The impact of neighborhood walkability on walking: Does it differ across adult life stage and does neighborhood buffer size matter?

Abstract

We explored the impact of neighborhood walkability on young adults, early-middle adults, middle-aged adults, and older adults' walking across different neighborhood buffers. Participants completed the Western Australian Health and Wellbeing Surveillance System Survey (2003-2009) and were allocated a neighborhood walkability score at 200m, 400m, 800m, and 1600m around their home. We found little difference in strength of associations across neighborhood size buffers for all life stages. We conclude that neighborhood walkability supports more walking regardless of adult life stage and is relevant for small (e.g., 200m) and larger (e.g., 1600m) neighborhood buffers.

Highlights

- This study explored variation in the association between walkability and walking across life stages, and by neighborhood buffer.
- There were few differences in strength of associations across 200m, 400m, 800m, and 1600m for all adult life stages.
- The results suggest that neighborhood walkability supports more walking regardless of adult life stage and is relevant at smaller and larger neighborhood buffers.

Key words

Walkability, life stage, adults, older adults, neighborhood buffer, walking

Background

Walking is a popular, versatile, affordable, and potentially enjoyable activity that is recognized as a means of increasing levels of physical activity for the majority of the population (Simpson et al., 2003). There is accumulating evidence that the way neighborhoods are designed (i.e., built environment) influences walking behavior (Owen et al., 2004, Transportation Research Board, 2005). The built environment is commonly conceptualized in terms of its 'walkability', a composite index combining neighborhood design attributes likely to reflect pedestrian-friendliness and ease of travel (Frank et al., 2010).

To date, research suggests that adults living in more walkable neighborhoods (i.e., higher residential density with mixed land use and connected streets) have higher levels of walking than those in less walkable neighborhoods (Doyle et al., 2006, Saelens et al., 2003). Similar associations are found in the handful of studies on older adults (Berke et al., 2007, Frank et al., 2010, King et al., 2011, Carlson et al., 2012). Despite evidence of the association between walkable neighborhoods and walking, there is a lack of evidence in relation to how this relationship varies across life stages (Papas et al., 2007, Saelens and Handy, 2008). None have addressed variation in the association between walkability and walking across life stages within a single study.

The neighborhood buffer at which the built environment has the strongest influence may differ across life stages (Hooper et al., 2012). The importance of neighborhood buffer is relatively understudied and there is no consensus on what defines a 'neighborhood' (e.g., shape or size). Distances of 200m-1600m around participants' homes are typically used to represent the size of the 'neighborhood' because these typically represent 'walkable' distances to local destinations (Hooper et al., 2012). There appear to be no published studies (Learnihan et al., 2011) concurrently exploring the impact of neighborhood buffer size across various adult life stages, although it is hypothesized that the neighborhood size for older adults is likely to be smaller than for younger adults (Giles-Corti et al., 2005). Thus, we aimed to explore associations between walkability and walking across: 1) adult life stages (i.e., young adults, early-middle adults, middle-aged adults, and older adults); and 2) different neighborhood buffer sizes.

Methods

Study participants

This study forms part of the Life Course Built Environment and Health (LCBEH) project, a cross-sectional data linkage study that aims to explore the impact of built environment features on health across different life stages. Participants were a stratified random sample of the Perth metropolitan area who completed the Western Australian Health and Wellbeing Surveillance System (HWSS) survey from 2003-2009 (n=21,347) administered by the Department of Health of Western Australia. Overall 74.7% consented to data linkage and had a geocoded home address (n=15,954). Children (<18 years) were excluded because their walking behavior was not asked in the survey (n=2964). Life stages were reclassified as young adults (18-29 years; n=1663), early-middle adults (30-44 years; n=2546), middle-aged adults (45-64 years; n=4703), and older adults (65+ years; n=3611) to reflect adult life stages. Ethics approval was obtained.

Measures

Any walking (outcome variable)

Self-reported total minutes of walking continuously for at least 10 minutes, for recreation, exercise or to get to or from places in the last week as asked in the HWSS survey, was dichotomised into 'no walking' (0 minutes; 25.8%) vs. any walking (>0 minutes).

Neighborhood walkability (independent variable)

Geographic Information Systems (GIS) software was used to identify the neighborhood areas that could be reached along the road network within 200m, 400m, 800m, and 1600m from each participant's home. Using GIS software (ArcGIS v10), a measure of neighborhood walkability was objectively determined for each neighborhood buffer size area (i.e., 200, 400, 800 and 1600m) using a walkability index (WI), which included: 1) **land-use mix** (Area in km^2 of land use types calculated according to an entropy formula adapted from that originally used by Frank et al., (2005) (Christian et al., 2011, Frank et al., 2005)); 2) **street connectivity** (ratio of number of three-way or more intersections to area in km^2;), and 3) **residential density** (ratio of number of dwellings to residential area in hectares). Standardized z-scores of each measure were summed to construct a WI score (and quartiles) representative of each participant's neighborhood at each buffer size. Previous studies using walkability indices to investigate associations between the built environment and health related behaviors have commonly grouped walkability scores into quartiles or quintiles (Li et al., 2009, Christian et al., 2011, Frank et al., 2005).

Covariates

A range of variables typically recognized in the literature to influence associations between the built environment and walking were adjusted for in analyses (Frank et al., 2006). These included sex (male, female), age (continuous), and education (<mid-secondary; upper secondary; final year of secondary school; Trade qualification; university degree or equivalent). Moreover, socio-economic index for areas, which is a national measure of socio-economic status based on a range of social and economic indicators was adjusted for (i.e., SEIFA (Australian Bureau of Statistics, 2008); continuous).

Statistical analyses

SPSS v19 was used for analyses. Interactions between age group and walkability (continuous and quartiles) were also explored by including the interaction in the full models described below. Binary logistic regressions were used to estimate the effect (odds ratio) of neighborhood walkability (quartiled with reference category = lowest walkability quartile) on any walking (reference category = no walking) for each adult life stage at each neighborhood buffer, and for all adults, adjusting for demographics (a total of 20 models). All models were repeated using the continuous walkability score. Values of $p<0.05$ were considered statistically significant. To explore whether the walkability quartile for a participant changed across the different buffer sizes we used cross-tabulations for each respective increase in buffer size (i.e., 200m by 400m, 400m by 800m, 800m by 1600m), and for the biggest increase in buffer size (200m by 1600m), and calculated the percentage of participants that remained in the same quartile or moved to a lower or higher quartile. Additionally, Pearson's product-moment correlation coefficients were computed for the continuous walkability scores.

Results

Table 1 shows the percentage of participants that changed walkability quartiles as the neighborhood buffer size increased, and the correlations in continuous walkability scores across buffer sizes. For each doubling of buffer size (i.e., next level of neighborhood buffer), approximately 50% of participants changed walkability quartile. When the neighborhood buffer size increased from 200m to 1600m, 65.6% of participants changed walkability quartile. The correlations in continuous walkability score were moderately strong for each doubling of buffer size (r=0.7-0.8) but lower for the largest buffer size increase from 200m to 1600m (r=0.41).

Insert table 1 here

Table 2 shows the adjusted odds ratios of walking for all ages, young adults, early-middle adults, middle-aged adults, and older adults at different neighborhood buffer sizes. Interactions between age group and walkability (continuous and quartiles) were tested but there were *no* significant interactions (not presented here) at any buffer size. The results for all ages show that there were few differences in associations across the four neighborhood buffer sizes. Nevertheless, the age group stratified results show that at 200m, the odds of walking in each adult life stage was significantly increased if they lived in the most (vs. least) walkable neighborhood, although there was no significant increase with the continuous walkability score for young adults (Table 2). At 400m, early-middle adults and middle-aged adults living in the most walkable neighborhood were respectively 56% and 43% more likely to walk than those living in the least walkable neighborhood ($p<0.05$). At 800m, the odds of walking for early-middle adults and older adults were higher for those living in the most walkable neighborhood vs. the least walkable neighborhood ($p<0.05$). Similarly at 1600m, early-middle adults, middle-aged adults and older adults were more likely to walk if they lived in a more walkable neighborhood ($p<0.05$). The continuous walkability results show that for adults ≥30 years, the results were similar across all neighborhood buffer sizes.

Insert table 2 here

Discussion

We explored the impact of walkability on walking at different adult life stages and across varying neighborhood buffers. As the neighborhood buffer increased from 200m to 1600m, the neighborhood walkability quartile changed for the majority of participants. Therefore, there was sufficient potential, should it exist, to detect a trend in the strength of the association with increasing neighborhood buffer size. However, the results also indicate moderately strong correlations between buffer sizes, indicating limited ability to detect a change in the effect of continuous walkability score across neighborhood buffer sizes. Further, there is typically low variation in walkability across the Perth metropolitan region, which may also be partly why no differences were found.

The results suggest that for all adults and separately for every adult life stage, those living in more walkable neighborhoods were more likely to walk. For adults aged 30 years and older, this association was of similar magnitude across neighborhood buffer sizes. Although the interaction tests suggest the effect of walkability on walking is similar for all life stage age

groups, for younger adults (18-29 years), the only significant association occurred at the 200m buffer (p=0.022) and only for the highest vs. lowest WI quartile. It is thus unclear if neighborhood walkability is less relevant for younger adults. If this is true, it may be that the focus of younger adult's activities is being conducted *away* from the local area (Matthews et al., 2005, Vallee et al., 2010, Zenk et al., 2011), resulting in less time walking in their 'neighborhood' (up to 1600m), particularly for recreation. Overall, the results suggest that highly walkable neighborhoods characterized by well-connected streets with more residential housing and a greater mix of land uses *proximate* to home appear important for *all* adults.

Notably, neighborhood walkability was also associated with older adults' walking even at the larger neighborhood buffers. This finding is in contrast to the literature where much of the research to date has only focused on smaller buffers (e.g., 200m) than those typically used among younger adults (Kerr et al., 2012). The use of smaller buffers have been based on the assumption that older people have a slower walking speed, thus the *nearby* environment would be more strongly associated with walking (Van Cauwenberg et al., 2011). However, it is also possible that the influence of neighborhood buffer size depends on walking purpose (e.g., walking for transport to get to and from destinations vs. walking for recreation/leisure). For example, a greater buffer size and distance to destinations may be more important for older adults' recreational walking in particular. Moreover, unlike younger adults, time may be less of a barrier for older adults when it comes to walking locally (Strath et al., 2007). In the current study for example, 89% of older adults in the sample were retired and thus, provided they were sufficiently mobile, they may have more freedom to spend their time on preferred activities rather than work commitments. Indeed, others have found that older adults are more likely to travel to a shop further away from home rather than shops nearby (Nathan et al., in press). Further consideration into appropriate neighborhood buffers specific to walking purpose is needed.

This study is limited by its cross-sectional design therefore causality cannot be assumed; however the large sample is representative and generalizable. The measure for walking included *all* walking (e.g., inside and outside the neighborhood), thus it was not neighborhood- or purpose-specific (i.e., walking for recreation or transport). Moreover, the dichotomization of the walking outcome means that the findings are more relevant to whether walkability is related to uptake of walking rather than whether it encourages more walking among those who do walk. Finally, it is important to note that because of the generally low variation in walkability across Perth, this may be why no differences between life stage and walking at different neighborhood buffer sizes were found. This is a major limitation in the study and future studies may replicate this current study in more varied built environment contexts.

There are associations with other features of the built environment which may vary across the life stage and by neighborhood buffer. Future research might examine how the relationship between walking and built environment features such as destinations, connectivity, and residential density, varies across life stages and across neighborhood buffers. Future studies might also consider including other life stages such as children and adolescents, the oldest-old (>85 years) and mobility impaired. Despite the limitations, this study is unique in that it has explored the relationship between walking and walkability in different life stages and across varying neighborhood buffer. In summary, neighborhood walkability supports more walking regardless of adult life stage and is relevant for small (e.g., 200m) and larger (e.g., 1600m) neighborhood buffers.

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Table 1. Percentage of participants changing walkability quartiles over each neighborhood buffer size, and correlations between buffer sizes

Scale change	Same quartile (%)	Lower quartile (%)	Higher quartile (%)	Pearson's r correlation
200m → 400m	50.0	26.5	23.6	0.70**
400m → 800m	51.4	25.4	23.2	0.81**
800m → 1600m	50.3	25.5	24.2	0.76**
200m →1600m	34.4	33.2	32.5	0.41**

**Correlations are significant at the $p<0.01$ level.

Table 2. Adjusted odds ratios of walking for all ages, young adults, early-middle adults, middle-aged adults and older adults at different neighborhood buffer sizes

Variable	All adults (≥18 years)	Young adults (18-29 years)	Early-middle adults (30-44 years)	Middle-aged adults (45-64 years)	Older adults (≥65 years)
	OR (95% CI) p-value	*OR (95% CI) p-value*	*OR (95% CI) p-value*	*OR (95% CI) p-value*	*OR (95% CI) p-value*
200m buffer					
WI Quartile 1	1.00	1.00	1.00	1.00	1.00
WI Quartile 2	1.18 (1.05-1.32) 0.004*	1.15 (0.79-1.59) 0.541	1.62 (1.26-2.08) <0.001*	1.23 (1.02-1.48) 0.027*	1.06 (0.86-1.31) 0.587
WI Quartile 3	1.29 (1.15-1.44) <0.001*	1.22 (0.86-1.73) 0.262	1.48 (1.13-1.92) 0.004*	1.24 (1.03-1.49) 0.022*	1.26 (1.01-1.55) 0.037*
WI Quartile 4	1.39 (1.24-1.56) <0.001*	1.51 (1.06-2.14) 0.022*	1.39 (1.07-1.81) 0.013*	1.50 (1.23-1.82) <0.001*	1.26 (1.02-1.55) 0.028*
Continuous WI score	1.08 (1.05-1.11) <0.001*	1.07 (0.98-1.16) 0.145	1.09 (1.02-1.16) 0.010*	1.10 (1.05-1.15) <0.001*	1.06 (1.02-1.11) 0.008*
400m buffer					
WI Quartile 1	1.00	1.00	1.00	1.00	1.00
WI Quartile 2	1.08 (0.96-1.21) 0.181	1.06 (0.74-1.50) 0.755	1.21 (0.94-1.57) 0.144	1.13 (0.94-1.36) 0.189	0.96 (0.78-1.19) 0.730
WI Quartile 3	1.15 (1.02-1.29) 0.019*	1.15 (0.80-1.64) 0.451	1.27 (0.98-1.65) 0.073	1.16 (0.97-1.39) 0.107	1.04 (0.84-1.29) 0.722
WI Quartile 4	1.34 (1.19-1.51) <0.001*	1.13 (0.79-1.60) 0.510	1.56 (1.20-2.04) 0.001*	1.43 (1.18-1.74) <0.001*	1.19 (0.96-1.48) 0.111
Continuous WI score	1.06 (1.03-1.09) <0.001*	1.05 (0.96-1.14) 0.265	1.03 (0.97-1.09) 0.291	1.07 (1.03-1.12) 0.001*	1.08 (1.03-1.13) 0.001*
800m buffer					
WI Quartile 1	1.00	1.00	1.00	1.00	1.00
WI Quartile 2	1.11 (0.99-1.25) 0.067	1.32 (0.92-1.89) 0.132	1.06 (0.81-1.37) 0.685	1.13 (0.94-1.36) 0.203	1.07 (0.87-1.32) 0.507
WI Quartile 3	1.10 (0.98-1.24) 0.097	0.98 (0.69-1.39) 0.929	1.08 (0.83-1.40) 0.578	1.19 (0.99-1.43) 0.062	1.06 (0.86-1.31) 0.566
WI Quartile 4	1.25 (1.11-1.40) <0.001*	1.18 (0.82-1.69) 0.374	1.46 (1.11-1.92) 0.007*	1.15 (0.95-1.38) 0.153	1.31 (1.05-1.63) 0.015*
Continuous WI score	1.04 (1.02-1.07) <0.001*	1.02 (0.95-1.10) 0.572	1.05 (0.99-1.11) 0.070	1.04 (1.00-1.07) 0.050*	1.07 (1.02-1.11) 0.003*
1600m buffer					
WI Quartile 1	1.00	1.00	1.00	1.00	1.00
WI Quartile 2	1.14 (1.02-1.28) 0.022*	1.32 (0.92-1.89) 0.133	1.00 (0.79-1.27) 0.979	1.19	1.17 (0.94-1.44) 0.154
WI Quartile 3	1.16 (1.03-1.30) 0.013*	1.04 (0.73-1.47) 0.833	1.13 (0.88-1.44) 0.337	1.10 (0.91-1.31) 0.323	1.27 (1.03-1.56) 0.028*
WI Quartile 4	1.31 (1.17-1.48) <0.001*	1.14 (0.80-1.63) 0.456	1.37 (1.04-1.80) 0.027*	1.32 (1.08-1.60) 0.006*	1.40 (1.13-1.73) 0.002*
Continuous WI score	1.06 (1.04-1.08) <0.001*	1.02 (0.96-1.09) 0.500	1.07 (1.02-1.12) 0.006*	1.06 (1.02-1.09) 0.001*	1.08 (1.04-1.13) <0.001*

*$p \leq 0.05$

Outcome variable = any walking (>0 minutes/week)

WI= Walkability Index

WI quartiles: (least walkable = WI Quartile 1 = reference; most walkable = WI Quartile 4)

OR = Odds ratio

CI = Confidence Interval

Adjusted for sex (female = reference), age (continuous), education (<mid-secondary = reference), socio-economic status (SEIFA, continuous)