Walking and the Preservation of Cognitive Function in Older Populations

Thomas R. Prohaska, PhD,1,2 Amy R. Eisenstein, MA,2 William A. Satariano, PhD,3 Rebecca Hunter, MEd,4 Constance M. Bayles, PhD,5 Elaine Kurtovich, PT, MPH,6 Melissa Kealey, MPH,6 and Susan L. Ivey, MD,7

Purpose: This cross-sectional study takes a unique look at the association between patterns of walking and cognitive functioning by examining whether older adults with mild cognitive impairment differ in terms of the community settings where they walk and the frequency, intensity, or duration of walking. Design and Methods: The sample was based on interviews with 884 adults aged 65 years and older, residing in 4 locations across the United States: Alameda County, California; Cook County, Illinois; Allegheny County, Pennsylvania; and Durham/Wake Counties, North Carolina. Cognitive function was assessed using a modified Mini-Mental State Examination (MMSE) and the Mental Alternation Test (MAT). Multiple linear regressions were conducted between self-reported walking activities and cognitive measures, controlling for psychosocial, demographic, health status, functional performance, and neighborhood characteristics. Results: The community setting where people walk and the intensity of walking in their neighborhood were significantly associated with cognitive status. After controlling for individual and neighborhood characteristics, better MAT scores were significantly associated with brisk walking and walking fewer times per week. Compared with the MMSE, the MAT was more likely to be associated with patterns of walking among older adults. Older adults with lower MAT scores were more likely to walk in indoor shopping malls and less in parks, whereas those with higher cognitive function scores on the MMSE were less likely to walk in indoor gyms. Implications: This investigation provides insight into the extent to which walking is associated with preservation of cognitive health, setting the stage for future longitudinal studies and community-based interventions. Key Words: Cognitive performance, Physical activity, Environmental barriers, Person-environment fit

Although health benefits of physical activity among older adults are well documented, greater attention is now being directed to the association between specific types and levels of physical activity on health and well being and factors contributing to performing specific physical activities. Walking is increasingly being examined as a means of health promotion and disease prevention. Leisure-time walking among older adults is associated with a broad array of positive health outcomes. Recently, walking has been suggested as being protective for cognitive health (Abbott et al., 2004; Barnes, Whitmen, & Yaffe, 2007).

Although there is evidence that walking may be protective of cognitive status, there is little information as to the association between cognitive status and patterns of walking among older adults. Is one’s cognitive status associated with where, how often, and how briskly one walks? This study examines whether older adults with mild cognitive impairment differ in terms of the community settings where they walk and the frequency, intensity, or duration of walking. If walking is to be encouraged
among individuals with cognitive decline, it is important to identify the frequency, intensity, and duration of walking that is to be suggested and the least challenging environmental settings for walking. Environmental barriers and preferences for community settings where individuals with mild cognitive impairment are likely to walk should also be examined.

**Background**

Walking is the most common form of physical activity among older adults (Rafferty, Reeves, Mcegee, & Pivarnik, 2002). Findings from the Behavioral Risk Factor Surveillance System show that more than 70% of persons aged 65 years and older walk for leisure either occasionally or regularly (Eyler, Brownson, Bacak, & Housemann, 2003). Although the prevalence of walking for exercise among older adults has increased in recent decades (Simpson et al., 2003), only 24.8% of those who walk for leisure activity meet current recommendations for physical activity—30 min of at least moderate activity 5 or more days per week (Eyler et al., 2003). The residential neighborhood is the most common location for walking among older adults, although other community settings such as shopping malls, parks, and walking/jogging trails are also common (Eyler et al., 2003).

There is evidence that the amount of walking among older adults is associated with cognitive functioning (Abbott et al., 2004; Barnes et al., 2007; Wang, Larson, Bowen, & van Belle, 2006). Weuve and colleagues (2004) found that walking at a leisurely pace for at least 1.5 hr per week over a 2-year period was protective against cognitive decline when compared with walking less than 40 min per week in older women. Similar findings on the protective effects of walking to reduce the risk for dementia have also been demonstrated for older men (Abbott et al., 2004).

Although the benefits of physical activity on cognitive performance are well documented, the extent to which persons with cognitive limitations are likely to walk in specific community settings is not known. Verbrugge and Jette (1994) note that disablement (physical and cognitive) is a dynamic process that is influenced by intrinsic person-level factors and extrinsic environmental factors. When environmental demands become too great, disability can result. Because community settings vary in their level and types of environmental challenges, older adults with cognitive impairment may choose not to walk or be incapable of walking in some settings. Similarly, Shumway-Cook and colleagues (2002) identify environmental demands that influence places where older adults with physical disabilities walk and the environmental barriers that result in mobility disability. As in physical disability, environmental challenges among older adults with cognitive impairment may influence the settings in which they walk.

The association between walking and cognitive status may be confounded by factors known to be associated with both. Factors associated with walking include demographic characteristics, physical health status and functional status (physiological and psychological), attitudes and beliefs about walking, and neighborhood environmental characteristics (Rafferty et al., 2002; Simonsick, Guralnik, & Fried, 1999). Simonsick and colleagues reported a significant negative association between increased levels of walking and problems with mobility, fatigue, older age, Black race, and living alone. They also found that among adults aged 65 years and older, those who reported poor cognition were less likely to walk eight or more blocks in their neighborhood than those reporting no cognitive problems. However, once demographic characteristics and the level of difficulty walking were controlled, these differences were no longer significant. Several studies have found that perceived self-confidence in walking is positively associated with amount of walking among older adults (Eyler et al., 2003). Health status factors associated with lower walking for leisure include depressive symptoms, vision and balance problems, physical ability, and being overweight (Simonsick et al., 1999).

The association between walking and cognitive performance may also depend on the measure of cognitive performance used. A common measure used in determining the association between cognitive functioning and walking in community-based research is the Mini-Mental State Examination (MMSE; Folstein, Folstein, & McHugh, 1975), or a modification of the MMSE (Barnes, Yaffe, Satariano, & Tager, 2003). Although the MMSE is useful in documenting positive effects of walking, it is not clear that it is sufficiently sensitive to detect differences due to variation in walking settings that present different environmental challenges to persons with minimal cognitive impairment. The Mental Alternation Test (MAT) is a measure of mild cognitive impairment that,
while being significantly correlated with the MMSE (Billick, Siedenburg, Burgert, & Bruni-Solhkhah, 2001), tests individual’s spatial and sequential abilities. Shumway-Cook and colleagues (2002) propose that temporal factors and attention demands, such as finding a route in an unfamiliar location, may pose a challenge on some older adults’ ability to safely walk. The MAT may be more sensitive in identifying this challenge in older adults. This study examines whether older adults with varying levels of mild cognitive impairment exhibit differences in walking patterns with regard to the community settings where they walk and the frequency, intensity, or duration of walking. This association is examined using two measures of cognitive performance, the MMSE and the MAT, controlling for factors known to be associated with walking behavior among older adults.

Methods

Interviews were conducted with 884 adults aged 65 years and older, residing in four areas in the U.S.: Alameda County, California; Cook County, Illinois; Allegheny County, Pennsylvania; and Durham/Wake Counties, North Carolina. Eligibility criteria included age 65 years or older, English speaking, currently living in one of the four geographical areas, having lived at present location for at least 12 months and no plans to move during the next 3 months, and cognitive functioning sufficient to complete an in-person interview. Persons were excluded if they had a health condition or functional disability that precluded them from walking for exercise, were restricted from walking outdoors on doctor’s orders, or self-reported inability to walk outdoors due to a medical condition. Medical conditions warranting exclusion include chronic or serious conditions that limit participation in unsupervised light physical activity (e.g., unstable angina, diagnosed with or hospitalized for chest pain, heart surgery or myocardial infarction in the past 6 months) and major surgery within the past 3 months.

To ensure ethnic, socioeconomic, and neighborhood diversity and representation, the recruitment procedure involved identifying all aging service settings in the four regions, stratifying the settings into quintiles of housing density using Geographic Information Systems data (ArcGIS), and randomly ordering these settings for recruitment sites. In most occasions, the aging services settings were senior centers. Approximately 12 participants were recruited at each site. An effort was made to obtain persons in fair to poor health as well as those in good to excellent health at each site. The recruitment procedures and materials made it clear that we wanted all participants, including those who may or may not currently walk in their neighborhood.

Eligible participants were interviewed at the senior organization or at their homes by trained interviewers. The assessment required about 1 hr and included an interview survey and a performance assessment. All participants provided written informed consent to participate in the study as approved by the university’s institutional review boards at each of the respective sites.

Measures

The interview consisted of questions regarding individual characteristics including demographics, physical and mental health status, functional mobility competence, walking activity, neighborhood characteristics, and cognitive function. Demographic characteristics included age, gender, race (Caucasian, African American, and other), marital status, years of formal education, and county of residence. Physical health measures included self-reported overall health (excellent, good, fair, and poor), body mass index, and the total number of health problems in the past month causing difficulty walking outside. Health problems were based on a checklist of 16 items such as pain in legs, back, or spine; trouble keeping balance; trouble seeing steps; frequent need to use the bathroom; and dizziness or light-headedness. Depressive symptoms were measured by a short form of the Center for Epidemiological Studies-Short Depression scale (Kohout, Berkman, Evans, & Cornoni-Huntley, 1993).

Physical performance testing focused on lower body function and mobility (Guralnik, Ferrucci, Simonsick, Salive, & Wallace, 1995). This included the chair stand (number of seconds required for the person to sit and stand five times), a series of progressive balance tests (tandem, semi-tandem), and a walking test (number of times a person can walk a 10-foot length in 60 s). A lower body function score was created by summing the 5-point balance score, 4-point chair stand score, and 4-point walking speed score, with higher scores indicating better lower extremity function (Guralnik score; range 0–13).
Walking measures were adapted from the International Physical Activity Questionnaire (Craig et al., 2003) and Physical Activity Scale for the Elderly (PASE; Washburn, Smith, Jette, & Janney, 1993). Walking activity included the number of times in a given week the person walks (frequency), whether the person walks at a leisurely pace and brisk pace (intensity), and the total number of minutes he/she walks per week (duration). Participants were also asked if they walk in their neighborhood streets, parks, shopping malls, indoor gym, and on walking/jogging trails. Walking included walking for exercise, leisure walking, and utilitarian walking.

Self-assessments of the participant’s neighborhood environment based on the modified Neighborhood Environment Walkability Survey (NEWS) were included (Saelens, Sallis, Black, & Chen, 2003). Subscales from the modified NEWS included access to services, land use, street connectivity, places for walking, neighborhood surroundings, traffic safety, and safety from crime. This measure has reasonable validity and reliability and has been associated with physical activity (Saelens et al., 2003). Two additional measures associated with performance of physical activity were included: fear of falls and self-efficacy for walking. Fear of falls was assessed by a single question asking how much they worry about falls (a lot, some, a little, never worry about falls). Respondents were asked to indicate how confident they were that they can walk 10 blocks without slowing down or stopping to rest. Scores range from 1 (not at all confident) to 10 (absolutely confident).

The dependent measure, cognitive function, was assessed using an abbreviated MMSE (Barnes et al., 2003) and the MAT. The abbreviated MMSE has six items, with a scoring range of 0–18 (Satariano, Haight, & Tager, 2002). Based on the Trail Making Test (Reitan, 1958), the MAT is a single-item scale that requires the individual to alternate between numbers and letters sequentially (i.e., 1-a, 2-b, 3-c). The number of correct alterations in 30 s determines the score (26 letters and 26 corresponding numbers for a maximum total score of 51). The MAT correlates significantly with the MMSE ($r = .84$), and has a sensitivity and specificity above 90% in geriatric populations (Billick et al., 2001).

**Results**

The participants ranged in age from 65 to 88 years ($M = 74.8$ years), were primarily female (77%), and had a mean education level of 13.8 years (Table 1). The majority were White (65%); 23% were African American and 10% of another race. The sample was distributed approximately equally across the four sites. Most rated their health as fair/poor, whereas 22% rated their health as good/excellent. The sample means for the two cognitive measures were 14.66 of 18 and 13.88 of 51 for the MMSE and the MAT respectively.

Table 2 provides the means and frequencies for the walking measures for participants and bivariate associations between the walking measures and the cognitive status of MMSE and MAT. In terms of frequency, duration, and intensity of walking, participants reported walking 3.6 times per week, with a mean of 167.8 min per week. More than one third (35.7%) reported that they engage in brisk walking once a week or more. Most walk in their neighborhood (54.2%), followed by parks (29%). There were regional differences in places where participants walk. Participants from Allegheny County were less likely to walk on walking/jogging trails than older adults from Alameda County. Older Alameda County participants were less likely to walk in shopping malls and indoor gyms than older adults in the other study areas (findings not shown).

Only intensity of walking was significantly associated with cognitive status at the bivariate level (Table 2). Self-report of brisk walking was significantly more likely among those with higher MMSE
and MAT scores. With the exception of neighborhood walking, cognitive status was significantly associated with reports from older adults about where they walk (walking/jogging trails, parks, shopping malls, and indoor gyms). Compared with older adults with lower MMSE and MAT scores, those with higher scores were more likely to walk on jogging trails and in parks. Those with lower MAT scores were more likely than those with higher scores to walk in shopping malls and indoor gyms.

Table 3 presents findings from the multiple regressions between patterns of walking (intensity, duration, and frequency) and location or places where older adults walk for exercise/leisure and their cognitive functioning. The regressions were run separately for MMSE and MAT using a backward elimination method removing nonsignificant variables at a level of $p < .10$. Independent variables included individual factors (demographics, health status, attitudes and beliefs about exercise), walking variables, and neighborhood characteristics (the four NEWS scales). In total, 9 items remained in the regression for MMSE and 15 items for the MAT (Table 3). The full-model $R^2$ for the MMSE was .29 ($df = 9,737, F = 34.3$) and for the MAT .53 ($df = 15,765, F = 58.7$).

Age, geographic region, grades completed, and race were significantly related to MMSE. Younger age and higher education were significantly associated with higher cognitive function as measured by the MMSE. Other than regional differences, no significant differences in demographic characteristics were found for the MAT. All significant differences by region for both the MMSE and the MAT showed significantly higher cognitive functioning in the referent group (Alameda County) compared with the other regions.

In terms of health factors, lower body functioning as measured by the Guralnik scale significantly predicted cognitive functioning. Better performance on the functioning scale was significantly associated with higher scores on the MMSE and MAT. The MAT scores were also significantly associated with two attitudes and beliefs: worry about falls and perceived self-efficacy for walking 10 blocks. The greater the fear of falling reported by the older adults, the higher the cognitive function as indicated by the MAT. Also, the greater the level of self-efficacy for walking, the higher the cognitive function on the MAT.

Only one of the walking measures was significantly associated with MMSE. Those with lower MMSE scores were significantly more likely to walk in indoor gyms than those with higher cognitive scores on the MMSE. Three walking measures were significantly associated with MAT scores: the likelihood respondents walk in their neighborhood, walk in parks, and walk in shopping malls. Contrary to expectations, compared with respondents with lower MAT scores, older adults with higher scores reported walking more frequent times per week in their neighborhood.

**Discussion**

Findings from this cross-sectional study indicate that there is a complex association between cognitive performance and patterns of walking among
older adults in the community. The findings suggest that cognitive status is associated with the number of times people walk per week and the community settings where older adults are more likely to walk. These findings are compatible with several perspectives concerning environmental influence in walking behavior including environmental demands associated with mobility in community

Table 3. The Association Between Patterns in Walking and Cognitive Performance, Controlling for Neighborhood and Individual Characteristics

| Characteristics | MMSE | | | | | | MAT | | | |
|-----------------|------|------|------|------|------|------|------|------|------|------|------|
|                 | M % | B   | SE  | t    | B   | SE  | t    | B   | SE  | t    | B   | SE  | t    |
| Walking variables |      |      |      |      |      |      |      |      |      |      |      |      |
| No. of times walked in neighborhood per week | 3.61 | 0.04 | 0.02 | 1.66 | 0.03 | 0.06 | 0.49 |      |      |      |      |      |
| Minutes per week of total walking | 167.8 | 0.00 | 0.00 | 0.80 | 0.00 | 0.00 | 0.39 |      |      |      |      |      |
| Brisk pace walking (yes/no) | 35.7 | 0.76 | 0.52 | 3.16** | 2.99 | 0.59 | 50.4** |      |      |      |      |      |
| Destination variables |      |      |      |      |      |      |      |      |      |      |      |      |
| Walk on walking/jogging trails | 17.3 | 1.00 | 0.29 | 3.45** | 3.81 | 0.73 | 5.25** |      |      |      |      |      |
| Walk on neighborhood streets | 54.2 | 0.09 | 0.22 | 0.42 | 0.81 | 0.56 | 1.44 |      |      |      |      |      |
| Walk in parks | 29 | 0.75 | 0.24 | 3.06** | 2.92 | 0.61 | 4.82** |      |      |      |      |      |
| Walk at a shopping mall | 22.7 | −0.25 | 0.27 | −0.92 | −2.40 | 0.66 | −3.64*** |      |      |      |      |      |
| Walk at an indoor gym | 19.7 | −0.16 | 0.28 | −0.55 | −1.88 | 0.70 | −2.69*** |      |      |      |      |      |

Notes: MMSE = Mini-Mental State Examination; MAT = Mental Alternation Test. 
**p < .01.
settings among older adults with disabilities (Shumway-Cook et al., 2002) and Lawton’s (1980) perspective on person–environment fit.

The finding that cognitive impairment was associated with a lower frequency of walking in the neighborhood indicates that persons with cognitive impairment may be less likely to meet current physical activity recommendations for older adults of at least moderate intensity level of physical activity. The findings also imply that the MAT may be more sensitive in identifying environmental challenges associated with walking in differing community settings than the MMSE. Significant mean differences were found between MAT scores in reference to the number of times that older adults walked per week and in walking in two community settings, in parks and in shopping malls. Although these findings are preliminary, they provide support that measures of mild cognitive impairment may be useful in detecting environmental barriers associated with walking.

The finding that persons with lower MAT scores walked more frequently than those with higher MAT scores was unexpected. Total number of minutes walked per week did not differ significantly by MAT scores. This may mean that those with lower MAT scores are taking walks of shorter duration, which suggests a more restricted range in their walking activities. This possibility of self-restricting range in walking with increases in cognitive impairment should be explored further.

The finding that neither the MMSE nor the MAT was associated with walking in neighborhoods was not expected. All participants were screened and excluded if significant cognitive impairment was identified. Given that participants had to have lived in the neighborhood for at least 1 year and walking in one’s neighborhood is the most common form of walking (Eyler et al., 2003), participants may be more familiar with their immediate neighborhood environment and are better able to navigate it even with greater cognitive impairment compared with other settings.

Limitations

Several cautions should be raised in interpreting the findings. First, the causal relationship between walking level and cognitive status cannot be determined by the cross-sectional design. Second, although we included an extensive assessment of walking behavior, the findings were based on self-reported walking activities. However, researchers have found that self-report measures of physical activity, such as the PASE, are correlated with objective measures of physical activity (Washburn & Flicker, 1999). Also, although the NEWS scale is a comprehensive assessment of environmental characteristics in the person’s neighborhood, a similar assessment was not made for the parks, walking trails, or shopping malls. Information on the quality of these walking settings and whether they are located in the respondent’s neighborhood would help to determine why they are used differently by persons with higher versus lower cognitive ability. Also, this study focused on walking and the built environment in the community and did not explore walking in the home (e.g., treadmill walking). It is possible that those with lower cognitive functioning may increase exercise activities in their home as a response to environmental challenges in their community.

Conclusions

Although considerable longitudinal research demonstrates that walking is protective of cognitive capacity, this study suggests that the relationship is bidirectional—cognitive capacity potentially influences walking activities. If the public health message is that physical activity may be protective of cognitive capacity at the primary, secondary, and tertiary levels, then it is critical that we understand the environmental challenges to participating in walking among older adults with differing levels of cognitive ability. Walking interventions should consider the unique environmental challenges in designing walkable settings for older adults varying not only in physical disability but also in cognitive capacity. Future research should explore the specific environmental challenges of older adults and assist them in their efforts to remain independent and active in their community.

Funding

This study was funded by the Robert Wood Johnson Foundation, W. Saratiano, principal investigator.

References


Received July 2, 2008

Accepted October 27, 2008

Decision Editor: Angela K. Hochhalter, PhD