A Multilevel Analysis of Change in Neighborhood Walking Activity in Older Adults

Fuzhong Li, K. John Fisher, and Ross C. Brownson

The article reports on a multilevel analysis conducted to examine change in neighborhood walking activity over a 12-month period in a community-based sample of 28 neighborhoods of 303 older adults age 65 and over. The study employed a multilevel (residents nested within neighborhoods) and longitudinal (4 repeated measures over 1 year) design and a multilevel analysis of change and predictors of change in neighborhood walking activity. Results indicated a significant neighborhood effect, with neighborhood-level walking characterized by a downward trajectory over time. Inclusion of baseline variables using selected perceived neighborhood-level social- and physical-environment measures indicated that neighborhoods with safe walking environments and access to physical activity facilities had lower rates of decline in walking activity. The findings provide preliminary evidence of neighborhood-level change and predictors of change in walking activity in older adults. They also suggest the importance of analyzing change in physical activity in older adults from a multilevel or macrolevel framework.

Key Words: environmental influences, physical activity, aging

Research on the predictors and correlates of exercise and physical activity in older adults has primarily focused on individual-level factors (Dishman, 1988, 1994; Dishman & Sallis, 1994). The individual-level approach often overlooks the broader environmental context in which the physical activity of individuals occurs. Because most physical activities (e.g., walking, jogging) occur in social settings (e.g., neighborhood streets, public parks, walking trails) rather than in indoor facilities, the relevant influences of the contexts in which such physical activities take place have grown in importance. Currently, the social- and behavioral-science literature has begun to focus on the influence of neighborhood factors on health (Kawachi & Berkman, 2003) and physical activity (Bauman, Sallis, & Owen, 2002; Li et al., 2005; Saelens, Sallis, & Frank, 2003; Sallis & Owen, 2002). Thus, in addition to individual-level (demographic, psychosocial)
influences, it is imperative to take into account the impact of social-, physical-, and built-environment characteristics and to emphasize the role that such environments play in shaping and promoting physical activity. This calls for a multilevel approach to research on exercise and physical activity (King, Stokols, Talen, Brassington, & Killingsworth, 2002; Li et al.).

Despite the links between personal and environmental factors and physical activity in older adults (e.g., King et al., 2000), multilevel analyses of neighborhood effects on physical activity among older adults are relatively rare in the existing literature. In a cross-sectional analysis of neighborhood walking activity, Fisher, Li, Michael, and Cleveland (2004) and Li and Fisher (2004) provided initial evidence of variation in physical activity (walking) at the neighborhood level, suggesting the need to consider heterogeneity across neighborhoods as an important source for explaining variation in physical activity. These studies also shed light on the importance of several neighborhood-level variables, such as social cohesion, income, and access to and availability of physical activity facilities, in association with variation in neighborhood walking activity at the neighborhood level. Substantively, the findings from these studies provided important information about the effects of neighborhood clustering (that is, individuals in each neighborhood share similarities in levels of physical activity but differ in physical activity levels from individuals in other neighborhoods).

Although providing important evidence with regard to neighborhood-level variation in older adults’ physical activity, Fisher et al.’s study (2004), like the majority of reported findings, used a cross-sectional design and did not address the important issue of change in neighborhood-level physical activity over time. To date, only one published study has considered change in physical activity in relation to change in perceptions of environmental attributes (Humpel, Marshall, Leslie, Bauman, & Owen, 2004). Humpel et al. reported that change in perceptions of neighborhood environmental attributes (e.g., aesthetics, access, traffic) was associated with change in neighborhood walking over a 10-week interval in a university-based sample of adults age 18–69 years. The temporal change based on a short time interval of two assessment points, using individual-level measures of environmental influences, warrants further investigation. More studies that extend the time interval between observations involving multiple time points (i.e., longitudinal or repeated-measures designs) are needed for a more rigorous examination of change and correlates of change in physical activity at both the neighborhood and the individual level.

Furthermore, information on changes in physical activity participation over time are needed in order to better understand general trends in physical activity, to determine variation in change (whether at the individual or the neighborhood level), and to examine predictors, correlates, and mechanisms of such change (Li et al., 2005). For example, data from the Behavioral Risk Factor Surveillance System indicated an increase in the percentage of U.S. older adults (65+ years) who reported walking for leisure-time physical activity from 1987 to 2000 (Simpson et al., 2003). It would be unreasonable to assume, however, that all individual-
level physical activity data followed the same trajectories of change over time. It is more likely that these data reflect heterogeneity in change, ranging from those who are fully active to those who are sedentary, as well as variation in change in state-to-state levels of physical activity over this time period. Thus, to effectively capture variation in change and subsequently examine predictors and correlates of such change, one needs to consider neighborhood-level population heterogeneity, individual-level heterogeneity, and level-specific variables that can explain patterns of heterogeneity in physical activity over time. This requires a multilevel modeling approach to identify sources of variation at both the individual and the neighborhood level and that disentangles level-specific effects that influence change at either level (Li et al.).

In taking a multilevel approach, we designed this study to address the issue of change and predictors of change in older adults’ physical activity at both the neighborhood and the individual level. Using a multilevel- and longitudinal-design data set, we conducted a multilevel analysis of change in neighborhood walking activity in a sample of neighborhoods of older adults drawn from the metropolitan area of a large city in the Pacific Northwest. Specifically, using multilevel modeling techniques, we examined both individual- and neighborhood-level change in physical activity behavior in older adults over a 12-month period and predictors of change in walking activity using selected neighborhood-level perceived social- and physical-environment measures.

Method

STUDY DESIGN AND POPULATION

This study used a subsample of a previously published neighborhood-based walking intervention study (Fisher & Li, 2004). The original study used a multilevel sampling scheme in which neighborhoods were first sampled, followed by the recruitment of senior residents, age 65 years or more, within these neighborhoods. This multilevel sampling design resulted in a two-level data structure with residents at Level 1 and neighborhoods at Level 2. Therefore, neighborhoods corresponded to the primary sampling unit, and residents were the secondary unit. The details describing the study’s multistage sampling scheme have been presented elsewhere (Fisher et al., 2004).

SAMPLING METHODS

From 93 recognized neighborhood associations in Portland, OR, identified by the City of Portland, 56 neighborhoods were selected to participate in a neighborhood-based walking intervention study (Fisher & Li, 2004). A total of 582 senior residents were randomly selected from the 56 neighborhoods. The study recruitment was conducted through computer-assisted telephone-interview procedures and direct mail (Rowland et al., 2004). For the purpose of this study, a subsample of 303 residents (110 men, 193 women) from 28 nonintervention neighborhoods
was selected for the analyses of change in physical activity over a 1-year period. The data were collected over 10 months, from March through December 2001. The neighborhood cluster size for the selected sample in this study ranged from 7 to 16, with a mean of 10.82.

Data related to the neighborhood walking-activity outcome and individual- and neighborhood-level measures were collected during a 30- to 40-min face-to-face interview at baseline. Follow-up data at 3 months, 6 months, and 12 months were collected through mailed surveys or follow-up phone interviews. The Institutional Review Board of the Oregon Research Institute approved the research protocol, and all study participants provided written informed consent before enrolling in the study.

THE OUTCOME VARIABLE

The outcome variable in this study was neighborhood walking, assessed through self-report. At baseline, participants were asked “over the past 12 months, how much have you done the following”: (a) “walked or strolled in your neighborhood,” (b) “walked or done any other physical activity with neighbors,” and (c) “gone to a neighborhood park for walks or other physical activities.” Participants rated each item on a five-point Likert scale ranging from 1 (not at all) to 5 (a great deal). This measure was repeated 3 months, 6 months, and 12 months after the baseline assessment. Missing data were minimal (1% at 3 months, 4% at 6 months, and 7% at 12 months). Therefore, the common-mean imputation method (which replaces the missing values of a variable by the mean of its observed values) was used to replace missing values. The scores of these three walking items were averaged to obtain a single neighborhood-walking score at each of the four measurement time points. Internal consistency (measured by Cronbach’s alpha coefficient) was acceptable: $\alpha = .72$ for baseline, $\alpha = .65$ for Month 3, $\alpha = .67$ for Month 6, and $\alpha = .67$ for Month 12. A 3-month test–retest (stability indicator) on this set of questions using individual-level scores was also adequate (the coefficient of stability, $r = .77$).

NEIGHBORHOOD-LEVEL INDEPENDENT VARIABLES

Neighborhood-level variables were assessed at baseline through self-report. These included neighborhood social cohesion, access to neighborhood physical activity facilities, and safety of walking in the neighborhood. The social-cohesion construct was measured by a five-item scale adapted from a study by Sampson, Raudenbush, and Earls (1997). These items reflected the perceived level of connectedness among individual members of each neighborhood (i.e., “people around here are willing to help their neighbors,” “people in this neighborhood share the same values,” “this is a close-knit neighborhood,” and “people in this neighborhood can be trusted” and “get along with each other”). Each item was measured on a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The individual scores were aggregated to create a mean score for the neighborhood-level variable of social cohesion. High scores indicated high social (neighborhood) cohesion.
Internal consistency for this measure, calculated using individual-level scores, was adequate, $\alpha = .73$. Stability for this measure, as shown by the test–retest coefficient, was also satisfactory ($r = .71$).

Access to neighborhood physical activity facilities was measured through a single item assessing the extent to which participants agreed or disagreed with the following statement: “There are playgrounds, parks, or gyms close by that I can get to easily.” The scale ranged from 1 (strongly disagree) to 5 (strongly agree). Test–retest reliability (3 months apart) for this measure was $r = .56$. The individual scores for each neighborhood were aggregated to create a mean score for that neighborhood. A single item was also used to measure perceptions of the safety of walking in the neighborhood (Sallis et al., 1997). On a scale ranging from 1 (strongly disagree) to 5 (strongly agree), participants were asked to indicate the extent to which they agreed or disagreed with the statement “It is safe to walk or jog alone in my neighborhood during the day.” The test–retest stability coefficient for this measure was $r = .38$. The individual scores for each neighborhood were aggregated to create a mean score for each neighborhood.

**RESIDENT-LEVEL INDEPENDENT VARIABLES**

A number of individual-level variables were considered in this study, including participants’ education level (0 = completed high school, 1 = some college or higher), median household income (1 = below $29,999, 0 = above $30,000), and health status measured on a five-point scale (1–5: poor, fair, good, very good, or excellent). An adapted measure of exercise self-efficacy (McAuley & Mihalko, 1998) was used in this study. The scale, containing nine items, assessed each participant’s belief that he or she could walk for 30 min, three times per week, in the presence of barriers (e.g., weather, vacation). Responses to each item ranged from 1 (not confident at all) to 5 (completely confident). An excellent internal-consistency coefficient was obtained for this measure, $\alpha = .97$. The test–retest stability coefficient for this measure was $r = .62$. A composite score for walking efficacy was obtained by averaging all items.

**A MULTILEVEL MODEL OF CHANGE**

To examine change in neighborhood walking over time, at both the neighborhood level and the resident level, as well as predictors of change using perceived, aggregated neighborhood social and physical measures, a multilevel (between-neighborhoods, within-neighborhood) longitudinal latent-curve model was used (see Figure 1). This model was formed with four time points (baseline, 3 months, 6 months, 12 months) for the neighborhood-walking measure, defined by the two latent variables (intercept, slope) specified at each level. For the between-neighborhoods part of the model, we specified explanatory variables of neighborhood social cohesion, access to neighborhood physical activity facilities, and neighborhood safety of walking as predictors of initial status and rate of change over time in neighborhood walking. For the within-neighborhood part of the model, we
Figure 1  A multilevel analysis of change in neighborhood walking activity.
included walking self-efficacy, health status, education level, and median household income as individual-level baseline covariates associated with physical activity. (Initial analyses showed no age or gender effects on the outcome variable. These were removed for model parsimony purposes.)

**DATA ANALYSIS**

The previously described multilevel model of change in neighborhood walking was analyzed using latent-curve-modeling methodology (Muthén, 1997), with the *Mplus* software program used for statistical analysis with latent variables (Muthén & Muthén, 1998–2004). In our multilevel modeling of walking-activity data, both neighborhoods and residents are the units of analysis, enabling the simultaneous investigation of between-neighborhoods and within-neighborhood variability in the resident-level walking-activity outcome. The overall analysis goal was to decompose the total variation in the neighborhood-walking scores ($Y_T$) at the resident level into a between- and a within-neighborhood part: $\Sigma_T = \Sigma_B + \Sigma_W$, where $\Sigma_B$ refers to neighborhood-level variation and $\Sigma_W$ refers to resident-level variation in walking activity. This type of multilevel model is referred to as a disaggregated model for multilevel data (Muthén).

To operationalize the latent-curve aspect of the model shown in Figure 1, we defined the intercept factor as the initial status (i.e., the expected score at baseline), which is constant over time (as reflected by the fixed loadings of all time points on this factor to 1). We defined the slope factor as the slope of a linear curve, which was modeled by fixing the loadings of the four nonequidistant time points on this factor to 0, 1, 2, and 4 (to reflect the nonequidistant time intervals of the assessments). This latent-curve multilevel model included both means and variances of growth factors. Note, however, that means of the intercept and slope factors ($\text{Mean}_{intB}$, $\text{Mean}_{slpB}$) were specified and estimated only at the neighborhood level, in addition to the variance of the intercept and slope factors. The mean of the intercept factor was an estimate of the common intercept, and the mean of the slope factor was an estimate of the common slope. Neighborhood- and individual-level deviations for the common intercept were modeled by the variance of the intercept factor ($\text{Variance}_{intB}$ at the neighborhood level, $\text{Variance}_{intW}$ at the resident level), and neighborhood- and individual-level deviations in the slope of the curve were modeled by the variance of the slope factor ($\text{Variance}_{slpB}$ at the neighborhood level, $\text{Variance}_{slpW}$ at the resident level). Covariance between intercept and slope was allowed and estimated. In each part of the model, there are time-specific measurement errors signified by a straight single-headed arrow pointing into each of the observed variables of neighborhood walking (shown in boxes).

The neighborhood- and resident-level variables were specified at their corresponding levels to account for variation in the two latent-curve variables—the intercept (initial-status) factor and slope (growth-rate) factor for neighborhood walking. The overall model testing proceeded in two steps. A model without level-specific baseline (explanatory) variables (unconditional model) was tested
first to examine change in the neighborhood-walking outcome variable. This was followed by a model (conditional model) in which the intercept and slope factors, at each level, were regressed on level-specific explanatory variables. The aim of this analysis was to jointly analyze the data from the two levels of the hierarchy. Maximum-likelihood estimation was used to estimate the model’s parameters. Values for \( p \) of .05 or less (two-tailed) are reported.

Results

NEIGHBORHOOD CHARACTERISTICS

Portland is the largest city in Oregon, with a population of 1.2 million. Each of the 93 city-defined neighborhoods has a self-administered neighborhood association of annually elected residents. These neighborhoods contain a total of 218,907 residences. According to the 2000 census, 12% of households were below the poverty level. The median household income was $49,186. With respect to ethnicity, Whites accounted for 78% of the population and African Americans accounted for about 7%. Almost a third (32%) of neighborhood residents had a high school education or less. About 12% of the population were 65 years or older and 5% of residents commuted by walking.

RESIDENT CHARACTERISTICS

Characteristics of the original study participants were obtained from personal interviews and are summarized in a previously published work (Fisher et al., 2004). Relevant to this study, participants’ ages ranged from 65 to 94 years (mean age = 73.94, \( SD = 6.24 \)). Most of the participants were women (64%), married (49%), White (92%), had a high school degree or higher (88%), and had a household income of $29,999 or below (65%). About 63% were nondrinkers, and about 88% were nonsmokers. The mean value for the health-status variable at the resident level (\( N = 303 \)) was 3.33 (\( SD = 0.96 \)).

THE MULTILEVEL MODEL OF CHANGE

The intraclass correlations (between-neighborhoods variation) of the observed variable for neighborhood walking at each time point were .10 at baseline, .20 at 3 months, .31 at 6 months, and .23 at 12 months. The intraclass correlations for the growth-factor variance were .05 for the intercept factor and .14 for the slope factor. The magnitude of these coefficients indicates a reasonable amount of variation occurring at the neighborhood level. This provides sufficient evidence and justification for using multilevel analysis to examine between-neighborhoods-level variation in change in the response variables.

The multilevel model of change without level-specific predictors (i.e., the unconditional model) resulted in a chi-square value of 28.91, with eight degrees of freedom, \( p < .001 \). The model-fit index of root-mean-square error of approximation (RMSEA; Browne & Cudeck, 1993) suggests that the a priori linear-growth
model fit the empirical data marginally well, RMSEA = 0.08. With respect to the
growth-parameter estimates, a significant negative mean of the slope factor was
observed, $\mu = -0.21, t = -2.92 \ (p = .004)$, indicating that on average, neighborhoods
evidenced an overall decreasing trend in walking activity from baseline to the end
of the 12-month assessment period.

The growth model with nonequidistant time points (0, 1, 2, 4) indicated that
the decreasing trend was linear. (A nonsignificant nested chi-square test indicated
that a nonlinear model was not tenable for the data.) The intercept variance and slope
variance at the between-neighborhoods level were not statistically significant at the
.05 level, nor was the covariance between the two growth factors. A significant,
negative covariance was observed, however, at the within-neighborhood level,
$-0.457, t = -3.13 \ (p = .002)$. This negative value suggests that older adults who had
higher walking-activity scores at baseline tended to have greater rates of decrease
in walking activity over the 12-month period than others reporting low levels of
walking activity at baseline. With respect to estimates of error variance associated
with each occasion of measurement, only within-neighborhood error terms were
statistically significant. Parameter estimates for both between-neighborhoods and
within-neighborhood portions of the growth model are presented in Table 1.

### Table 1  Parameter Estimates of the Unconditional Multilevel Growth Model

<table>
<thead>
<tr>
<th></th>
<th>Estimate</th>
<th>Standard error</th>
<th>$t$ value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Between-neighborhoods part of the model</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>mean intercept</td>
<td>7.79</td>
<td>0.21</td>
<td>36.92**</td>
</tr>
<tr>
<td>mean slope</td>
<td>-0.21</td>
<td>0.07</td>
<td>-2.92*</td>
</tr>
<tr>
<td>intercept variance</td>
<td>0.27</td>
<td>0.37</td>
<td>0.71</td>
</tr>
<tr>
<td>slope variance</td>
<td>0.02</td>
<td>0.09</td>
<td>0.21</td>
</tr>
<tr>
<td>covariance between intercept and slope</td>
<td>0.06</td>
<td>0.12</td>
<td>0.51</td>
</tr>
<tr>
<td>baseline variance (NW$_{B0}$)</td>
<td>0.52</td>
<td>0.39</td>
<td>1.34</td>
</tr>
<tr>
<td>3 months variance (NW$_{B3}$)</td>
<td>1.18</td>
<td>0.66</td>
<td>1.80</td>
</tr>
<tr>
<td>6 months variance (NW$_{B6}$)</td>
<td>2.06</td>
<td>1.11</td>
<td>1.86</td>
</tr>
<tr>
<td>12 months variance (NW$_{B12}$)</td>
<td>0.94</td>
<td>0.97</td>
<td>0.97</td>
</tr>
<tr>
<td><strong>Within-neighborhood part of the model</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>intercept variance</td>
<td>4.54</td>
<td>0.78</td>
<td>5.80**</td>
</tr>
<tr>
<td>slope variance</td>
<td>0.11</td>
<td>0.06</td>
<td>1.63</td>
</tr>
<tr>
<td>covariance between intercept and slope</td>
<td>-0.46</td>
<td>0.15</td>
<td>-3.13*</td>
</tr>
<tr>
<td>baseline variance (NW$_{W0}$)</td>
<td>2.49</td>
<td>0.52</td>
<td>4.78*</td>
</tr>
<tr>
<td>3 months variance (NW$_{W3}$)</td>
<td>2.21</td>
<td>0.20</td>
<td>11.33**</td>
</tr>
<tr>
<td>6 months variance (NW$_{W6}$)</td>
<td>2.69</td>
<td>0.31</td>
<td>8.74**</td>
</tr>
<tr>
<td>12 months variance (NW$_{W12}$)</td>
<td>3.07</td>
<td>0.79</td>
<td>3.88**</td>
</tr>
</tbody>
</table>

*Note. NW = neighborhood walking.

* $p < .05$. ** $p < .001$. 
The model with individual- and neighborhood-level predictors (i.e., the conditional model) yielded a chi-square value of 51.71, with 27 degrees of freedom, $p = .003$, RMSEA = .05, a reasonably good fit of the model to the data. Structural-parameter estimates for both between-neighborhoods and within-neighborhood parts of the multilevel growth model are summarized in Table 2. Parameter estimates indicated that of the three between-neighborhoods-level variables at baseline, only social cohesion was significantly related to the initial status (the intercept factor), $\beta = 0.62$ (where $\beta$ is the standardized estimate), showing that neighborhoods with high levels of social cohesion were associated with greater levels of neighborhood walking at baseline. Path coefficients estimating the relationships between baseline neighborhood-level variables and the slope factor of neighborhood walking indicated that both safety of walking and facility accessibility were significantly

### Table 2 Parameter Estimates of the Conditional Multilevel Growth Model

<table>
<thead>
<tr>
<th></th>
<th>Unstandardized estimate</th>
<th>Standardized estimate</th>
<th>Standard error</th>
<th>$t$ value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Between-neighborhoods part</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>social cohesion $\rightarrow$ initial status</td>
<td>0.83</td>
<td>0.62</td>
<td>0.24</td>
<td>3.49**</td>
</tr>
<tr>
<td>safety $\rightarrow$ initial status</td>
<td>0.25</td>
<td>0.11</td>
<td>0.56</td>
<td>0.45</td>
</tr>
<tr>
<td>accessibility $\rightarrow$ initial status</td>
<td>-0.16</td>
<td>-0.15</td>
<td>0.35</td>
<td>-0.46</td>
</tr>
<tr>
<td>social cohesion $\rightarrow$ rate of change</td>
<td>0.02</td>
<td>0.04</td>
<td>0.08</td>
<td>0.31</td>
</tr>
<tr>
<td>safety $\rightarrow$ rate of change</td>
<td>0.44</td>
<td>0.44</td>
<td>0.15</td>
<td>2.92*</td>
</tr>
<tr>
<td>accessibility $\rightarrow$ rate of change</td>
<td>0.30</td>
<td>0.61</td>
<td>0.10</td>
<td>2.96*</td>
</tr>
<tr>
<td><strong>Within-neighborhood part</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>walking self-efficacy $\rightarrow$ initial status</td>
<td>0.07</td>
<td>0.36</td>
<td>0.02</td>
<td>3.64**</td>
</tr>
<tr>
<td>health status $\rightarrow$ initial status</td>
<td>0.02</td>
<td>0.01</td>
<td>0.16</td>
<td>0.11</td>
</tr>
<tr>
<td>education $\rightarrow$ initial status</td>
<td>0.77</td>
<td>0.17</td>
<td>0.27</td>
<td>2.86*</td>
</tr>
<tr>
<td>median household income $\rightarrow$ initial status</td>
<td>-0.42</td>
<td>-0.09</td>
<td>0.25</td>
<td>-1.67</td>
</tr>
<tr>
<td>walking self-efficacy $\rightarrow$ rate of change</td>
<td>0.01</td>
<td>0.002</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>health status $\rightarrow$ rate of change</td>
<td>0.01</td>
<td>0.03</td>
<td>0.05</td>
<td>0.19</td>
</tr>
<tr>
<td>education $\rightarrow$ rate of change</td>
<td>-0.16</td>
<td>-0.21</td>
<td>0.07</td>
<td>-2.26*</td>
</tr>
<tr>
<td>median household income $\rightarrow$ rate of change</td>
<td>-0.05</td>
<td>-0.06</td>
<td>0.07</td>
<td>-0.69</td>
</tr>
</tbody>
</table>

*Note.* The arrow sign $\rightarrow$ indicates the prediction of the independent variables to the latent growth variables representing the initial status and rate of change (slope) in neighborhood walking.

* $p < .05$. ** $p < .001$. 


predictive of change in neighborhood walking, $\beta = 0.44$ for safety and $\beta = 0.61$ for accessibility, indicating that neighborhoods with safety of neighborhood walking and greater access to physical activity facilities tended to show less decline (i.e., smaller rates of decline) in walking activity over the four assessment points.

At the within-neighborhood level, results showed that older adults with high levels of walking self-efficacy and education reported higher initial levels of walking ($\beta = 0.36$ for self-efficacy and $\beta = 0.17$ for education). The education variable was also found to be negatively associated with change in walking over time ($\beta = -0.21$), indicating that older adults with higher levels of education tended to have steeper rates of decline over time in walking activity.

**Discussion**

In research dealing with older adults and physical activity, little attention has been paid to the issue of change in physical activity at the neighborhood level. Most studies that have assessed the influence of neighborhoods on physical activity have been cross-sectional in nature. Therefore, relatively little information is available with respect to neighborhood-level change and predictors or correlates of change in physical activity levels over time. To fill this void, this study provided preliminary evidence of neighborhood-level change in walking activity over a 1-year period. The observed downward trend indicated that the overall neighborhood-level walking activity declined over time in our sampled neighborhoods. This finding is congruent with reports showing that many older Americans are inactive (Agency for Healthcare Research and Quality & Centers for Disease Control and Prevention, 2002; U.S. Department of Health and Human Services [USDHHS], 2002a) and that older adults (65 years and over) represent the largest proportion of never walkers and the lowest proportion of regular walkers in this country (Eyler, Brownson, Bacak, & Housemann, 2003).

The results of our study should be interpreted in the context of several limitations. First, the study is limited to one aspect of walking activity based on self-reports (i.e., walking for physical activity in the neighborhood). There are other aspects of purposeful walking, such as walking for transportation, errands, or total walking, for which change, and predictors or correlates of change, need to be investigated. Second, the data analyzed in this study are restricted to a single geographic area, the city of Portland, OR. The results might only be generalizable to the geographic characteristics of that region. A much larger geographic area with diverse population characteristics needs to be considered in future studies. Third, the neighborhood sample ($N = 28$) is relatively small in relation to the number of variables included in the models. As a result, there might have been insufficient power to detect other significant effects. Furthermore, the relatively small number of individuals per neighborhood (ranging from 7 to 16, median = 10) resulted in less than optimal within-neighborhood variation. Replications of these findings with larger between- and within-neighborhood samples from the same neighborhoods...
are clearly needed. Fourth, the 1-year study period might be too short an interval to capture meaningful change in physical activity at the neighborhood level. Future studies should attempt to collect longitudinal data on a yearly basis. Finally, there might be unmeasured seasonal confounders in the study results. It is possible that declines from baseline to 12 months could reflect less favorable weather conditions at 12 months relative to baseline. In other words, there might be effects of seasonal variations in the temporal changes in physical activity observed in the study. This issue has rarely been addressed in the current physical activity literature. Future studies should consider collecting seasonal measures that enable the capture of climatic influences on change in physical activity.

Despite these limitations, the study does make important contributions toward the understanding of physical activity patterns and predictors from the neighborhood context. The multilevel-growth-modeling results suggest that neighborhood walking activity was decreasing systematically over time and the functional form of this decrease was linear. Although no significant intraneighborhood differences in rate of change over time were observed, there was a significant correlation between the two growth factors at the within-neighborhood level, indicating that higher levels of walking activity at baseline were associated with lower walking activity over the 1-year period.

With respect to the prediction of change over time, findings showed that neighborhoods with safer walking and access to physical activity facilities were associated with less decline in neighborhood walking over time. This finding suggests that neighborhoods with streets that are safe for walking and that have better or convenient access to physical recreation facilities are more likely to provide a social and physical environment that is conducive to physical activity such as neighborhood walking. These results extend findings from earlier cross-sectional studies that have shown association between physical-environment factors and physical activity, including walking (Brownson, Baker, Housemann, Brennan, & Bacak, 2001; Owen, Humpel, Leslie, Bauman, & Sallis, 2004).

It is now well documented that physical inactivity and associated health problems have substantial economic consequences, not only for individuals of retirement age but also for the U.S. health-care system (Carbonell, 2003; USDHHS, 2002a, 2002b). A physically inactive population is both a medical and a financial risk for many chronic-disease conditions including heart disease, stroke, colon cancer, diabetes, obesity, and osteoporosis (USDHHS, 2002a). In contrast, increased physical activity has been shown to be associated with a reduced risk for developing various chronic-disease problems (USDHHS, 1996). Unfortunately, physical inactivity rates for older adults in the United States remain high (USDHHS, 2002a), and the prevalence of older adults meeting physical activity recommendations has not increased (Merck Institute of Aging & Gerontological Society of America, 2002).

Interventions designed to promote physical and mental health have traditionally been targeted at the individual level. The results of this study suggest the need to pay greater attention to directing physical activity promotion and interventions at communities (e.g., neighborhoods) instead of at people. Directing efforts and
resources conducive to physical activity at the neighborhood or community level might be more effective at improving and maintaining health status, particularly in older adults (Li et al., 2004). Indeed, a recent neighborhood-based walking intervention that showed neighborhood-level improvements in quality-of-life indicators through a 6-month intervention (Fisher & Li, 2004) supports this contention. Our findings of safety and access indicators in predicting declines in neighborhood walking activity over time also support recent findings (Humpel, Owen, & Leslie, 2002; Owen et al., 2004; Saelens et al., 2003) indicating that safety of walking and greater access to physical activity facilities are important contextual features that positively increase physical activity at the society level.

In conclusion, the results of this study show that levels of neighborhood walking change over time and that neighborhood-level physical-environment factors such as safety of walking and access to nearby physical activity facilities are important for shaping habitual walking behavior and slowing the decline in older adults’ physical activity over time. From a public health perspective, these results suggest the need for a multilevel approach that identifies, intervenes, and arrests the decline in older adults’ physical activity at the community level.

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References


