High Neighborhood Walkability Mitigates Declines in Middle-to-Older Aged Adults’ Walking for Transport

Hiroko Shimura, Takemi Sugiyama, Elisabeth Winkler, and Neville Owen

Background: Neighborhood walkability shows significant positive relationship with residents’ walking for transport in cross-sectional studies. We examined prospective relationships of neighborhood walkability with the change in walking behaviors over 4 years among middle-to-older aged adults (50–65 years) residing in Adelaide, Australia. Methods: A baseline survey was conducted during 2003–2004, and a follow-up survey during 2007–2008. Walking for transport and walking for recreation were assessed at both times among 504 adults aged 50–65 years living in objectively determined high- and low-walkable neighborhoods. Multilevel linear regression analyses examined the associations of neighborhood walkability with changes over 4 years in walking for transport and walking for recreation. Results: On average, participants decreased their time spent in walking for transport (–4.1 min/day) and for recreation (–3.7 min/day) between the baseline and 4-year follow-up. However, those living in high-walkable neighborhoods showed significantly smaller reduction (adjusted mean change: –1.1 min/day) in their time spent in walking for transport than did those living in low-walkable neighborhoods (–6.7 min/day). No such statistically-significant differences were found with the changes in walking for recreation. Conclusions: High-walkable neighborhoods may help middle-to-older aged adults to maintain their walking for transport.

Keywords: walking, physical activity, built environment, health promotion, Australia

Walking is a popular, common form of physical activity, with known health benefits. Walking occupies a substantial portion of adults’ overall physical activity time and is a central element in public health strategies to promote more-active lifestyles. There is a wide range of health benefits, particularly for middle-aged and older adults. However, adults tend to decrease their walking behaviors as they get older. Data of successive age cohorts in Australia show decline in the proportion of those who walk for transport from 57% of men and 55% of women aged 30–44 years, 46% of men and 52% of women aged 45–59 years, to 42% of men and 47% of women aged 60 years and older. Given that sports and exercise do not play a large part in the overall activity levels of adults aged 50 years and over, walking is important for this age group to maintain activity levels.

Built-environment attributes are known to be associated with walking. Neighborhood walkability, a composite measure incorporating dwelling density, street connectivity, land-use mix, and net retail area ratio, has been shown to have a significant positive relationship with adults’ walking for transport. Since people’s behaviors may be more susceptible to environmental conditions as they get older, it can be argued that more-walkable neighborhood environments may assist in maintaining walking for transport by middle-to-older aged adults. A small number studies have examined travel-behavior changes with modifications to built-environment attributes. However, little is known about the influence of neighborhood walkability on the maintenance of walking behaviors (for transport and for recreation). We examined the prospective relationships of neighborhood walkability with the change in walking behaviors over 4 years, among adults aged 50–65 years who reside in Adelaide, Australia.

Methods

Study Design and Participants

This study is part of an observational epidemiological study known as PLACE (Physical Activity in Localities and Community Environments), designed to investigate associations between neighborhood environmental attributes and residents’ physical activity levels. Baseline and follow-up surveys were conducted during the same months of 2003–2004 and 2007–2008, in the city of Adelaide (1.2 million), Australia. Detailed study methods have been described elsewhere. The Behavioral and Social Science Ethics Committee of the University of Queensland approved the study.
Study participants were recruited from 32 neighborhoods within the Adelaide Statistical Division. Each of these neighborhoods consisted of 3–9 contiguous Census Collection Districts (CCDs), which were the smallest geographical unit used in collecting census data in Australia, encompassing approximately 250 households each. Neighborhoods were rated on their walkability (using a method described later), and 16 neighborhoods were chosen from the top and bottom quartiles, respectively (total 32 neighborhoods, 156 CCDs). In each neighborhood, an invitation letter was sent to 250 randomly-sampled residential addresses inviting 1 person from each address to participate in the study. Those who met the eligibility criteria (living in private dwellings, aged 20–65, able to walk without assistance, and able to take part in survey in English) and agreed to participate were sent a questionnaire; 2650 eligible participants from 154 CCDs returned the baseline survey questionnaire. The overall response rate (as a proportion of the total number of residential addresses initially identified in our sampling frame, which included ineligible households) was 11.5%. The 4-year follow-up survey questionnaire was returned by 1098 participants (41.4% of those who completed the baseline survey, excluding those who moved to another CCD). This analysis focused on those aged over 50 years who answered both surveys and completed data on walking (n = 504) and all relevant covariates (n = 488) were available.

**Measures**

**Outcome Variables: Changes of Time Spent in Walking.** Walking for transport and for recreation were assessed at baseline and follow-up, using the long form of the International Physical Activity Questionnaire (IPAQ). The reliability and validity of the instrument has been tested across 12 countries. Participants were asked “During the last 7 days, on how many days did you walk for at least 10 minutes at a time to go from place to place?” (number of days) and “How much time did you usually spend on one of those days walking from place to place?” (hours and minutes) to determine walking for transport. The same questions asking walking “in your leisure time” (instead of “to go from place to place”) were used to determine walking for recreation. The average duration (min/day) of each type of walking was calculated, following established IPAQ protocols. The outcome variables of the study were the changes in participants’ time spent in walking for transport and for recreation, computed by subtracting the reported time at the follow-up from reported time at the baseline (a negative value means a decline). Although walking at baseline and follow-up was skewed, change in walking approximately followed a normal distribution both for walking for transport and for recreation. 

**Area-Level Predictor Variables.** Neighborhood walkability was the main independent variable of the study. Walkability aims to identify the extent to which a neighborhood is conducive to walking and is a composite measure consisting of dwelling density, street connectivity, land-use mix, and net retail area ratio. These environmental attributes were calculated for each CCD using census data, street centerline data, land use (zoning) data, and shopping-area location data in Geographic Information Systems. CCDs were ranked into deciles for each of the 4 environmental attributes, with higher scores indicating higher walkability. Four decile scores were then summed to form a walkability index, which ranged from 6–38 (possible score ranged from 4 to 40). Neighborhoods were rated on the walkability of their constituent CCDs, and those in the top and bottom quartiles were classified as ‘high’ and ‘low’ walkability, respectively.

**Individual-Level Predictor Variables.** Participants provided information on age, gender, educational attainment, work status, and household income. They were also asked to report their weight and height, from which body mass index (BMI) was calculated. Variables other than age were categorized.

**Statistical Analysis**

We compared attributes of those who participated in the follow-up survey and those who did not, and reported any statistically significant difference or sizeable difference of 10% or more.

It was possible that participants in the same area (CCD or neighborhood) were more likely to be similar in terms of their outcomes than those chosen from different areas due to exposure to the same environmental characteristics. We examined whether there was evidence of within-area clustering by using variance components analysis with maximum likelihood estimation in SPSS version 15.0. The level of clustering was negligible when neighborhood was used as an area-level unit: intraclass correlation coefficient (ICC) was 0.003 for walking for transport and 0.002 for walking for recreation. When CCD was specified as an area-level unit, clustering was negligible in walking for transport (ICC < 0.001), but moderate in walking for recreation (ICC = 0.032). Therefore, we conducted multilevel analysis with individuals (Level 1) being nested within CCDs (Level 2). Linear regression analysis with a random intercept for CCD was used to examine the change of walking for transport and walking for recreation according to walkability. Potential confounders that showed an association with the outcome at P < .2 in univariate analysis were included in the final analysis. Models adjusted for age, gender, work status, household income, BMI, and time spent in walking for transport and for recreation at baseline. Regression models excluded participants with missing data on covariates (n = 16, 3.2%). Multilevel analyses were conducted using Stata version 10.1 in 2009. Statistical significance was set at P < .05 (two-tailed).

**Results**

There were no statistically significant or sizeable differences between the follow-up survey participants and
dropouts, except that those who dropped out spent less time in walking for recreation at baseline: median 11.0 (25th percentile: 0.0, 75th percentile: 31.6) min/day vs. 8.6 (0.0, 28.6) min/day ($P = .010$).

Table 1 shows demographic attributes and walking behaviors of participants residing in high- and low-walkable neighborhoods. Those who lived in the high-walkable neighborhoods were more likely to be tertiary educated and working.

Change in walking over the 4-year period (follow-up minus baseline) was $-4.1$ min/day (95% CI: $-7.7$, $-0.6$) for transport, and $-3.7$ minutes (95% CI: $-6.8$, $-0.6$) for recreation. For the high-walkable areas, it was $-2.4$ min/day (95% CI: $-7.8$, $3.0$) for transport, and $-5.2$ minutes (95% CI: $-10.1$, $-0.3$) for recreation. For the low-walkable areas, it was $-5.4$ min/day (95% CI: $-10.2$, $-0.6$) for transport, and $-2.6$ minutes (95% CI: $-6.7$, $1.5$) for recreation.

After adjusting for potential confounders, multilevel linear regression found a statistically significant difference in the 4-year changes in walking for transport between participants from the high- and low-walkable neighborhoods ($P = .037$). The adjusted mean change in walking for transport was $-1.1$ (95% CI: $-5.1$, $2.9$) min/day for participants of the high-walkable neighborhoods, and $-6.7$ (95% CI: $-10.1$, $-3.4$) min/day for participants of the low-walkable neighborhoods. (Figure 1, adjusted for age, gender, work status, household income, BMI, and time spent in walking for transport and for recreation at baseline). The adjusted mean change in recreational walking did not differ significantly between residents of high-walkable neighborhoods ($-5.3$ min/day; 95% CI: $-9.5$, $-1.1$) and residents of low-walkable neighborhoods ($-3.0$ min/day; 95% CI: $-6.7$, $0.7$).

### Discussion

An overall decrease in walking for transport and for recreation was observed among participants (aged 50–65 years) over the 4-year study period. However, participants residing in high-walkable neighborhoods showed

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**Table 1** Demographic Attributes at Baseline and Walking Behaviors at Baseline and Follow-Up of Participants Residing in High- and Low-Walkable Neighborhoods

<table>
<thead>
<tr>
<th></th>
<th>Total (n = 504)</th>
<th>High-walkable (n = 211)</th>
<th>Low-walkable (n = 293)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demographic attributes at baseline</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>57.0 (53.0, 60.0)</td>
<td>57.0 (53.0, 60.0)</td>
<td>57.0 (53.5, 61.0)</td>
</tr>
<tr>
<td>Gender</td>
<td>46.0 (232)</td>
<td>43.6 (92)</td>
<td>47.8 (140)</td>
</tr>
<tr>
<td>Education (n = 498)</td>
<td>44.0 (222)</td>
<td>54.5 (115)</td>
<td>36.5 (107)</td>
</tr>
<tr>
<td>Work status (n = 494)</td>
<td>52.8 (266)</td>
<td>58.3 (123)</td>
<td>48.8 (143)</td>
</tr>
<tr>
<td>Household income</td>
<td>41.5 (209)</td>
<td>41.7 (88)</td>
<td>41.3 (121)</td>
</tr>
<tr>
<td>BMI (n = 498)</td>
<td>25.7 (23.7, 28.9)</td>
<td>25.3 (22.9, 28.6)</td>
<td>25.9 (24.0, 29.1)</td>
</tr>
<tr>
<td>Overweight (n = 498)</td>
<td>58.1 (293)</td>
<td>52.6 (111)</td>
<td>62.1 (182)</td>
</tr>
<tr>
<td>Walking behaviors at baseline and follow-up</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Walking for transport</td>
<td>12.9 (2.9, 34.3)</td>
<td>12.9 (4.3, 38.6)</td>
<td>12.9 (2.5, 34.3)</td>
</tr>
<tr>
<td>Walking for recreation</td>
<td>11.1 (0.0, 31.6)</td>
<td>11.4 (0.0, 30.0)</td>
<td>10.7 (0.0, 34.3)</td>
</tr>
</tbody>
</table>

*Note.* Table presents % (n) for categories, or median (25th, 75th percentile) for nonnormal data.

*a* n < 504 due to missing data on survey items; n = 488 with full data.
a significantly smaller reduction in time spent in walking for transport, compared with those from low-walkable neighborhoods (after adjusting for potential confounders including time spent in walking for transport and for recreation at baseline). These findings suggest that high walkability may help middle-to-older aged adults to maintain their walking for transport. No significant association was found between walkability and change in walking for recreation over 4 years. These prospective relationships add to previously reported findings, in which neighborhood walkability had a significant cross-sectional association with walking for transport, but not with walking for recreation.14

In conclusion, our prospective study adds to the growing literature on the role of neighborhood environments in residents’ physical activity patterns. Further prospective studies are required to corroborate our findings, ideally with more than 2 observation points, long-term follow-ups, and with objective measurement of physical activity using motion sensors.

Acknowledgments

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