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Distances walked to and from local destinations: Age-related variations and implications for determining buffer sizes

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ABSTRACT

Introduction: Neighborhood environmental attributes can influence health-related physical activity, particularly walking. A better understanding of the distances adults walk to local destinations is needed to identify the appropriate geospatial boundaries within which environmental attributes are measured (buffer sizes). This study sought to identify the distances adults of different ages walk to/from public transit (PT) stops, shops/services, and natural features.

Methods: Data from the 2009–12 South-East Queensland Travel Survey were used. Our sample consisted of 2105 adults (18–84 years) who reported at least one home-based walking trip to/from those destinations. We reported the median (with the 20th and 80th percentiles) distances walked to/from each destination category by age groups. Multilevel regression analyses examined whether the distances walked differed by age groups.

Results: Participants reported 4029 walking trips, with the median distance of 0.68 km and the 80th percentile of 1.35 km. The median walking distance (80th percentile) to/from utilitarian destinations (PT stops, shops/services) and natural features was 0.63 (1.16) km and 1.15 (2.27) km, respectively. The overall median walking distance by age groups was 0.62 km for the younger (18–34 years), 0.67 km for younger middle (35–49 years), 0.79 km for older middle (50–64 years) and 0.72 km for older (65–84 years) groups. Regression analyses found that older middle-aged adults walked significantly longer overall and to/from utilitarian destinations than any of the other age groups.

Conclusions: Our findings support buffer sizes around 600–1200 m for studies examining environmental correlates of walking for utilitarian purposes. For recreational walking to get to natural features, larger buffer sizes ranging from 1200 to over 2000 m may be suitable. We did not find consistent evidence supporting the use of different buffer sizes for different age groups.

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1. Introduction

Health benefits of walking are well established. Higher volumes of walking time are associated with reduced risk of mortality and chronic diseases (Hamer and Chida, 2008; Kelly et al., 2014). Since walking is a common and accessible form of physical activity (Australian Bureau of Statistics, 2015; Cole et al., 2006), it is a key element in public health approaches to enhancing population health (Lee and Buchner, 2008). Walking for transport to get to/from local destinations (including public transit stops, shops, and services) is known to contribute significantly to adults' physical activity levels (Chaix et al., 2014; Cole et al., 2006). Walking for recreation, which includes walking to parks and other natural features, is also an important source of physical activity, due to its longer duration relative to walking for transport (Kang et al., 2017; Yang and Diez-Roux, 2012) and its feasibility in neighborhoods without local retail/service destinations.

Built-environment attributes have an important role in walking. Active living research has been investigating neighborhood built environmental attributes that facilitate residents' physical activity, typically walking (Sallis et al., 2012). It has been shown that having destinations within the local area and pedestrian-friendly routes to get there can facilitate walking for transport by adults (Owen et al., 2007; Sugiyama et al., 2012) and by older adults (Cerin et al., 2017). Recreational walking has been found to be associated with the presence of larger parks or parks with attractive features (Koohsari et al., 2018; Sugiyama et al., 2015). Such findings are often obtained using environmental attributes calculated within a "buffer" area, a geospatial boundary around the resident's home address where active behaviors are considered to occur. To date, different buffer sizes ranging from 400 m to 1.6 km have been used (Adams et al., 2014; Gunn et al., 2017; Villanueva et al., 2014; Duncan et al., 2011). However, there is lack of consensus on the size of buffers that are most appropriate to use (Auchincloss et al., 2012; Brownson et al., 2009). Identifying appropriate buffer sizes is important to ensure that environmental attributes are measured within an area where the relevant active behaviors take place. Empirical data on how long people walk to various local destinations can be informative to better capture the size of local areas within which residents walk.

Several studies have examined how far adults walk to various destinations. For instance, studies using travel surveys have examined the distances walked from home to public transit (PT) stops in Canada (Alshalalfah and Shalaby, 2007) and in Australia (Daniels and Mulley, 2013). A Canadian study using global positioning systems reported distances walked to various specific destinations (Millward et al., 2013). It is important in this context to understand how age groups differ in their walking distance to local destinations, since adults' functional capacity begins to decline from mid-age (Peeters et al., 2013). Older adults may walk less distance than those who are younger to get to destinations, which can have implications for the buffer sizes that will capture the relevant environmental attributes for different age groups. The two studies on walking to PT stops described above reported the distances walked by age groups and produced mixed findings. The Canadian study conducted in the city of Toronto found that the median walking distance to PT stops was similar across all age groups (Alshalalfah and Shalaby, 2007), while the Australian study in Sydney and its suburbs showed that older (≥ 65 years) adults walked shorter distances to PT stops than middle-aged (30–49 years) adults (Daniels and Mulley, 2013). For other types of destinations, Millward et al. (2013) reported the distances to specific destinations without age stratification.

To better understand the potential need to vary buffer sizes in studies of neighborhood environmental attributes associated with walking, evidence is required on the distances to common destination types to which adults walk on a regular basis, and whether they are different between age groups. Using data from a large-scale travel survey conducted in a region of Australia, this study sought to identify how far adult residents walk to/from PT stops, shops/services, and natural features such as parks, and whether walking distances to these differ by age group.

2. Methods

2.1. Data source

Data from the 2009–12 South-East Queensland Travel Survey (SEQTS) were used. The SEQTS is a cross-sectional survey administered in the Sunshine Coast, Brisbane, and Gold Coast Statistical Divisions in Queensland (a state of Australia), which include major cities (urban and suburban areas) and regional areas, according to the Australian Statistical Geography Standard (Australian Bureau of Statistics, 2016b). The SEQTS used multistage random sampling in which Census Collection Districts (CCDs), the smallest geographic units for Census data collection (Australian Bureau of Statistics, 2006c), were selected first, followed by households within each CCD. Data were collected from 14,489 households (response rate: approximately 60%). All residents in the selected households were asked to complete self-administered questionnaires. They reported details of their travels conducted on the specified survey day, including origin, destination, start time, end time, mode, and purpose, using a 24-hour travel diary. The survey was administered by the Queensland Government in accordance with ethical guidelines under government statutes and regulations. Informed consent was obtained from participants.

2.2. Participants

From the entire travel survey data set (37,916 respondents), we identified 14,634 adult participants (aged 18–84 years) who reported at least one home-based trip in any travel mode to/from PT stops, shops/services, and parks and other natural features. Our analytical sample consisted of the 2105 respondents who reported at least one home-based walking trip to/from those destinations. They were categorized into four age groups: younger (18–34 years), younger middle (35–49 years), older middle (50–64 years), and

older (65–84 years). These groupings (separating the younger and older middle-aged) allowed us to investigate not only how middle age adults may differ from younger and older adults, but also whether middle-aged adults, who include those with declining physical function (Peeters et al., 2013), are heterogeneous in terms of walking distance.

2.3. Measures

The outcomes were the distance of walking trips to/from PT stops, shops/services, and natural features (typically parks). The shortest road-network distance between participant's residence and each destination provided in the travel diary was used for this purpose. We also produced the joint category of PT stops and shops/services to identify walking distances to/from utilitarian destinations. [Supplementary Table 1](#) shows the list of destinations included in each category. We reported the median distance with the 20th and 80th percentiles. The 80th percentile was chosen since previous studies used this value as the distance threshold of walking trips; i.e., the upper-limit distance most people would walk (Cole et al., 2017; Morency et al., 2014).

2.4. Statistical analyses

We examined to what extent age groups differed in their walking distance to/from each destination category. Since the distribution of walking distance was skewed, we used Generalized Linear Models (GLMs) with a log-link function and gamma distribution. We fitted three-level models, in which walking trips were nested within participants who were nested in local areas. For the area unit, we used Statistical Area 1 (SA1), which is the latest geographical unit developed for Australian Census data with an average population of approximately 400 people (Australian Bureau of Statistics, 2016a). SA1 rather than CCD was used as the former is more consistent in population size and homogeneous than the latter (Australian Bureau of Statistics, 2016a). Model parameters were estimated using the *meglm* command in Stata 14. Analyses estimated differences in walking distance between the age groups for each destination category, adjusting for gender and area-level socio-economic status (SES) but not for other age-related socio-demographic variables. For the area-level SES, the Index of Relative Socio-Economic Disadvantage (IRSD) at the SA1 level was used. The IRSD incorporates indicators such as area-level income, education, and employment, with higher scores pertaining to lower levels of disadvantage (Australian Bureau of Statistics, 2008). We did not adjust for age-related factors (e.g., work status, household composition, and income), since holding them statistically constant risks disregarding the different life circumstances that are inherent to each age group.

Table 1

Characteristics of the 2105 study participants who reported at least one home-based walking trip to/from the destinations (PT stops; shops/services; natural features).

	Younger 18–34 years (N = 728)	Younger middle 35–49 years (N = 524)	Older middle 50–64 years (N = 491)	Older 65–84 years (N = 362)	Total (N = 2105)
Proportion of study participants who reported walking trips, % ^a	21	12	12	13	14
Gender, % women	55	57	60	51	56
Working, % yes	73	81	60	7	61
Driving license, % yes	54	80	88	73	72
Household composition, %					
Sole person	5	11	21	32	15
Couple without children	22	14	46	51	31
Couple with children	36	56	23	5	32
Single parent	8	7	1	1	5
Other	29	12	9	11	17
Household income, %					
< \$799/week	14	12	24	51	22
\$800–\$1399/week	17	16	22	23	19
\$1400–\$2499/week	32	29	25	14	26
\$2500+ /week	28	33	18	9	24
Missing	9	10	11	3	9
Household car ownership, %					
No car	20	22	22	35	24
1 car	44	53	47	52	48
2 + cars	36	25	31	13	28
Mean IRSD ^b (SD)	1026 (73)	1029 (74)	1023 (76)	1002 (90)	1022 (78)

^a Percentage of study participants among those who reported at least one home-based trip to/from the destinations in any travel modes (N = 14,634 for the total sample).

^b Index of Relative Socio-economic Disadvantage (higher scores indicating lower levels of disadvantage).

Table 2

Number and distance of home-based walking trips to/from each destination category for younger, younger middle, older middle, and older adults, and the total sample.

Destination category	Walking trips	Younger 18–34 years	Younger middle 35–49 years	Older middle 50–64 years	Older 65–84 years	Total 18–84 years
PT stops	N (%) ^a	883 (63%)	490 (45%)	311 (38%)	192 (62%)	1876 (52%)
	Distance ^b	0.56 (0.27, 1.00)	0.51 (0.23, 0.90)	0.53 (0.24, 0.89)	0.45 (0.27, 0.83)	0.53 (0.25, 0.95)
Shops/services	N (%) ^a	335 (6%)	322 (4%)	450 (6%)	434 (7%)	1541 (6%)
	Distance ^b	0.71 (0.34, 1.43)	0.75 (0.42, 1.83)	0.86 (0.41, 1.57)	0.76 (0.39, 1.39)	0.77 (0.39, 1.50)
PT stops and shops/services	N (%) ^a	1218 (18%)	812 (9%)	761 (8%)	626 (10%)	3417 (11%)
	Distance ^b	0.60 (0.28, 1.13)	0.61 (0.27, 1.13)	0.69 (0.34, 1.22)	0.67 (0.32, 1.16)	0.63 (0.30, 1.16)
Natural features	N (%) ^a	119 (28%)	173 (25%)	200 (36%)	120 (34%)	612 (30%)
	Distance ^b	0.90 (0.33, 1.95)	1.10 (0.55, 2.34)	1.48 (0.55, 2.60)	0.97 (0.38, 2.27)	1.15 (0.51, 2.27)
Overall	N (%) ^a	1337 (18%)	985 (10%)	961 (10%)	746 (11%)	4029 (12%)
	Distance ^b	0.62 (0.29, 1.16)	0.67 (0.30, 1.41)	0.79 (0.38, 1.60)	0.72 (0.33, 1.38)	0.68 (0.32, 1.35)

^a Percentage of walking trips to the total trips in any mode to/from the destination.

^b Median distance in km (20th, 80th percentile).

3. Results

Table 1 shows the characteristics of 2105 participants who reported at least one home-based walking trip to/from the designated destinations on the survey day. The majority were women, working, and living in households with one or more cars. They resided in 748 SA1s. The median number of participants in the area unit was 2 (range: 1–20). The median population density of these SA1s was 23 persons/ha (range: 1–102). The mean IRSD score of participating SA1s was 1011 (SD: 84).

Table 2 shows the number and distance of home-based walking trips to/from each destination category by age groups. The total number of home-based trips to/from these destinations was 33,350. Of these, 4029 (12%) were walking trips. The mean number of walking trips per participant was 1.9 (median: 2, range: 1–7). Walking was prevalent for trips to/from PT stops (52% of the total trips) but not so for trips to/from shops/services (6%). The median walking distance overall was 0.68 km (80th percentile: 1.35 km). The median walking distances to/from utilitarian destinations (PT stops, shops/services) was 0.63 km, which was about half of the median distance to/from natural features (1.15 km). The 80th percentile of the distances ranged from about 1 km for trips to/from PT stops, 1.5 km to/from shops/services, to over 2 km to/from natural features. There were some variations in walking distances by age: the younger adults walked the shortest distance (median: 0.62 km), while the older middle-aged adults walked the longest distance (median: 0.79 km). The older and younger participants were generally lower in the 80th percentile distances walked, compared to the middle-aged participants, except for the younger participants' walking to/from PT stops.

Table 3 shows the results of multilevel GLM analyses comparing the distances walked between the age groups. The older middle group was set as the reference category, since the descriptive analysis (Table 2) found that their walking distance was the longest in most of the destination categories. Overall, relative to the distances walked by the older middle group, the other age groups walked significantly shorter distances (by 14–21%). The same relationship was observed for the distance to/from the joint category of PT stops and shops/service, with smaller differences between age groups (12–16%). No significant age difference was found for the distances walked to/from natural features. The distances walked by older participants were consistently shorter than those of older middle-aged participants.

4. Discussion

Using data from a travel survey in Australia, the study examined distances walked to common local destinations by adult residents of different ages. Overall, walking trips accounted for only 12% of all trips to the destinations, showing that car use was dominant in this study area. However, there were over 4000 home-based walking trips reported, analysis of which revealed differences in walking

Table 3

Regression coefficients (95%CI) showing age differences in distances walked to/from each destination category: Multilevel GLM analyses.

Destination category	Younger 18–34 years	Younger middle 35–49 years	Older middle 50–64 years	Older 65–84 years
PT stops	1.05 (0.92, 1.19)	0.96 (0.83, 1.11)	Ref	0.85 (0.70, 1.03)†
Shops/services	0.88 (0.75, 1.02)†	0.98 (0.84, 1.14)	Ref	0.84 (0.73, 0.96)*
PT stops and shops/services	0.84 (0.76, 0.93)**	0.88 (0.79, 0.98)*	Ref	0.88 (0.78, 0.99)*
Natural features	0.80 (0.61, 1.04)†	0.94 (0.74, 1.20)	Ref	0.87 (0.66, 1.15)
Overall	0.79 (0.71, 0.87)***	0.86 (0.78, 0.96)**	Ref	0.85 (0.76, 0.95)**

†p < 0.10, *p < 0.05, **p < 0.01, ***p < 0.001.

All analyses adjusted for gender and IRSD (area-level SES), and corrected for clustering at the level of participant and local area (SA1). Regression coefficients are exponentiated betas, representing proportional differences (figures below 1 indicating shorter walking distances in comparison to the reference group).

distances by destination category and to a lesser extent by age group.

4.1. Distance walked by destination types

It was found that distances walked varied by destination types. The median distance ranged from 0.6 km to/from the combined category of PT stops and shops/services to 1.2 km to/from natural features. The 80th percentile of walking distances also varied from 1.2 km for utilitarian destinations to 2.3 km for natural features. Our findings suggest that for utilitarian walking (to get to/from PT stops and shops/services), buffers sizes around 1200 m may capture the majority of walking trips, while those smaller than 600 m may miss half of walking trips. However, it is important to note that only 6% of the trips to/from shops/services were done by walking. Since shopping trips often involve carrying goods and possibly multiple stops, shops within shorter distances from home may matter more to walking. Future research needs to examine how the proportion of walking trips differs between different distance ranges. For walking to natural features, larger buffer sizes over 2 km may be needed to capture most walking trips, while a 1.2 km buffer may catch half of such recreational walking trips. This suggests that a 1 km buffer often used in the literature (Oliver et al., 2007; Picavet et al., 2016) may not be large enough, as less than half of walking trips to natural features were contained within this buffer size.

4.2. Distance walked by age groups

In terms of differences between age groups, we found that older middle-aged adults (aged 50–64 years) walked longer overall and to utilitarian destinations than the other three age groups examined. Although some in this age group begin to experience functional decline (Peeters et al., 2013), there appears to be many without any functional limitations who can engage in longer walking. Older adults (aged 65–84 years) walked shorter distances overall and to/from utilitarian destinations than did the older middle-aged group. The shorter distances may reflect older adults' declining functional capacity. However, our findings did not strongly support the need for using different buffer sizes for different age groups in examining environmental correlates of walking. The difference between the older middle and the older adults' walking to utilitarian destinations was significant in Table 3, but they did not differ greatly in the median distances in Table 2. In walking to/from natural features, Table 2 shows a shorter median distance for younger and older adults compared to older middle-aged adults, but the differences did not reach significance in Table 3. A large within-age group variability in walking distance to/from natural features and smaller counts of trips may be reasons for not detecting significant differences.

4.3. Comparison with previous studies

Our findings regarding the distances to/from PT stops are generally consistent with the findings from the study in Sydney (Australia), where the median distance ranged from 400 to 600 m, with older adults walking a shorter distance than middle-aged adults (Daniels and Mulley, 2013). However, they are different from the Toronto (Canada) study, where walking distance to/from PT stops was around 230 m with little difference between age groups (Alshalalfah and Shalaby, 2007). The difference may be due to study settings. The two Australian studies collected data from diverse areas (urban to regional), while the Canadian study focused on the urban area, where population density is high and PT stops are more accessible. For the walking distance to shops/services, our findings are similar to those from the study conducted in Halifax (a Canadian city with a lower density than Toronto), which reported 0.6–0.8 km distances walked to shops/services (Millward et al., 2013). The walking distance to parks and other natural features found in our study (median 1.2 km) was longer than that reported in the Halifax study (mean 0.8 km). However, our findings are in line with an American national study, which found walking for recreation to be considerably longer than walking for utilitarian purposes (Yang and Diez-Roux, 2012).

4.4. Limitations and strength

Since our findings are affected by local characteristics such as population density and car ownership, they may be generalizable to other cities with similar local characteristics (e.g., low-density Australian or North American cities) but may not be applicable to cities with higher population densities. Further empirical data of walking distances in diverse localities are needed to produce a more refined understanding about suitable buffer sizes. Another limitation of our study is the use of a 24-hour travel diary, which may not be long enough to capture regular (but not daily) walking behaviors such as walking to shops and parks. In addition, distances walked were estimated based on the reported destinations and road network. Using pedestrian-only routes or walking through parks can shorten the distance, while avoiding barriers such as high-speed traffic or poor pedestrian infrastructure can make the distance longer. Sampling weights were not applied in data analysis. Our findings may thus be influenced by sampling bias. Other individual and environmental characteristics not measured in the study (e.g., ethnicity, hilliness) may also affect the findings. A strength of our study is the use of a large-scale travel survey, in which data were collected from diverse (urban, suburban, and regional) areas.

5. Conclusion

Our findings support the use of buffers around 600–1200 m from home in examining environmental correlates of utilitarian walking, at least in the context of Australia. Although studies have used a larger buffer of 1600 m from home (Villanueva et al., 2014;

Duncan et al., 2011), we found that only a limited proportion of utilitarian walking trips reached this distance. For recreational walking, larger buffer sizes ranging from 1200 to over 2000 m may be suitable, as the majority of walking trips to natural features were within this distance range. We did not find consistent evidence supporting the use of different buffer sizes for different age groups.

An implication of our findings is that local areas where shops/services exist within a short distance from home with natural features surrounding such a service area may assist residents walk more for utilitarian and recreational purposes. Future studies can investigate whether such typologies of urban form are conducive to residents' active lifestyles. Health research examining contextual effects, which has been relying on buffers to identify environmental exposures, has begun to explore the concept of “activity space” to capture an area where individuals are truly exposed (Laatikainen et al., 2018; Perchoux et al., 2013). Information on how long residents walk to local destinations may be used to define activity space by identifying destinations that are within the walking distance from participant's address. Future research could compare activity spaces obtained through GPS (global positioning system) tracking devices worn by participants with those obtained by mapping destinations within empirically-determined walking distances.

Disclosure

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jth.2019.100621>.

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