



Short Report

Built environment and change in body mass index in older women

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ABSTRACT

We examined the association between neighborhood walkability and changes in body mass index (BMI) and obesity during a 14-year follow-up among community-dwelling women 71 years of age on average ($n=1008$ representing 253 census tracts). Multilevel models predicted change in BMI or incidence of obesity controlling for age, marital status, number of incident comorbidities, self rated health, and death, over a follow-up of 14 years. Among non-sedentary older women, average BMI remained stable ($\beta=0.007$, $p=0.291$); risk of becoming obese increased 3% per year (odds ratio=1.03, 95% CI 1.01, 1.05). Walkability was not associated with BMI or risk of obesity. Future research should consider additional neighborhood characteristics relevant to older adults, such as proximity to retail, public transit, or parks.

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1. Introduction

Approximately 35% of the older American population (60 years and older) is overweight or obese (Flegal et al., 2010). Older women are more likely to be obese compared to older men, 13.3% (95% CI: 11.0–15.5) versus 11.6% (95% CI: 9.3–13.8) (Flegal et al., 2010). The prevalence of obesity in adults aged 60 and over increased about 35% between 1990 and 2000 (Arterburn et al., 2004; Villareal et al., 2005); since 2000 the increase has stabilized in older women although not in older men (Flegal et al., 2010).

Research indicates that urban sprawl, defined by low-density, low street connectivity, and few walking destinations, is associated with obesity in adults (Frank et al., 2004; Lopez, 2004; Scott et al., 2009; Vandegrift and Yoked, 2004). However, few studies have evaluated neighborhood walkability characteristics and obesity in older adults and those results are mixed (Berke et al., 2007; Grafova et al., 2008; King et al., 2011; Lee et al., 2009; Li et al., 2009, 2008). Only three studies of older adults have investigated body size longitudinally (King et al., 2011; Lee et al., 2009; Li et al., 2009).

Lawton and Nahemow (1973) proposed an ecological model of human behavior and function known as the theory of Environmental Press. Lawton proposed that behavior is contingent on the dynamic interplay between the competence of the individual, and the demands placed on the individual by their environment. Focusing explicitly on the residential environment, Glass and Balfour (2003) proposed a model of neighborhood effects on

aging that extends Lawton's theory of environmental press to incorporate the concept of environmental buoying. This model suggests that neighborhood environment can potentially mitigate the impact of diminishing competence on behavior. Based on this model, a neighborhood with greater walkability would allow older women to remain active as they age and thus maintain a healthy weight. In prior research we established that neighborhood walkability was positively associated with number of blocks walked among non-sedentary women at baseline (Michael et al., 2011). Thus, we tested the hypothesis that living in a neighborhood characterized by greater neighborhood walkability reduces the risk of becoming obese or increasing BMI among non-sedentary older women independent of known risk factors and health behaviors using longitudinal data from The Study of Osteoporotic Fractures (SOF) from the Portland, Oregon metropolitan area (1986–2004) (Walsh et al., 2001). Regional and local planning policies were put into place during this period to limit sprawl and enhance non-motorized transit (Chapman and Lund, 2004).

2. Methods

We restricted our analysis to the 1382 SOF Portland participants recruited at baseline who reported walking outside the house for exercise or routine activities. We restricted our analysis to non-sedentary women because we hypothesized that physical sedentarism modifies the relationship between neighborhood walkability and BMI and obesity. Given that only nonsedentary women interact with their neighborhood environment for walking,

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we would not expect an association among sedentary women. While all women reported walking, the variability in the average number of blocks walked per week among these non-sedentary women was large (median=7 blocks, range 1–96) (using the median block length in the study area, the average women walked slightly more than 2 miles per week). We excluded women who did not attend a full clinic visit at visit 2, did not have at least one additional visit during follow-up, could not be geocoded (e.g., post office boxes), or had missing information on covariates (*n*=374). The second visit (1990) was selected to optimize the temporal match between participant data and data on the built environment. Included women (*n*=1008) were significantly younger (71 years versus 73), better educated (13 years versus 12 years), and more likely to report manual labor employment (36% versus 22%) compared to excluded women (*n*=374) (*p* < 0.05). Women were assessed for outcomes of interest during research clinic visits every two to four years until 2004. Of the 1008 women included, 902 (89%) of the women contributed at least 3 years of follow-up, 642 (64%) contributed at least 8 years of follow-up, and 354 (35%) contributed 14 years of follow-up. Similar to other cohorts of older adults, death was the primary reason for loss to follow-up (Hardy et al., 2009). Compared to women who were alive at the end of the study (*n*=458), women who died (*n*=550) were older at baseline (mean age: 73 years versus 70 years), more likely to have two or more comorbidities (23.8% versus 13.5%) and more likely to report fair, poor, or very poor self-rated health (14.6% versus 9.6%). Women who died were no different with regard to baseline BMI (26.0 versus 26.2), neighborhood socioeconomic status, or measures of walkability. The protocol was approved by the Institutional Review Boards (IRB) for Kaiser Permanente Northwest and Drexel University.

Neighborhood-level data were joined to participant records by census tract (253 census tracts included). Data from the 1990 U.S. Census were used to assess neighborhood socioeconomic status for each census tract by summing z-scores for six variables (Diez Roux et al., 2001).

As in prior research, greater street connectivity and street density were used as indicators of more neighborhood walkability (Berrigan

et al., 2010; Hess et al., 1999; Saelens and Papadopoulos, 2008; Saelens et al., 2003). Measures were obtained from the 1990 Topologically Integrated Geographic Encoding and Referencing system (TIGER). Street connectivity was assessed using alpha (ratio of the actual number of complete loops to the maximum number of possible loops given the number of intersections), and gamma (ratio of actual street segments to maximum possible given the number of intersections). Higher values indicate greater walkability. Street density was assessed using block size (feet²) and block length (feet). Lower values indicate greater walkability. Results for the two measures of street connectivity were the same so only one (alpha) is displayed in tables; similarly one measure of street density (block length) is displayed.

Body mass index (BMI, kg/m²) was computed based on weight and height measured in the clinic using standardized procedures at baseline and five follow-up visits. Women were classified as obese (BMI > 29.9) at each time point. Data on potential confounders – including age, educational attainment, and self-reported history of years of manual labor – were obtained at the first visit. History of chronic conditions and self-reported health were assessed at baseline and updated at all subsequent visits.

Using all available data at multiple time points for each individual, we estimated an unconditional growth model to determine trajectories of BMI and obesity individuals across time. In subsequent models, we examined how trajectories varied by neighborhood walkability, adjusting for factors that explained the between-person variation in the intercept and the slope of change over time. A two-level logit model was used for obesity. Analyses were conducted in HLM 6 (Raudenbush, 2004). A two-tailed alpha of .05 was used to assess statistical significance.

3. Results and discussion

At baseline, obese women were slightly younger and less educated; the probability of obesity did not vary by neighborhood walkability (Table 1). Average BMI did not change during 14-years of follow-up (β =0.007, *p*=0.291). The risk of becoming obese

Table 1
Summary of selected baseline characteristics of 1008 Study of Osteoporotic Fractures participants who lived in the Portland, Oregon metropolitan area at baseline, 1990–2004, mean (range) or percent.

Characteristics	Overall	Not obese at baseline (BMI ≤ 29.9)	Obese at baseline (BMI > 29.9)	P-value ^a
	N=1008	N=823	N=185	
Individual				
Age (years)	71 (65, 96)	72 (65, 96)	70 (65, 85)	0.0007
Education (years)	13 (1, 19)	13 (1, 19)	12 (3, 19)	0.0097
History of manual labor > 10 years (%)	36%	35%	42%	0.2035
2+ comorbidities (%)	18%	17%	22%	0.0757
Self-reported health fair/poor/very poor (%)	12%	12%	13%	0.6195
Neighborhood				
Neighborhood socioeconomic status score ^b	0.3 (−15, 13)	0.5 (−15, 13)	−0.5 (−7, 13)	0.0022
Alpha ^c	0.19 (0.02, 0.40)	0.19 (0.02, 0.40)	0.20 (0.04, 0.39)	0.3650
Gamma ^d	0.46 (0.35, 0.60)	0.46 (0.35, 0.60)	0.46 (0.36, 0.59)	0.3604
Area of street blocks (feet ²)	1,422,689 (68,620, 60,416,712)	1,474,894 (68,620, 60,416,712)	1,190,448 (93,268, 21,082,258)	0.2721
Block length (feet)	3,217 (1,047, 28,261)	3,262 (1,047, 28,261)	3,016 (1,175, 14,436)	0.1699

BMI: Body mass index.

^a P-value tests difference in characteristics by obesity status at baseline.

^b Neighborhood socioeconomic score for each census tract was assessed by summing z-scores for six U.S. Census variables: median household income; percentage of households with interest, dividend, or rental income; median value of housing units; percentage of persons 25 or over having completed high school; percentage of persons 25 or over having completed college; and percentage of persons in executive, managerial, or professional specialty occupations.

^c Alpha is the ratio of actual number of complete loops to the maximum number of possible loops given the number of intersections and is used to evaluate the number of alternate routes to travel from one location to another within a neighborhood. Alpha can range from 0 to 1; areas with higher complexity and connectivity have higher alpha values.

^d Gamma is the ratio of the actual number of street segments to maximum possible given the number of intersections. Gamma can range from 0 to 1; areas with streets in a grid pattern will have high gamma values.

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