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Built environment attributes related to GPS measured active trips in mid-life and older adults with mobility disabilities

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Abstract

Background—Understanding factors which may promote walking in mid-life and older adults with mobility impairments is key given the association between physical activity and positive health outcomes.

Objective—To examine the relationship between active trips and objective measures of the home neighborhood built environment.

Methods—Global positioning systems **(**GPS) data collected on 28 adults age 50+ with mobility disabilities were analyzed for active trips from home. Objective and geographic information systems (GIS) derived measures included Walk Score, population density, street connectivity, crime rates, and slope within the home neighborhood. For this cross-sectional observational study, we conducted mean comparisons between participants who took active trips from home and those who did not for the objective measures. Effect sizes were calculated to assess the magnitude of group differences.

Results—Nine participants (32%) took active trips from home. Walking in the home neighborhood was significantly associated with GIS derived measures (Walk Score, population density, and street density; effect sizes .9-1.2). Participants who used the home neighborhood for active trips had less slope within 1 km of home but the difference was not significant (73.5 meters

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±22 vs. 100.8 meters ±38.1, p=.06, d=0.8). There were no statistically significant differences in mean scores for crime rates between those with active trips from home and those without.

Conclusions—The findings provide preliminary evidence that more walkable environments promote active mobility among mid-life and older adults with mobility disabilities. The data suggest that this population can and does use active transportation modes when the built environment is supportive.

Keywords

Built environment; active trips; GPS; mid-life and older adults; mobility impairment

Introduction

The risk for mobility disability increases as adults age. Data from the Health and Retirement Study suggest that adults over 50 have, on average, over 2 mobility limitations.[1] People with disabilities are less likely to engage in leisure-time physical activity and meet physical activity recommendations compared to people without disabilities.[2] Physical activity is associated with decreased risk for depression and improved functional status and quality of life in adults with disabilities and with older adults,[3] and with decreased risk for cognitive impairment[4],[5] and type 2 diabetes in older adults.[6] Understanding factors which may promote or deter walking in mid-life and older adults with mobility impairments is key given the association between physical activity and beneficial health effects, including mental, physical, social, and functional health.[7, 8] Walking is accessible in terms of skill and cost and has been shown to be a preferred mode among older adults.[9] Additionally, given transportation constraints associated with disability (e.g. dependence on walking, public transit, or other people for transportation needs)[10] walking offers value as a mode of physical activity as well as a means to reach destinations such as those for food, prescriptions, and/or medical care.

One limitation of the existing literature related to physical activity and the built environment is that few studies examine older adults with mobility impairments. One prospective study showed evidence for new onset of mobility impairments among older adults living in areas of heavy traffic, poor lighting, and high noise volume.[11] A study of older adults in Chicago found that people with impaired mobility and living in neighborhoods with poor street conditions were four times more likely to report severe difficulty with walking compared to those who live in neighborhoods with better street conditions.[12] Given the lack of research on associations between built environment characteristics and active trips among those with mobility disability, the purpose of this study was to examine differences in objective measures of the built environment between those with and without active trips in the home neighborhood in a sample of adults age 50 and older with mobility disabilities.

Methods

Original Study Purpose and Participants

The Built Environment, Accessibility, and Mobility Study (BEAMS) was a conducted in urban and suburban neighborhoods in King County, Washington (WA). The purpose of the original cross-sectional observational study was to document built environment barriers to physical activity and mobility among adults age 50 and older who reported having a mobility disability. Mobility disability was defined broadly as self-reported use of an assistive device (e.g. cane, walker, wheelchair, scooter) for mobility. Participants were recruited from a range of neighborhoods (e.g. high and low walkability; high and low income) through announcements and flyers at senior centers, senior housing facilities, community events, and local newsletters. Inclusion criteria for the study were 50 years of age and older, require use of an assistive device for mobility, reside in King, County, Washington, speak and read English, and leave home 3 days per week or more. The study procedures were approved by the Institutional Review Board at the University of Washington. Further details of the original study design, procedures, and qualitative data analysis are available elsewhere.[10, 13]

Procedures

After eligibility verification and verbal consent by phone to participate in the study, participants were mailed a Qstarz BT-Q1000XT, (Qstarz International Co.,Ltd., Taipei, Taiwan). Participants were instructed to wear the GPS device for at least 12 hours on 3 days including 2 weekdays and 1 weekend day. The GPS was returned by mail to study researchers using a prepaid envelope. Home-based in-depth interviews were conducted after return of the GPS device. Prior to the home interview, maps depicting the routes taken while the participant wore the GPS device were printed and used as a prompt during the interviews.

GPS Data Processing

The GPS data was uploaded to the Personal Activity Location Measurement System (PALMS) [14] for processing in 30-second epochs. The PALMS output provided identification of trips, mode of travel as determined by speed (pedestrian, scooter and vehicle), date and time stamps, speed of travel, and latitude and longitude coordinates. The data were uploaded for further analysis within a geographic information system (GIS) along with publically available data layers from King County, WA (http://www.kingcounty.gov/operations/GIS/GISData.aspx).

The primary outcome of analysis was active trips taken over the three days, with the definition of a trip consistent with previous studies.[15-17] PALMS identifies trips based on speed, elevation change, change in distance between satellite fixes, signal loss time, outdoor location, and satellite signal to noise ratio (https://ucsd-palms-project.wikispaces.com/).Trips less than five minutes were excluded from analysis to reduce risk of categorizing walking at home as trips away from home.[18, 19] Return trips (i.e., back to the original destination) were classified in PALMS as a separate trip. The trip time was cumulative, including the stops, until the target destination was reached. In circumstances of a round-trip walk, i.e., the starting and end point were the same location, this was categorized as a single trip. The starting location for active trips was further categorized as “at home” or “not at home” based on the geocoded home address.

To reduce subjective inference, multiple methods were employed in the identification of the outcome variables. For example, destinations identified within the GIS were confirmed by processing the latitude and longitude coordinates in BatchGeo (http://batchgeo.com/).[20] Destinations were also compared to those cited during the in-depth interviews as being accessed during the GPS recording period or accessed on a regular basis by the participants. A summary of the methods used for each outcome variable are displayed in Table 1.

GIS-Derived Neighborhood Built Environment Measures

Walkability—Walkability of each participant's home neighborhood was estimated using the Walk Score® as calculated at www.walkscore.com. Walk Score has been validated as an estimator of the walkability of cities and neighborhoods in the U.S. based on proximity to destinations such as stores, restaurants, parks, schools, and more within a 1 mile radius of the scored address.[21, 22]

Population Density—Population density was calculated as the number of individuals per square kilometer by block groups. Area calculations and number of individuals per block group were obtained from the U.S. Census website (www.census.gov). Population density is reported per participant's block group.

Street Connectivity—Two measures of street connectivity were used in the analysis.[23] Street density was calculated as the number of linear kilometers of street per square kilometer of land, for the buffered area of 1 km from the home residence. Average block length was calculated as the mean of all blocks within 1 km of the home residence.

Slope—Raster files with 10m elevation data for the study area were obtained from the Geospatial data gateway (http://datagateway.nrcs.usda.gov/ref) and combined with participant home neighborhood and active trip data. Slope, in meters, was calculated as an indicator of the change in elevation in a participant's neighborhood by subtracting the lowest elevation point within a 1km circular buffer of each participant's home from the highest elevation point within the same buffer.[24]

Crime—For participants living within Seattle city limits, crime data was obtained from the Seattle police department (http://www.seattle.gov/police/crime/) for the three years preceding the year of data collection (2008-2010) and averaged across the three years. The rates of violent and property crimes per 100,000 was calculated at the precinct population level within the city limits. For participants in other parts of King County violent and property crime data was obtained from the local city police departments and also calculated as rates per 100,000 at the local city population level.

Data Analysis

Analyses were performed using Stata version 12.1 (Stata Corporation, College Station, TX). Descriptive statistics were computed for number of trips, mode of transport, and number of active trips from home, transit time, and starting locations (home and away from home), and common destinations. Mean Walk Score and environmental measures were compared by t-test, or the Wilcoxon rank sum text for non-normally distributed variables, for those who took active trips from home to those who did not. Alpha level was set at .05 a priori. Effect sizes were calculated using Cohen's d = (M_1–M_2/σpooled) to assess the magnitude of group differences. Cut points of 0.2, 0.5, and 0.8 were used to identify small, medium, and large effect sizes, respectively.[25]

Results

Thirty-five participants completed the GPS monitoring and in-depth interviews. The sample had an average age of 67 (range 50-86), 74% were female, and 86% were white. Most participants used multiple types of assistive devices with 57% reporting use of a cane, 57% reporting use of a walker, and 20% reporting use of a manual wheelchair (for more details of the sample characteristics, see Rosenberg et al., 2013).[13] Of the 35 study completers, GPS analysis was completed on 28. Of the seven participants excluded from analysis, interviews confirmed that all took trips outside of the home but these were not captured sufficiently by the GPS units. Reasons for insufficient GPS data capture were: one device malfunctioned, one had interference with satellite communication due to living in downtown Seattle with tall buildings, and four participants did not have a sufficient amount of GPS data for analysis due to forgetting to carry the GPS with them during trips, failing to charge the device, or taking trips too short to identify as a trip vs. error in the GPS signals which really were indicative of movement at home. One participant was eligible for the interview portion of the study but did not meet eligibility criteria of using a cane, walker, wheelchair, or scooter for mobility for this secondary analysis study. Thirteen participants (46%) had active trips of which nine participants (32%) took active trips from home. Six participants used a power wheelchair for outdoor transport or recreational wheeling and these were classified as non-active trips. Among the 13 participants with active trips, 5 (39%) first used a vehicle to get to a destination where they then made their active trip, including one participant who also took an active trip from home. A summary of descriptive statistics of participants and all active trips are presented in Table 2. The shortest trip length was 5 minutes; however, all participants with a 5 minute trip also had additional trips of longer duration. Among those who walked in the home neighborhood, seven (78%) took a round-trip walk, four (44%) walked to food destinations (grocery stores, restaurants) and one walked to a drugstore. Using the PALMS mode of travel classification, with conformation by interview data and GIS data visual inspection, 19 subjects were identified as having motorized vehicle and/or scooter trips from home but no active trips from home.

Objective built environment and active trips

Results for mean comparisons of objective built environment measures are presented in Table 3. Population density, property crime rates, violent crime rates, and street density were not normally distributed and group mean differences were tested using the Wilcoxon rank-sum test. There were significant differences between participants with active trips from home compared to those without for Walk Score (83.1 vs. 65.9, p=0.03, d=1.0), population density (5230.7 vs. 2662.9, p=0.01, d=0.9), and street connectivity as estimated by street density (60.5 km vs. 42.6 km, p=0.01, d=1.2). Also, participants who used the home neighborhood for active trips had less slope within 1 km of home but the difference was not significant (73.5 meters±22 vs. 100.8 meters ±38.1, p=.06, d=0.8). There were no statistically significant differences in mean scores for crime rates or street connectivity measured by average neighborhood block length.

Discussion

This data provides preliminary evidence that more walkable environments promote active mobility among mid-life and older adults with mobility disabilities. Furthermore, the data suggest that mid-life and older adults with mobility disabilities can and do use active transportation modes when the built environment is supportive. There are several policy implications as the population ages and the number of older adults with disabilities is expected to increase from the current estimates of 37% of older adults.[26] Helping baby boomers prepare for future mobility declines by encouraging residence in walkable neighborhoods may enhance their activity and mobility levels which could positively impact their independence as they face declines in health. City planning policies for transportation infrastructure allocations, such as sidewalk improvements, traffic reduction modifications, and mixed-used zoning (including affordable senior housing), may be optimized by considering impacts on mobility for an aging population.

Results from the current study are, for the most part, aligned with previous findings of associations between built environment features and walking in older adults. Higher residential density was significantly associated with outdoor mobility in the current study which is consistent with previous studies of older adults.[27, 28] Similar to the outcomes reported in reviews by Foster and Giles-Corti[29] and Humpel et al.,[30] in the current study there was no association between objectively measured crime and active transport from home. Comparable to findings by Satariano et al.,[31] there was no difference in the average block length within 1 km for those with active trips compared to those without active trips. However, those who took active trips from home did have significantly greater street density, (i.e., total number of kilometres of street within 1 km of home) indicating a greater number of route options for walking in the home neighborhood. This method for assessing street connectivity and the significant findings are consistent with those from Li et al.[32]

Due to problems differentiating between physical and environmental determinants of disability (i.e. disability is the result of incongruity between physical ability and environmental demands[33]), eligibility criteria did not include physical ability to take an active trip nor were participants queried directly on their ability to take active trips either by walking or manual wheelchair propulsion. It is possible that some participants could not take an active trip, although the majority self-identified as having the physical ability to do so. With respect to limitations of the GIS analysis, objective measures of the built environment were assessed at the closest level available within 1 km of home for each participant. However, data for the variables of crime and population density were only available for larger administrative neighborhood areas (e.g., precinct, city, and census block) which may have resulted in biased exposure estimates.[34] The small sample size limits our ability to generalize our findings though these preliminary results indicate further study in this area is warranted.

Previous work has shown the multiple health benefits associated with walking and outdoor mobility, particularly for older adults, including improved cognitive function,[5] reduced risk for type 2 diabetes,[6] and reduced depressive symptoms.[35] Endorsement and maintenance of active transport in mid-life and older adults with mobility disabilities has the added potential of promoting social interaction, functional independence, and physical capacity in this at-risk population. This study demonstrates that objectively measured features of the neighborhood environment such as walkability, street connectivity, and residential density support active travel for older adults with mobility disabilities. With the projected increase in the number of older adults over the next two decades, creating residential environments that support active mobility will allow greater numbers of older adults to age in place while contributing to health and independence.

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Table 1

Summary of methods used to identity outcome variables

Variable	Method 1	Method 2	Method 3
Destination	Identified as stopping point within GIS (layers used: food, medical, common interest, park)	Batchgeo confirmation	Compared to destinations identified/described in interview
Time spent traveling	Using the timestamp from GPS converted to local time in PALMS. Based on first and last point of trip as identified by PALMS	6 datapoints (3 minutes) on either side of each trip visually inspected for travel. If there appeared to be travel not identified by PALMS additional minutes were inspected until the start of the trip was identified as first movement away from the current location	
Mode of Transport	PALMS calculated mode (stationary, pedestrian, bicycle, vehicle)	Visual inspection within GIS for travel path (along roads, paths, bus route, or inside buildings), speed of travel, and distance traveled.	Confirmed and/or adjusted based on interview data. The majority of bicycle trips were confirmed as power wheelchair/scooter trips or vehicle trips as no participants rode a bicycle for transportation
Walking Trips	PALMS identified pedestrian trips, visual inspection of stationary point moving consecutively along a path of travel to a destination or in a round-trip.	Confirmed by visual inspection with time/distance traveled consistent with ambulation	Confirmed against interview data

Table 2

Descriptive statistics of participants (n=28) and active trips

	Mean (SD) and Range or N (Percent)
Age	67 (9.4) Range 50-86
Females	21 (75%)
Race	
White	25 (89%)
Black	1 (4%)
Asian	1 (4%)
Multi-racial	1 (4%)
Highest education level	
Some high school	1 (4%)
Some college or vocational training	9 (32%)
Completed college	8 (29%)
Completed graduate degree	10 (36%)
Number of self-reported medical conditions	3.7 (1.8)
Participants with active trips	13 (46%)
Participants with outdoor trips by power wheelchair	6 (21%)
Number of participants with active trips starting from home	9 (32%)
Number of participants with active trips after first taking a vehicle to a destination	5 (18%)
Mean time of active trips (minutes)	22.2 (12.1) Range 5-65

Table 3

Comparison of objective built environment measures between those with active trips from home and those without

	Active trips Mean (SD) N=9	No active trips Mean (SD) N=19	t-statistic or Wilcoxon rank-sum	df	P	Effect size (Cohen's d)
Block length (km)	0.12 (0.02)	0.12 (0.03)	0.11*	26	0.91	0.01
Population density per km^2	5230.7 (2959.5)	2662.9 (2939.5)	−2.58	26	0.01	0.9
Rate of property crime/100,000 people 2008-2010	4757.2 (1212.1)	4483.4 (1232.6)	−0.24	25	0.81	0.2
Rate of violent crime/100,000 people 2008-2010	402.3 (156.6)	450.1 (345.7)	0.24	25	0.81	0.2
Slope (Meters)	73.5 (22.0)	100.8 (38.1)	1.99*	26	0.06	0.8
Street density (km of roads within 1 km buffer)	60.5 (17.3)	42.6 (15.4)	−2.09	26	0.04	1.2
Walk Score (0-100)	83.1 (15.8)	65.9 (19.8)	−2.28*	26	0.03	1.0

*indicates t-statistic

km=kilometer