Health & Place 13 (2007) 713–724

HEALTH & PLACE

www.elsevier.com/locate/healthplace

Destinations that matter: Associations with walking for transport

Ester Cerin[a,*], Eva Leslie[b], Lorinne du Toit[c], Neville Owen[c], Lawrence D. Frank[d]

[a]*Institute of Human Performance, The University of Hong Kong, 111 Pokfulam Road, Pokfulam, Hong Kong*
[b]*School of Health and Social Development, Deakin University, Australia*
[c]*Cancer Prevention Research Centre, The University of Queensland, Australia*
[d]*School of Community and Regional Planning, The University of British Columbia, Canada*

Received 15 May 2006; received in revised form 5 November 2006; accepted 16 November 2006

Abstract

Associations between access to destinations and walking for transport were examined. Households ($N = 2650$) were selected from 32 urban communities varying in walkability and socio-economic status. Respondents reported perceived proximity of destinations, transport-related walking, reasons for neighbourhood selection, and socio-demographic characteristics. Geographic Information Systems data defined objective measures of access to destinations. Measures of access to destinations were associated with transport-related walking. Associations depended on socio-demographic factors and type of destinations. Workplace proximity was the most significant contributor to transport-related walking, especially among women. Regular walking to work resulted in the accrual of sufficient physical activity for health benefits.

Keywords: Walking for transport; Physical activity; Access to destinations; Land-use mix; Socio-demographics; Moderators

Introduction

Regular walking has been associated with health benefits (Manson et al., 1999). Walking is the most common form of physical activity among adults (Rafferty et al., 2002), and walking for transport makes up a non-ignorable portion of adults' total activity (Cole et al., 2006). For example, a recent study found that walking for transport significantly contributed to the accrual of sufficient physical activity for health in Australian men (7%) and women (15%) (Cole et al., 2006). Recent reviews identify how researchers in population health (Owen et al., 2004) and in transport and urban planning (Saelens et al., 2003a; Sallis et al., 2004) are examining potential environmental determinants of walking for transport. Evidence on associations between characteristics of the built environment and transport-related walking is growing (Transportation Research Board, 2005).

Access to destinations has been show to be positively correlated with walking for transport (Frank et al., 2003; Handy et al., 2002; Saelens et al., 2003b). Access includes *proximity of destinations* and *spatial distribution* of different land uses (land-use mix; LUM) within a geographic area. Areas with high LUM are those with a variety of

*Corresponding author. Tel.: +852 2817 9846.
E-mail address: ecerin@hku.hk (E. Cerin).

1353-8292/$ - see front matter
doi:10.1016/j.healthplace.2006.11.002

uses such as commercial offices, stores, restaurants, banks, and recreation facilities (Cervero and Kockelman, 1997). Areas with a greater mixing of complementary land uses (live, work, play) are considered to be more conducive to utilitarian walking, that is, to be more 'walkable' (Frank et al., 2006).

Access to destinations can be measured objectively [environmental audits (Hoehner et al., 2005) and geographic information systems (GIS) data on land use (Frank and Pivo, 1994)] or using self-reports [e.g., number of non-residential destinations in the neighbourhood (Saelens et al., 2003b)]. A GIS-based, objective measure of LUM (hereafter termed objective index of LUM) developed by Frank and Pivo (1994) has been used to quantify the degree to which different land uses are evenly distributed within a given land area. This index has been found to be positively associated with walking for transport (Cervero and Kockelman, 1997; Frank and Pivo, 1994; Frank et al., 2004). Although unevenness of LUM is a plausible determinant of transport-related walking, it does not provide information on the actual profile, or composition, of land uses within a given community.

The objective profile of LUM, here defined as the composition of land uses within a community (e.g., residential and commercial; commercial and industrial), may encompass more-specific determinants of walking than does an overall objective index of LUM, especially in areas of sub-maximal heterogeneity of land use. To illustrate, the likelihood of walking to a destination may depend on the nature of the destination. Commercial destinations (food outlets, stores) are likely to be visited more frequently and by more residents than are recreational destinations such as parks or sport fields (Sallis et al., 2004). It is, however, possible that communities with many commercial destinations and communities with many recreational destinations have identical values on an objective index of LUM. In such case, an analysis of the specific objective profile of LUM would add to the prediction of walking for transport, over and above an overall index of LUM.

Any analysis of the profile of broad land use categories (e.g., commercial, residential, industrial, recreational) can provide only limited information on the accessibility to specific destinations that may determine choices to walk for transport. The generic nature of land-use categories used in current data sets may be too coarse for a fine-tuned analysis of the relationship between specific land uses and walking for transport. Giles-Corti and colleagues (Giles-Corti et al., 2005) have noted that, in an attempt to explain walking for transport, the type and mix of commercial destinations (e.g., grocery store, restaurant, and post office) may be more important than the mere presence of commercial destinations. For example, it is plausible to assume that residents will visit grocery and supermarkets more often than a local bookshop or restaurant. Some support for this contention has been found in a recent study of older women where objective measures of walking (pedometer counts) were positively associated with presence of department, discount or hardware stores within walking distance from home but not with presence of a post office, restaurant, bar or pub (King et al., 2003).

Importantly, the utility and frequency of use of particular destinations is also likely to vary across socio-demographic groups. Restaurants and cafes may be more pertinent to younger people, hardware stores to male residents, and schools and playgrounds to parents of younger children. The mixture of uses most likely to stimulate walking will thus be unique for different populations. However, little is known on the moderating effects of socio-demographic factors on the relationship between walking for transport and access to specific destinations (Transportation Research Board, 2005).

To address some of the above-mentioned limitations of current research, we examined the associations of objective and perceived measures of access to destinations (objective index of LUM; objective profile of LUM; perceived LUM; and perceived proximity of specific destinations) with self-reported walking for transport. In doing so, we considered the moderating effects of age, gender, education, presence of children in the household, children's age, household size, marital status, and socio-economic status (SES). Additionally, we examined the extent to which the observed associations may be attributable to residents' choosing to live in their neighbourhood because of the accessibility of specific destinations (hereafter termed neighbourhood selection). Such an analysis can help identify possible independent effects (rather than mere associations due to residents' neighbourhood preferences) of the environment on walking for transport (Handy et al., 2006). Finally, to gain further insight on the types of destinations conducive to higher levels of walking, we examined the contribution of frequency of walking to specific destinations to overall transport-related walking.

It was hypothesized that (1) a general objective index of LUM would be positively associated with transport-related walking; (2) that information on the specific nature of the objective profile of LUM would add to the explanation of walking for transport, over and above the general objective index of LUM; (3) that the associations between transport-related walking and perceived proximity of specific destinations would depend on the type of destination and (4) vary across socio-demographic groups; (5) and that the observed associations between perceived proximity of destinations and transport-related walking would be only in part explained by neighbourhood selection, indicating an independent effect of proximity of destinations on walking.

Method

This study used cross-sectional survey data from the Physical Activity in Localities and Community Environments (PLACE) study in Adelaide, Australia. The PLACE study was based on the Neighborhood Quality of Life Study of adults conducted by Sallis, Frank, and Saelens in the USA (www.nqls.org). Both studies were designed to investigate associations between neighbourhood environments and residents' habitual physical activity.

Participants and procedure

The study was conducted in the Adelaide, Australia. Participant recruitment ($N = 2650$) consisted of several steps. The general aim of the PLACE study was to examine the associations between neighbourhood environments and physical activity, with a specific focus on walking for transport. Hence, to maximize variance in the neighbourhood characteristics hypothesized to be related to such utilitarian walking, participants were recruited from 32 neighbourhoods (comprising 154 census collection districts; CCD) with high (8th–10th decile) and low (1st–3rd decile) scores on an objectively determined walkability index (Frank et al., 2004; Leslie et al., 2007). These high and low walkable neighbourhoods were matched on SES (median split of median household income based on census data) so to represent high walkable/high SES; high walkable/low SES; low walkable/high SES; and low walkable/low SES areas. The walkability index was based on GIS-derived data on neighbourhood residential density, street connectivity, land-use mix, and net retail area (see Leslie et al., 2007 for details).

Simple random sampling, without replacement, was used to select households from each neighbourhood. Participant recruitment and data collection was by mail. Eligible participants were adults aged 20–65, able to walk without assistance and take part in surveys in English, and who lived in private dwellings. In households with multiple eligible participants the person with the most recent birthday was asked to complete the questionnaires. Given the large amount of data requested from the participants (24 scales) and the fact that one of the aims of the study was to examine seasonal variations in physical activity patterns, two questionnaires were mailed to the participants with a 6-month interval between the first ($N = 2650$) and the second ($N = 2194$). The content of the questionnaires was different except for the items gauging physical activity patterns (International Physical Activity Questionnaire; IPAQ; Craig et al., 2003). A lottery-based incentive was provided. For the purpose of this paper we used data on weekly minutes of walking for transport, perceived LUM, perceived proximity of destinations, and neighbourhood selection from the first survey; and data on monthly frequency of walking to destinations from the second survey. The study was approved by the Behavioural and Social Sciences Ethics Committee of the University of Queensland.

The overall response rate was 11.5% (eligible households completing the survey/eligible households to whom the survey was mailed). The low response rate is likely to be partly due to having households rather than residents as the sampling units. The estimated percentage of ineligible participants based solely on the grounds of the study age delimitations (20–65 years) was approximately 25% (Australian Bureau of Statistics, 2006; du Toit et al., 2005). However, due to the nature of the sampling frame, it was impossible to exclude those potentially ineligible households from the list of mailing addresses. This means that, in this study, the true response rate might have actually been around 35%, i.e., within the expected response rate ranges for postal surveys in health-related research (Harrison and Cock, 2004). Approximately 74% of eligible participants known to be contacted (i.e., responding to the invitation to participate) completed the first survey. Eighty-three percent of first-survey participants completed the second survey. Participants' socio-demographic characteristics are shown in Table 1. A detailed description of the study design, response rates and socio-demographic characteristics has been given elsewhere (du Toit et al., 2005).

Measures

Weekly minutes of walking for transport: Weekly minutes of walking for transport were assessed using the long version of the IPAQ (long format; Craig et al., 2003). The respondents were instructed to report the frequency and duration of walking for transport during the past 7 days. Total weekly minutes of walking for transport were computed and values were truncated to 1860 min (4 h per day).

Monthly frequency of walking to specific destinations: Participants reported on the number of days in the past month they had walked from home to a list of 9 common destinations. These were food store, retail store, school or day care centre, post office, restaurant or café, gym or recreation facility, park, work and bus/train stop.

Objective index of LUM: Objective LUM was quantified as an index across a CCD. Land use was classified into the following categories: residential, commercial, industrial, recreational and other. The objective index of LUM was computed via the following formula (Cervero and Kockelman, 1997):

$$-\frac{\sum_k (p_k \ \ln \ p_k)}{\ln \ N},$$

where k is the category of land use; p is the proportion of the land area within a CCD devoted to a specific land use; N is the number of land use categories. The objective index of LUM ranges from 0 to 1, with 0 representing homogeneity (all land uses are of a single type), and 1 representing maximal heterogeneity (the land use categories are evenly represented in the CCD).

Objective profiles of LUM: Two-step cluster analysis was used to identify natural groupings of CCDs with similar land use profiles, i.e., with similar average proportions of land use categories (commercial, light-industrial, residential, recreational and other uses) within a unit area. Membership to a specific cluster of CCDs represented the nominal-level measure of objective profile of LUM.

Perceived LUM and proximity of destinations: A subscale of the Neighborhood Environment Walkability Scale (NEWS) (Saelens et al., 2003b), measuring proximity of access to non-residential land uses, was employed. The NEWS has been shown to be a reliable and valid instrument (Leslie et al., 2005). Respondents were asked to report the perceived walking distance from home to 24 types of destinations. Responses ranged from 1–5 min walking distance (here coded as 5) to > 30-min walking distance (here coded as 1). Three measures of perceived LUM representing the number of reported destinations within 5, 6–10 and 11–20 min walks from home were computed. Perceived proximity of specific destinations, defined as the average responses on items constituting conceptually similar

Table 1
Socio-demographic characteristics of the sample ($N = 2650$)

Characteristic	Estimate	Characteristic	Estimate
Male, %	35.8	Educational attainment, %	
Missing values	0.5	Year 10 or less	23.8
Employment status, %		Year 12/trade	29.5
Full time	38.2	Tertiary	45.5
Part time/casual/family	25.2	Missing values	1.7
Unemployed or home duties	13.9	Annual household income, %	
Retired/permanently unable to work	13.7	< $20,800	24.2
Other	6.6	$20,800–$41,599	25.2
Missing values	2.3	$41,600—$77,999	27.8
Age, mean (SD), y	44.5 (12.3)	> $77,999	19.2
Missing values, %	1.3	Missing values	4.6
Children in household, %			
Yes	30.5		
Missing values	3.0		

Note: Sample at survey 1.

(and empirically inter-correlated as shown by principal components analysis) destinations, were also used as explanatory variables of walking for transport (value ranging from 1 to 5; 1 denoting > 30-min walking distance and 5 denoting a 1–5 min walking distance). These types of destination were: (1) commercial destinations (e.g., local shops, supermarket, greengrocer, laundry/dry cleaners); (2) home/car commercial destinations (hardware store, car service/repair, appliance store); (3) schools (primary and other schools); (4) workplace; (5) bus/train stop; (6) recreational destinations (park, nature reserve, sports field, fitness centre); (7) beach/river.

Neighbourhood selection: Respondents were asked to report on a 5-point Likert-type scale the perceived importance of moving to their neighbourhood for the following reasons: closeness to open space; closeness to job or school; closeness to public transportation; desire for nearby shops and services; and closeness to recreational facilities.

Socio-demographic attributes: Participants were asked to report their age, gender, educational attainment, marital status, annual household income before taxes, employment status, ethnicity, number of children under 18 years in the household, children's age and household size.

Data analysis

Identification of objective profiles of LUM: To identify natural groupings of CCDs with similar objective profiles of LUM, two-step cluster analysis of land use categories data was performed using SPSS 13.0 (SPSS Inc., 2004). This analysis, also called taxonomy analysis, is a way to create groups of objects (in this case, CCDs) so that the profiles or characteristics of the CCDs in the same grouping or cluster are very similar and that the profiles of CCDs in different groupings are quite distinct. This analysis was based on data on the proportion of 5 categories of land use (commercial, industrial, residential, recreational and other) within the CCDs. Differences between clusters of CCDs were delineated descriptively (means and standard deviations of proportions of land use and objective index of LUM). Differences between clusters of CCDs (objective profiles of LUM) were analysed using *t*-tests for independent samples.

Relationships between objective measures of access to destinations and weekly minutes of walking for transport: To examine the relationship between the objective index of LUM and weekly minutes of walking for transport (Hypothesis 1), adjusting for the effects of socio-demographic covariates, generalized linear models (GLM) were used (Hardin and Hilbe, 2001). A second-order polynomial of the objective index of LUM was used to account for a possible nonlinear relationship. As data on weekly minutes of walking for transport are usually considerably positively skewed (Frank et al., 2006) and can be only positive or equal to zero, the γ-variance function was used (Hardin and Hilbe, 2001). Two sets of models were fitted, one with the identity link function and the other with a logarithmic link function. The models with the best fit were retained. To account for the clustering effect due to the sampling strategy adopted in this study, modified Sandwich standard errors for correlated data were used (Hardin and Hilbe, 2001). To test Hypothesis 2 (that information on the objective profile of LUM would add to the explanation of walking for transport over and above the index of LUM), indicator variables denoting membership to specific profiles of LUM were subsequently added to the previous model.

Relationships between perceived measures of access to destinations and walking for transport: GLM models with γ-variance function and identity or logarithmic link function (with Sandwich standard error estimates) were used to examine the independent associations of perceived LUM (number of destinations within a 5, 6–10, and 11–20 min walk) and perceived proximity of types of destination with weekly minutes of walking for transport, adjusting for socio-demographic confounders (see Measures section) (Hypothesis 3). To examine the independent effect of perceived proximity of destinations on transport-related walking (Hypothesis 5), a separate set of analyses was run where appropriate neighbourhood-selection variables were added as predictors to the model. A significant effect of proximity of destination after controlling for neighbourhood selection would indicate an effect of proximity of destinations on walking for transport independent of one's reasons for living in a particular neighbourhood. The relationships between monthly frequency of walking to specific destinations and their perceived proximity were assessed using GLM with a Poisson variance function, logarithmic link functions and Sandwich standard errors (Hypothesis 3). To explore the moderating effects of socio-demographic factors on the relationships between walking for transport and proximity to destinations, two-way interaction terms were added to the main effect models described above (Hypothesis 4). To examine the contribution of monthly frequency of walking to specific destinations in the neighbourhood to overall weekly minutes of walking for transport (in and outside the neighbourhood), a series of univariate GLM models (γ-variance distribution and identity link), adjusting for socio-demographic factors, were performed. Associations between overall weekly minutes of walking and frequency of walking to a specific destination, adjusting and not adjusting for frequency of walking to other destinations, were examined (Hypothesis 3). All GLM were estimated using Stata 9.1 (Stata Corp, 2006). A significance level of 0.05 was adopted.

Results

Identification of objective profiles of LUM

The two-step cluster analysis yielded three groupings of CCDs based on Schwarz's Bayesian Information Criterion of 386 and the highest log-likelihood distance measures (ratio = 2.3). The first cluster consisted of 100, the second of 10 and the third of 43 CCDs. The three profiles of land use are depicted in Table 2. The first cluster of CCDs (here, named 'Residential') had the highest mean proportion of residential land use, the lowest mean proportion of commercial land use and the lowest average objective index of LUM. The second cluster of CCDs (named 'Recreational') had the highest average proportion of recreational land use and a significantly greater average objective index of LUM than the 'Residential' CCDs. The third cluster, named 'Commercial/Industrial', had the highest proportion of commercial and industrial land use but an average objective index of LUM similar to the 'Recreational' CCDs.

Relationships between objective measures of access to destinations and weekly minutes of walking for transport (Hypotheses 1 and 2)

Complete data for these analyses were available for 2369 participants (89.4%). On average, respondents reported 182 weekly minutes of walking for transport (SD = 269; median = 90; IQR = 120). No significant association was found between the objective index of LUM and weekly minutes of walking for transport ($b_x = 30$; 95% CI: −165, 224; $p = .765$; $b_{x^2} = -63$; 95% CI: −318, 192; $p = 639$). In contrast, objective profiles of LUM were significant correlates of walking for transport (controlling for the objective index of LUM). Residents living in 'Commercial/Industrial' areas reported, on average, 39.6 more weekly minutes (95% CI: 0.4, 78.9; $p = .048$) of walking for transport than residents from 'Recreational' CCDs (Table 2). No significant differences were found between residents of 'Recreational' and residents of 'Residential' CCDs.

Table 2
Objective profiles of land-use mix (LUM) and transport-related walking

Profile of LUM	Average proportion of land use (standard deviation)						
	Commercial	Industrial	Recreational	Residential	Other	Objective index of LUM*	Transport-related walking—min/wk*
Residential (a) ($N = 100$)	0.04^{c} (0.05)	0.08^{c} (0.08)	0.08^{b} (0.10)	$0.84^{b,c}$ (0.12)	<0.01 (0.03)	$0.33^{b,c}$ (0.17)	193.0 (21.4)
Recreational (b) ($N = 10$)	0.06 (0.15)	0.08^{c} (0.12)	$0.54^{a,c}$ (0.22)	0.32^{a} (0.17)	0.06 (0.13)	0.54^{a} (0.15)	168.3^{a} (21.4)
Commercial/ Industrial (c) ($N = 43$)	0.14^{a} (0.16)	$0.48^{a,b}$ (0.18)	0.08^{b} (0.08)	0.46^{a} (0.19)	<0.01 (0.03)	0.59^{a} (0.11)	207.9^{b} (20.0)

Note. Superscript letters indicate the profile(s) of LUM (a–c) that significantly differed from the profile of LUM represented by a specific row ($p<.05$); CCDs = census collection districts; N = number of CCDs with a specific profile of LUM; * Means and standard errors (in brackets) after adjusting for socio-demographic factors.

Relationships between perceived measures of access to destinations and weekly minutes of walking for transport (Hypotheses 3–5)

Complete data for these analyses was available for 2155 participants (81.3%). On average, respondents reported 6.3 types of destinations within a 5-min walk from home (SD = 4.9), 5.1 types of destination within 6–10 min (SD = 3.9), and 5.0 types of destinations within 11–10 min walking distance from home (SD = 4.1). A positive linear relationship was found between the reported number of different types of destinations within a 5-min walk from home and weekly minutes of walking ($b = 3.8$; 95% CI: 1.2, 6.3; $p = .004$). The inclusion of the other two measures of perceived LUM—number of types of destinations within 6–10 and 11–20 min walk from home—did not significantly add to the explanation of walking ($b = -1.0$; 95% CI: −4.0, 2.0; $p = .499$; $b = -1.3$, 95% CI: −4.5, 2.0, $p = .449$, respectively).

The descriptive statistics for perceived proximity of types of destinations are presented in Table 3 (column 2). A significant positive association was found between the average perceived proximity of commercial destinations and weekly minutes of walking for transport (Table 3; column 3). This effect was no longer significant after adjusting for neighbourhood selection (Table 3; column 4).

No significant relationships were found between walking and proximity of home/car commercial destinations, schools, bus/train stops, beach/river, and recreational destinations. A marked positive association was observed between walking and proximity of workplace (Table 3; column 3). This relationship remained significant even after controlling for perceived proximity of other groups of destinations ($b = 15.1$; 95% CI: 3.3, 26.8; $p = .011$), and the relevant neighbourhood selection variable (Table 3; column 4).

A significant interaction was observed between gender and proximity of recreational facilities ($b = 25.5$; 95% CI: 0.3, 50.7; $p = .047$). While proximity to recreation facilities tended to be negatively associated with walking for transport in men, a positive association was found among women. Men who reported recreational destinations to be more than a 30-min-walk distance from their home did walk for transport more ($M = 278.8$; 95% CI: 213.7, 343.8) than did their female counterparts ($M = 205.0$; 95% CI: 151.0, 259.0). In contrast, men who reported recreational destinations to be within a 5-min walk from home walked for transport less ($M = 210.8$; 95% CI: 156.6, 264.1) than women ($M = 307.0$; 95% CI: 221.6, 392.7). This interaction effect was attenuated after controlling for neighbourhood selection ($b = 23.1$; 95% CI: −3.8, 50.1; $p = .093$).

A significant interaction effect between gender and proximity of workplace on walking was also observed ($b = 28.6$; 95% CI: 8.8, 48.3; $p = .005$; $b = 29.2$; 95% CI: 9.5, 48.9; $p = .004$ when

Table 3
Perceived proximity of types of destinations and relationship with weekly minutes of transport-related walking ($N = 2155$)

Destinations	*M* (SD)	*b* (95% CI)*	*b* (95% CI)**	Moderators
Commercial destinations (local shops, supermarket, greengrocer, laundry/dry cleaners, etc.)	3.5 (1.0)	12.4 (0.2, 28.8)[a]	8.3 (−4.4, 21.0)	None
Home/car commercial destinations (hardware store, car service/repair, appliance store)	3.0 (1.0)	8.5 (−3.3, 20.3)	7.1 (−4.6, 18.8)	None
Schools (primary and other schools)	3.3 (1.0)	8.9 (−1.5, 19.3)	7.7 (−2.5, 17.9)	Having a child (<18)
Workplace	1.8 (1.3)	16.0 (4.6, 27.5)[b]	15.0 (3.3, 26.7)[a]	Gender; education
Bus/train stop	4.7 (0.7)	−0.8 (−16.8, 15.2)	−1.7 (−17.7, 14.3)	None
Recreational destinations (park, nature reserve, sports field, fitness centre)	3.5 (0.9)	−0.1 (−11.4, 11.2)	−6.5 (−18.5, 5.5)	Gender
Beach/river	1.9 (1.1)	7.0 (−4.0, 17.9)	4.2 (−7.4, 15.7)	None

Note. Means (*M*) and standard deviations (SD) of average perceived proximity of specific destinations from home are reported in column 2 (values ranging from 1 to 5), where 1 = 'more than a 30-min walk from home and 5 = 'up to a 5-min walk from home'. Regression coefficients (b) represent main effects adjusted for socio-demographic factors; 95% CI = 95% confidence interval *unadjusted for neighborhood selection; **adjusted for neighborhood selection.

[a]$p < 0.05$.

[b]$p < 0.01$.

adjusting for neighbourhood selection). Proximity of workplace was a significant predictor of walking in women (see above) but not in men ($b = -4.1$; 95% CI: -22.6, 14.4; $p = .663$; $b = -6.1$; 95% CI: -24.6, 12.4; $p = .520$ when controlling for neighbourhood selection).

Education was a moderator of the relationship between weekly minutes of walking for transport and workplace proximity ($b = -20.7$; 95% CI: -40.7, -0.7; $p = .042$; $b = -23.1$; 95% CI: -43.3, -2.7; $p = .026$ controlling for neighbourhood selection). No significant association was found between workplace proximity and walking among respondents with a tertiary education but a positive relationship was found among respondents without a university degree ($b = 26.3$; 95% CI: 10.3, 42.2; $p = .001$). Having a child moderated the relationship between walking and proximity of schools ($b = 12.9$; 95% CI: 0.2, 26.1; $p = .047$) but only when neighbourhood selection was excluded from the regression model. Residents with children tended to report more walking for transport if they lived close to schools.

Relationships between perceived measures of access to types of destinations and monthly frequency of walking to specific destinations (Hypotheses 3–5)

The total sample for these analyses was 1868 (85.1% of participants who completed the second survey). Descriptive statistics on monthly frequency of walking to specific destinations are reported in Table 4. Significant relationships were observed between proximity of types of destinations and monthly frequency of walking to specific destinations (all $p < .001$), with and without controlling for neighbourhood selection, with the exception of bus/train stops. An increase of k units in average proximity to specific types of destinations [ranging from 1 (> *30-min walk from home*) to 5 (*1 to 5-min walk from home*)] was estimated to result in multiplicative effects ranging from 1.3^k to 2.1^k on monthly frequency of walking to those types of destinations without controlling for neighbourhood selection, and multiplicative effects ranging from 1.1^k to 2.0^k after adjusting for neighbourhood selection. The weakest effect was observed for schools and parks, and the strongest for restaurant/cafés.

A significant moderating effect of SES (annual household income dichotomized using the median split method) was found on the relationship between proximity and monthly frequency of walking to retail stores ($b = 0.3$; 95% CI: 0.1, 0.5; $p = .021$). This relationship held with and without controlling for neighbourhood selection. A significant moderating effect of SES was also observed on the relationship between proximity and monthly frequency of walking to restaurant/cafés ($b = -0.2$; 95% CI: -0.4, -0.1; $p = .036$; $b = -0.2$–0.4, -0.1; $p = .028$ adjusted for neighbourhood selection). A greater positive multiplicative effect of proximity of commercial destinations was observed among respondents of higher SES (2.3^k; 95% CI: 1.9^k, 2.6^k) than among lower SES residents (1.7^k; 95% CI: 1.5^k, 2.0^k; estimated monthly frequency for a k-unit increase in proximity). Lower-SES respondents with restaurant/cafes situated further than a 20-min walk from home reported lower frequencies of walking (0.1–0.3 walks per month) than their higher-SES counterparts (0.2–0.5 walks per month). In contrast, no significant difference in frequency of walking (to a restaurant/café) was observed between higher- and lower-SES residents reporting restaurants/cafés being closer to home.

Table 4
Descriptive statistics of monthly frequency of walking to specific destinations ($N = 1868$)

Types of destinations	*M* (SD)	Median (IQR)
Food store	5.1 (7.0)	3.0 (8.0)
Retail store	2.5 (4.8)	0.0 (3.0)
School	0.9 (4.0)	0.0 (0.0)
Post office	1.5 (3.1)	0.0 (2.0)
Restaurant/café	1.8 (3.9)	0.0 (2.0)
Recreational facility	0.5 (2.6)	0.0 (0.0)
Park	3.7 (6.6)	0.0 (4.0)
Bus/train stops	2.6 (5.9)	0.0 (2.0)
Work	1.7 (5.5)	0.0 (0.0)

Relationship between total weekly minutes of transport-related walking and monthly frequency of walking to specific destinations (Hypothesis 3)

Monthly frequencies of walking to specific destinations in the neighbourhood were significantly related to overall weekly minutes of walking for transport (see Table 5–Models 1). Frequencies of walking to food shops, local parks, bus/train stops and workplace were independently associated with weekly minutes of walking for transport (adjusting for frequency of walking to other destinations) (Table 5–Model 2).

Table 5
Relationships between weekly minutes of walking for transport and monthly frequency of walking to specific destinations

Monthly frequency of walking to …	Weekly minutes of walking for transport					
	Models1[a]			Model 2[b]		
	b	95% CI	*p*	*b*	95% CI	*p*
Food store	9.6	7.3, 11.8	<.001	4.6	1.5, 7.7	.004
Retail store	13.1	8.8, 17.5	<.001	2.6	−2.0, 7.1	.269
School	6.2	2.1, 10.3	.003	0.7	−2.4, 3.9	.648
Post office	22.3	14.0, 30.7	<.001	4.3	−3.8, 12.5	.296
Restaurant/café	11.2	6.9, 15.5	<.001	−0.6	−5.0, 3.8	.785
Recreational facility	9.2	2.5, 16.0	.007	3.1	−2.0, 8.3	.236
Park	6.1	3.6, 8.5	<.001	2.7	0.9, 4.6	.004
Bus/train stops	7.7	4.8, 10.7	<.001	3.7	1.3, 6.2	.003
Work	10.8	7.7, 14.0	<.001	8.3	5.2, 11.3	<.001

[a]Adjusted for socio-demographic factors.
[b]Adjusted for socio-demographic factors and walking to specific types of destinations (full model); 95% CI = 95% confidence interval.

Discussion

As in recent studies (Frank et al., 2004, 2005; Hoehner et al., 2005), we found that, overall, access to destinations was positively associated with transport-related walking. Consistent with our hypotheses, the explanatory power of measures of access to destinations increased with their specificity (Hypothesis 2); the contribution of access to destinations to the total amount of transport-related walking depended on the type of destinations (Hypothesis 3), as well as on the socio-demographic characteristics of the respondents (Hypothesis 4); and the relationships between walking and access to destinations were only in part explained by neighbourhood selection (Hypothesis 5). The last finding indicates that residents for whom active transport is not a priority may still be positively affected by destination accessibility, which, in turn, suggests that part of the 'effect' of built environment on transport-related walking may be direct (Frank et al., 2006; Handy et al., 2006).

As the ultimate goal of the public health agenda is to provide an environment that is conducive to a more active and healthy lifestyle (including transport-related walking) for all residents, we discuss the study findings in terms of which destinations matter, and to whom they matter, with respect to walking for transport.

Residents of neighbourhoods with a commercial/industrial *profile of LUM* reported significantly more transport-related walking than did residents of neighbourhoods with a recreational profile, even if these areas had a similar objective index of LUM. This explains why, contrary to our expectations, no significant association was observed between the objective index of LUM and transport-related walking. The studies that reported a positive association between an objective index of LUM and moderate-intensity physical activity (Frank et al., 2004, 2005) used an operational definition of LUM slightly different to ours whereby land-use categories that belong to a traditional design concept in urban development (residential, commercial and office/institutional spaces) were used and recreational spaces were excluded. These studies also based their measures on the distribution of floor space rather than land area across different uses, which can result in very different results. Land-area-based measures of LUM are required to capture the effects of open space and recreation on travel choice. However, recreational venues are likely to be regularly visited less often and by fewer people (Sallis et al., 2004) and, hence, their impact on residents' transport-related walking is bound to be limited. This was also confirmed by the present study, in which no significant association was found between transport-related walking and proximity of recreational destinations.

Proximity of workplace emerged as the most significant contributor to transport-related walking, and monthly frequency of walking to work as the most significant contributor to total transport-related walking. It was estimated that an individual who regularly walks to work (5 days a week) would on average accumulate 166 weekly minutes of walking and, thereby, meet current health-related physical activity guidelines for adults. This has important policy implications and suggests the need to intermingle different types of land uses within smaller geographic areas. Interestingly, however, the effect of proximity of workplace was significant for women but not for men, and was significant for residents with primary or secondary, but not with a tertiary education. At present, we can only speculate as to the reasons for these findings. It is possible that men are more 'attached' to their cars and prefer to drive rather than walk to work. It is also possible that men and tertiary-educated respondents tend to be economically superior within their own household and, therefore, less dependent on cheap modes of transport (Hamilton, 2002). The fact that walking to work can be a significant way to accumulate health-enhancing levels of physical activity indicates that changing the travel behaviour of residents living within walking distance of work may be an appropriate target for health promotion campaigns on physical activity. There appears to be considerable room for improvement in this respect, especially among sedentary men.

The importance of considering the moderating effects of socio-demographic factors on the destination-walking relationship is all the more highlighted by the findings pertaining to *access to schools* and *recreational destinations*. Although no main effects of proximity of these destinations were found on weekly amount of transport-related walking, significant positive associations were found in particular sub-groups. Proximity of schools was related to walking among respondents with children in the household. Parents of children living within a 5-min walk from school reported 60 min more transport-related walking than parents of children living more than 30 min away from a school. This association, however, was no longer significant after controlling for neighbourhood selection, which suggests that a substantial proportion of parents who walked their children to school may have decided to live in a specific neighbourhood because it was close to the school of their preference. Promoting walking to school among parents and children who live within walking distance from school does merit serious consideration. Given its regular pattern (trips to/from school 5 days a week), walking to school could contribute substantially to the accumulation of sufficient physical activity for health benefits.

The observed moderating effect of gender on the relationship between walking and proximity of recreational destinations is less intuitive. A positive relationship was found for women, whilst a negative relationship was found for men. It is possible that men are more prepared to regularly use and walk to recreational destinations even if they are not very accessible. In contrast, women may visit recreational facilities only if they are in a convenient location. This explanation fits the evidence that men engage in more leisure-time physical activity than do women (Leslie et al., 2004). Women might benefit doubly from having easy access to recreational facilities: it may facilitate their engagement in leisure-time physical activity as well as encourage them to walk to the same.

As expected, *proximity of commercial destinations* was positively associated with walking for transport. However, certain types of commercial destinations were more important than others. Specifically, car- and home-related commercial destinations were not predictive of walking, whereas more frequently visited venues such as food shops were significant contributors to total transport-related walking. While these findings held true for all socio-demographic groups, household income moderated the relationships between monthly frequency of walking and *proximity of restaurant/cafés* and commercial destinations (other than car- and home-related stores). These moderating effects were most likely due to differences in discretionary income.

Although this study did not find a significant association between *proximity of public transport* and transport-related walking, monthly frequency of walking to bus/train stops was predictive of total weekly transport-related walking. A previous study also observed a positive relationship between walking and access to public transport (Hoehner et al., 2005). This suggests that an efficient and integrated public transport network could contribute to a more active lifestyle in residents by providing better opportunities for active travel choices. Due to the characteristics of urban sprawl in most Australian and US cities, having a well-connected public transport network may not be viewed as a financially viable option. However, if we consider the costs associated with an inactive lifestyle (Goetzel et al., 1998) and automobile dependency in the adult population (Parker, 2005), the development of a high-quality public transport infrastructure becomes an effective solution with public health benefits.

The findings of this study reiterate some recent calls for greater context-specificity in the study of behaviours and their environmental correlates (Giles-Corti et al., 2005; Owen et al., 2004; Saelens et al., 2003). This was evident in the present study, where proximity of specific types of destinations was significantly related to frequency of walking to these destinations (from home), while these relationships were considerably attenuated when using a 'generic' measure of transport-related walking. The same reasoning applies to the environmental correlates of walking. We have seen that the objective index of LUM applied in this study was not predictive of transport-related walking, while those used in previous studies were. This may be partly due to the fact that previous measures encompassed land use categories that bear a strong theoretical relationship with walking for transport, while our measure included some categories of land use that are not as plausibly associated with utilitarian walking.

Although this study has several limitations due to its cross-sectional nature, reliance on self-report measures (with relatively large measurement errors), and use of a non-representative sample of the population of Australian adults (e.g., exclusion of non-English speakers; sampling of adults based on area characteristics rather than individual-level socio-demographics), it indicates that access to specific destinations in the neighbourhood can act as a facilitator for a more active lifestyle among its residents. It also strengthens the evidence base for a causal effect of the built environment on physical activity. Promoting a more active lifestyle by improving the accessibility of food stores and other destinations, developing a more functional public transport network, and promoting walking as a mode of transport to 'regular' daily destinations such as schools and the workplace is the key take-home message of this study.

Acknowledgements

The National Health and Medical Research Council (NHMRC) Grants #213114 and #301200 supported the PLACE study. The South Australian Government Department for Transport and Urban Planning provided access to the relevant GIS data and the National Centre for Social Applications of GIS (GISCA) supplied technical support. James Sallis, Adrian Bauman, Graeme Hugo, and Neil Coffee made significant contributions to the PLACE study. Dr. Leslie is supported by an NHMRC Public Health Fellowship #301261. Dr. Cerin was supported by an NHMRC Capacity Building Grant #252977.

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