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Gender and age differences in walking for transport and recreation: Are the relationships the same in all neighborhoods?☆

F. Ghani [a,b,*], J.N. Rachele [a,b], S. Washington [c], G. Turrell [a,b]

[a] Institute for Health & Ageing, Australian Catholic University, Level 6, 215 Spring Street, VIC 3000, Melbourne, Australia
[b] School of Public Health and Social Work and Institute of Health and Biomedical Innovation, Queensland University of Technology, Park Road, Kelvin Grove, QLD 4059, Brisbane, Australia
[c] School of Civil Engineering and Built Environment, Science and Engineering Faculty, Centre for Accident Research and Road Safety, Faculty of Health, Queensland University of Technology, Gardens Point, 2 George St, QLD 4000 Brisbane, Australia

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ABSTRACT

Introduction. Walking as regular physical activity (PA) is central to healthy aging, and environments influence walking. Multilevel neighborhood-based studies that only report average (fixed-effect) walking differences for gender and age implicitly assume that neighborhood environments influence the walking behavior of men and women, and younger and older persons, similarly. This study tests this assumption by examining whether gender and age differences in walking for transport (WfT) and walking for recreation (WfR) are similar or different across neighborhoods.

Methods. This paper used data from the HABITAT multilevel study, with 7,866 participants aged 42–68 years in 2009 living in 200 neighborhoods in Brisbane, Australia. Respondents reported minutes spent WfT and WfR in the previous week, categorized as: none (0 mins), low (1–59mins), moderate (60–149mins) and high (≥150 mins). Multilevel multinomial logistic models were used to estimate average differences in walking by gender and age, followed by random coefficients to examine neighborhood variation in these individual-level relationships.

Results. On average, women were more likely to engage in WfR at moderate and high levels (no gender differences found in WfT); and older persons were less likely to do WfT and more likely to do high levels of WfR. These average (Brisbane-wide) relationships varied significantly across neighborhoods.

Conclusion. Relationships between gender and walking, and age and walking, are not the same in all neighborhoods, (i.e. the Brisbane average conceals important information) suggesting that neighborhood-level factors differentially influence the walking behaviors of men and women and younger and older persons. Identifying these factors should be a priority for future research.

1. Introduction

Walking is an important health behavior that can significantly reduce or postpone morbidity and mortality (Fortes et al., 2013; Murtagh et al., 2015), particularly among women (Brown et al., 2012). It is also the most popular form of physical activity (PA) among older populations (Satariano et al., 2012; Touvier et al., 2010). Walking is typically undertaken within the local neighborhood (Van Dyck et al., 2009; Sugiyama et al., 2009) for the purposes of transport or recreation (Inoue et al., 2010). Walking can be incorporated into daily routines at minimal cost, hence it is the most modifiable form of PA among adult populations (Rhodes et al., 1999), with resultant public health, social and economic gains (Panter and Jones, 2010). However, seniors walk less at levels that contribute to recommended PA guidelines, particularly older women (Harris et al., 2009).

During the last decade, there have been numerous neighborhood-based multilevel studies of walking for transport and recreation that have included gender and age as part of their analyses (Van Dyck et al., 2013; Sundquist et al., 2011; Li et al., 2005; Shigematsu et al., 2009; Gauvin et al., 2008; Gómez et al., 2010; Van Dyck et al., 2012; Sugiyama et al., 2014; Kerr et al., 2015). Typically, these studies use gender and age as covariates or effect-modifiers (Van Dyck et al., 2013; Van Dyck et al., 2012; Sugiyama et al., 2014; Kerr et al., 2015), and only occasionally as primary predictors of substantive interest. Findings from these studies show that on average, women are less likely to walk for transport (Sundquist et al., 2011; Owen et al., 2007; Forsyth et al., 2009; Doescher et al., 2014) and recreation (Sundquist et al., 2011)

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* Corresponding author at: Institute for Health & Ageing, Australian Catholic University, Level 6, 215 Spring Street, VIC 3000, Melbourne, Australia.
E-mail addresses: fatima.ghanigonzalo@myacu.edu.au (F. Ghani), jerome.rachale@acu.edu.au (J.N. Rachele), simon.washington@qut.edu.au (S. Washington), gavin.turrell@acu.edu.au (G. Turrell).

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than men, while seniors walk less for transport (Van Dyck et al., 2012; Doescher et al., 2014; Turrell et al., 2014; Shimura et al., 2012) and more for recreation (Van Dyck et al., 2013).

Neighborhood studies that report average differences in walking by gender and age make the implicit assumption that the walking behaviors of men and women and younger and older persons are similarly affected by the neighborhood environment. However, average gender and age differences are produced by summing-over (i.e. pooling) neighborhoods, effectively ignoring the possibility that the average relationship might not be observed in all areas. For example, in low crime neighborhoods gender and age differences in walking for recreation might be minimal due to all demographic groups walking at high levels, whereas in high crime neighborhoods these differences might be more pronounced, with young males more likely to have a higher crime threshold for walking. In short, average effects obfuscate between-neighborhood variation in individual-level relationships, hence important information about how neighborhoods influence walking behavior is possibly omitted.

One approach to testing the assumption that individual-level associations are the same in all neighborhoods is via the use of random coefficient models. These models allow the examination of whether relationships between gender and walking, and age and walking, are the same everywhere (reflecting the average effect) or whether the relationships vary across neighborhoods (Merlo et al., 2005). This paper aims to advance current understanding of the contextual effects on walking by using random coefficient models to examine whether gender and age differences in walking for transport and walking for recreation are similar or different across neighborhoods as a complementary approach to multilevel analyses where only average gender and age differences in walking are reported.

Based on previous evidence, we hypothesized that men would report more transport (Owen et al., 2007; Forsyth et al., 2009; Doescher et al., 2014) and recreational (Sundquist et al., 2011) walking than women, while seniors would walk more for recreation (Van Dyck et al., 2013) and less for transport (Van Dyck et al., 2012; Doescher et al., 2014; Turrell et al., 2014; Shimura et al., 2012). Importantly, we expected these associations to vary significantly between neighborhoods, thus challenging the implicit assumption that neighborhood environments have a similar influence on the walking of all residents.

2. Methods

2.1. Study design and data collection

This investigation uses data from the second wave (2009) of the How Areas in Brisbane Influence healTh And acTivity (HABITAT) multilevel study of mid-age adults living in Brisbane (Australia). HABITAT uses a social-ecological framework that allows for the exploration of the relative contributions of environmental, social, psychological and socio-demographic factors on walking. Details regarding HABITAT's sampling design have been published elsewhere (Burton et al., 2009). Briefly, a multi-stage probability sampling design was used to select a stratified random sample ($n = 200$) of Census Collection Districts (CCDs), with a random sample of people aged 40–65 years from each CCD subsequently selected. Eligible participants were mailed a survey; of the 16,127 in-scope participants, 11,035 valid responses (68.4%) were received at baseline (2007) and of the 10,849 in-scope participants in the second wave, 7,866 valid responses (72.5%) were received in 2009. The baseline sample was representative of the general Brisbane population (Turrell et al., 2010). The HABITAT study received ethical clearance from the Queensland University of Technology Human Research Ethics Committee (Ref. no. 3967H & 1300000161).

2.2. Measures

2.2.1. Outcome variables

Walking for transport (WfT): a single question asked participants to report the total time (converted to minutes) spent WfT (i.e. traveling to and from work, to do errands, or to go from place to place) in the previous week. Walking for recreation (WfR): a single question asked participants to report the total time (converted to minutes) spent WfR, leisure or exercise in the previous week. These questions were closely modeled on the questions asked in the Active Australia (AA) survey: the AA questions have demonstrated reliability (Brown et al., 2004a) and validity against accelerometer measures (Timperio et al., 2004) and have been recommended for Australian population-based research (Brown et al., 2004b).

The distribution of the WfT and WfR variables were positively-skewed and included outlier values, which were top-coded to 840 minutes (i.e. equivalent to a maximum of two hours of walking per day) (Australian Institute of Health and Welfare, 2003). The quantitative measures of WfT and WfR (minutes per week) were categorized into: none (0 mins), low (1–59 mins), moderate (60–149 mins) and high (≥150 mins), as previously used in HABITAT investigations (Turrell et al., 2013; Wilson et al., 2012). Those in the high category met the current international (World Health Organization, 2010) and Australian PA guidelines (Commonwealth Department of Health, 2014), recommending at least 30 minutes of moderate intensity PA on most days of the week, through WfT alone or WfR alone.

2.2.2. Independent variables

Participants reported their gender and date of birth. A single-year age for each respondent was derived. Since an aim was to test for a dose–response relationship with age, participants were grouped into the following categories: 42–46; 47–51; 52–56; 57–61 and 62–68 years. A combined gender/age ten-category variable was also generated (with category 1 referring to men aged 42–46 and category 10 denoting women aged 62–68) to explore how particular gender-age subgroups differed in their walking behavior.

2.3. Statistical analyses

Of the 7,866 participants who returned a valid questionnaire in 2009, the following were excluded from further analyses: 567 (7.2%) who moved from their original neighborhood at baseline (2007) to capture a common neighborhood exposure effect; 28 (0.4%) were a different participant from baseline with missing age; 267 participants (3.7%) did not indicate minutes spent on WfT and 202 (2.8%) did not indicate minutes spent on WfR. The resulting analytic sample comprised 7,004 participants for WfT and 7,069 for WfR (Table 1) nested within 200 CCDs. The non-respondents to the WfT question did not significantly differ from the respondents on the basis of age or gender; however, WfR non-respondents were significantly more likely to be female (OR 1.39; CI 1.04–1.87).

WfT and WfR were analyzed in 2015 separately using multilevel multinomial regression models of participants within neighborhoods, corresponding to HABITAT's nested data structure. Data were prepared in Stata v.13 (StataCorp, 2016) and analyzed in MLwiN v.2.30 (MLwiN Version 2.35, 2015). Gender and age were the primary predictors of walking in the statistical models, undertaken in two stages. First, we fitted two-level random intercept Markov chain Monte Carlo (MCMC) multinomial logit models (first-order marginal quasi-likelihood base estimates, burn-in = 500, chain = 50,000) to determine the average neighborhood effects in the relationship between gender, age and the combined gender/age variable and levels of WfT and WfR. The reference categories for analysis were non-walkers (0 mins), men and the youngest age group (42–46 years). Results are presented as odd ratios (ORs) with 95% credible intervals (CrI). Second, we specified random coefficients (where the variance is calculated as a function of individual

Table 1
Socio-demographic characteristics of the 2009 HABITAT sample, and proportion of transport and recreational walkers[a].

	Total 2009[b]		Walking for transport		Walking for recreation	
	N	%[c]	N	% who walked for transport[d]	N	% who walked for recreation[e]
			N	%[b]	N	%[c]
Total	7866	100.0	7004	38.2	7069	71.8
Sex						
Males	3358	42.7	2991	39.3	3036	69.6
Females	4508	57.3	4013	37.5	4033	73.4
P-Value	–	–	–	0.126	–	0.000
Age[f]						
42–46	1434	18.2	1271	41.1	1269	72.1
47–51	1678	21.3	1506	42.6	1525	71.1
52–56	1607	20.4	1424	38.0	1445	70.4
57–61	1549	19.7	1386	36.4	1386	73.2
62–68	1568	19.9	1417	33.0	1444	72.4
P-Value	–	–	–	0.000	–	0.507
Sex/age[f]						
Males						
42–46	686	8.7	605	41.8	609	68.6
47–51	743	9.4	670	43.3	680	70.0
52–56	680	8.6	594	35.5	612	67.8
57–61	620	7.9	567	39.3	565	71.2
62–68	609	7.7	555	35.5	570	70.7
Females						
42–46	748	9.5	666	40.5	660	75.3
47–51	935	11.9	836	42.0	845	72.1
52–56	927	11.8	830	39.8	833	72.3
57–61	929	11.8	819	34.4	821	74.5
62–68	959	12.2	862	31.3	874	73.5
P-value	–	–	–	0.000	–	0.039

[a] The WfT and WfR databases were examined separately.
[b] This total includes movers.
[c] Percent of the entire analytical sample (column percentages).
[d] Percent of the WfT analytical sample (row percentages).
[e] Percent of the WfR analytical sample (row percentages).
[f] Age was missing for 30 respondents who were excluded in further analyses, 2 of which were movers.

characteristics) in each of the random intercept models to test whether the fixed (*average*) effects of gender, age, and gender/age differences in WfT and WfR varied across neighborhoods. We tested the statistical significance of the random coefficients using a Wald test to assess the null hypothesis of no neighborhood variation in walking between men and women and younger and older persons.

3. Results

A greater proportion of people walked for recreation than for transport in the previous week (72% compared to 38%, Table 1). The proportion of transport walkers was similar for men and women and tended to decrease with age. Similarly, no gender difference was observed in the proportion of recreational walkers, but this proportion was slightly lower for the mid-age cohorts. The rate of transport walking for the combined gender/age variable decreased with age and was generally lower for women compared to men, particularly for the oldest age groups. In contrast, the proportion of recreational walkers was higher for women in all age groups compared with men.

3.1. Walking for transport

There were no significant differences between men and women in their odds of WfT at low, moderate, or high levels (Table 2). However, the random coefficients – each of which was statistically significant – indicated that the association between gender and WfT, at all levels of walking, varied across neighborhoods.

There was no association between age-group and WfT at low levels (i.e 1–59 mins/week). Compared to the reference category (42–46 years), the odds of WfT at moderate levels (60–149 mins/week) were significantly lower for those aged 52–56 years (20% lower), 57–61 (26% lower) and 62–68 years (45% lower). The odds of WfT at high levels (150 mins or more per week) were significantly lower for respondents aged 62–68 years (36% lower). The random coefficients for each age group and level of WfT were statistically significant, indicating that relationships between age and transport walking varied across neighborhoods.

No significant differences were observed in the average effects when incorporating the combined gender/age variable at low walking levels of transport. However, compared to men aged 42–46 years, the odds of walking moderately for transport were significantly lower for men aged 62–68 years (40% lower), for women aged 57–61 years (36% lower), and for women aged 62–68 years (52% lower). A similar pattern was observed in the odds of walking at high levels; they were significantly lower for men aged 62–68 years (44% lower), and for women aged 57–61 (40% lower) and 62–68 (50% lower) years respectively. The random coefficients showed significant between-neighborhood variation across all gender/age groups at the low and moderate walking levels for transport, except for men aged 57–61 years, and only at the high walking level for men aged 52–56 years and men aged 62–68 years.

3.2. Walking for recreation

The odds of WfR in the previous week were significantly higher for women at the moderate, (20% higher) and high levels (23% higher, Table 3). There was significant between-neighborhood variation in the association between gender and all levels of WfR.

Compared with the reference group (42–46 years), the odds of WfR at low levels were significantly lower for the three oldest age groups. The odds of walking moderately for recreation were also lower for those aged 62–68 years (20% lower). On the other hand, the odds of WfR at high levels were significantly higher for those aged 57–61 years (28% higher) and 62–68 years (34% higher). The random coefficients indicated significant between-neighborhood variation in the association between each age group and at every level of WfR.

No significant differences were observed in the average effects incorporating the combined gender/age variable at low levels of WfR. However, compared to men aged 42–46 years, the odds of walking moderately for recreation were significantly higher for women aged 42–46 years (39% higher). The odds of doing high levels of WfR were significantly higher for men aged 57–61 (43% higher) and 62–68 years (46% higher), as well as for women in all age groups. There was significant between-neighborhood variation for each gender/age group at the high recreational walking level, excluding men aged 52–56 years; at the moderate level for all combined gender/age groups, except for men aged 47–51, 52–56 and 62–68 years respectively. At the lowest walking level, variation was recorded for men aged 57–61 years and women aged 47–51 and 57–61 years respectively.

4. Discussion

This study tested whether gender and age differences in levels of WfT and WfR varied across neighborhoods. The estimation of variation around the average neighborhood effect confirmed that the relationships between gender and walking, and age and walking, are not the same across neighborhoods; while some environments influence men and women and younger and older people similarly, other environments have a differential impact.

We observed no significant gender differences in the average neighborhood effects on WfT, which could be due to the generic measure of WfT used involving multiple destinations. Previous research using more specific measures (the International Physical Activity Questionnaire-long form) observed that women do less WfT than men (Sundquist et al., 2011; Owen et al., 2007; Forsyth et al., 2009;

Table 2
Relationships between gender, age and walking for transport: fixed (average) effects and random coefficients.

	Fixed-effects							Random coefficients (standard error)			
	None	Low		Moderate		High		None	Low	Moderate	High
	0 mins	1–59 mins		60–149 mins		≥150 mins		0 mins	1–59 mins	60–149 mins	≥150 mins
		OR	95% CrI	OR	95% CrI	OR	95% CrI				
Gender											
Males	–	1		1		1		–	–	–	–
Females	–	1.01	0.89,1.16	0.94	0.82,1.08	0.87	0.72,1.06	–	**0.153 (0.05)****	**0.173 (0.06)****	**0.269 (0.11)***
Age											
42–46	–	1		1		1		–	–	–	–
47–51	–	1.04	0.85,1.28	1.03	0.83,1.26	1.25	0.92,1.70	–	**0.236 (0.09)****	**0.231 (0.08)****	**0.256 (0.12)***
52–56	–	0.87	0.70,1.08	**0.80**	**0.64,0.98**	1.07	0.78,1.41	–	**0.310 (0.13)***	**0.213 (0.08)****	**0.276 (0.12)***
57–61	–	0.85	0.69,1.05	**0.74**	**0.60,0.92**	0.9	0.65,1.25	–	**0.247 (0.09)****	**0.296 (0.12)***	**0.380 (0.16)***
62–68	–	0.86	0.70,1.06	**0.55**	**0.43,0.69**	**0.64**	**0.46,0.91**	–	**0.194 (0.07)****	**0.295 (0.11)****	**0.289 (0.13)***
Gender/age											
Males											
42–46	–	1		1		1		–	–	–	–
47–51	–	1.18	0.86,1.62	0.91	0.66,1.24	1.19	0.79,1.82	–	**0.344 (0.16)***	**0.274 (0.12)***	0.443 (0.24)
52–56	–	0.77	0.55,1.09	0.74	0.54,1.02	0.64	0.39,1.02	–	**0.358 (0.15)***	**0.298 (0.13)***	0.377 (0.21)
57–61	–	0.89	0.64,1.24	0.82	0.59,1.13	0.95	0.61,1.49	–	**0.305 (0.15)***	0.392 (0.20)	0.440 (0.23)
62–68	–	1.01	0.72,1.39	**0.60**	**0.42,0.84**	**0.56**	**0.34,0.93**	–	**0.274 (0.12)***	**0.430 (0.19)***	0.452 (0.27)
Females											
42–46	–	1.10	0.80,1.51	0.92	0.67,1.25	0.68	0.43,1.10	–	**0.266 (0.11)***	**0.265 (0.11)***	0.425 (0.26)
47–51	–	1.04	0.77,1.41	1.04	0.78,1.40	0.91	0.60,1.37	–	**0.373 (0.18)***	**0.279 (0.12)***	0.348 (0.19)
52–56	–	1.03	0.76,1.40	0.78	0.58,1.05	1.08	0.73,1.62	–	**0.503 (0.22)***	**0.318 (0.13)***	**0.322 (0.15)***
57–61	–	0.90	0.67,1.23	**0.64**	**0.47,0.86**	**0.60**	**0.38,0.94**	–	**0.290 (0.12)***	**0.350 (0.17)***	0.439 (0.22)
62–68	–	0.85	0.63,1.15	**0.48**	**0.35,0.66**	**0.50**	**0.32,0.79**	–	**0.271 (0.10)***	**0.300 (0.12)***	**0.401 (0.20)***

Note: Boldface indicates significance (*P < 0.05; **P < 0.01).

Doescher et al., 2014). Older participants were less likely to walk at the moderate and high levels for transport compared to younger groups. This is consistent with previous research finding that age was negatively associated with WfT (Van Dyck et al., 2012; Doescher et al., 2014; Turrell et al., 2014; Shimura et al., 2012).

We confirmed significant gender-walking and age-walking variations in WfT across neighborhoods, suggesting that the neighborhood effects are not equally distributed. There are several potential reasons for the relatively large amount of variation observed at higher levels of WfT. For instance, a highly walkable neighborhood (characterized by high residential density, diversity of land use and street connectivity) might reveal minimal gender and age differences in WfT, while this difference might be larger in low walkable neighborhoods. Living in walkable neighborhoods has been consistently associated with more WfT (Van Dyck et al., 2012; Kerr et al., 2015) particularly in adults with a preference for passive transport and/or low intention to walk (Van Dyck et al., 2009), and stronger effects were observed in women (Inoue et al., 2010; Van Dyck et al., 2012) and seniors (Shimura et al., 2012), suggesting that these subgroups might require higher levels of environmental support to increase their WfT.

Table 3
Relationships between gender, age and walking for recreation: fixed (average) effects and random coefficients.

	Fixed-effects							Random coefficients standard error)			
	None	Low		Moderate		High		None	Low	Moderate	High
	0 min	1–59 mins		60–149 mins		≥150 mins		0 mins	1–59 mins	60–149 mins	≥150 mins
		OR	95% CrI	OR	95% CrI	OR	95% CrI				
Gender											
Males	–	1		1		1		–	–	–	–
Females	–	1.18	0.99,1.40	**1.2**	**1.06,1.37**	**1.23**	**1.08,1.38**	–	**0.155 (0.06)***	**0.157 (0.05)****	**0.140 (0.05)****
Age											
42–46	–	1		1		1		–	–	–	–
47–51	–	0.88	0.69,1.14	0.89	0.73,1.08	1.05	0.87,1.27	–	**0.203 (0.08)***	**0.231 (0.09)***	**0.143 (0.05)****
52–56	–	**0.74**	**0.57,0.97**	0.9	0.74,1.10	1.01	0.83,1.23	–	**0.193 (0.08)***	**0.157 (0.05)****	**0.178 (0.06)****
57–61	–	**0.73**	**0.55,0.97**	0.95	0.77,1.16	**1.28**	**1.04,1.56**	–	**0.221 (0.10)***	**0.193 (0.07)****	**0.160 (0.06)****
62–68	–	**0.75**	**0.57,0.98**	**0.8**	**0.66,0.98**	**1.34**	**1.10,1.62**	–	**0.202 (0.09)***	**0.208 (0.08)***	**0.146 (0.05)****
Gender/age											
Males											
42–46	–	1		1		1		–	–	–	–
47–51	–	1.03	0.70,1.51	1.03	0.77,1.40	1.13	0.83,1.51	–	0.257 (0.13)	0.359 (0.18)	**0.219 (0.10)***
52–56	–	0.77	0.51,1.15	0.94	0.69,1.28	1.07	0.79,1.43	–	0.272 (0.16)	0.303 (0.17)	0.376 (0.23)
57–61	–	0.79	0.51,1.22	0.97	0.71,1.33	**1.43**	**1.06,1.93**	–	**0.266 (0.13)***	**0.221 (0.10)***	**0.239 (0.10)***
62–68	–	0.83	0.54,1.26	0.87	0.64,1.21	**1.46**	**1.08,1.96**	–	0.384 (0.28)	0.313 (0.17)	**0.212 (0.09)***
Females											
42–46	–	1.40	0.96,2.05	**1.39**	**1.03,1.87**	**1.41**	**1.05,1.90**	–	0.475 (0.28)	**0.192 (0.08)***	**0.287 (0.13)***
47–51	–	1.06	0.73,1.53	1.06	0.80,1.41	**1.36**	**1.03,1.79**	–	**0.267 (0.13)***	**0.356 (0.17)***	**0.196 (0.08)***
52–56	–	0.98	0.67,1.42	1.17	0.87,1.55	**1.32**	**1.00,1.73**	–	0.284 (0.17)	**0.206 (0.08)***	**0.200 (0.08)***
57–61	–	0.93	0.63,1.37	1.24	0.92,1.66	**1.62**	**1.22,2.14**	–	**0.236 (0.12)***	**0.215 (0.09)***	**0.200 (0.08)***
62–68	–	0.93	0.63,1.35	1.01	0.75,1.34	**1.73**	**1.31,2.27**	–	0.272 (0.16)	**0.239 (0.12)***	**0.191 (0.08)***

Note: Boldface indicates significance (*P < 0.05; **P < 0.01).

Furthermore, the presence (or lack of) infrastructure important for large amounts of WfT might not be common across neighborhoods. Evidence indicates that WfT is greater in the presence and proximity of non-residential destinations such as public transport and retail outlets (Sundquist et al., 2011; Sugiyama et al., 2012), particularly among women (Bird et al., 2010) and older adults (Shigematsu et al., 2009) who spend less time at work than men and younger persons. Previous spatial research suggests that retail outlets are likely to be clustered within higher density 'hubs' which also contain public services such as health and transport (Doescher et al., 2014). Previous research has found that high destination density was associated with more minutes of total walking (King et al., 2015), and it is likely to facilitate WfT. Moreover, women with an average number of neighborhood destinations were more likely to walk for transport than women below the average (Suminski et al., 2005).

Women were more likely than men to walk for recreation at the moderate and high levels, which differs from a Swedish study which found that men walked more for recreation than women (Sundquist et al., 2011). The different results could be explained by differences in the built environment as well as social and cultural distinctions between countries.

Older participants were less likely to do WfR at low and moderate levels but more likely to engage in WfR at high levels. Other multilevel studies have observed older adults walking more for recreation (Van Dyck et al., 2013), possibly reflecting retirement age activities (Bjornsdottir et al., 2012). Retirement has been associated with increases in WfR in a longitudinal study, suggesting that this is a critical life-stage for promoting walking (Touvier et al., 2010).

The observed gender/age-walking variation in levels of WfR across neighborhoods might also be partly explained by between-neighborhood variation in actual crime or perceptions of crime. Previous research finds gender and age differences in perceptions of, and responses to crime; and crime has been shown to vary across neighborhoods. Women and seniors have higher perceptions of crime, which may seem to constrain their WfR (Van Dyck et al., 2013; Sugiyama et al., 2014; Bird et al., 2010), while these effects are not seen in younger men (Foster et al., 2004). Gender was a significant moderator in the relationship between perception of crime/safety, and recreational walking in a multi-country study, with women showing stronger associations than men (Sugiyama et al., 2014). Furthermore, seniors living in neighborhoods with higher perceived safety had a lower rate of decline in self-reported WfR over time (Li et al., 2005). Therefore, neighborhoods with low crime might have minimal gender and age-differences in WfR, whereas large gender and age-differences in WfR might be observed in high crime neighborhoods.

Neighborhood social cohesion might also partially explain the between-neighborhood age and gender variation in WfR, with highly cohesive neighborhoods likely to have minimal gender and age-differences in WfR. Neighborhood social cohesion has been associated with increases in WfR among women (Ball et al., 2010) and seniors (Wood et al., 2010).

This study has several limitations. Walking was self-reported, which has been shown to be less accurate than objective measures of walking (Shephard, 2003). The participants in this study may have overestimated the amount of walking they engage in (Boon et al., 2010) or might have underreported it (Tudor-Locke and Myers, 2001). Furthermore, seniors might have difficulties with recall (Yasunaga et al., 2008) and discriminating between WfT and WfR, as they might combine these activities (Gómez et al., 2010). Despite this, we observed between-neighborhood variation in the associations between gender and walking and age and walking across all levels of WfT and WfR.

Recent increases in life expectancy have important implications for social and public health policies regarding seniors (Satariano et al., 2012; Walker and Maltby, 2012) who are less active, particularly older women (Hallal et al., 2012; Koeneman et al., 2011; Sun et al., 2013). These PA trends should guide current research to inform gender and age-responsive multilevel strategies (Hallal et al., 2012), called for by the World Health Organization's *Active Ageing* frameworks (World Health Organization, 2002; World Health Organization, 2007), and the National Heart Foundation of Australia's *Blueprint for an active Australia* (National Heart Foundation of Australia, 2014). The effects of such strategies on increasing walking levels are potentially large and long-lasting in otherwise typically inactive population groups, thereby prolonging healthy life expectancy (Walker and Maltby, 2012) and reducing health care costs to society (Kendig and Browning, 2011).

5. Conclusion

This study advances current understanding of neighborhood effects on walking patterns by demonstrating significant between-neighborhood variation in the individual-level associations of gender and walking, and age and walking. These findings suggest that neighborhood exposures have a different impact on the walking behavior of men and women, and young and old. Further research is required to identify whether – and to what extent – the observed between-neighborhood variation in gender and walking and age and walking is a function of concomitant between-neighborhood differences in socioeconomic, built environment, and social factors. The identification of the specific neighborhood characteristics that explain this neighborhood variation can be used by urban planners and policy makers to develop interventions aimed at increasing the walking of all population groups, irrespective of their gender or age.

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