Change in Walking and Body Mass Index Following Residential Relocation: The Multi-Ethnic Study of Atherosclerosis

Jana A. Hirsch, MES, Ana V. Diez Roux, MD, PhD, Kari A. Moore, MS, Kelly R. Evenson, PhD, and Daniel A. Rodriguez, PhD

Objectives. We investigated whether moving to neighborhoods with closer proximity of destinations and greater street connectivity was associated with more walking, a greater probability of meeting the "Every Body Walk!" campaign goals (≥150 minutes/week of walking), and reductions in body mass index (BMI).

Methods. We linked longitudinal data from 701 participants, who moved between 2 waves of the Multi-Ethnic Study of Atherosclerosis (2004–2012), to a neighborhood walkability measure (Street Smart Walk Score) for each residential location. We used fixed-effects models to estimate if changes in walkability resulting from relocation were associated with simultaneous changes in walking behaviors and BMI.

Results. Moving to a location with a 10-point higher Walk Score was associated with a 16.04 minutes per week (95% confidence interval [CI] = 5.13, 29.96) increase in transport walking, 11% higher odds of meeting Every Body Walk! goals through transport walking (adjusted odds ratio = 1.11; 95% CI = 1.02, 1.21), and a 0.06 kilogram per meters squared (95% CI = –0.12, –0.01) reduction in BMI. Change in walkability was not associated with change in leisure walking.

Conclusions. Our findings illustrated the potential for neighborhood infrastructure to support health-enhancing behaviors and overall health of people in the United States. (*Am J Public Health.* 2014;104:e49–e56. doi:10.2105/AJPH.2013.301773)

A recent report by the National Academy of Sciences showed that people in the United States live shorter lives and have consistently worse health than people in other high-income countries.[1] A high burden of obesity, diabetes, and cardiovascular disease was identified as contributing to the United States' health disadvantages.[1] The report encouraged researchers and policymakers to identify the environmental factors that might be contributing to a high prevalence of these conditions in the United States, including the extent to which environmental conditions common in many communities shape the behavioral antecedents of cardiovascular disease.

Although international comparisons on levels of physical activity across countries are often inconclusive because of measurement differences,[2–4] the United States differs starkly from many other high-income countries in the extent to which residents engage in active travel, such as through walking or bicycling. For example, the overall bicycle share of work trips is currently 3 times higher in Canada than in the United States,[5] and the percentage of total trips by bicycle and foot are lower in the United States than in Ireland, France, Great Britain, Norway, Denmark, Finland, Germany, Sweden, Spain, Netherlands, and Switzerland.[6] Research indicates that walking is the most common leisure activity performed by adults and can be an important component of physical activity.[7–10] Consistent with this evidence, in April 2013, the US Surgeon General announced the "Every Body Walk!" campaign (http://www.everybodywalk.org) to promote walking as a simple and effective form of physical activity.

The success of campaigns to promote walking is likely to be strongly influenced by whether environmental conditions make walking feasible and safe.[11–13] In 2 international studies across 11 countries, fewer US participants reported having many shops within walking distance or transit stops within 10 to 15 minutes of their home than their international peers.[13,14] A comparison of global cities between 1980 and 1990 also revealed that cities in the United States have accelerated dramatically in their dependence on the automobile, with little improvements in transit use,[15] and that per capita automobile use and average gasoline consumption in the United States are 2 times higher than those in Australian cities, 4 times higher than those in European cities, and 10 times higher than those in Asian cities.[15,16] Additional disparities within the United States exist, with rates of walking and bicycling differing across various cities and states[6]; counties with high poverty and low education are less likely to implement local pedestrian- and bicycle-related projects using federal transportation funding.[17]

Although several reviews indicate that measures of neighborhood walkability (such as self-reported walkability, accessibility to destinations, and street connectivity) are cross-sectionally associated with walking,[18–20] physical activity,[18,21–23] and body mass index (BMI),[21,24,25] these studies cannot be used to draw policy-relevant causal inferences partly because of the impossibility of determining the temporal relation between neighborhood walkability and walking behavior.[18–25] Studies that examine how changes in environmental conditions are related to changes in behaviors are therefore needed.

A major challenge in estimating the causal effects of environments on health is accounting for the possibility that persons with predispositions to certain behaviors choose to live in certain types of neighborhoods.[26–31] Randomized studies of environmental interventions (such as increasing walkability) are logistically challenging and unlikely to be feasible on a large scale. Hence, reliance on rigorous use of observational data is necessary. Very few cohort studies have longitudinal assessments of changes in the environment to allow investigations of associations between neighborhood change and health-related outcomes.[32–34] Because built environments often change slowly, the impact can be practically examined by investigating changes occurring as part of residential relocation.[18,30,35–45] Although longitudinal studies do not completely overcome the effect of self-selection on the associations observed,[18] they have the potential to improve causal evidence, especially if they investigate the impact of changes in neighborhood conditions on changes in health.

We used data from a population-based and multiethnic longitudinal study conducted in 6 diverse areas of the United States to investigate whether changes in environmental features associated with residential relocation were linked to simultaneous changes in walking for transport or for leisure in adults. The presence of such a relationship would provide strong support for consideration of land use, development, and transportation policies as levers to increase physical activity in the United States. More generally, it would lend greater credence to the notion that at least some of the US health disadvantages could be the unintended consequence of a range of policy and development decisions that engineered physically active lifestyles, such as walking, out of the lives of some US adults.

METHODS

Our sample consisted of participants from the Multi-Ethnic Study of Atherosclerosis (MESA), a study of 6814 US adults aged 45 to 84 years without clinical cardiovascular disease at baseline.[46] Participants were recruited between 2000 and 2002 from 6 study sites (Baltimore, MD; Chicago, IL; Forsyth County, NC; Los Angeles, CA; New York, NY; and St. Paul, MN). After a baseline examination, participants attended 4 additional follow-up examinations. Of 4592 participants who completed both examination 3 (January 2004–September 2005) and examination 5 (April 2010–February 2012), 934 moved between both examinations and were eligible for these analyses. An additional 233 were excluded because of missing data in at least 1 examination or because they did not give consent to participate in the Neighborhood Ancillary Study, leaving 701 participants for analyses.

Exposure Measure

The extent to which the environment around a person's residence was conducive to walking was assessed using the Walk Score.[47] The Walk Score has been associated with both subjective and objective measures of walkability,[48–52] as well as with walking in cross-sectional analyses.[53–56] The Walk Score algorithm produces scores from 0 to 100 (higher scores indicating better walkability), based on distance to various categories of amenities (e.g., restaurants, shopping, schools, parks, and entertainment) weighted based on importance to walkability and summed. Scores are then adjusted for street network characteristics, such that areas with low intersection density and high block length receive lower scores.[57] The Street Smart Walk Score used in these analyses utilizes network distances by following the streets to amenities and allows for multiple amenities within each category to better capture depth of choice.[57] Because historical measures were not available, Walk Score measures created in May 2012 were linked to participants' street addresses between 2004 and 2012.

Outcome Measures

An interviewer-administered questionnaire adapted from the Cross-Cultural Activity Participation Study[58,59] was used to assess physical activity. The questionnaire was developed using extensive qualitative research[60] and has acceptable test-retest reliability and validity among a sample of women.[61] Two types of walking were assessed: walking for transport (e.g., walking to get to places such as to the bus, car, work, or store) and for leisure (e.g., walking for leisure, pleasure, social reasons, during work breaks, and with the dog). For each type of walking, participants were asked whether they engaged in that activity during a typical week in the past month, how many days per week, and how many minutes per day they did that activity. Each type of walking was examined as a continuous variable and dichotomized using the cutoff of meeting "Every Body Walk!" campaign goals ($\geq$150 minutes/week of walking).

BMI was calculated as measured weight in kilograms divided by measured height in meters squared. Categorical analyses were done using the World Health Organization classification system[62] of normal or underweight BMI ($<$25 kg/m^2), grade 1 overweight (25–29.9 kg/m^2), grade 2 overweight (30–39.9 kg/m^2), and grade 3 overweight ($\geq$40 kg/m^2).

Covariates

We obtained information on age, race/ethnicity, education, income, and working status by interviewer-administered questionnaire. Race/ethnicity was classified as Hispanic, non-Hispanic White, non-Hispanic Chinese, and non-Hispanic Black. Participants selected their education from 8 categories that were collapsed into 3 categories: less than high school, high school diploma or general equivalency diploma but less than college, and college degree or higher. Participants selected combined family income from 14 categories, and continuous income in US dollars was assigned as the midpoint of the selected category. Working status was categorized from 10 categories of current occupations as working at least part-time or not (including employed on leave, unemployed, and retired). Current marital status was self-reported and then dichotomized as "currently married or living with a partner" or "other" (including widowed, divorced, separated, and never married).

Participants were asked to rate their health compared with others their age as better, same, or worse. Arthritis was measured as having an arthritis flare-up in the past 2 weeks. Cancer diagnosis was determined as having a hospitalization because of cancer based on *International Classification of Diseases, Ninth Revision* code[63] or self-reported cancer at any time before the examination. Seasons were classified as winter (January–March), spring (April–June), summer (July–September), and fall (October–December).

Statistical Analyses

Descriptive analyses contrasted movers and nonmovers and compared selected characteristics across tertiles of change in Walk Score. We used the χ^2 test, *t*-test, or analysis of variance (ANOVA) to test for statistically significant differences ($P < .05$) across categories, as appropriate.

We used fixed-effects models[64] to estimate associations of within-person change in Walk Score with within-person changes in walking or BMI. This approach capitalized on within-person variability in exposure to estimate associations.[64] These models were adjusted only for time-varying covariates (age, income, working status, marital status, self-reported health, arthritis, cancer diagnosis, and season) because fixed-effects models tightly controlled for time-invariant characteristics. Additional models further adjusted for the other 2 time-varying outcomes (e.g., models for BMI were further adjusted for changes in leisure and transport walking). Naïve and multilevel marginal models were explored in sensitivity analyses; results were consistent and are not presented. All analyses were conducted in 2013 using SAS version 9.2 (Cary, NC).

RESULTS

The time between the 2 MESA examinations (examinations 3 and 5) ranged from 5.1 to 7.7 years, with a mean of 6.3 years (SD 0.4 years). Participants' age at the first time point ranged from 48 to 87 years, with an overall mean of 61.8 years (SD 9.3 years; Table 1). More than half (52.4%) of the participants were women. Participants' initial Walk Score ranged from 0 to 100 with a mean of 57.7 (SD = 30.6), and they moved to areas with changes ranging from 99 points lower to 93 points higher, with an mean of change of –7.7 (SD = 31.5) between both examinations.

Compared with the nonmoving individuals excluded from these analyses, movers were more likely to be Non-Hispanic Chinese or Hispanic, currently working, have a lower initial income, and be less likely to be currently married ($P < .05$). No significant differences between movers and nonmovers were found for education, self-reported health, arthritis in the past 2 weeks, initial and change in levels of walking or BMI, or initial Walk Score (data not shown).

Table 2 shows selected characteristics of participants according to tertiles of the change in Walk Score experienced as a result of residential relocation. Participants in tertile 1 had a mean decrease in Walk Score of 41.1 points (SD = 21.1), tertile 2 had a mean decrease of 5 points (SD 5.4), and tertile 3 had a mean increase of 22.8 points (SD = 20.3). Individuals who had the most negative change in walkability were slightly younger, had a higher initial income, were more likely to be currently working at examination 3 or start working between examinations 3 and 5, had lower initial levels of leisure walking, and had much higher initial Walk Scores. A more positive change in walkability score between examinations 3 and 5 was associated with greater increases in transport walking and with decreases in BMI. Similar patterns were observed when change in the walkability index

TABLE 1—Selected Characteristics of Participants (n = 701): Multi-Ethnic Study of Atherosclerosis at Baseline (Examination 3, January 2004–September 2005) and Follow-Up (Examination 5, April 2010–February 2012), United States

Characteristics	Baseline, Mean (SD) or %	Follow-Up, Mean (SD) or %
Age, y	61.8 (9.3)	68.1 (9.3)
Female	52.4	. . .[a]
Race/ethnicity		
Non-Hispanic White	36.5	. . .[a]
Non-Hispanic Chinese	17.1	. . .[a]
Non-Hispanic Black	23.7	. . .[a]
Hispanic	22.7	. . .[a]
Education		
≤ high school/GED	30.4	. . .[a]
Some college, technical/associates	27.8	. . .[a]
≥ college	41.8	. . .[a]
Income, in thousands	50.4 (35.0)	49.7 (35.6)
Currently married	58.9	54.1
Currently working	61.2	47.2
Health compared with others		
Better	58.6	58.9
Same	37.0	35.1
Worse	4.4	6.0
Arthritis in the past 2 wk	12.4	17.3
Cancer diagnosis	9.3	14.6
Transport walking		
Mean (min/wk)	237.1 (358.3)	306.5 (436.4)
Enough to meet Every Body Walk! goals[b]	43.1	50.6
Leisure walking		
Mean (min/wk)	181.4 (298.3)	238.4 (367.4)
Enough to meet Every Body Walk! goals[b]	36.5	45.4
BMI, kg/m^2		
Mean (SD)	28.2 (5.5)	28.4 (5.6)
Normal or underweight[c] (< 25 kg/m^2)	31.1	29.2
Grade 1 overweight[c] (25–29.9 kg/m^2)	36.5	37.7
Grade 2 overweight[c] (30–39.9 kg/m^2)	29.4	30.0
Grade 3 overweight[c] (≥ 40.0 kg/m^2)	3.0	3.1
Walk Score	57.7 (30.6)	50.0 (31.5)

Note. BMI = body mass index; GED =general equivalency diploma; Walk Score = Street Smart Walk Score from Front Seat Management, LLC.[47]
[a]These are time-invariant variables, percentages are the same between the 2 examinations.
[b]Meeting Every Body Walk! goals defined by ≥ 150 min/week.
[c]BMI categorized using World Health Organization categories.

TABLE 2—Selected Characteristics of Participants by Tertile of Change in Walkability: Multi-Ethnic Study of Atherosclerosis at Baseline (Examination 3, January 2004–September 2005) and Follow-Up (Examination 5, April 2010–February 2012), United States

	Change in Walk Score			
Characteristics	Tertile 1[a] (n = 236)	Tertile 2 (n = 227)	Tertile 3 (n = 238)	*P*[b]
Age, y, mean (SD)	60.7 (9.4)	62.2 (9.1)	62.5 (9.4)	.1
Female, %	55.1	51.1	50.8	.59
Race/ethnicity, %				.64
Non-Hispanic White	39.0	35.7	34.9	
Non-Hispanic Chinese	17.4	15.4	18.5	
Non-Hispanic Black	24.6	22.5	24.0	
Hispanic	19.1	26.4	22.7	
Education, %				.28
≤ high school/GED	25.4	34.4	31.5	
Some college, technical/associates	28.4	27.3	27.7	
≥ college	46.2	38.3	40.8	
Initial levels (exam 3)				
Income, in thousands, mean (SD)	54.9 (35.7)	47.8 (34.4)	48.2 (34.6)	.05
Currently married, %	62.7	57.3	56.7	.34
Currently working, %	68.2	55.1	60.1	.01
Health compared with others, %				.25
Better	58.5	58.2	59.2	
Same	36.4	35.7	38.7	
Worse	5.1	6.2	2.1	
Arthritis in the past 2 wk, %	13.1	13.2	10.9	.69
Cancer diagnosis, %	8.9	10.6	8.4	.72
Transport walking				
Mean (SD), min/wk	249.1 (372.2)	246.6 (374.1)	216.1 (328.2)	.16
Median (interquartile range), min/wk	120.0 (280.0)	120.0 (280.0)	105.0 (210.0)	
Enough to meet Every Body Walk! goals,[c] %	45.8	44.1	39.5	.36
Leisure walking				
Mean (SD), min/wk	158.8 (273.6)	186.0 (293.9)	199.4 (324.6)	.08
Median (interquartile range), min/wk	60.0 (210.0)	120.0 (225.0)	97.5 (240.0)	
Enough to meet Every Body Walk! goals,[c] %	29.7	40.1	39.9	.03
BMI, kg/m^2				.69
Mean (SD)	28.3 (5.6)	28.0 (5.4)	28.3 (5.6)	.77
Normal or underweight[d] (< 25), %	31.4	33.9	28.2	
Grade 1 overweight[d] (25-29.9), %	36.0	35.2	38.2	
Grade 2 overweight[d] (30-39.9), %	28.4	28.2	31.5	
Grade 3 overweight[d] (≥ 40.0), %	4.2	2.6	2.1	
Walk Score, mean (SD)				
Change (between baseline and follow-up)	69.8 (21.7)	62.8 (31.6)	40.7 (30.0)	< .001
Time between exams	6.4 (0.4)	6.3 (0.4)	6.3 (0.3)	.01
Change in income, in thousands, mean (SD)	–1.1 (23.9)	1.2 (26.4)	–1.9 (23.0)	.38
Currently married, %				.18
No longer married[e]	7.2	11.5	12.2	
New marriage[e]	3.8	6.6	5.9	

Continued

was categorized into quartiles rather than tertiles.

Moving to a location with a 10-point higher Walk Score increased transport walking levels by 17.51 minutes per week (95% confidence interval [CI] = 5.96, 29.06), and increased odds of meeting "Every Body Walk!" goals through transport walking by 11% (adjusted odds ratio [AOR] = 1.11; 95% CI = 1.02, 1.21; Table 3). The association between walkability and amount of transport walking was slightly attenuated (16.04 min/week; 95% CI = 5.13, 26.96) or did not change at all (AOR = 1.11; 95% CI = 1.02, 1.21) when adjusted for change in BMI and leisure walking. By contrast, a change in Walk Score was not associated with changes in leisure walking.

Moving to an area with a 10-point higher Walk Score was associated with 0.06 lower BMI (95% CI = –0.12, –0.01), after accounting for changes in both transport and leisure walking. This is equivalent to 0.36 pounds less for an average woman (164.1 cm) and 0.42 pounds less for an average man (178.2 cm). No association was seen between change in Walk Score and categories of BMI.

DISCUSSION

Moving to an area with higher walkability was associated with an increase in transport walking and a decrease in BMI in this multicity and multiethnic sample. There was no association between changes in walkability and changes in leisure walking. Associations persisted after controlling for observed time-varying covariates and all observed and unobserved time-invariant covariates.

The association between change in walkability and change in transport walking extended previous research that showed that living in a more highly walkable neighborhood helped individuals to maintain or increase walking levels over time.[65–68] In sensitivity analyses, there were no statistically significant differences in the effect of change in walkability on change in walking by length of time in the new residence (data not shown). This might indicate that the effect of moving to more walkable neighborhoods did not diminish or increase over time. The increase in transport walking after moving to a more supportive environment was concordant with previous

TABLE 2—*Continued*

Currently working, %				.04
Stopped working[e]	19.9	11.9	20.2	
Started working[e]	4.7	3.5	2.1	
Health Compared with others,[f] %				.86
Declining health	22.6	25.4	24.2	
Increased health	27.1	27.0	31.5	
Arthritis in the past 2 wk, %				.91
No longer have flare-up	6.8	7.5	5.9	
New flare-up	11.9	12.3	10.5	
New cancer diagnosis, %	4.2	5.3	6.3	.6
Change in transport walking, min/wk				
Mean (SD)	−9.3 (460.9)	128.5 (533.3)	91.2 (462.2)	.007
Median, interquartile range	−30.0 (257.5)	0.0 (305.0)	30.0 (285.0)	
Change in leisure walking, min/wk				
Mean (SD)	37.4 (361.5)	87.9 (420.9)	46.8 (417.7)	.36
Median (interquartile range)	7.5 (210.0)	0.0 (240.0)	0.0 (180.0)	
Change in BMI, kg/m^2, mean (SD)	0.5 (2.2)	0.2 (1.9)	−0.1 (2.6)	.01
Change in Walk Score, mean (SD)	−41.1 (21.1)	−5.0 (5.4)	22.8 (20.3)	. . .[g]

Note. BMI = body mass index; GED = general equivalency diploma; Walk Score = Street Smart Walk Score.[47]
[a]Tertile 1 defined as Walk Score change ≤ −16; tertile 2 defined as Walk Score change > −16, and ≤ 1; tertile 3 defined as Walk Score change > 1.
[b]*P* value from the χ^2 or Fisher exact test for categorical variables and appropriate analysis of variance or Kruskal–Wallis for continuous variables across tertiles of change in Walk Score.
[c]Meeting Every Body Walk! goals defined by ≥ 150 min/week.
[d]BMI categorized using World Health Organization categories.
[e]Percentage for change in marriage and working status are over the entire sample.
[f]Declining health measured as reporting a lower category of health compared with others at follow-up than baseline (going from “better” to “same” or “worse” or going from “same” to “worse”); increasing health measured as reporting a higher category of health compared with others at follow-up than baseline (going from “worse” to “same” or “better” or going from “same” to “better”).
[g]Did not compare across tertiles because this was used to determine tertile.

research in other countries[40] and select US cities.[37–39,42] By using data from a multiethnic and multicity sample, this research provided evidence that environmental modifications might be an important strategy for increasing walking across a broader US context.

The lack of associations between change in walkability and change in leisure walking was consistent with previous cross-sectional research[56] and with the methods used to create the walkability index. Walk Score primarily measured access to destinations, which influenced whether errands or other transportation could occur on foot, but might not capture other elements of the built environment that encourage leisure-time walking, such as aesthetic quality, street traffic, or availability of walking trails. Differences in the associations of walkability with transport and leisure walking highlight the importance of matching environmental measures to specific behaviors when studying associations between health behaviors and the environment.[69]

The finding that moving to a more walkable neighborhood was associated with declines in BMI illustrated the potential of environmental interventions to influence health outcomes and cardiovascular risk. Previous research on neighborhood walkability and weight trajectories showed the importance of the environmental context in maintaining a healthy weight,[65,70–73] but longitudinal evidence linking changes in the environment to changes in weight and BMI was inconsistent.[36,44,74] Conflicting results might be because of different definitions of neighborhoods or the types of measures the built environment used. Previous studies examined radii around homes,[36] city-designated neighborhoods,[74] or counties,[44] all of which might not capture the neighborhood environment in the same way as the Walk Score. Additionally, self-reported evaluations of walkability[74] or land cover data,[36,44,74] might represent different aspects of the environment than the street distances to specific destinations used in the Walk Score. In our analyses, the effects of change in walkability on change in BMI was not reduced after controlling for change in transport and leisure walking, suggesting that the BMI effect was not mediated through effects on walking. Measurement error in walking might have affected our results. In addition, moving to more walkable areas might also be associated with greater bicycling or transit use. It was also possible that more walkable locations increased options for healthier food, and that dietary changes were also associated with moving to more walkable areas.

Recent research examined the roles of lifestyle and preferences in the selection of neighborhoods.[26,29,31,34,75] Evidence suggested that walkability was an important consideration when individuals selected residential locations,[26,76–78] that support for more walkable neighborhoods was increasing nationwide,[79] and that preference for easily walkable neighborhoods might be associated with BMI.[34] We had no information on reasons for moving or preferences in our sample. Previous studies that accounted for residential preferences or predispositions toward active transport found limited attenuation of results.[35,40] To the extent that preferences and predispositions are stable person-level traits, we accounted for them by using fixed-effects models that accounted for all stable person-level attributes. Additional longitudinal evidence is needed that illustrates whether walking behavior responds to changes in neighborhood walkability for individuals who do not move.

Study Limitations

Self-reported measures of walking might not be as accurate as those assessed objectively using pedometers or accelerometers. However, because our analyses investigated change in walking within participants, stable overestimates and underestimates of walking by a given person were accounted for. Our study was limited to a middle-aged and older adult population of movers and might not be generalizable to younger individuals who remained in the same residential location. The use of

TABLE 3—Within-Person Change in Transportation Walking, Leisure Walking, and Body Mass Index Associated With an Increase in Walkability: Multi-Ethnic Study of Atherosclerosis, United States, 2004–2012

	Unadjusted		Adjusted[a]		Further Adjusted[b]	
Variables	Change (95% CI) or OR (95% CI)	P	Change (95% CI) or OR (95% CI)	P	Change (95% CI) or OR (95% CI)	P
Transport walking						
Mean change in minutes	17.31 (5.84, 28.78)	.003	17.51 (5.96, 29.06)	.003	16.04 (5.13, 26.96)	.004
OR of meeting Every Body Walk! goals	1.11 (1.02, 1.20)	.01	1.11 (1.02, 1.21)	.01	1.11 (1.02, 1.21)	.01
Leisure walking						
Mean change in minutes	6.12 (−3.34, 15.57)	.2	6.51 (−3.03, 16.05)	.18	1.26 (−7.85, 10.36)	.79
OR of meeting Every Body Walk! goals	0.94 (0.88, 1.02)	.14	0.95 (0.88, 1.03)	.2	0.94 (0.87, 1.02)	.12
BMI						
Mean change in BMI	−0.06 (−0.11, −0.00)	.03	−0.06 (−0.11, −0.00)	.04	−0.06 (−0.12, −0.01)	.02
OR of becoming a higher BMI category	1.00 (0.97, 1.03)	.9	1.00 (0.97, 1.02)	.85	1.00 (0.97, 1.02)	.79

Note. BMI = body mass index; CI = confidence interval; OR = odds ratio. Increase in walkability was defined as a 10-unit increase in Walk Score.[47]
[a]Adjusted for time-varying age, income, season, working status, current marriage status, health compared with others, arthritis in the past 2 weeks, and cancer diagnosis.
[b]Additionally adjusted for the other 2 time-varying outcomes shown in the table (e.g., the model using BMI as an outcome is additionally adjusted for transportation and leisure walking).

Walk Score from 2012 for both pre- and postmove residential locations relied on the assumption that Walk Scores for locations remained stable over time. This assumption might have introduced measurement errors and resulted in attenuations of the association between changes in Walk Score and changes in the outcomes. We could not control or examine the effect by study site because of small sample sizes. In our analyses, the persons who experienced the greatest reductions in Walk Score as a result of the move were also those with the highest starting levels. It was plausible that the effect of a given change was modified by the starting level. However, the limited sample size precluded us from investigating this important question. Limited sample size also prevented us from investigating whether a minimum change in the environment was necessary for an effect on walking behavior (i.e., whether a threshold effect was present). In addition, although we controlled for several time-varying covariates and our models tightly controlled for time-invariant person characteristics, residual confounding by other time-varying factors could not be ruled out.

Conclusions

This study provided longitudinal evidence that transport walking and BMI shifted favorably in response to changes in the walkability of the residential neighborhood. Individuals who moved to an area with higher walkability walked more for transport and weighed less than before their move. These findings illustrated the potential for local infrastructure to support health-enhancing behaviors and highlight the potential effects of nonhealth policies, including urban planning, transportation policy, and economic development policy, on health-related outcomes.[80] Contrasts between different neighborhood environments within the United States gave insight into the factors that might be limiting US health in comparison with other countries. Increasing effort to work collaboratively across disciplines must be pursued to facilitate changes in the neighborhood environment, which could improve the health of US communities. ■

About the Authors

Jana A. Hirsch, Ana V. Diez Roux, and Kari A. Moore are with the Department of Epidemiology, University of Michigan School of Public Health, Ann Arbor. Kelly R. Evenson is with the Department of Epidemiology, Gillings School of Global Public Health, University of North Carolina at Chapel Hill. Daniel A. Rodriguez is with the Department of City & Regional Planning, University of North Carolina at Chapel Hill.

Correspondence should be sent to Jana A. Hirsch, University of Michigan School of Public, Center for Social Epidemiology and Population Health, 2675 SPH I, 1415 Washington Heights, Ann Arbor, MI 48109-2029 (e-mail: Jahirsch@umich.edu). Reprints can be ordered at http://www.ajph.org by clicking the "Reprints" link.

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Contributors

J. A. Hirsch conceptualized the research question, acquired the Walk Score data, ran the analysis, and wrote the drafts of the article for submission and resubmission. K. A. Moore linked Walk Score data with MESA data, supervised and assisted with data analysis, and provided comments and edits to drafts of the article. K. R. Evenson and D. A. Rodriguez gave input on the interpretation of the results within the existing physical activity and urban planning literatures, and provided comments on the drafted article. A. V. Diez Roux supervised the research question, oversaw data analysis, and provided comments and edits to drafts of the article throughout the writing process.

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Human Participant Protection

The study was approved by institutional review boards at each site, and all participants gave written informed consent.

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