and presence of other health conditions. We evaluated the potential confounding role of these risk factors by categorizing these variables, and including a separate category that captures covariates with missing values.

2.5 Statistical analysis

The data were analyzed using SAS 9.4 (SAS Institute, 2016). Pearson correlation coefficients were estimated to describe the interrelationships between the land cover characteristics of the participants. The distributional characteristics of these characteristics of greenness and impervious surfaces were calculated across categories of: age, BMI, ethnicity, marital status, income, and smoking status. This was done to identify those factors that could potentially confound associations between the land cover characteristics and obesity, and physical activity.

Logistic regression was used to describe associations between residential land cover characteristics and obesity, or physical activity. Obesity was dichotomized as those who had a BMI less than < 30, versus 30 or higher. For physical activity, we classified subjects as active if they had expended at least 67.1 MET-Hours per week on activities that corresponded to the upper tertile of MET-hours per week in the study population. We also classified measures of greenness, and impervious surfaces into tertiles. The measures of association, the odds ratios and their 95% confidence intervals, were adjusted for other possible confounders. Our previous work has suggested that sociodemographic factors are most likely to exert a confounding role on associations between greenness and health outcomes. Therefore, we initially adjusted our risk estimates for income, marital status and ethnicity. We then evaluated whether other lifestyle risk factors such as cigarette smoking further confounded our risk estimates. We dropped those terms that did not substantially impact our risk estimates to obtain a parsimonious model, and minimize the standard error for the built environment exposures. We also adjusted our odds ratios for census area to account for differential participation rates by region, and take into account spatial clustering.

We performed stratified analyses to investigate possible differences by age group, socioeconomic, place of residence (i.e. rural vs urban), census tract population and census region. For these analyses we estimated odds ratios for four age categories (35 – < 45, 45 – <

55, 55 – < 65, 65 years of age), four income categories (< \$15,000, \$15,000–< \$37,500, \$37,500–< \$50,000, and \$50,000), and by urban or rural place of residence. For these stratified analyses of income, we excluded the approximately 2000 women who did not provide household income data.

Physical activity was evaluated as a possible mediator of the relationship between greenness and obesity by applying previously described methodology (MacKinnon et al., 2007). This approach relied on fitting three separate regression equations,

$$Y = i_1 + cX + e_1 \quad \text{Equation 1}$$

$$M = i_3 + aX + e_3 \quad \text{Equation 2}$$

$$Y = i_2 + c'X + bM + e_2 \quad \text{Equation 3}$$

Where i_1 , i_2 , i_3 are intercepts, Y is the dependent variable (i.e., obesity), X is the independent variable (i.e., greenness), and M is the mediator (i.e., physical activity).

The association described by the first equation was evaluated using a logistic regression model captures the relation between residential measure of greenness and obesity (BMI 30) – this yielded an estimate for the parameter c . We choose to model greenness using the 500m buffer as this buffer produced largely similar results to other possible distances, and because this represents distance that could be covered by most participants within a 15 minute time interval. The second equation captures the relationship between the outcome obesity (BMI 30), and the total number of MET-hours in a week expended on physical activity. This parameter estimate corresponding to physical activity yields an estimate of c' . We then fit a model characterizing the association between greenness within a 500m buffer as the outcome and physical activity as an independent variable. The percent attenuation, or alternatively, the proportion of the association between greenness and obesity mediated by physical activity was estimated by $PM = 1 - \frac{c'}{c}$ (MacKinnon et al., 2007).

3.0 Results

The spatial distribution of the residential addresses of the Sister Study participants at baseline is presented in Figure 1. Pearson correlation coefficients for the residentially assigned land-cover characteristics at 250m and 500m buffers are presented in Table 1. At a 250m buffer distance, the correlation between the two measures of greenness (with and without open spaces) was 0.77. Similar correlations were obtained using a 500 m buffer ($r=0.81$). As anticipated, impervious surfaces were inversely correlated with greenness ($-0.61 < r < -0.74$) at both buffers.

The mean percentage of greenness and impervious areas within a 500m buffer across several characteristics is presented in Table 2. There was no clear gradient in these means across age-groupings. In contrast, there were marked disparities by race; participants who were White tended to live in greener areas relative to Blacks or Hispanics. Similarly, those who were married also tended to live in greener areas when compared to those of a different marital status. This difference was largest between those who were married (19.2%) versus those who had never been married (10.7%). Residential greenness was inversely associated with increased BMI, while positively associated with the total number of hours of physical activities, and the total MET-hours of activity per week. The percentage of greenness within a 500m buffer was substantially lower in urban areas (21.7%), when compared to rural areas (52.3%).

The odds ratios that describe associations between greenness and obesity (BMI ≥ 30) are presented in Table 3. Those in the upper tertile of greenness based on forest, shrubland and herbaceous areas within a 250m buffer (*green1*), were less likely to be obese (OR=0.87, 95% CI=0.83–0.92) relative to those in the lowest tertile. This inverse association was stronger among those who lived in urban or suburban areas (OR=0.81, 95% CI=0.75–0.87) when compared to those who lived in rural areas (OR=0.93, 95% CI=0.86–1.00). When the measure of greenness was expanded to include developed open spaces (i.e., *green2*) there were no substantial changes in the odds ratios. Similarly, we found no differences in the strength of the associations when we modeled a 500m buffer rather than a 250m. As expected based on the Pearson correlations, the associations between obesity and impervious and developed high intensity areas were of similar magnitude, but in the opposite direction, to those found for the greenness metrics.

Associations between land cover characteristics using 250 and 500 m buffers and the weekly number of MET-hours of physical activity and exercise over the past year are presented in Table 4. The mean number of MET-hours spent in these activities increased across tertiles of greenness was evident in both urban and rural places of residence. Overall, women in the upper tertile of greenness were 14% more likely to expend more than 67.1 MET-hours per week when compared to those in the lowest tertile (OR=1.14, 95% CI=1.08–1.20). There was no appreciable difference in the strength of the association across the two buffers applied, and the strength of the associations were similar between those who lived in urban versus rural residences. When we repeated analyses to exclude utilitarian physical activities (i.e., chores) from the overall calculation of week MET-hours, the odds ratio did not change appreciably (Table A6).

The findings from stratified analyses by census describing associations between greenness and obesity, and physical activity are presented in Tables A4, A5. While beneficial impacts of greenness on both these outcomes were evident in all census regions, the strongest associations were noted in the western region of the US.

We also modeled the 500m buffer of greenness across household income and age categories of participants of the Sister Study (Figure 2). A reduced risk of obesity was observed in the highest tertile of greenness in each of the four income categories examined, but not as pronounced among those with incomes exceeding \$50,000 annually. Those who lived in the

upper tertile of greenness had reduced risks of obesity relative to those in the lowest tertile across all age groups (Figure 2). We repeated these analyses using weekly MET-hours of activity as our outcome, and Figure 3 shows that these associations are stronger than for obesity. There was a clear stepwise gradient between higher residential greenness and increased odds of being physically active.

The findings from the mediation analyses (Figure 4) revealed statistically significant inverse associations between residential greenness and obesity, and positive associations between greenness and the number of MET-hours of activity per week ($p < 0.05$). The parameter estimate associated with greenness (*green1*) within a 500m buffer and obesity changed from -0.00179 to -0.00121 after the weekly number of MET-hours of physical activity was entered into the model. The estimated percentage of the association between greenness and obesity mediated by physical activity was 32%.

4.0 Discussion

Our cross-sectional analyses of nearly 50,000 women who participated in the Sister Study found that those who lived in areas with more green space were less likely to be obese, and more likely to be physically active. These associations were evident in both urban and rural areas. Importantly, we observed that residential measures of greenness remained inversely associated with obesity after taking into account the mediating role of physical activity. These associations persisted after adjusting for a number of other risk factors, including ethnicity, age and socio-demographic. For the most part, the strength in these associations were similar when green space was measured using either 250m or 500m buffer. This study adds to a growing literature suggesting that greenness may play an important role in helping adults adopt a less sedentary lifestyle.

Previous studies have suggested that exposure to green space helps to reduce health inequalities related to social determinants of health, including income. For example, a cross-sectional study in the UK found that the income-related differences in mortality rates were attenuated as the amount neighborhood green space increased (Mitchell and Popham, 2008). Our findings provide modest support for this; associations between green space and obesity were similar across income categories. Of note, if anything, the greenspace-obesity gradients were stronger among women with household income less than \$50,000, when compared to those who were more affluent. These findings suggest that efforts to increase the amount of green spaces in low income urban areas help reduce health inequalities.

In the Sister Study, participation in physical activities was found to attenuate the association between residential measures of greenness and obesity by approximately 30%. There have been relatively few attempts to assess the mediating impact of physical activity on other features of the built environment as it pertains to obesity. Elsewhere, a study in Ottawa, Canada found that food landscapes and social cohesiveness also influence both participation in physical activities and obesity (Prince et al., 2011). More recently, in an analyses of the US Nurses Study, walkability was found to be a nonlinear confounder of the relationship between greenness and body mass index (James et al., 2017). In children, excessive screen time has also been shown to be inversely associated with greenness (Dadvand et al., 2014).

thereby representing a pathway that reduces participation in physical activity. Unfortunately, within the Sister Study measures of walkability, food landscapes and social cohesion were not readily available. Further research is needed to provide more clarity on how these factors independently, and jointly, impact obesity and participation in physical activity.

Our study has a number of distinct strengths. First, we were able to geocode individuals' exact residential address for a large proportion of subjects. This positioned us to better detect possible differences in the strength of the association across different buffers. Second, this study used objectively determined measures of height and weight, thereby avoiding possible biases inherent in self-reported measures of anthropometry. Third, unlike several previous studies that relied on the NDVI, we used land-cover indices of vegetation that allowed us to evaluate whether associations varied across different measures of vegetation. Lastly, our analyses were national in scope, and to our knowledge, there have been no previous attempts to characterize these associations on a national level throughout the US.

Study participants were women who had a sister previously diagnosed with breast cancer, and who agreed to participate in the Sister Study. As such, findings may not generalize to all women. As in other volunteer cohorts, when compared to US women, participants in the Sister Study are more likely to be white, married, and have higher household income. However, finding an association with greenspace across all categories of household income supports the scientific generalizability of these findings.

Self-reported measures of physical activity used in this study inevitably introduced some degree of misclassification of participants' true physical activity levels. Although direct measures of physical activity are preferred, such an approach would have been impractical given the large sample sizes. Generally, duration of physical activity is over-reported when questionnaires are used; however, evidence has shown that standardized questionnaires have practical value in assigning individuals to different levels of physical activity. Moreover, this misclassification would have only biased our findings if it was differential by level of greenness.

An important limitation of this study is its cross-sectional nature that does not allow us to identify causal effects. Therefore, we are unable to determine to what extent increased access to green space is directly responsible for increased participation in leisure time physical activity, or whether this association is influenced by more active individuals choosing to live in these areas. It has been cautioned that ignoring this self-selection bias will lead to overestimating the impacts of the built environments on determinants of health (Handy, 2009). While we are unable to estimate the impacts of this self-selection bias, it is noteworthy that our strongest associations with obesity were observed among those of lower income, who would be least likely to be able to choose which neighborhoods they do live in. The preferred approach is to track individuals over time to evaluate to what extent their behaviours change in relation to changes in their built environment. We are planning to extend these analyses by evaluating associations between green space, obesity, and physical activity using longitudinal data collected from these participants.

In this study, we were able to assign multiple measures of greenness using the NLCD to the exact address of nearly all study subjects. Most other studies have been unable to assign exposure at this fine a resolution, and have had to rely on Zip code, or postal codes. While the NLCD differs somewhat from the widely used NDVI, both are satellite-based measures that characterizes the amount of vegetation. Both of these metrics are unable to capture other features of urban spaces that may be important predictors of physical activity such as accessibility, safety, and quality. There remains an important need to develop metrics that incorporate these features. Recent examples of such work includes the green space index developed for Vancouver, Canada (Rugel et al., 2017), and the green view index that captures street-level metrics of vegetation and tree canopy (Li et al., 2015).

6.0 Conclusions

Our findings suggest that there is an association between green space and physical activity, where increased availability of green space has a beneficial effect on the level of physical activity. Additionally, neighbourhoods with more green space also tend to have a smaller number of obese individuals. Interestingly, both associations remain true regardless of the household income level, and in both urban and rural areas. These findings shed light on the impact that green space in residential areas has on population health, and further efforts should extend these analyses to investigate the role that other features of greenness (quality, accessibility, and safety) have on these associations.

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Abbreviations

BMI	Body mass index
IRB	Institutional Review Board
MET	Metabolic equivalent
NDVI	Normalized Difference Vegetation Index
NLCD	National Land Cover Database
SES	Socioeconomic status
WHO	World Health Organization

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Highlights

- Women who lived in areas with greater amounts of greenness were less likely to be obese, and had higher activity levels.
- These patterns were evident in both urban and rural areas, and the strongest associations were observed in the western US census region.
- The association between greenness and obesity was partially mediated by physical activity

Figure 1.
The spatial distribution of residential addresses of the Sister Study participants during the baseline recruitment period. Each participant is represented by an orange dot.

Figure 2.

Adjusted* odds ratio of obesity (BMI ≥ 30) across household income and age-group categories by tertile of greenness based on a 500m buffer, the Sister Study

* Odds ratios estimated for greenness metric based on forest, shrubland, herbaceous and developed open spaces; they were adjusted for age, ethnicity, marital status, population of census tract, and census area

Figure 3.

Adjusted* odds ratio of being physically active (67.1 MET-hours weekly) across household income and age-group categories by tertile of greenness based on a 500m buffer, the Sister Study

* Odds ratios estimated for greenness metric based on forest, shrubland, herbaceous and developed open spaces; they were adjusted for age, ethnicity, marital status, population of census tract, and census area

Figure 4.

Regression coefficients for the association between residential greenness (500m), total weekly hours of physical activity and exercise, and obesity, Sister Study

All parameter estimates (a , b , c , c') were adjusted for age, ethnicity, marital status, and place of residence (urban/rural)

c' represents the coefficient between residential greenness and obesity with additional adjustment for physical activity (weekly number of MET-hours)

Pearson Correlation Coefficients between selected land-cover characteristics (using buffers of 250m and 500m) at the primary place of residence of 49,649 participants of the Sister Study

Table 1

	250m buffer				500 m buffer			
	G1	G2	IMP	DHI	G1	G2	IMP	DHI
Forest, shrubland and herbaceous	(G1) 1.00				1.00			
Forest, shrubland and herbaceous + Developed open spaces	(G2) 0.77	1.00			0.81	1.00		
Impervious surface	(IMP) - 0.61	-0.74	1.00		-0.64	-0.73	1.00	
Developed High Intensity	(DHI) - 0.19	-0.31	0.59	1.00	-0.26	-0.38	0.65	1.00

Mean percentage of greenness and impervious area across selected characteristics based on a 500m buffer from the place of residence among Sister Study participants

Table 2

Characteristic	N	%	Greenness *		Impervious (%)
			G1 (%)	G2 (%)	
Age					
35 – 44	6425	12.9	16.3	35.1	26.4
45 – 54	17081	34.4	17.6	36.5	25.2
55 – 64	17445	35.1	18.2	37.6	24.7
65 – 74	8698	17.5	17.0	36.2	25.6
Body Mass Index					
<25	19232	38.8	17.9	37.7	24.8
25 – <30	15630	31.5	17.9	37.0	24.7
30 – <35	8492	17.1	17.2	35.6	25.7
35	6278	12.6	15.8	34.3	27.0
Ethnicity					
White	42259	85.1	18.2	37.5	24.1
Black	4454	9.0	12.9	32.8	31.4
Hispanic	1634	3.3	10.5	25.8	36.9
Other	1292	2.6	19.5	37.5	25.6
Marital Status					
Married	37157	74.8	19.2	38.7	23.0
Never Married	2671	5.4	10.7	27.2	36.1
Divorced/separated	7320	14.8	12.7	30.8	31.6
Widowed	2491	5.0	15.0	33.9	27.6
Income					
< \$15,000	4822	9.7	17.1	35.3	26.6
\$15,000 – < \$37,500	16981	34.2	16.9	34.9	26.0
\$37,500 – < \$50,000	13049	26.3	19.0	38.3	23.2
\$50,000	14797	29.8	17.1	37.7	25.9
Smoking Status					

Characteristic	Greenness *			Impervious		
	N	%	G1 (%)	G2 (%)	(%)	(%)
Current	4149	8.4	17.3	35.0	26.5	
Former	18889	38.1	17.4	36.9	25.5	
Never	26553	53.5	17.7	36.7	24.9	
Total hours of physical activity						
< 7.7	12310	25.0	16.1	35.0	27.1	
7.7 – < 12.3	12315	25.0	16.8	35.8	26.4	
12.3 – < 18.6	12307	25.0	17.9	37.4	24.4	
18.6	12313	25.0	19.4	38.6	22.9	
Total MET hours physical activity						
< 27.1	12311	25.0	16.1	35.0	27.1	
27.1 – < 44.3	12311	25.0	16.6	35.9	26.3	
44.3 – < 67.1	12310	25.0	18.0	37.2	24.6	
67.1	12313	25.0	19.5	38.7	22.8	
Residence type						
Urban	9430	19.0	6.2	21.7	40.8	
Suburban	19364	29.1	12.3	35.2	40.8	
Small town	10642	21.5	17.3	38.0	23.3	
Rural	9983	20.1	38.8	52.3	6.2	
Other	142	0.30	13.3	28.0	32.6	

* Where G1 represents forest, shrubland and herbaceous land characteristics and G2 represents forest, shrubland and herbaceous land characteristics and developed open spaces.

Odds ratios* (OR) for obesity (BMI ≥ 30) according to tertiles of selected land characteristics based on 250m and 500m buffers, by age group, the Sister Study

Table 3

Land cover characteristic	Place of residence						Overall		
	Rural or small town			Urban or suburban			% obese	OR	95% CI
	% obese	OR	95% CI	% obese	OR	95% CI			
G1 (250 buffer)									
Lowest tertile	33.1	1.0		30.3	1.0		31.0	1.0	
Middle tertile	31.8	0.97	0.89 – 1.05	28.0	0.92	0.87 – 0.98	29.6	0.94	0.89 – 0.98
Upper tertile	29.7	0.93	0.86 – 1.00	24.7	0.81	0.75 – 0.87	28.0	0.87	0.83 – 0.92
G2 (250 buffer)									
Lowest tertile	33.8	1.0		32.8	1.0		31.8	1.0	
Middle tertile	31.7	0.91	0.84 – 0.99	31.1	0.91	0.87 – 0.96	29.9	0.91	0.87 – 0.96
Upper tertile	29.7	0.88	0.81 – 0.95	28.0	0.83	0.79 – 0.87	27.6	0.83	0.79 – 0.87
Impervious (250 buffer)									
Lowest tertile	29.6	1.0		28.4	1.0		27.9	1.0	
Middle tertile	31.8	1.06	0.99 – 1.14	29.8	1.09	1.03 – 1.15	28.8	1.09	1.03 – 1.15
Upper tertile	36.0	1.28	1.18 – 1.39	33.7	1.32	1.25 – 1.40	32.6	1.32	1.25 – 1.40
G1 (500 buffer)									
Lowest tertile	33.3	1.0		29.9	1.0		30.6	1.0	
Middle tertile	32.0	0.96	0.88 – 1.05	29.3	1.01	0.95 – 1.07	30.3	0.99	0.95 – 1.04
Upper tertile	30.1	0.95	0.87 – 1.03	25.8	0.85	0.79 – 0.91	28.3	0.90	0.86 – 0.95
G2 (500 buffer)									
Lowest tertile	32.9	1.0		31.1	1.0		31.6	1.0	
Middle tertile	32.3	0.98	0.90 – 1.06	28.6	0.91	0.86 – 0.97	30.1	0.93	0.89 – 0.98
Upper tertile	29.6	0.91	0.84 – 0.99	25.0	0.77	0.72 – 0.83	27.5	0.83	0.79 – 0.87
Impervious (500 buffer)									
Lowest tertile	29.7	1.0		24.0	1.0		28.2	1.0	
Middle tertile	32.0	1.06	0.99 – 1.14	27.3	1.15	1.05 – 1.25	28.8	1.08	1.03 – 1.14
Upper tertile	35.8	1.24	1.14 – 1.36	31.5	1.37	1.26 – 1.49	32.2	1.29	1.22 – 1.37

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* Odds ratios adjusted for age, ethnicity, marital status, population of census tract, and census area

Table 4

Odds ratios* (OR) for participation in physical activity* based on selected land characteristics based on 250m and 500m buffers, by rural and urban residency, the Sister Study

Land cover characteristic	Place of residence						Overall		
	Rural or small town			Urban or suburban					
	Mean MET-hrs	OR	95% CI	Mean MET-hrs	OR	95% CI	Mean MET-hrs	OR	95% CI
G1 (250 buffer)									
Lowest tertile	51.9	1.0		48.1	1.0		49.1	1.0	
Middle tertile	52.2	1.03	0.95 – 1.12	49.1	1.07	1.00 – 1.14	50.4	1.06	1.00 – 1.11
Upper tertile	54.5	1.13	1.05 – 1.22	50.9	1.12	1.03 – 1.21	53.2	1.14	1.08 – 1.20
G2 (250 buffer)									
Lowest tertile	52.1	1.0		47.5	1.0		48.8	1.0	
Middle tertile	52.3	1.03	0.94 – 1.12	49.1	1.11	1.04 – 1.19	50.4	1.22	1.03 – 1.14
Upper tertile	54.3	1.13	1.04 – 1.23	50.7	1.22	1.13 – 1.32	52.7	1.19	1.13 – 1.26
Impervious (250 buffer)									
Lowest tertile	54.7	1.0		51.6	1.0		53.8	1.0	
Middle tertile	52.2	0.85	0.80 – 0.92	49.9	0.90	0.83 – 0.98	50.7	0.88	0.83 – 0.92
Upper tertile	49.3	0.70	0.64 – 0.77	47.0	0.74	0.68 – 0.81	47.4	0.72	0.68 – 0.76
G1 (500 buffer)									
Lowest tertile	52.1	1.0		48.0	1.0		48.9	1.0	
Middle tertile	52.4	1.04	0.95 – 1.14	49.0	1.06	0.99 – 1.13	50.4	1.05	1.00 – 1.11
Upper tertile	54.0	1.10	1.01 – 1.20	50.3	1.09	1.01 – 1.18	52.6	1.10	1.04 – 1.17
G2 (500 buffer)									
Lowest tertile	52.4	1.0		47.6	1.0		48.9	1.0	
Middle tertile	52.1	1.00	0.92 – 1.09	49.0	1.09	1.02 – 1.17	50.3	1.06	1.01 – 1.12
Upper tertile	54.3	1.09	1.00 – 1.18	50.7	1.21	1.12 – 1.30	52.7	1.17	1.10 – 1.23
Impervious (500 buffer)									
Lowest tertile	54.7	1.0		51.7	1.0		53.8	1.0	
Middle tertile	51.7	0.84	0.78 – 0.90	49.6	0.89	0.82 – 0.96	50.3	0.86	0.81 – 0.91
Upper tertile	49.8	0.74	0.67 – 0.81	47.3	0.78	0.71 – 0.85	47.8	0.75	0.70 – 0.80

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*The cut-point used for to define those physically active was 67.1 MET-Hours per week (which represented the upper tertile). Odds ratios adjusted for age, ethnicity, marital status, population of census tract, and census area

Table A1

Land cover types in the 2006 National Land Cover Database

Class	Value	Description
Water	11	Open water - areas of open water, generally with less than 25% cover of vegetation or soil.
	12	Perennial Ice/Snow - areas characterized by a perennial cover of ice and/or snow, generally greater than 25% of total cover.
Developed	21	Open Space - areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20% of total cover. These areas most commonly include large-lot single-family housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes.
	22	Low Intensity - areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20% to 49% percent of total cover. These areas most commonly include single-family housing units.
	23	Medium Intensity - areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50% to 79% of the total cover. These areas most commonly include single-family housing units.
	24	High Intensity - highly developed areas where people reside or work in high numbers. Examples include apartment complexes, row houses and commercial/industrial. Impervious surfaces account for 80% to 100% of the total cover.
Barren	31	Rock/Sand/Clay - areas of bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, sand dunes, strip mines, gravel pits and other accumulations of earthen material. Generally, vegetation accounts for less than 15% of total cover.
Forest	41	Deciduous Forest - areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. More than 75% of the tree species shed foliage simultaneously in response to seasonal change.
	42	Evergreen Forest - areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. More than 75% of the tree species maintain their leaves all year. Canopy is never without green foliage.
	43	Mixed Forest - areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. Neither deciduous nor evergreen species are greater than 75% of total tree cover.
Shrubland	51	Dwarf Scrub - Alaska only areas dominated by shrubs less than 20 centimeters tall with shrub canopy typically greater than 20% of total vegetation. This type is often co-associated with grasses, sedges, herbs, and non-vascular vegetation.
	52	Shrub/Scrub - areas dominated by shrubs; less than 5 meters tall with shrub canopy typically greater than 20% of total vegetation. This class includes true shrubs, young trees in an early successional stage or trees stunted from environmental conditions.
Herbaceous	71	Grassland/Herbaceous - areas dominated by graminoid or herbaceous vegetation, generally greater than 80% of total vegetation. These areas are not subject to intensive management such as tilling, but can be utilized for grazing.
	72	Sedge/Herbaceous - Alaska only areas dominated by sedges and forbs, generally greater than 80% of total vegetation. This type can occur with significant other grasses or other grass like plants, and includes sedge tundra, and sedge tussock tundra.
	73	Lichens - Alaska only areas dominated by fruticose or foliose lichens generally greater than 80% of total vegetation.
	74	Moss - Alaska only areas dominated by mosses, generally greater than 80% of total vegetation.
Planted/Cultivated	81	Pasture/Hay - areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle. Pasture/hay vegetation accounts for greater than 20% of total vegetation.
	82	Cultivated Crops - areas used for the production of annual crops, such as corn, soybeans, vegetables, tobacco, and cotton, and also perennial woody crops such as orchards and vineyards. Crop vegetation accounts for greater than 20% of total vegetation. This class also includes all land being actively tilled.
Wetlands	90	Woody Wetlands - areas where forest or shrubland vegetation accounts for greater than 20% of vegetative cover and the soil or substrate is periodically saturated with or covered with water.
		Emergent Herbaceous Wetlands - Areas where perennial herbaceous vegetation accounts for greater than 80% of vegetative cover and the soil or substrate is periodically saturated with or covered with water.

Source: http://www.mrlc.gov/nlcd06_leg.php

Adjusted odds ratios* (OR) for obesity (BMI 30) according to tertiles of selected land characteristics based on 250m and 500m buffers, by population size of census tract, the Sister Study

Table A2

Land cover characteristic	Population Size of Census Tract									
	< 4162					4162 – < 6006				
	% obese	OR	95% CI	% obese	OR	95% CI	% obese	OR	95% CI	6006
G1 (250 buffer)										
Lowest tertile	32.5	1.0		30.0	1.0		30.5	1.0		
Middle tertile	29.4	0.93	0.86 – 1.01	29.3	0.99	0.91 – 1.08	30.1	1.00	0.93 – 1.09	
Upper tertile	27.7	0.93	0.86 – 1.02	27.5	0.97	0.89 – 1.05	28.6	0.98	0.90 – 1.07	
G2 (250 buffer)										
Lowest tertile	33.5	1.0		30.5	1.0		31.1	1.0		
Middle tertile	30.3	0.91	0.84 – 0.99	29.3	0.95	0.88 – 1.04	30.0	0.98	0.90 – 1.07	
Upper tertile	27.0	0.84	0.77 – 0.91	27.4	0.90	0.83 – 0.99	28.5	0.95	0.87 – 1.04	
Impervious (250 buffer)										
Lowest tertile	27.8	1.0		31.1	1.0		28.3	1.0		
Middle tertile	28.4	0.94	0.87 – 1.03	30.0	0.99	0.91 – 1.08	29.3	0.98	0.90 – 1.06	
Upper tertile	34.6	1.19	1.09 – 1.30	28.5	1.11	1.01 – 1.21	31.9	1.08	0.99 – 1.18	
G1 (500 buffer)										
Lowest tertile	31.9	1.0		30.2	1.0		29.9	1.0		
Middle tertile	30.9	1.03	0.95 – 1.12	29.2	0.98	0.90 – 1.07	35.2	1.08	0.99 – 1.18	
Upper tertile	28.2	1.00	0.92 – 1.09	28.0	0.98	0.90 – 1.07	35.1	1.01	0.93 – 1.11	
G2 (500 buffer)										
Lowest tertile	32.8	1.0		36.2	1.0		30.7	1.0		
Middle tertile	31.0	0.97	0.89 – 1.05	33.0	0.92	0.84 – 1.00	30.3	1.00	0.92 – 1.09	
Upper tertile	27.0	0.87	0.80 – 0.95	30.8	0.86	0.78 – 0.94	28.5	0.95	0.87 – 1.04	
Impervious (500 buffer)										
Lowest tertile	27.9	1.0		28.0	1.0		28.5	1.0		
Middle tertile	28.9	0.96	0.88 – 1.05	27.9	0.93	0.86 – 1.02	29.6	0.98	0.90 – 1.06	
Upper tertile	35.7	1.14	1.04 – 1.24	31.3	1.07	0.98 – 1.17	30.5	1.04	0.95 – 1.14	

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* Odds ratios adjusted for age, ethnicity, marital status, population of census tract, and census area

Adjusted odds ratios for participation in physical activity according to tertiles of selected land characteristics based on 250m and 500m buffers, by population size of census tract, the Sister Study

Land cover characteristic	Population Size of Census Tract								
	< 4162			4162 – < 6006			6006		
	Mean MET-hrs	OR	95% CI	Mean MET-hrs	OR	95% CI	Mean MET-hrs	OR	95% CI
G1 (250 buffer)									
Lowest tertile	49.0	1.0		49.5	1.0		48.7	1.0	
Middle tertile	51.0	1.11	1.02 – 1.22	50.5	1.05	0.97 – 1.15	49.9	1.10	1.01 – 1.20
Upper tertile	54.7	1.34	1.23 – 1.46	53.0	1.18	1.08 – 1.29	52.2	1.18	1.08 – 1.29
G2 (250 buffer)									
Lowest tertile	48.8	1.0		49.3	1.0		48.1	1.0	
Middle tertile	51.0	1.16	1.07 – 1.27	50.5	1.10	1.00 – 1.20	49.9	1.10	1.00 – 1.20
Upper tertile	53.8	1.34	1.22 – 1.46	52.6	1.24	1.13 – 1.36	51.9	1.18	1.08 – 1.29
Impervious (250 buffer)									
Lowest tertile	54.8	1.0		53.4	1.0		53.3	1.0	
Middle tertile	51.2	0.82	0.75 – 0.90	50.9	0.86	0.79 – 0.94	50.0	0.82	0.75 – 0.89
Upper tertile	47.5	0.65	0.59 – 0.71	48.0	0.70	0.64 – 0.77	46.7	0.64	0.58 – 0.71
G1 (500 buffer)									
Lowest tertile	48.8	1.0		49.4	1.0		48.4	1.0	
Middle tertile	50.6	1.13	1.04 – 1.24	50.6	1.05	0.96 – 1.15	49.9	1.08	0.98 – 1.18
Upper tertile	54.1	1.32	1.21 – 1.45	52.3	1.13	1.04 – 1.24	51.6	1.16	1.06 – 1.27
G2 (500 buffer)									
Lowest tertile	49.0	1.0		49.4	1.0		48.2	1.0	
Middle tertile	50.9	1.16	1.06 – 1.26	50.7	1.07	0.98 – 1.17	49.5	1.05	0.96 – 1.15
Upper tertile	53.7	1.30	1.18 – 1.42	52.3	1.19	1.08 – 1.30	52.1	1.23	1.12 – 1.36
Impervious (500 buffer)									
Lowest tertile	54.8	1.0		53.3	1.0		53.4	1.0	
Middle tertile	50.4	0.78	0.72 – 0.85	50.9	0.86	0.79 – 0.94	49.7	0.80	0.74 – 0.87
Upper tertile	48.1	0.69	0.63 – 0.75	48.1	0.73	0.66 – 0.80	46.9	0.65	0.59 – 0.72

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The cut-point used for to define those physically active was 67.1 MET-Hours per week (which represented the upper tertile). Odds ratios adjusted for age, ethnicity, marital status, and census area

*

Adjusted odds ratios* (OR) for obesity (BMI ≥ 30) according to tertiles of selected land characteristics based on 250m and 500m buffers, by census region, the Sister Study

Table A4

Land cover characteristic	Census Region							
	Northeast		Midwest		South		West	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
G1 (250 buffer)								
Lowest tertile	1.0		1.0		1.0		1.0	
Middle tertile	1.08	0.96 – 1.22	0.96	0.88 – 1.05	1.05	0.96 – 1.14	0.80	0.72 – 0.90
Upper tertile	0.99	0.88 – 1.12	0.94	0.85 – 1.03	1.06	0.98 – 1.15	0.80	0.72 – 0.90
G2 (250 buffer)								
Lowest tertile	1.0		1.0		1.0		1.0	
Middle tertile	1.09	0.96 – 1.24	0.90	0.83 – 0.98	1.02	0.93 – 1.12	0.87	0.79 – 0.97
Upper tertile	0.91	0.80 – 1.03	0.87	0.79 – 0.96	1.02	0.93 – 1.12	0.74	0.66 – 0.82
Impervious (250 buffer)								
Lowest tertile	1.0		1.0		1.0		1.0	
Middle tertile	1.17	1.04 – 1.32	0.89	0.81 – 0.97	0.98	0.91 – 1.06	0.95	0.83 – 1.08
Upper tertile	1.16	1.03 – 1.31	1.08	1.08 – 1.19	1.03	0.94 – 1.13	1.31	1.16 – 1.47
G1 (500 buffer)								
Lowest tertile	1.0		1.0		1.0		1.0	
Middle tertile	1.18	1.03 – 1.34	1.00	0.92 – 1.09	1.08	0.99 – 1.18	0.93	0.84 – 1.03
Upper tertile	1.12	0.98 – 1.28	0.96	0.87 – 1.06	1.09	1.00 – 1.18	0.83	0.74 – 0.92
G2 (500 buffer)								
Lowest tertile	1.0		1.0		1.0		1.0	
Middle tertile	1.18	1.04 – 1.35	0.92	0.85 – 1.00	1.02	0.93 – 1.13	0.85	0.77 – 0.94
Upper tertile	0.95	0.84 – 1.08	0.84	0.76 – 0.93	1.02	0.94 – 1.12	0.73	0.65 – 0.82
Impervious (500 buffer)								
Lowest tertile	1.0		1.0		1.0		1.0	
Middle tertile	1.15	1.02 – 1.30	0.88	0.81 – 0.97	0.94	0.87 – 1.02	1.00	0.89 – 1.14
Upper tertile	1.11	0.98 – 1.25	1.03	0.93 – 1.13	1.04	0.94 – 1.14	1.25	1.12 – 1.41

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* Odds ratios adjusted for age, ethnicity, marital status, and population of census tract, and census division.

Adjusted odds ratios for participation in physical activity according to tertiles of selected land characteristics based on 250m and 500m buffers, by census region, the Sister Study

Table A5

Land cover characteristic	Census Region							
	Northeast		Midwest		South		West	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
G1 (250 buffer)								
Lowest tertile	1.0		1.0		1.0		1.0	
Middle tertile	1.13	1.00 – 1.29	1.09	0.99 – 1.20	1.02	0.93 – 1.12	1.17	1.05 – 1.30
Upper tertile	1.36	1.20 – 1.54	1.24	1.12 – 1.38	1.09	1.00 – 1.19	1.35	1.22 – 1.50
G2 (250 buffer)								
Lowest tertile	1.0		1.0		1.0		1.0	
Middle tertile	1.12	0.98 – 1.28	1.09	0.99 – 1.19	1.01	0.91 – 1.12	1.26	1.14 – 1.40
Upper tertile	1.30	1.15 – 1.48	1.27	1.15 – 1.41	1.13	1.02 – 1.24	1.42	1.27 – 1.58
Impervious (250 buffer)								
Lowest tertile	1.0		1.0		1.0		1.0	
Middle tertile	0.77	0.68 – 0.87	0.84	0.76 – 0.92	0.87	0.81 – 0.95	0.76	0.68 – 0.86
Upper tertile	0.67	0.59 – 0.76	0.67	0.60 – 0.74	0.70	0.63 – 0.77	0.61	0.55 – 0.68
G1 (500 buffer)								
Lowest tertile	1.0		1.0		1.0		1.0	
Middle tertile	1.06	0.92 – 1.23	1.13	1.03 – 1.24	1.06	0.96 – 1.17	1.09	0.98 – 1.21
Upper tertile	1.30	1.14 – 1.50	1.23	1.11 – 1.36	1.08	0.99 – 1.18	1.30	1.17 – 1.44
G2 (500 buffer)								
Lowest tertile	1.0		1.0		1.0		1.0	
Middle tertile	1.19	1.04 – 1.37	1.06	0.97 – 1.16	0.97	0.88 – 1.08	1.18	1.07 – 1.32
Upper tertile	1.33	1.17 – 1.52	1.26	1.14 – 1.40	1.06	0.96 – 1.17	1.39	1.25 – 1.54
Impervious (500 buffer)								
Lowest tertile	1.0		1.0		1.0		1.0	
Middle tertile	0.79	0.70 – 0.89	0.80	0.73 – 0.88	0.85	0.79 – 0.92	0.74	0.65 – 0.83
Upper tertile	0.64	0.57 – 0.73	0.71	0.64 – 0.78	0.74	0.66 – 0.82	0.63	0.57 – 0.70

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* Odds ratios adjusted for age, ethnicity, marital status, and population of census tract, and census division.

Table A6

Adjusted odds ratios for participation in recreational physical activity according to tertiles of selected land characteristics based on 250m and 500m buffers, by census region, the Sister Study

Land cover characteristic	Place of residence						Overall		
	Rural or small town			Urban or suburban					
	Mean MET-hrs	OR	95% CI	Mean MET-hrs	OR	95% CI	Mean MET-hrs	OR	95% CI
G1 (250 buffer)									
Lowest tertile	40.2	1.0		38.3	1.0		38.8	1.0	
Middle tertile	40.5	0.98	0.90 – 1.07	39.1	1.06	0.99 – 1.13	39.7	1.04	0.98 – 1.09
Upper tertile	42.5	1.12	1.04 – 1.21	40.9	1.18	1.09 – 1.27	42.0	1.16	1.10 – 1.23
G2 (250 buffer)									
Lowest tertile	40.3	1.0		37.8	1.0		38.5	1.0	
Middle tertile	40.5	1.03	0.95 – 1.13	39.0	1.13	1.06 – 1.22	39.7	1.10	1.05 – 1.16
Upper tertile	42.4	1.14	1.05 – 1.24	40.7	1.28	1.18 – 1.38	41.7	1.23	1.16 – 1.30
Impervious (250 buffer)									
Lowest tertile	42.5	1.0		41.5	1.0		42.2	1.0	
Middle tertile	40.7	0.87	0.81 – 0.94	37.3	0.88	0.81 – 0.95	40.1	0.88	0.83 – 0.92
Upper tertile	38.1	0.71	0.65 – 0.78	39.8	0.72	0.66 – 0.79	37.5	0.72	0.68 – 0.76
G1 (500 buffer)									
Lowest tertile	40.3	1.0		38.3	1.0		38.7	1.0	
Middle tertile	40.8	1.02	0.93 – 1.12	39.0	1.04	0.98 – 1.11	39.7	1.04	0.99 – 1.09
Upper tertile	42.0	1.09	1.00 – 1.19	40.3	1.14	1.05 – 1.23	41.4	1.12	1.06 – 1.19
G2 (500 buffer)									
Lowest tertile	40.5	1.0		37.9	1.0		38.6	1.0	
Middle tertile	40.4	1.01	0.93 – 1.10	39.0	1.14	1.06 – 1.27	39.6	1.10	1.04 – 1.16
Upper tertile	42.4	1.12	1.03 – 1.21	40.6	1.27	1.18 – 1.37	41.6	1.22	1.15 – 1.28
Impervious (500 buffer)									
Lowest tertile	42.5	1.0		41.2	1.0		42.1	1.0	
Middle tertile	40.4	0.84	0.78 – 0.91	39.6	0.87	0.80 – 0.95	39.9	0.86	0.81 – 0.91
Upper tertile	38.5	0.74	0.67 – 0.81	37.6	0.75	0.69 – 0.82	37.8	0.74	0.70 – 0.79

* The cut-point used for to define those physically active was 53.5 MET-Hours per week (which represented the upper quartile of total METs expended in a week for all activities less those spent on chores. Odds ratios adjusted for age, ethnicity, marital status, population of census tract, and census area