Personal Factors, Perceived Environment, and Objectively Measured Walking in Old Age

Lucelia Luna de Melo, Verena Menec, Michelle M. Porter, and A. Elizabeth Ready

This study examined the associations between walking behavior and the perceived environment and personal factors among older adults. Sixty participants age 65 yr or older (mean 77 ± 7.27, range 65–92) wore pedometers for 3 consecutive days. Perceived environment was assessed using the Neighborhood Environment Walkability Scale (abbreviated version). Physical function was measured using the timed chair-stands test. The mean number of steps per day was 5,289 steps (SD = 4,029). Regression analyses showed a significant association between personal factors, including physical function (relative rate = 1.05, \( p < .01 \)) and income (RR = 1.43, \( p < .05 \)) and the average daily number of steps taken. In terms of perceived environment, only access to services was significantly related to walking at the univariate level, an association that remained marginally significant when controlling for personal characteristics. These results suggest that among this sample of older adults, walking behavior was more related to personal and intrinsic physical capabilities than to the perceived environment.

Keywords: health, function, older adults, pedometers

Physical inactivity is associated with several chronic conditions later in life (Kruger, Ham, & Sanker, 2008), including pain, mobility limitation, and emotional problems (Sawatzky, Liu-Ambrose, Miller, & Marra, 2007). A physically active lifestyle may increase functional independence (Di Francesco et al., 2005; Lim & Taylor, 2005; McAuley et al., 2007) and reduce the risk for or severity of chronic diseases, particularly among older adults (Van der Bij, Laurant, & Wensing, 2002).

Walking is the most common type of physical activity in which community-dwelling older adults engage (Lim & Taylor, 2005; Michael, Beard, Choi, Farquhar, & Carlson, 2006) and is associated with greater adherence than more vigorous activities (Lamb, Bartlett, Ashley, & Bird, 2002). Benefits of walking for older adults include improvements in cardiorespiratory fitness, increased levels of energy, prevention of physical disability (Wong, Wong, Pang, Azizah, & Dass, 2003), and better cognitive function (Wuve et al., 2004). Given walking’s benefits and
potentially high participation rates, the encouragement of regular walking could greatly enhance public health and the well-being of older adults.

Ecological models have been used as multifocal frameworks to explain physical activity participation. In an ecological approach, the physical environment and the sociocultural environments such as the economy, public policies, and social factors play an important role in the decision to be physically active (Sallis & Owen, 1999; Stokols, 1992). Although environmental characteristics of urban settings, such as accessibility of services (King et al., 2005; Michael et al., 2006; Patterson & Chapman, 2004), safety (King, 2008; Li, Fisher, & Brownson, 2005; Taylor et al., 2007), and aesthetics (Kowal & Fortier, 2007), have been associated with increased physical activity engagement among older adults, a closer association between physical activity and personal factors than with the physical environment has also been reported (King, 2008). Among personal factors, higher levels of physical function are associated with increased walking among older adults and, consequently, with maintained mobility and prevention of functional decline (Boyle, Buchman, Wilson, Bienias, & Bennet, 2007; Visser et al., 2005; Wong et al., 2003). However, the association between personal factors, including physical function, and the neighborhood environment for walking among older adults has not been extensively studied, particularly using objective measurements. The purpose of this study was to examine the associations between walking behavior and the perceived environment and personal factors among older adults living in a downtown neighborhood of a midsized prairie city. We hypothesized that both the perceived environment and personal factors would have significant associations with walking.

Methods

Participants and Study Setting

Participants were 60 independent ambulatory volunteers recruited from five seniors’ apartment buildings located in a downtown neighborhood of a midsized Canadian city, as defined by the local health authority. Participants had to be 65 years of age or older and had to have resided in the neighborhood for at least 1 year. They were excluded if they used any walking devices such as walkers, canes, or wheelchairs. Each participant completed the Physical Activity Readiness Questionnaire (PAR-Q) before participating in the study. In the case of “yes” responses to the PAR-Q, physician’s approval was required. This study had ethics approval from the research ethics board of the University of Manitoba, and all subjects provided written informed consent.

Measures

Demographic and Health Assessment. A questionnaire was used to determine demographic information including age, sex, household income, educational level, marital status, and number of health conditions. Self-rated health was assessed using the following question: “How would you rate your health compared to others of your age?” Answers ranged from 1 (excellent) to 5 (poor).

Physical Function. The Functional Fitness Test (Rikli & Jones, 1999) was initially used to assess physical function. However, the timed chair-stands test
(number of chair rises in 30 s) was used as the main measure of physical function for its highest correlation with the outcome variable \( r = .549, p < .05 \). The timed chair-stands test was also chosen for its association with lower limb strength (McCarthy, Horvat, Holtsberg, & Wisenbaker, 2004), balance, sensorimotor function, psychological factors (Lord, Murray, Chapman, Munro, & Tiedemann, 2002), and gait (Brown, Sinacore, & Host, 1995) in older adults. The chair-stands test has been shown to be a reliable method for assessing lower body strength in older adults (Jones, Rikli, & Beam, 1999). It has also been shown to be a strong predictor of functional decline in community-dwelling older adults (Forrest, Zmuda, & Cauley, 2006), including the ability to perform activities of daily living (Gill, Williams, Leon, & Tinetti, 1997; Gill, Williams, & Tinetti, 1995).

**Perceived Neighborhood Environment.** A modified version of the Abbreviated Neighborhood Environment Walkability Scale (NEWS-A; Cerin, Saelens, Sallis, & Frank, 2006) was used for this study. Five aspects of perception of the neighborhood environment were addressed: access to services (six items), street connectivity (three items), infrastructure for walking and cycling (three items), aesthetics (four items), and safety (nine items). Answers are provided on a Likert scale ranging from *strongly disagree* (1) to *strongly agree* (4). The highest possible score in each category is the number of items multiplied by 4, with higher values corresponding to more positive perception of the neighborhood. The Neighborhood Environment Walkability Scale (NEWS; long version) has shown moderate to high test–retest reliability (Leslie et al., 2005; Saelens, Sallis, Black, & Chen, 2003) and has been used with adult and older adult populations (Shigematsu et al., 2009). Confirmatory factor analysis between NEWS and NEWS-A scores ranges from .82 to .97 at the group level and from .83 to .97 at the individual level. Both scales have shown factorial and criterion validity (Cerin et al., 2006).

**Walking Behavior.** The main outcome variable was steps walked per day, objectively measured using pedometers (StepsCount SC-01, Ontario, Canada) for a 3-day period (Thursday, Friday, and Saturday). According to previous research, a 3-day period of monitoring is sufficient to predict weekly physical activity (Tudor-Locke et al., 2005). Pedometry data have shown acceptable reliability (Strycker, Duncan, Chaumeton, Duncan, & Toobert, 2007) among older adults. Participants received written information before using the equipment, as well as a demonstration trial. They were instructed to wear the device all day (except during water-based activities and at bedtime). At the end of each day they recorded the number of steps taken on a form and reset the device to zero. Participants were contacted by phone during the 3-day period to ensure that no problems arose. In case of problems with the equipment (two instances) or lack of compliance with the proposed timeline (two instances), participants repeated the protocol the following week. The average number of steps for the 3 days was calculated by summing the steps taken in the 3-day period and dividing the resulting score by 3.

We also used a questionnaire we developed for this study to gather information about walking behavior, including how often participants usually walk in summer and winter, where they usually walk (indoors or outdoors), their main reason for walking (health, transportation, or recreation), whether they drive, and with whom they usually walk (alone, with a friend, or with a spouse).
Statistical Approach

Data were analyzed using SPSS version 16 for Windows. We used $t$ tests and analysis of variance (ANOVA) to test for differences between groups. We used $t$ tests to examine differences in age and environmental perceptions between the two time series for data collection (fall and spring). A $t$ test was also used to examine differences in demographic variables and walking-behavior variables in relation to the outcome variable. ANOVA was used to determine differences in age groups in relation to steps taken per day and in relation to physical function, as well as to determine differences in the purpose of walking in relation to steps taken per day. Bivariate correlations were used to determine any significant association between the neighborhood environment, personal factors, and walking behavior. All associations statistically significant at the $p < .05$ level were considered for further, multivariate analyses. The average daily number of steps was treated as a continuous variable and analyzed using a negative binomial distribution. This distribution provided an excellent fit to the skewed, overdispersed steps per day. A hierarchical-regression approach was taken whereby blocks of variables that were significantly related to steps walked at the univariate level were forced into the regression model.

Results

The mean number of steps per day was 5,289 ($SD$ 4,029, range 854–22,091). Figure 1 illustrates the substantial difference in the average number of steps per day by age group, as well as the variability within age groups. ANOVA analysis

![Figure 1](image)

**Figure 1** — Daily number of steps by age category for individual participants, $N = 60$. Age 65–74 $n = 24$, Age 75–84 $n = 25$, Age 85+ $n = 11$. 
indicated that the mean number of steps per day for those age 65–74 years (7,169 ± 4,898) was significantly different ($F = 5.147, p < .01$) from those age 75–84 (4,339 ± 2,762) and 85 years and above (3,560 ± 2,766). However, the older two age groups did not differ in terms of steps taken per day. Physical function also varied significantly between the three age groups ($F = 11.14, p < .001$). The 65- to 74-year group had an average of 13.5 ± 4.4 chair stands, the 75- to 84-year group had an average of 9.7 ± 4.4, and the 85 years and above group had an average of 5.6 ± 5.5 chair stands. Tukey’s HSD indicated that the number of chair stands for the 65- to 74-year group was significantly different from the 75- to 84- ($p < .05$) and the 85 years and above groups ($p < .001$). The number of chair stands for the 75- to 84-year group was also significantly different from the 85 years and above group ($p < .05$). No difference between the genders was found. Characteristics of the subjects, as well as perceptions of the environment and physical function, are described in Table 1.

Forty percent of the total sample (24) were tested during the fall; 60% (36) were tested during the spring. The severe winter weather in our city could increase the likelihood of individuals’ being less active than they normally might be. Although those who were tested in the spring had fewer mean steps per day (4,533 ± 2,467) than those who were tested in the fall (6,422 ± 5,491), the difference was

Table 1  Participants’ Descriptive Characteristics, Perceptions of the Environment, and Physical Function

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>$M$ (% where indicated)</th>
<th>$SD$</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>77.0</td>
<td>7.3</td>
<td>65–92</td>
</tr>
<tr>
<td>Female (%)</td>
<td>75.0</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Have college or university degree (%)</td>
<td>21.0</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Living in relationship (married or common-law partner; %)</td>
<td>43.3</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Number of close friends</td>
<td>12.7</td>
<td>13</td>
<td>0–62</td>
</tr>
<tr>
<td>Income level (%):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>annual income $0–29,999</td>
<td>38.3</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>annual income $30,000 or above</td>
<td>61.7</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Retired (%)</td>
<td>93.3</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Self-rated health (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>excellent</td>
<td>23.3</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>very good</td>
<td>43.3</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>good</td>
<td>30.1</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Number of health conditions</td>
<td>1.6</td>
<td>1.2</td>
<td>0–7</td>
</tr>
<tr>
<td>Chair stands</td>
<td>10.4</td>
<td>5.4</td>
<td>0–23</td>
</tr>
<tr>
<td>Access to services</td>
<td>20.8</td>
<td>2.3</td>
<td>13–24</td>
</tr>
<tr>
<td>Street connectivity</td>
<td>10.7</td>
<td>1.3</td>
<td>7–12</td>
</tr>
<tr>
<td>Infrastructure for walking</td>
<td>9.9</td>
<td>1.7</td>
<td>6–12</td>
</tr>
<tr>
<td>Aesthetics</td>
<td>12.6</td>
<td>2.6</td>
<td>4–16</td>
</tr>
<tr>
<td>Safety</td>
<td>24.9</td>
<td>4.1</td>
<td>17–35</td>
</tr>
</tbody>
</table>
not significant \( (t = 1.81, p > .05) \). There was no age difference between the group tested in the fall and the one tested in the spring. Furthermore, no significant differences were found in the perceived environment in relation to seasonal changes. Consequently, both groups were combined for data analyses. Responses to the walking-behavior questionnaire are shown in Table 2.

The average number of steps walked per day was moderately but significantly correlated with personal and environmental variables. Among variables related to the environment, only access to services, but none of the other NEWS-A subscales, was associated with steps per day (Table 3). At the personal level, participants with higher income \( (t = 2.93, p < .01) \) and better perceived health \( (t = 2.30, p < .05) \) had more steps taken than those with lower income and worse perceived health. Sex, marital status, and social support were not associated with steps walked. In addition, none of the walking-behavior variables were related to steps taken per day. The variables that did not reach statistical significance were therefore excluded from further analysis.

Four regression models were constructed to best explain factors associated with steps walked per day. The first model included only demographic character-

### Table 2 Walking Behaviors

<table>
<thead>
<tr>
<th>Percentage of participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walk outside almost every day in the summer.</td>
</tr>
<tr>
<td>Walk outside almost every day in the winter.</td>
</tr>
<tr>
<td>Locations differ between summer and winter.</td>
</tr>
<tr>
<td>Usually walk outdoors (streets or parks).</td>
</tr>
<tr>
<td>Main reason for walking:</td>
</tr>
<tr>
<td>transportation</td>
</tr>
<tr>
<td>recreation</td>
</tr>
<tr>
<td>health</td>
</tr>
<tr>
<td>Usually walk alone.</td>
</tr>
<tr>
<td>Belong to a walking club.</td>
</tr>
<tr>
<td>Drive a car.</td>
</tr>
</tbody>
</table>

### Table 3 Variables Significantly Associated With Steps Walked per Day

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pearson’s correlation coefficient ( (r) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>(-.50^{**})</td>
</tr>
<tr>
<td>Annual income</td>
<td>NA</td>
</tr>
<tr>
<td>Self-rated health</td>
<td>NA</td>
</tr>
<tr>
<td>Physical function</td>
<td>(.55^{**})</td>
</tr>
<tr>
<td>Number of health conditions</td>
<td>(.48^{**})</td>
</tr>
<tr>
<td>Access to services (NEWS-A)</td>
<td>(.27^{*})</td>
</tr>
</tbody>
</table>

*Significant at .05 level (two-tailed). **Significant at .01 level (two-tailed).
Younger age was associated with more walking, as was higher income. When health variables were added to the second model, age, income, and self-rated health became significantly related to number of steps. In the third model, which also included physical function, those with higher physical function were 1.04 times more likely to walk a greater number of steps than those with lower levels of function. Age and income remained significantly associated with walking, whereas self-rated health was no longer associated with walking. In the fourth model, which included access to services, income and physical function remained significantly associated with walking. Access to services remained marginally significantly related to steps taken per day, whereas age was no longer associated with walking.

**Discussion**

Relatively few studies have examined the role of the neighborhood environment in older adults’ walking behavior, and fewer yet have used objective measures of walking. Using pedometers under free-living conditions, this study adds to the literature by providing a real picture of walking behavior among a sample of older adults. As hypothesized, personal factors, particularly higher income and better physical function, were significantly associated with more walking. The relationship between perceptions of the neighborhood environment and walking was not as consistent, however.
Although the older adults in this study lived in the community and reported very good health status and frequent walks, their average number of steps taken per day was 5,289, below the minimum of 6,000 (Tudor-Locke & Myers, 2001) to 6,565 (Bohannon, 2007) steps suggested for health. This discrepancy in findings may be caused by the fact that the mean age of our sample was higher than in previous studies of older adults that used pedometers to assess walking behavior (Croteau, Richeson, Farmer, & Jones, 2007; King et al., 2005; Tudor-Locke et al., 2002). Other studies that investigated steps taken among older adults in the seventh decade of life reported an average of 3,285 (Bennett, Wolin, Puleo & Emmons, 2006) and 3,987 steps (Strath, Schwartz, & Cashin, 2009), also below the recommended minimum. Age was also no longer associated with steps per day once physical function was controlled, indicating that age per se is not a strong predictor of activity level in the regression models.

Most participants reported being frequent walkers, regardless of the season. Preferred places for walking were local streets, parks, or at a mall, similar to findings of prior studies (Eyler, Brownson, Bacak, & Housemann, 2003; Giles-Corti & Donovan, 2002). Health was identified as the primary reason for walking. This is in contrast to others studies that found transportation or recreation (Hoehner, Ramirez, Elliot, Handy, & Brownson, 2005; McGinn, Evenson, Herring, & Huston, 2007; Owen et al., 2007) to be the most important reasons. Unlike the current study, those studies were done with younger adults and specifically examined the relationship between the purpose of walking and the physical environment. Walking for transportation has been shown to be more strongly associated with the perceived environment than walking for recreation among younger and older adults (Shigematsu et al., 2009). Perhaps the lack of association between walking and the perceived environment in our study may be explained by the fact that most participants walked for health reasons, not transportation or recreation. For instance, if one walks to stay healthy, the environment may be less of a concern.

Other measures related to walking behavior were also not related to walking. For instance, 30% of participants indicated that they usually walked with somebody. However, having a walking companion did not translate into more walking. Perhaps a more in-depth assessment of walking behavior would have yielded different results.

Our finding that income was significantly associated with increased walking supports results of previous studies. Higher income (Chad et al., 2005) and higher socioeconomic-status neighborhoods (Hoehner et al., 2005) have also been shown to be related to increased physical activity. On the other hand, those with lower income or residents of lower socioeconomic-status neighborhoods are less likely to engage in moderate physical activity than those living in higher socioeconomic-status neighborhoods (Ball et al., 2007; Lee, Cubbin, & Winkleby, 2007).

When health variables were added into the model, self-rated health had a significant and positive association with steps taken. However, this relationship was no longer apparent when physical function was added into the model. Functional capacity, particularly greater lower body strength, has also been associated with walking in previous research (Puthoff, Janz, & Nielson, 2008; Simonsick, Guralnick, Volpato, Balfour, & Fried, 2005). The average of 10.4 repetitions found for chair stands is comparable to another study done with older adults (Hruda,
In our study, chair-stands performance decreased significantly with advancing age, particularly among those age 85 years and above, who had an average of 5.6 repetitions, suggesting that physical function may have a strong contribution for walking among older adults. Another study that investigated number of chair stands among women in the sixth decade of life reported an average of 13.97 repetitions (McCarthy et al., 2004), which is also in agreement with our findings.

Perceptions of the neighborhood environment were only weakly related to walking. Of the five subscales of the NEWS-A, only access to services was associated with walking at the univariate level, a relationship that remained only marginally significant once personal characteristics were controlled in the analyses. Although several studies have reported a significant association between accessibility of services and physical activity (Foster, Hillsdon, & Thorogood, 2004; Michael et al., 2006; Miles & Panton, 2006) or walking in particular (Cerin, Leslie, du Toit, Owen, & Frank, 2007; Hoehner et al., 2005), none of these studies controlled for physical function, which in the current study was found to be significantly related to walking. Differences in the samples and the contexts of the study may explain any discrepancies in findings. Specifically, the current study was conducted with mostly very old individuals living in downtown neighborhoods. The fact that participants were recruited from a few seniors’ apartments may also explain the weak association between walking and the perceived environment, because individuals living in the same building may have similar perceptions of the neighborhood environment, thus reducing the variability in perceptions.

Several other limitations of the current study must be acknowledged. First, although previous research suggests that measuring steps with pedometers over a 3-day period is sufficient to provide reliable results, in our sample of quite aged individuals this may have been too short a time period. For instance, fluctuations in health or fatigue may be common and require a longer assessment period. Having participants complete a detailed daily diary to record, for example, when they put on the pedometer and when they took it off, the kinds of activities they engaged in, and any unusual circumstances (e.g., sickness), would have been useful to gain a more in-depth understanding of the context of activity patterns. Second, we only examined one neighborhood located in a downtown area. Drawing individuals from several neighborhoods, both downtown and in more suburban areas, might lead to higher variability in responses and a stronger association between perceptions of the neighborhood and walking. Finally, the sample size was small, thus reducing the power to detect significant effects.

Nonetheless, this study adds to the literature by using objective measures of physical activity and function in a sample of older adults. Overall, the findings indicate that personal factors were significantly associated with walking, particularly higher income and better physical function. The perceived environment was less important in our sample of older adults. The study also points to the need for further research with older adults. Objective measures of the environment, as well as longitudinal data, are needed to better understand the relationships between personal and environmental factors and walking, particularly among older adults who still reside in the community, including those in the seventh or eighth decade of life and over.
Acknowledgments

There is no conflict of interest declared for the study.

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