Published in final edited form as:

Health Place. 2013 July ; 22: 7–10. doi:10.1016/j.healthplace.2013.02.001.

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 ($n = 1,008$ 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 percent 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.

Keywords

built environment; walkability; obesity; older adults

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 percent (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; Li et al., 2008). Only three studies of older adults have investigated body size longitudinally (King et al., 2011; Lee et al., 2009; Li et al., 2009).

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Conflict of Interest statement

The authors declare that there are no conflicts of interest.

Lawton (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, Balfour and Glass (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).

Methods

We restricted our analysis to the 1,382 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, 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 to 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 vs 73), better educated (13 years vs 12 years), and more likely to report manual labor employment (36% vs 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.

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 ($\beta = 0.007$, $p = 0.291$). The risk of becoming obese increased 3 percent each year (odds ratio = 1.03, 95% CI 1.01, 1.05) (Table 2). Neighborhood walkability was not associated with BMI trajectory or risk of developing obesity during follow-up (Table 2).

In this prospective study of non-sedentary older women, neighborhood walkability did not explain change in BMI or obesity during follow-up. Our results are consistent with a longitudinal study in older men (mean age 70 years) reporting no direct association of built environment with 5-year change in BMI (Lee et al., 2009). Li and colleagues reported no overall association in a population aged 62 years on average. However, they reported a significant interaction between physical activity and neighborhood walkability indicating that living in walkable neighborhoods was associated with a decrease in measured weight and waist circumference during 1-year follow-up among people who engaged in vigorous physical activity (Li et al., 2009). King and colleagues found that older adults (mean age = 74.4 years) living in higher walkable neighborhoods had lower self-reported BMI (mean = 26.2) compared to those in lower walkable neighborhoods (mean = 27.1) (King et al., 2011). The difference in findings may relate to the advanced age of the women in SOF, averaging 85.5 years of age by the end of follow-up. Weight and BMI generally increase until age 60 and then remain stable (Villareal et al., 2005). Modest levels of physical activity may attenuate aging-related weight loss (Dziura et al., 2004). Neighborhood walkability may have a greater impact on maintaining normal BMI in older populations. Our results

contribute to the small number of longitudinal studies evaluating built environment and obesity (Feng et al., 2010).

Our study has several limitations. We included street connectivity and street density as measures of neighborhood walkability similar to previous studies (Lee et al., 2009; Li et al., 2009); other aspects of the built environment such as access to green space or retail were not assessed. Second, we did not assess changes in land-use; given the land-use policies in the Portland metropolitan region to reduce sprawl (Chapman and Lund, 2004) improvements were likely. Third, due to limitations of the data, we were unable to account for factors that might influence the extent and degree to which women interact with their residential neighborhood environment, such as type of residence and use of transportation. Fourth, our analysis is limited by reliance on BMI to assess fatness; other measures of body composition, such as waist circumference, are preferred for older adults (Baumgartner, 2000; Villareal et al., 2005). Fifth, missing data due to death is a limitation but one that is not uncommon in studies of older cohorts with long follow-up as in the SOF (Hardy et al., 2009). Excluding women who died during follow-up from the study sample would likely result in biased estimates. The model used in this study allowed us to include participants as long as they have data on predictors and at least one outcome assessment. The assumption inherent in this modeling approach is that the trajectory for BMI after death was similar to the trajectory among participants who do not die. While it is not possible to empirically test this assumption, compared to women who remained in the analysis, the women who died were not statistically significantly different with regard to baseline BMI or neighborhood characteristics. Sixth, analyses were restricted to older women living in a single geographic area who reported walking outside the home, which may limit the generalizability of our results. However, this study has important strengths, including its prospective design, focus on an under-studied and high risk population, and the ability to consider neighborhood and individual level socioeconomic status (Balfour and Kaplan, 2002; Robert and Li, 2001).

Conclusion

Additional prospective studies that include other aspects of the built environment, evaluate change in built environment, and consider person-environment interactions are essential for establishing whether policy approaches to improving the built environment hold promise for preventing obesity for older adults.

Acknowledgments

Data on street connectivity were obtained from the Rand Center for Population Health and Disparities (CPHD). The data were funded by grant 1-P50-ES012383 from the National Institute of Environmental Health Sciences. For more information on CPHD, go to <http://www.rand.org/health/centers/pophealth/index.html>.

The authors acknowledge the contribution of the study participants and the support of the SOF staff and investigators.

Funding

This work was supported by a grant from the National Institutes of Aging (AG028254). Study infrastructure, data collection, and follow-up of study participants were supported by the National Institute of Aging and National Institute of Arthritis and Musculoskeletal and Skin Diseases (R01 AG005407, R01 AR35582, R01 AR35583, R01 AR35584, R01 AG005394, R01 AG027574, and R01 AG027576).

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Table 1

Summary of selected baseline characteristics of 1,008 Study of Osteoporotic Fractures participants who lived in the Portland, Oregon metropolitan area at baseline, 1990–2004, mean (range) or percent

Characteristics	Overall N = 1008	Not obese at baseline (BMI < 29.9) N = 823	Obese at baseline (BMI ≥ 29.9) N = 185	P-value ^a
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)	1422689 (68620, 60416712)	1474894 (68620, 60416712)	1190448 (93268, 21082258)	0.2721
Block length (feet)	3217 (1047, 28261)	3262 (1047, 28261)	3016 (1175, 14436)	0.1699

BMI: Body Mass Index

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

^bNeighborhood 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.

^cAlpha 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.

^dGamma 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.

Table 2

Growth model^a of BMI and obesity: The Study of Osteoporotic Fractures Portland, Oregon metropolitan area, 1990–2004 (n = 1008)

	BMI (kg/m ²)		Obese (BMI > 29.9)	
	β	95% CI	Odds ratio	95% CI
Time ^b	0.007	-.01, .02	1.03	1.01, 1.05
Street connectivity * time	-0.07	-0.21, 0.07	0.97	0.85, 1.12
Block length * time	-0.001	-0.013, 0.011	1.00	0.98, 1.02

Results statistically significant at the alpha less than 5% are in bold. BMI: body mass index; kg: kilogram; m²: meters squared; CI: confidence interval

^a All parameter entries are maximum likelihood estimates fitted using HLM 6. Effects reported as regression coefficients or odds ratios with associated 95% confidence intervals. Models controlled for baseline age, marital status, average number of incident comorbidities, and average self-rated health during follow-up.

^b Time assesses the change in BMI or odds of obesity across the 14-year follow-up; the estimate provides the average one-year change.