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Neighborhood environment and physical activity among older adults: Do the relationships differ by driving status?

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Abstract

Some attributes of neighborhood environments are associated with physical activity among older adults. This study examined whether the associations were moderated by driving status. Older adults from neighborhoods differing in walkability and income completed written surveys and wore accelerometers (*N*=880, mean age=75 years, 56% women). Neighborhood environments were measured by geographic information systems and validated questionnaires. Driving status was defined on the basis of a driver's license, car ownership, and feeling comfortable to drive.

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Outcome variables included accelerometer-based physical activity and self-reported transport and leisure walking. Multilevel generalized linear regression was used. There was no significant Neighborhood Attribute × Driving Status interaction with objective physical activity or reported transport walking. For leisure walking, almost all environmental attributes were positive and significant among driving older adults but not among nondriving older adults (five significant interactions at $p<0.05$). The findings suggest that driving status is likely to moderate the association between neighborhood environments and older adults' leisure walking.

Keywords

built environment; walking; moderator; moderation

Despite numerous health benefits of regular physical activity (Bouchard, Blair, & Haskell, 2012; Nelson, et al., 2007), older adults remain the least active age group (Centers for Disease Control and Prevention, 2010). In a study based on national data of objectively measured physical activity, only 2.4% of US adults age 60 or older met the recommended physical activity levels (Troiano et al., 2008).

Increasing evidence from multiple disciplines has underscored the importance of built environments to physical activity (Heath, et al., 2006; Sallis, Floyd, Rodriguez, & Saelens, 2012). As a result of functional declines and fears of navigating outdoor environments (Rantakokko et al., 2009), attributes of community design may be especially important to older adults (Shigematsu et al., 2009), particularly those with mobility impairments (King et al., 2011). However, only a small number of studies have examined neighborhood environments in relation to physical activity among older adults, and findings were mixed (Cunningham & Michael, 2004; Van Cauwenberg et al., 2011). Overall, neighborhood environments had more consistent associations with self-reported physical activity than with objectively measured physical activity among older adults (Van Cauwenberg et al., 2011). There is evidence supporting the association of physical activity with access and proximity to recreation facilities (Berke et al., 2006; Li, Fisher, Brownson, & Bosworth, 2005; Shigematsu et al., 2009) and with mixed land use patterns (Frank, Kerr, Rosenberg, & King, 2010; Li, Fisher, Bauman et al., 2005; Shigematsu et al., 2009). These attributes of neighborhood environments might interact with other individual and environmental characteristics (Heath et al., 2006; Sallis et al., 2006). Examining potential moderators is the most frequently cited recommendation for future research on the associations between built environments and physical activity (Ding & Gebel, 2012).

One important factor that influences physical activity is transportation mobility, which is often associated with driving status in car-dependent societies (Davey, 2007). On the basis of the 2001 U.S. National Household Travel Survey, older adults depended on personal vehicles for 89% of their traveling needs (Collia, Sharp, & Giesbrecht, 2003). Although most older adults continue to drive at an old age, some reduce or cease driving as aging progresses (Betz & Lowenstein, 2010). Driving older adults with age-related illnesses and functional limitations are at higher risk for traffic-related injuries and fatalities (Hakamies-Blomqvist, 2004). However, older adults who cease driving experience transportation deficiency (Kim, 2011) and face social exclusion and challenges in independent living (Engels & Liu, 2011; Freeman, Gange, Munoz, & West, 2006). This driving dilemma for older adults in the United States is created by land use patterns and transportation policies that have encouraged car dependency in most U.S. cities (Giuliano, 2004).

Because driving and non-driving older adults have different transportation options and mobility, one could hypothesize that the associations between built environments and physical activity differ by driving status (Eriksson, Arvidsson, Gebel, Ohlsson, & Sundquist, 2012). A study of rural Japanese women found that convenient bus service was positively associated with physical activity among non-drivers, but not drivers (Kamada, et al., 2009). This implies that attributes of neighborhood environments may be more important to non-driving older adults because their activities are likely to be confined to the immediate neighborhood. However, such potential moderating effects may vary by domain of physical activity. For example, we expect that neighborhood environments may play a less important role in active transport than in leisure time physical activity among nondrivers, because travel behavior is a derived demand (Handy, Boarnet, Ewing, & Killingsworth, 2002); therefore, nondrivers may have to travel actively for errands when there is a demand, regardless of neighborhood environments. To understand the complex relationships among neighborhood environments, driving, and physical activity, it is essential to identify characteristics of drivers and nondrivers, and to test driving as a moderator with overall and domain-specific physical activity outcomes. Understanding the interactive effects of neighborhood environments and driving on physical activity can help identify disadvantaged population subgroups that face environmental barriers in active aging and help inform policy initiatives to address common issues older adults experience in their daily life, such as transportation deficiency, physical inactivity, and sedentariness.

In this study, we examined whether driving status moderated the associations of neighborhood environments with physical activity among older adults. We used objectively assessed physical activity as well as self-reported domain-specific walking (i.e., for leisure and errands). In addition, we described and compared characteristics of driving and non-driving older adults. We hypothesized that the association between neighborhood environments and physical activity differ by driving status, in which the association is stronger among nondrivers than drivers. We further hypothesized that compared to driving older adults; nondriving older adults are older, less healthy, and less active.

Methods

Procedures

The current analysis is part of the Senior Neighborhood Quality of Life Study, an observational epidemiological study designed to examine the relationship of neighborhood environments to multiple health and well-being outcomes among older adults (age 66 or older). The study design was very similar to that of the Neighborhood Quality of Life Study (Sallis et al., 2009) on working age adults (20–65) and details of the study design and procedures have been published elsewhere (King et al., 2011; Shigematsu et al., 2009). Briefly, older adults were recruited from 228 census block groups in Seattle-King County, WA, and Baltimore-Washington, DC, regions. These census block groups were selected because they differed in socioeconomic status (measured by 2000 Census median household income) and neighborhood environment attributes (measured by a walkability index). The walkability index was calculated using parcel-level land use data, street centerline data, and census data within geographic information systems (Frank, Sallis, et al., 2010).

Older adults were recruited from individual homes and retirement living facilities. For community-dwelling older adults, investigators obtained basic demographic and contact information for residents living within the selected block groups from a marketing firm and sent out introduction letters to households with residents in the target age range. For retirement-living older adults, facilities were identified in selected block groups and contacted by phone. When facilities agreed to participate, resident liaisons were identified to work with investigators to develop recruitment plans, identify interested residents, or facilitate distribution of materials and communication with residents. All participants had to be age 66 or older, be able to complete written surveys in English, be able to walk at least 10 ft at a time, have lived in the current neighborhood for 3 months or more, and have no plans to move within the next 12 months.

After obtaining written informed consent, participants were sent a survey package, an accelerometer, and instructions. Participants were provided with an incentive of $25 for completing an assessment. Of 3,611 eligible contacts, 883 returned the initial survey, resulting in an overall enrollment rate of 24.5%. All study procedures were approved by the institutional review boards at Stanford University and San Diego State University.

Measurement

Independent variables—A geographic information systems-derived walkability index was calculated for a 500-m street-network buffer around participants' residences as a composite score of four neighborhood characteristics known to facilitate walking for transportation: net residential density, land-use mix, retail floor area ratio, and intersection density (Frank, Sallis, et al., 2010). The buffer size was selected on the basis of preliminary analyses that found environmental characteristics within a 500-m buffer to be the most predictive of physical activity in this age group. The 500-m buffer does not meet a rigorous definition of neighborhood, but for present purposes, *neighborhood* is used as a convenient term to refer to the buffer-based local area. Examples of high- and low-walkable buffer-based local areas are presented (Figure 1).

The total number of public parks within or intersecting a 500-m buffer was determined using parcel-level land use data and lists from local park agencies (Abercrombie et al., 2008). The total number of private recreation facilities within a 500-m buffer was determined using manually searched and geocoded information about private recreation facilities (e.g., gyms, dance studios). The two numbers were summed to represent the number of nearby locations for recreational physical activity.

An older adult-modified version of the Neighborhood Environment Walkability Scale (Cerin, Saelens, Sallis, & Frank, 2006; Saelens, Sallis, Black, & Chen, 2003) was used to measure attributes of neighborhood environments expected to be associated with physical activity. This scale has good reliability and validity (Brownson, et al., 2004; Brownson, Hoehner, Day, Forsyth, & Sallis, 2009) and has been validated against geographical information system measures (Adams et al., 2009). Subscales included Residential Density (six items), Land Use Mix-Diversity (26 items), Land Use Mix-Access (six items), Street Connectivity (three items), Walking-Bicycling Infrastructures (four items), Aesthetics (four items), Traffic Safety (three items), Pedestrian Safety Structures (seven items), and personal safety (seven items). The Residential Density subscale score was computed as a weighted sum of 5-point response options; other subscale scores were computed as means of either 4- or 5-point response options (Saelens, Sallis, Black, & Chen, 2003). A single Neighborhood Environment Walkability Scale item regarding proximity to bus or train stops was used as a separate variable. A microscale summary score was created by averaging subscale scores on Walking-Bicycling Infrastructure, Aesthetics, Traffic Safety, Pedestrian Safety Structures, and proximity to bus or train stops. The microscale summary complemented the macro-level walkability index. Compared to macroscale land use features, microscale characteristics refer to smaller details in the environment that can usually be changed more easily and inexpensively (Sallis et al., 2011).

Outcome variables—Actigraph uniaxial accelerometers (Models 7164 and 71256; Actigraph LLC, Shalimar, CA) were used to objectively assess physical activity. Accelerometers provide valid measures of physical activity (Welk, 2002) and have been widely used in research (Troiano et al., 2008). Participants were instructed to wear the accelerometer during waking hours for 7 consecutive days. Movement was recorded in 1-min epochs. A valid wearing hour included no more than 45 consecutive zeroes, and a valid wearing day included at least 8 valid wearing hours. Participants were asked to wear the accelerometer again if their data included fewer than five valid wearing days or 66 valid wearing hours across 7 days. Data were cleaned and scored using MeterPlus Version 4.0 software from Santech, Inc. (http://www.meterplussoftware.com). Two accelerometer-based activity outcomes were analyzed, including moderate-to-vigorous physical activity (≥1,952 counts/min) per valid wearing day (Buman et al, 2010) and total physical activity, measured by mean counts per minute across all valid wearing days.

Walking was measured using two items from the Community Healthy Activities Model Program for Seniors, a questionnaire for older adults with reasonably good reliability and validity (Stewart et al., 2001). Participants reported the number of times during a typical week in the past four weeks that they walked to do errands and the number of times they walked leisurely for exercise or pleasure. Owing to skewed data distribution, both types of walking behaviors were dichotomized as “any” if participants reported walking at least once per week and “none” if otherwise.

Potential moderator: Driving status—Three variables were considered essential for driving: a driver’s license, car availability, and capability to drive. Older adults who reported having a driver’s license, having a car in the household, and feeling comfortable to drive for at least 1 mi from home were defined as drivers. Those who did not meet all three criteria were classified as nondrivers because the absence of any one condition would critically impede driving. On the basis of this composite measure, 95% of the nondrivers reported not driving a car for transportation in the past 4 weeks and 99% of the drivers reported driving at least once per week, indicating good validity of the current measure.

Covariates—Geographic region (Seattle-King County vs. Baltimore-Washington, DC) and reported demographic characteristics of age, gender, educational attainment (college degree vs. not), race/ethnicity (non-Hispanic White vs. non-White), marital status (married or living with a partner vs. not), living situation (community dwelling vs. retirement living), and years at the current address were adjusted for as covariates. In addition, medical history and mobility impairment were adjusted for. Medical history was an index (count) of having the following conditions: visual impairments, hearing problems, confusion, and depression. Mobility impairment was measured using the validated 11-item advanced lower extremity function subscale from the Late-Life Function and Disability Instrument (Haley et al., 2002; Sayers et al., 2004).

Data analyses

All statistical analyses were conducted in 2012 using IBM SPSS 19.0 (IBM Corp., Armonk, NY). When comparing characteristics of driving and nondriving older adults, *t* tests were used to compare unadjusted means and chi-square tests were used to compare unadjusted percentages. In adjusted models, owing to the structure of data with individuals nested within census block groups, multilevel modeling was used. For continuous outcomes (accelerometer-based physical activity), mixed linear regression was used. Unstandardized regression coefficients were reported, representing adjusted mean differences in the outcome with one-unit differences in independent variables. For dichotomous outcomes (transport walking and leisure walking), mixed generalized linear regression models were fitted specifying a logit link (McCulloch, 2006). The exponents of unstandardized regression coefficients were reported, which can be interpreted similarly to odds ratios. All models adjusted for covariates as fixed effects, and census block group was entered as a random effect to adjust for participant clustering. When testing driving status as a moderator, one neighborhood environment variable was entered together with driving status and an interaction term of the two in each model, adjusted for all covariates. Stratified analyses further explored associations of neighborhood attributes with physical activity outcomes separately for driving and nondriving older adults. Stratified analyses were conducted regardless of the significance of interactions because the small sample size of nondriving older adults limited the power for detecting significant interactions. An alpha of .05 was used for tests of main effects and interactions.

Data analyses used the combined sample of community-dwelling and retirement-living older adults because the patterns of difference between driving and nondriving older adults were similar in both samples (Appendix). Furthermore, we conducted a sensitivity analysis among only community-dwelling older adults and found similar patterns of associations compared with the combined sample, but fewer significant interactions as a result of less statistical power.

Results

Descriptive statistics

The final study sample included 880 older adults aged 66–97 years (mean age = 75 years, 56% women, 30% non-White) with complete survey data, of whom 726 were drivers and 154 were nondrivers. Descriptive statistics of driving and nondriving older adults are presented in Table 1. Compared to driving older adults, nondriving seniors were older, more likely to be women, non-White, without a college degree, without a partner, and living in retirement living facilities. In addition, nondriving older adults were more likely to have visual impairment, hearing problems, confusion, and poorer lower extremity function. Nondriving older adults were also more likely to reside in high-walkable neighborhoods as defined by objectively measured walkability index and self-reports (i.e., Neighborhood Environment Walkability Scale residential density, land use mix, and street connectivity subscales), neighborhoods that included nearby parks and recreation facilities, and neighborhoods with better access to public transit and better infrastructure for walking and bicycling. However, nondriving older adults reported their neighborhoods to be less safe.

Physical Activity by Driving Status

In unadjusted models, nondriving older adults had less moderate to vigorous physical activity and less total physical activity. In adjusted models, the differences in objective physical activity outcomes were no longer significant (Table 2). In both unadjusted and adjusted models, nondriving older adults were more likely to report transport walking and leisure walking at least once a week in the past 4 weeks.

Neighborhood Environment and Physical Activity by Driving Status

No significant interactions appear in Table 3, and significant interactions are indicated with bold in Table 4. Overall, associations of neighborhood environments with accelerometer-based outcomes and transport walking did not differ by driving status (Table 3). With leisure walking as the outcome, several interactions with driving status were significant, including reported street connectivity ($p = .012$), walking-bicycling infrastructure ($p = .046$), traffic safety ($p = .048$), pedestrian safety structures ($p = .008$), and overall microscale sum score ($p = .013$). All significant interactions followed similar patterns in which the associations between neighborhood environments and leisure walking were significant and positive among driving older adults but inverse and nonsignificant among nondriving older adults.

Discussion

There is evidence that driving could be a moderator for the associations between neighborhood environments and physical activity. The potential moderating effects differed by domains of physical activity, and all significant Neighborhood Environments × Driving Status interactions involved leisure walking as the outcome. We found no significant interactions with other physical activity measures. Overall, the findings are not as expected because we hypothesized the association to be stronger among nondrivers and for transport walking.

Five of the 13 tested interactions with leisure walking were significant, and the direction of interactions was not as expected. It is unknown why leisure walking was not related to any environmental characteristics in the expected direction among nondriving older adults. One possible explanation is that nondriving older adults might be more likely to walk for leisure in protected areas, such as the home, yards, and public indoor places. In fact, the instrument used for measuring leisure walking explicitly prompted older adults to include treadmill walking. Walking in these private or indoor places is less likely to be related to outdoor neighborhood environments. By contrast, driving older adults may be more influenced by neighborhood environments because (through driving) they are aware of more choices in settings to do their walking, including outdoors in the neighborhood, if it is suitable. Moreover, there is a wider range in the behaviors of driving older adults who are more active overall, and studies have shown that access to a car was a predictor of overall physical activity in older adults (Frank, Kerr, Rosenburg, & King., 2010). Future studies should include measures for location-specific physical activity and take into account the particular contexts in which physical activity takes place (Handy et al., 2002).

In this study, we found no significant interaction of environmental attributes and driving status with objectively measured physical activity or reported transport walking as outcomes, suggesting consistency in the patterns of associations regardless of driving status. Overall, more environmental attributes were significantly associated with reported walking than with objective physical activity measured by accelerometers. This pattern of associations is consistent with a recent review on older adults (Van Cauwenberg et al., 2011) and is similar to findings from a recent semiquantitative review among other age groups (Ding, Sallis, Kerr, Lee, & Rosenburg, 2011). Conceptually, many attributes of neighborhood environments (e.g., sidewalks, pedestrian safety structures) are more relevant to walking, particularly to walking in the neighborhood, than to total physical activity, which includes domains that are less likely to be related to neighborhood environments, such as occupational and household physical activity (Owen, Humpel, Leslie, Bauman, & Sallis, 2004; Saelens & Handy, 2008; Saelens, Sallis, & Frank, 2003). This behavior-specific approach was recommended for research in built environments and physical activity (Giles-Corti, Timperio, Bull, & Pikora, 2005).

This study found that nondriving older adults were a distinctive group compared with driving older adults. Nondriving older adults were more likely to be older, women, minorities, without a college degree, and without a partner. Most of these demographic characteristics of nondrivers were consistent with the literature (Rosenbloom, 2004). The lack of driving ability could signify deteriorating health and impaired mobility, as indicated by lower extremity function and key medical conditions. On the basis of objective measures, nondriving older adults were less physically active than driving older adults, and the inactivity was partly due to health and physical functions, because the difference in accelerometer-based physical activity diminished once lower extremity functions and key medical history were adjusted for. In the current analyses of environments and physical activity, we adjusted for all confounders that accounted for the difference in physical activity levels of drivers and nondrivers. Therefore, the differential associations between environmental attributes and leisure walking are likely the result of driving, not of confounding variables for which driving is an indicator. Nondriving older adults were also more likely to live in neighborhoods with activity-friendly environmental features. Because temporal order could not be determined from the current study, it is unknown whether older adults relocated to walkable neighborhoods after giving up driving or gave up driving because they lived in neighborhoods where they did not need a car for daily activities. More specific questions about driving (or driving cessation) need to be asked to understand the associations between neighborhood environments and driving.

Limitations

Despite methodological strengths, such as including both objective and reported measures for neighborhood environments and physical activity, this study has several limitations. First, this study did not directly assess driving behavior. Instead, three related variables (a driver's license, car ownership, and feeling comfortable to drive) were used to conceptualize driving status to take into account different scenarios in which older adults could not drive freely. It is a conservative measure, but our analysis suggested good validity of this measure when compared with self-reported driving for transportation. Future studies should ask participants specific questions about driving behavior for transportation, leisure, and other purposes.

Second, the conceptualization of driving status as a potential moderator was based on the assumption that nondrivers were less mobile and had fewer transportation options. Although this assumption is generally supported by the literature (Kim, 2011), it is possible that older adults who were classified as nondrivers in this study had easy access to a vehicle as a rider (through social networks or transportation service), therefore having similar mobility to that of drivers. It is also possible that driving status measured in the current study was an indicator of other characteristics, such as lifestyle and life circumstances. Future studies should consider other modes of transportation, examine overall mobility in addition to driving mobility, and take into account life circumstances related to transportation behavior.

Third, this study did not include location-specific physical activity measures. Therefore, it was impossible to determine whether the location of physical activity matched that of environmental attributes. This may explain some nonsignificant associations that were conceptually important, such as neighborhood environments with leisure walking among nondriving older adults. Future studies should include combined GPS and accelerometry measures (Oliver, Badland, Mavoa, Duncan, & Duncan, 2010) or ask about walking and other physical activity that take place in the neighborhood.

Conclusions

This study examined driving status as a potential moderator for the association of neighborhood environments with physical activity among older adults. There was some evidence suggesting moderating effects with leisure walking, but little evidence with other physical activity outcomes. The pattern of interactions, in which neighborhood environments had stronger associations with leisure walking among driving older adults, were not as expected. Most attributes of neighborhood environments were related to transport walking regardless of driving. This highlights the importance of an activity-friendly neighborhood environment to active travel for all older adults. Therefore, policies and programs should focus on improving the "senior-friendliness" of neighborhoods to facilitate walking and providing alternative transportation options to help older adults fulfill their daily needs. The increasing number of older adults who cannot or do not want to drive makes it imperative to consider alternatives to driving in transportation and land use policies and practices. To better understand the complex relationships among neighborhood environments, physical activity, and transportation mobility among older adults, future studies should identify transportation options of nondriving older adults and the locations in which driving and nondriving older adults are active.

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Appendix

Descriptive Statistics of Driving and Nondriving Older Adults by Living Situation

Variable	Community-Dwelling Older Adults (*M* [SD])		Retirement-Living Older Adults (*M* [SD])	
	Driving (*n* = 636)	**Nondriving (*n* = 80)**	**Driving (*n* = 90)**	**Nondriving (*n* = 74)**
Continuous (M [SD])				
Age	73.9 (6.0)***	77.9 (7.4)	79.5 (7.3)	79.7(7.8)
Lower extremity function (lowest-highest = 0–100)	58.8 (17.2) ***	44.4 (17.5)	50.0 (16.6)**	41.2 (19.4)
Neighborhood walkability	−0.4 (2.5)***	1.9 (3.6)	0.1 (2.9)**	1.8 (3.9)
Residential density (unit: 100)	2.3 (0.7)***	3.0 (0.7)	2.7(1.2)	3.0 (1.2)
Land use mix				
diversity[a]	2.3 (0.8)	2.5 (0.9)	2.3 (0.7)	2.4 (0.8)
access[a]	2.7 (0.6)**	2.9 (0.6)	2.8 (0.5)	2.8 (0.6)
Street connectivity[a]	3.0 (0.7)	2.9 (0.7)	3.0 (0.6)	3.1(0.7)
Walking/cycling infrastructures[a]	2.8 (0.8)	2.7 (0.8)	3.0 (0.8)	3.0 (0.7)
Neighborhood aesthetics[a]	3.1 (0.8)	3.1 (0.7)	3.0 (0.7)	3.2 (0.7)
Traffic safety[a]	2.6 (0.7)	2.7 (0.7)	2.7 (0.8)	2.7 (0.7)
Pedestrian safety structures[a]	2.6 (0.5)	2.6 (0.5)	2.7 (0.4)	2.7 (0.4)
Personal safety[a]	2.7 (0.8)	2.8 (0.8)	3.0 (0.8)	2.9 (0.7)
Microscale sum score[a,b]	3.1 (0.6)	3.1 (0.8)	3.3 (0.7)	3.2 (0.7)
Categorical (%)				
Women	50.4%***	75.0%	56.7%***	87.8%
Non-Hispanic White	28.2%*	38.8	32.2%	33.8%
Completed college	49.9%	41.3%	46.7%*	31.1%
Married or living with a partner	59.7%***	33.8%	41.1%***	13.5%
Visual impairment	5.2%***	17.5%	12.2%	18.9%
Hearing problems	12.4%*	22.5	18.9%	18.9%
Confusion	9.4%	15.0%	13.3%	23.0%
Depression	10.7%	13.8%	10.0%	14.9%
Having parks within 500 m from home	58.6%**	77.5%	62.2%*	79.7%
Having recreation facilities within 500 m from home	41.0%**	56.3%	50.0%	62.2%

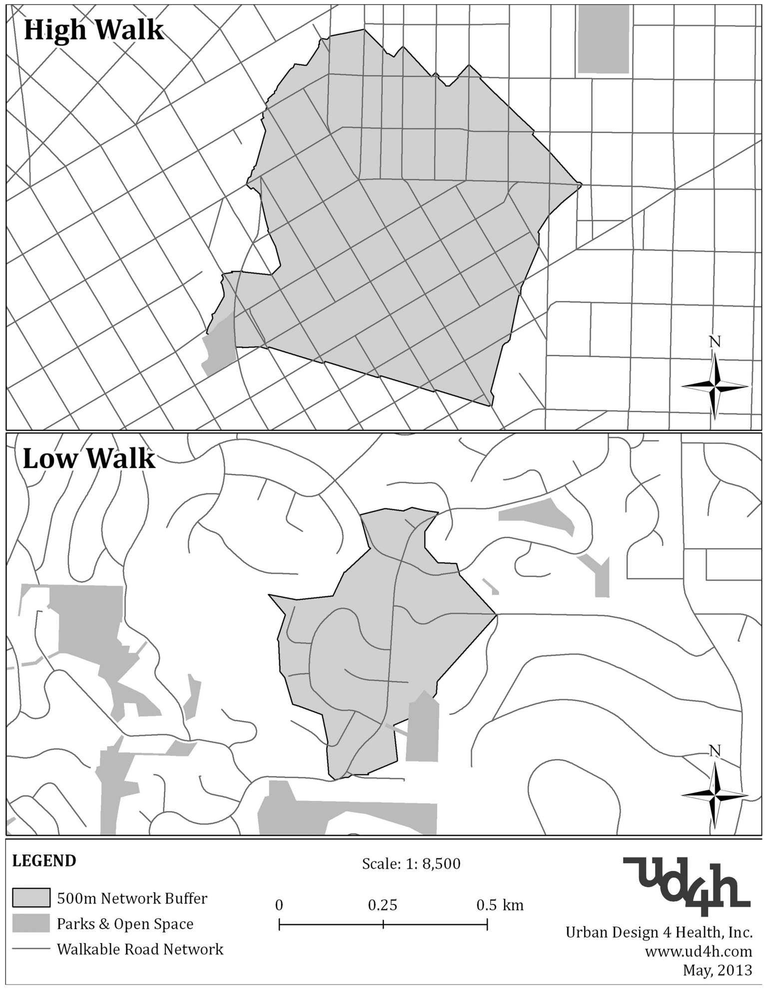
[a]Based on Neighborhood Environment Walkability Scale; scores range 1 to 4, with higher numbers representing more activity-friendly attributes.

[b]Mean score of walking or cycling facilities, aesthetics, traffic safety, pedestrian safety structures, and transit stops.

* $p < .05$,

** $p < .01$,

*** $p < .001$.


High Walk
N
Low Walk
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LEGEND
500m Network Buffer
Parks & Open Space
Walkable Road Network
Scale: 1: 8,500
0
0.25
0.5 km
Urban Design 4 Health, Inc.
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May, 2013

Figure 1.

Table 1

Characteristics of Driving and Nondriving Older Adults in the Senior Neighborhood Quality of Life Study

Variable	Driving older adults (n = 726)[a]	Nondriving older adults (n = 154)[b]
Continuous (M [SD])		
Age	74.6 (6.4)***	78.8 (7.6)
Lower-extremity function (lowest-highest=0–100)	57.7 (17.4)***	42.8 (18.4)
Neighborhood walkability index	−0.38 (2.60)***	1.86 (3.70)
Residential density (unit: 100)	2.34 (0.83)	2.98 (1.27)
Land use mix[c]		
diversity	2.31 (0.80)*	2.45 (0.88)
access[c]	2.69 (0.60)***	2.89 (0.62)
Street connectivity[c]	2.95 (0.66)*	3.07 (0.67)
Walking and cycling infrastructures[c]	2.74 (0.85)***	2.88 (0.78)
Neighborhood aesthetics[c]	3.13 (0.66)	3.12 (0.76)
Traffic safety[c]	2.74 (0.69)	2.64 (0.70)
Pedestrian safety structures[c]	2.65 (0.45)	2.65 (0.48)
Transit access	3.20 (1.00)*	3.42 (0.94)
Microscale sum score[c,d]	2.89 (0.48)	2.94 (0.50)
Personal safety[c]	3.42 (0.60)***	3.11 (0.70)
Categorical, %	%	%
Women	51.2***	81.2
Non-Hispanic White	71.3*	63.6
Completed college	49.5**	36.4
Married or living with a partner	57.4***	24.0
Community dwelling	87.6***	51.9
Visual impairment	6.1***	18.2
Hearing problems	13.2*	20.8
Confusion	9.9**	18.8
Depression	10.6	14.3
Having parks within 500m from home	59.0***	78.6
Having recreation facilities within 500m from home	42.1***	59.1

[a] n = 712 for accelerometer-related outcomes.

[b] n = 149 for accelerometer-related outcomes.

[c] Based on Neighborhood Environment Walkability Scale, scores range 1 to 4, with higher numbers representing more activity-friendly attributes.

[d] Mean score of walking or cycling facilities, aesthetics, traffic safety, pedestrian safety structures, and transit stops.

[*] $p < .05$,

[**] $p < .01$,

[***] $p < .001$.

Table 2

Physical Activity Among Driving and Nondriving Older Adults

Outcome	*n*	Unadjusted *M* [95%CI]	Adjusted *M* [95% CI][a]
Objective			
Moderate-to-vigorous physical activity (min/day)			
driving	712	13.7 [12.5, 14.8]***	10.9 [9.2, 12.8]
nondriving	149	6.5 [3.9, 9.0]	11.0 [8.3, 13.7]
Total physical activity (counts/min)			
driving	712	189.0 [181.9, 196.1]***	172.1 [161.6, 182.7]
nondriving	149	130.8 [115.2, 146.4]	162.2 [146.6, 177.8]
	n	**%**	**Unadjusted OR [95%CI][b]**
Reported			
Leisure walking			
driving (reference group)	726	69.5	1.00
nondriving	154	80.5	1.96 [1.26, 3.07]**
Transport walking			
driving (reference group)	726	37.0	1.00
nondriving	154	62.3	2.84 [1.97, 4.01]***

Note. All models adjusted for age, gender, marital status, ethnicity, living situation (community dwelling vs. retirement living), educational attainment, study site (Seattle vs. Baltimore), years in current location, number of key medical conditions, and lower-extremity functions. All models also included block group number as a random effect. CI = confidence interval; OR = odds ratio.

[a]Based on multi-level linear models.

[b]Based on multilevel generalized linear models with a binary logit link.

* $p < .05$,

** $p < .01$,

*** $p < .001$.

Table 3

Unstandardized Regression Coefficients and 95% Confidence Intervals for the Associations of Neighborhood Attributes and Accelerometry Outcomes Among Driving and Nondriving Seniors

Environment	Total Physical Activity (Counts/Min)		Moderate-to-Vigorous Physical Activity (Min/Day)	
	Driving (*n* = 712)	Nondriving (*n* = 149)	Driving (*n* = 712)	Nondriving (*n* = 149)
Objective environment				
Parks and recreation facilities (ref = 0)				
1	10.80 [−6.66, 28.28]	14.76 [−22.84, 52.37]	1.09 [−1.92, 4.10]	−0.90 [−6.26, 4.46]
2+	11.98 [−3.79, 27.20]	27.84 [−7.11, 62.79]	2.36 [−0.31, 5.03]	2.52 [−2.74, 7.22]
Walkability	3.23* [0.61, 5.82]	1.09 [−1.92, 4.10]	0.72** [0.27, 1.16]	0.06 [−0.37, 0.49]
Perceived environment				
Residential density (100 housing unit)	1.49 [−7.10, 10.07]	0.28 [−8.08, 8.64]	0.77 [−0.71, 1.69]	0.46 [−0.76, 1.68]
Land use mix				
diversity[a]	11.24** [2.88, 19.59]	9.20 [−3.31, 21.72]	2.53*** [1.09, 3.96]	1.87* [0.12, 3.61]
access[a]	9.67† [−1.42, 20.76]	9.15 [−8.02, 26.32]	1.98* [0.07, 3.89]	1.60 [−0.84, 4.05]
Street connectivity[a]	2.58 [−6.84, 12.00]	−9.77 [−25.62, 6.07]	−0.66 [−2.28, 0.96]	−2.45* [−4.68, −0.21]
Walking/cycling infrastructures[a]	0.85 [−6.87. 8.58]	0.68 [−13.36, 14.71]	0.39 [−0.94, 1.72]	0.77 [−1.23, 2.76]
Neighborhood aesthetics[a]	5.14 [−4.92, 15.21]	−5.58 [−20.29, 9.12]	0.27 [−1.46, 2.01]	−0.31 [−2.41, 1.79]
Traffic safety[a]	−0.01 [−0.48, 0.50]	−13.72† [−29.29, 1.72]	−0.01 [−1.63, 1.62]	−1.24 [−3.45, 0.98]
Pedestrian safety structures[a]	−3.01 [−17.34, 11.33]	0.94 [−20.94, 22.82]	0.78 [−1.68, 3.25]	0.13 [−3.00, 3.24]
Transit access[a]	3.04 [−3.53, 9.60]	2.26 [−9.08, 13.60]	1.05† [−0.08, 2.17]	0.92 [−0.69, 2.53]
Overall microscale attributes[b]	2.58 [−11.37, 16.53]	−5.78 [−27.87, 16.31]	1.43 [−0.97, 3.82]	0.34 [−2.82, 3.50]
Personal safety[a]	2.03 [−9.48, 13.22]	−10.84 [−27.78, 6.10]	−0.20 [−2.16, 1.75]	0.49 [−1.94, 2.91]

Note. Multilevel linear models adjusted for age, gender, marital status, ethnicity, living situation (community dwelling vs. retirement living), educational attainment, study site (Seattle vs. Baltimore), years in the current location, number of key medical conditions, and mobility impairment. All models also included block group number as a random effect cluster variable.

[a] Based on Neighborhood Environment Walkability Scale, scores range 1–4, with higher number representing more activity-friendly attributes.

[b] Mean score of walking/cycling infrastructures, aesthetics, traffic safety, pedestrian safety structures, and transit access

† $p < .10$,

* $p < .05$,

** $p < .01$,

*** $p < .001$

Table 4

Odds Ratios and 95% Confidence Intervals for the Associations of Neighborhood Attributes and Reported Walking Among Driving and Nondriving Older Adults

Environment	Transport Walking (Yes vs. No)		Leisure Walking (Yes vs. No)	
	Driving (*n* = 726)	Nondriving (*n* = 154)	Driving (*n* = 726)	Nondriving (*n* = 154)
Objective Environment				
Parks and recreation facilities (ref. = 0)				
1	0.49† [0.93, 2.89]	0.82 [0.14, 4.81]	1.07 [0.70, 1.67]	0.61 [0.09, 3.94]
2+	4.44*** [2.72, 7.24]	3.71 [0.76, 18.17]	1.36 [0.92, 1.99]	1.08 [0.19, 6.23]
Walkability	1.34*** [1.23, 1.46]	1.57*** [1.25, 1.97]	1.11** [1.03, 1.20]	1.01 [0.86, 1.19]
Perceived Environment				
Residential density (100 housing unit)	1.80*** [1.38, 2.34]	1.75* [1.08, 2.80]	1.19 [0.94, 1.49]	1.03 [0.68, 1.58]
Land use mix				
diversity[a]	2.59*** [1.99, 3.35]	4.01*** [2.18, 7.39]	1.35* [1.07, 1.68]	1.02 [0.57, 1.86]
access[a]	5.99** [4.10, 8.76]	4.66*** [2.10, 10.38]	1.49* [1.12, 1.99]	1.35 [0.60, 3.03]
Street connectivity[a]	1.51** [1.14, 2.10]	1.36 [0.67, 2.75]	1.34* [1.04, 1.72]	0.51 [0.23, 1.17]
Walking or cycling infrastructures[a]	1.65*** [1.30, 2.12]	3.94*** [1.95, 15.64]	1.25* [1.03, 1.52]	0.68 [0.34, 1.35]
Neighborhood aesthetics[a]	1.34* [1.01, 1.80]	2.29* [1.17, 4.48]	1.30* [1.01, 1.68]	1.03 [0.51, 2.08]
Traffic safety[a]	1.20 [0.90, 1.58]	1.13 [0.59, 2.18]	1.22 [0.95, 1.55]	0.46† [0.21, 1.01]
Pedestrian safety structures[a]	2.29*** [1.48, 3.56]	2.61* [1.02, 6.69]	1.93*** [1.32, 2.83]	0.43 [0.15, 1.28]
Transit access[a]	1.63*** [1.32, 2.01]	2.01** [1.21, 3.32]	1.12 [0.94, 1.31]	0.80 [0.46, 1.38]
Overall microscale attributes[b]	3.10*** [1.99, 4.85]	7.03*** [2.39, 20.49]	1.73** [1.21, 2.51]	0.41 [0.13, 1.27]
Personal safety[a]	1.08 [0.77, 1.54]	1.46 [0.69, 3.06]	0.84 [0.63, 1.15]	0.52 [0.23, 4.26]

Note. Multilevel generalized linear models with a binary logit link, adjusted for age, gender, marital status, ethnicity, living situation (community dwelling vs. retirement living), educational attainment, study site (Seattle vs. Baltimore), number of months in current location, number of key medical conditions, and mobility impairment. All models also included block group number as a random effect cluster variable. Bold cells indicate significant Environmental Attribute x Driving Status interactions.

[a] Based on Neighborhood Environment Walkability Scale; scores range 1–4, with higher numbers representing more activity-friendly attributes.

[b] Mean score of walking or cycling infrastructures, aesthetics, traffic safety, pedestrian safety structures, and transit access.

† $p < .10$,

* $p < .05$,

** $p < .01$,

*** $p < .001$