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# Residents' perceptions of walkability attributes in objectively different neighbourhoods: a pilot study

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## Abstract

Physical attributes of local environments may influence walking. We used a modified version of the Neighbourhood Environment Walkability Scale to compare residents' perceptions of the attributes of two neighbourhoods that differed on measures derived from Geographic Information System databases. Residents of the high-walkable neighbourhood rated relevant attributes of residential density, land-use mix (access and diversity) and street connectivity, consistently higher than did residents of the low-walkable neighbourhood. Traffic safety and safety from crime attributes did not differ. Perceived neighbourhood environment characteristics had moderate to high test–retest reliabilities. Neighbourhood environment attribute ratings may be used in population surveys and other studies.


*Keywords:* Built environment; Environmental perceptions; Walking; Public health

## Introduction

There is growing interest in understanding the influence of attributes of the built environment on habitual physical activity (Humpel et al., 2002; Killingsworth, 2003; Frank and Engelke, 2001; Sallis et al., 1998). In Australian studies, Giles-Corti and Donovan have demonstrated that having greater access to recreational facilities is associated with an increased likelihood of being active (Giles-Corti and Donovan, 2002a, b) and that both objective (access to open spaces) and perceived (aesthetic) environmental attributes are associated with walking at recommended levels (Giles-Corti and Donovan, 2003). Walking is the most common adult physical activity behaviour (Australian Bureau of Statistics (ABS), 1999) and walking in and around local neighbourhoods is an important component of most adults' total physical activity (Humpel et al., 2004b).

In the context of the public health goal to increase regular moderate-intensity physical activity, walking is the behaviour that is most likely to be amenable to influence (Siegel et al., 1995). Physical attributes of local walking environments may be related to walking for

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particular purposes, such as walking for exercise, pleasure or transport. However, there is only a modest body of evidence on how best to measure residents' perceptions of neighbourhood built environment factors and how these perceptions may be related to corresponding objectively assessed attributes.

Researchers in planning and transportation have identified land-use mix (diversity of uses and access to facilities), residential density and street connectivity as the key aspects for creating walkability indices (Frank and Pivo, 1994). Higher population density, greater connectedness of streets (higher number of intersections) and mixed land use has been consistently associated with higher rates of walking and bicycling trips for transportation (Saelens et al., 2003b). More recently, these relationships have been extended to include impacts of the built environment to the prevalence and likelihood of obesity (Frank et al., 2003; Ewing et al., 2003).

Relationships between neighbourhood physical environment and active travel frequency persist after controlling for residents' socio-economic and other potential confounding factors. A Neighbourhood Environment Walkability Scale (NEWS) developed for use in the USA has been found to have moderate to high test–retest reliabilities (with a majority of items $\geqslant 0.75$); there was evidence of construct validity, with residents in high–walkable neighbourhoods reporting higher residential density, land-use mix and street connectivity than did residents in low-walkable neighbourhoods (Saelens et al., 2003a). In that study, the high-and low-walkable communities were chosen on the basis of the investigators' perceptions about the selected neighbourhoods' density, connectivity and land use. However, these factors were not quantified objectively by examination of land-use and street network databases using Geographic Information Systems (GIS).

Two neighbourhoods in Adelaide, South Australia were chosen as high and low on walkability, based on objective indices derived from GIS databases. We compared ratings of five environmental attributes modified from the NEWS scale among residents from these two neighbourhoods and examined the test–retest reliability of the items.

## Methods

The Behavioural and Social Sciences Ethics Committee of the University of Queensland approved the study.

### *Defining walkability*

The index of walkability, based on Frank et al. (Manuscript under review), was calculated for Census Collection Districts (CCDs), the smallest spatial unit defined by the Australian Bureau of Statistics (ABS), and applied to the Adelaide Statistical Division. The CCD layer was filtered for urban CCDs only to remove the influence of larger sparsely populated CCDs upon the classification and analysis of walkability. This was based on the ABS definition of urban CCDs which have a population density of $>200$ persons/km$^2$ and are adjacent or proximal to other urban CCDs.

GIS data for roads, intersections and land use were analysed to create:

(1) intersection density (a measure of street connectivity based on the number of true intersections within a given area);[1]
(2) dwelling density (a measure of dwelling density which equals the number of dwelling units divided by the land area in residential use within each CDD);
(3) a measure of land-use mix based on the distribution of development across five- uses (residential, commercial, industrial, recreation and other) for each CCD.

Each of the three built environment variables was classified into deciles and the classes recoded to a 1 to 10 score with 1 the lowest value and 10 the highest. Deciles were used to provide a standard score for the three measures, with 1 representing the lowest 10 per cent of CCDs for each measure and 10 representing the top 10 per cent of CCDs for each measure. After recoding each layer, the three layers were summed to create a single CCD data layer with the recoded variables for dwellings, intersections and land use to provide a walkability score. The walkability score was then classified into quartiles, with the 1st and 4th quartiles used to represent the lowest and highest walkability CCDs respectively.

### *Procedures*

Potential participants were identified from one high-walkable suburb (Norwood) and one low-walkable suburb (Hawthorndene) chosen using street address data available in the Legal Property Identifying System (see Fig. 1). The two areas were chosen so as to have similar 2001 Census-level median household weekly income (high walkable \$800–\$1199, low walkable \$800–\$1199) and a similar median resident age (high walkable 33–41 years, low walkable 35–40 years).

The high-walkable area (Norwood) is closer to the city centre, generally flat and typically has grid-like street systems with many intersections (see Fig. 2). The

[1]True intersections have three or more legs. More intersections per unit of area results in the ability to traverse more directly between destinations and a higher level of connectivity. Due to limitations with existing data, intersection density was solely defined based on the roadway and does not represent the presence of sidewalks.

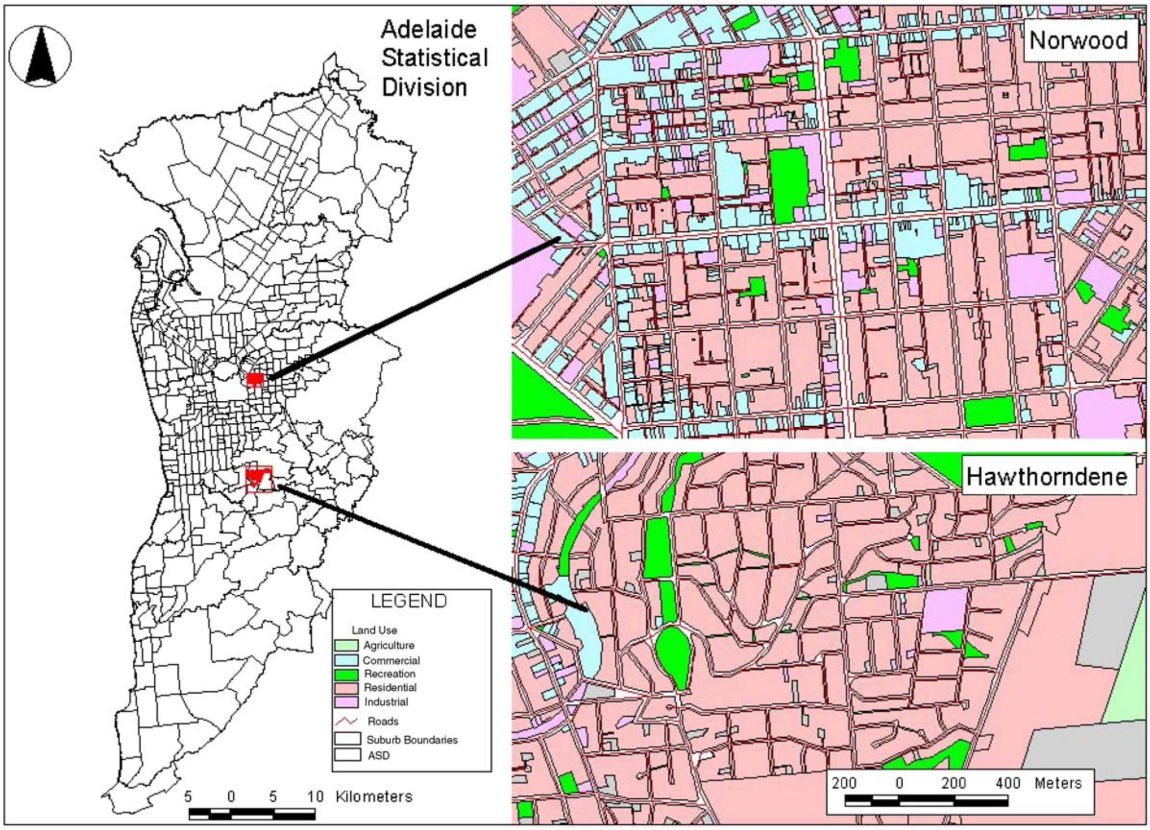


Fig. 1. Norwood and Hawthorndene neighbourhoods.

area has high population density with a mixture of traditional dwelling styles (often without household parking space) and newer housing developments (apartments, small living units, multiple storey complexes). The main streets are busy thoroughfares and have considerable land-use mix with many retail stores and services. The smaller streets are often narrow and many have connecting laneways. Most of the streets typically have footpaths (sidewalks) but not median strips, although there are frequently street trees and occasionally median strips separating larger roadways. There are many community facilities such as churches, libraries, schools and small parks with play and picnic facilities and several public transport routes are available.

The low-walkable area (Hawthorndene) is further out from the city centre, where the topography is hillier and the roads tend to be winding (see Fig. 3). The road design reflects the topography and larger block sizes that were typical of the development era of this neighbourhood, with some cul-de-sacs, fewer intersections and greater distance between intersections, resulting in lower residential density. There is mostly off-street parking with few formal pathways separating the roadway from residences. Most of the area is residential, with predominately single-family homes, some schools and only a few stores. There is considerable vegetation and adjoining bushland (including a national park and recreation reserves) but few local parks with play facilities for children. There is one bus service through the area.

Initially, addresses from two CCDs in Norwood ($n = 600$) and one in Hawthorndene ($n = 270$) were identified. Residential addresses were then selected from this list and telephone numbers obtained by matching names and addresses using the electronic White Pages. This resulted in a total of 289 (140 and 149) cases. From this list of potential households in each area, random telephone numbers were called and a member of the household who had most recently had a birthday was asked to participate. To be eligible, participants had to be between 40 and 60 years of age. Telephone calls were made until a total of 100 people willing to participate in the study were recruited. Of those called who were in the eligible age range, 68.5% from Norwood and 90.9% from Hawthorndene completed the interview and agreed to participate in the study. Participants were then mailed the first survey. A second survey was mailed 11 days later, resulting in an approximate 2-week test–retest


Fig. 2. Norwood neighbourhood characteristics.

evaluation. One week after the second survey was sent, those who had not yet returned the first survey were called by telephone. Two weeks after the second survey was sent, those who had returned the first but not the second survey were reminded by telephone.

## Survey instrument

A modified version of the NEWS (Saelens et al., 2003a) was used to assess neighbourhood environment characteristics with known relationships to walking behaviour. The original survey was developed for use in the USA and also included items on bicycle use. Some minor wording changes were required and some items related specifically to bicycling were deleted. A copy of the Australian survey instrument is available from the first author. The survey form and scoring protocols for the original NEWS survey are available at http://www.drjamessallis.sdsu.edu/NEWS.pdf and http://www.drjamessallis.sdsu.edu/NEWSscoring.pdf, respectively.

Environmental characteristics assessed in the survey included: residential density; proximity to and ease of access to non-residential land uses such as restaurants and retail stores (land-use mix diversity and land-use mix access); street connectivity; walking facilities (e.g., footpaths, walking paths); aesthetics; traffic safety; and safety from crime. With the exception of the residential density and land-use mix-diversity subscales, items were scaled from 1 to 4 (1 = strongly disagree to 4 = strongly agree), with higher scores indicating a more favourable value of the environmental characteristic. A number of items were reverse scored to reflect the same direction (e.g., 'major barriers to walking' in the land-use mix-access subscale).

Residential density items asked about the frequency of different types of neighbourhood residences, from detached single-family residences to apartments/flats that were 6+ stories, with a response range from 1 = none to 5 = all. In the study conducted in the USA (Saelens et al., 2003a), residential density items were weighted relative to the average density of single-family detached residences to reflect the influence of apartments and condominiums (which are more person-dense than

Fig. 3. Hawthorndene neighbourhood characteristics.

single-family residences), as these dwelling types are far more prevalent in their study areas. Having weighted the residential density, they then summed the adjusted values to create the residential density subscale score. In Adelaide, especially in the Norwood and Hawthorndene neighbourhoods, single-storey dwellings are the norm, with only a few two-storey dwellings in the Norwood area. Therefore, applying weighting to residential density was unnecessary in this instance. The residential density items were combined to derive a residential density subscale score.

Diversity of uses (land-use mix) was self-assessed by respondents based on their perceived walking proximity from home to shops or other facilities. Respondents were asked to provide their perception on how much time it would take to walk from home to reach these facilities. The range of time was coded in 5 min increments ranging from 1–5 min walking distance (coded as 5) to 30+ minute walk (coded as 1). Higher scores on land-use mix-diversity indicated closer average proximity. With the exception of the residential density, subscale scores were calculated as the mean across the subscale items.

*Data analyses*

Data were coded, entered and checked using SPSS® v10.0 for Windows. Individual test-retest reliabilities for items were reported as Spearman's correlations. One-way single-measure intra-class correlations were used to evaluate the test-retest reliability of each of the subscales. The complete Survey 1 sample responses were used to compare mean subscale scores (using an independent sample *t*-test) between residents of the different neighbourhoods to assess construct validity of the perceived walkability factors.

## Results

Eighty-seven participants, with a mean age of 44.1 years completed Survey 1 (23 men; 64 women). Car ownership was high among participants (96.5%) and

Table 1
Test-retest reliability (intra-class correlation) and mean (standard deviation) subscale scores for high-and low-walkable neighbourhoods

| Perceived neighbourhood environment characteristic (no. items) | Test-retest reliability ($N=71$) | High-walkable (Norwood) residents ($N=40$), mean (SD) | Low-walkable (Hawthorndene) residents ($N=47$), mean (SD) |
|---|---|---|---|
| Residential density (5) | 0.78 | 2.26 (0.23)[a] | 1.92 (0.32) |
| Land-use mix diversity[b] (21) | 0.88 | 4.02 (0.31)[a] | 3.40 (0.40) |
| Land-use mix access (7) | 0.80 | 3.58 (0.43)[a] | 2.91 (0.47) |
| Connectivity (5) | 0.74 | 3.00 (0.41)[a] | 2.61 (0.49) |
| Infrastructure for walking (6) | 0.76 | 3.19 (0.49)[a] | 2.78 (0.42) |
| Aesthetics (6) | 0.86 | 2.71 (0.39)[c] | 3.06 (0.25) |
| Traffic safety (6) | 0.62 | 2.46 (0.32) | 2.42 (0.39) |
| Safety from crime (6) | 0.63 | 3.08 (0.40) | 2.98 (0.44) |

[a]High walkable >low walkable, all $p<.001$.
[b]Land-use mix-diversity scale reverse scored to reflect the same directionality of other environment characteristics, that is, higher scores = higher walkability.
[c]Low walkable >high walkable, $p<.001$; subscales scores ranged from 1 to 4 (with the exceptions of land use mix-diversity and residential density, possible range of 1–5), with higher scores indicating higher levels of the construct.

only a very small proportion used public transport 'most of the time' (1.2%). Seventy-one participants completed both surveys (16 men; 55 women). The median time difference between actual completion of Surveys 1 and 2 was 12 days.

Test-retest reliability and mean subscale scores are in Table 1. Intra-class correlations for the test–retest of the Neighbourhood Environment Walkability subscales were all $\geqslant 0.62$. The majority of individual test–retest values were $\geqslant 0.60$, $p<0.001$. A list of individual item test–retest reliabilities is provided in Table 2.

Comparisons of mean scores on Neighbourhood Environment Walkability subscales between residents in high- and low-walkable neighbourhoods are in Table 1. Residents in the high-walkable neighbourhood provided ratings indicative of higher residential density ($t(84)=8.25$, $p<0.001$), land-use mix diversity ($t(67)=-4.37$, $p<0.001$) and land-use mix access ($t(83)=6.81$, $p<0.001$), street connectivity ($t(82)=3.95$, $p<0.001$) and infrastructure for walking ($t(85)=4.13$, $p<0.001$), than did residents of the low-walkable neighbourhood. However, residents of the low-walkable neighbourhood had higher ratings of aesthetics of their neighbourhood ($t(85)=-4.97$, $p<0.001$) than did residents of the high-walkable neighbourhood. Residents of the high and low-walkable neighbourhoods did not differ in perceived crime safety ($t(85)=1.11$, $p=0.771$) or traffic safety ($t(85)=-0.54$, $p=0.473$).

## Conclusions

Participants perceived neighbourhood environment characteristics were related to objectively assessed 'walkability'. There were statistically significant differences in residents' ratings of environment characteristics between those living in objectively 'high'- and 'low'-walkable areas for density, land-use mix, street connectivity and infrastructure for walking (all $p<0.001$), indicating that residents from neighbourhoods with different characteristics do perceive these attributes differently. The neighbourhoods were selected to differ objectively on residential density, land-use mix, and street connectivity, and in fact residents perceived these differences according to their self-report. The remaining factors of infrastructure for walking, aesthetics, traffic safety and safety from crime were not used as the criteria for neighbourhood selection. The different direction for the neighbourhood-based differences in aesthetics (residents of the low-walkable neighbourhood had higher ratings of aesthetics) is likely to be attributable to the low-walkable area having a much 'bushier' and hillier topography, with more trees, shrubs and open green spaces as well as scenic views, than did the high-walkable area.

It is interesting to note that the mean values for land-use mix and street connectivity for the high- and low-walkable neighbourhoods in the present study were higher, respectively, than in the study carried out in the USA using the same measures and the same high- versus low-walkability neighbourhood comparison methodology (Saelens et al., 2003a). This can be explained by the fact that overall levels of metropolitan density are somewhat higher in Australia than in most north American regions (Newman and Kenworthy, 1991). However, the magnitudes of the mean differences between the high- and low- walkability neighbourhoods on these factors between our study and that in the USA

Table 2
Test–retest reliability (Spearman's correlation) for individual items in the neighbourhood survey

| Subscale | Item | Test–retest reliability |
|---|---|---|
| Residential density | Detached single-family residences | .69 |
| | Townhouses | .81 |
| | Apartments or flats 1–3 stories | .64 |
| | Apartments or flats 4–6 stories | .69 |
| | Apartments or flats >6 stories | — |
| Land-use mix diversity | Walking proximity to local shops | .68 |
| | Walking proximity to a supermarket | .84 |
| | Walking proximity to a hardware store | .86 |
| | Walking proximity to a greengrocers | .88 |
| | Walking proximity to a laundry/dry cleaners | .73 |
| | Walking proximity to a post office | .81 |
| | Walking proximity to a library | .89 |
| | Walking proximity to a primary school | .84 |
| | Walking proximity to other schools | .65 |
| | Walking proximity to a book shop | .74 |
| | Walking proximity to a café | .76 |
| | Walking proximity to a video outlet | .82 |
| | Walking proximity to a pharmacy | .80 |
| | Walking proximity to your job | .91 |
| | Walking proximity to a bus or train stop | .67 |
| | Walking proximity to a park | .68 |
| | Walking proximity to natural bushland | .74 |
| | Walking proximity to a fitness/recreation center | .72 |
| | Walking proximity to a sports field | .84 |
| | Walking proximity to a beach | .48 |
| | Walking proximity to a river | .70 |
| Land-use mix access | Can do most of day to day shopping in local area | .54 |
| | Many shops within easy walking distance | .73 |
| | Many places to go within easy walking distance | .54 |
| | Easy to walk to public transport | .64 |
| | Streets are hilly | .91 |
| | Major barriers to walking, e.g., freeways that limit routes | .54 |
| | Car parking is difficult in local shopping areas | .63 |
| Street connectivity | Not many cul-de-sacs | .70 |
| | Walkways connecting cul-de-sacs to streets, pathways | .67 |
| | Short distance between intersections | .62 |
| | Many four-way intersections | .72 |
| | Many alternate routes | .60 |
| Infrastructure for walking | Footpaths on most streets | .83 |
| | Footpaths are well maintained | .69 |
| | A park or nature reserve is easily accessible | .50 |
| | Footpaths separated from streets by grass/dirt strip | .53 |
| | Footpaths separated from road/traffic by parked cars | .59 |
| | A bicycle/walking path is easily accessible | .65 |
| Aesthetics | Lots of greenery around my local area (e.g., trees, bushes, gardens) | .81 |
| | Tree cover or canopy along footpaths | .51 |
| | Many interesting things to look at while walking | .56 |
| | Neighbourhood free from litter or graffiti | .61 |
| | Attractive buildings/homes in local area | .69 |
| | Pleasant natural features in local area | .83 |
| Traffic safety | Heavy traffic along most nearby streets, walking difficult | .47 |
| | Live on/near arterial road or busy thoroughfare | .60 |
| | Slow speed of traffic on most nearby streets | .26 |
| | Traffic slowing devices in local area | .43 |
| | Pedestrian crossings and traffic signals available to help cross busy streets | .53 |

Table 2 (*continued*)

| Subscale | Item | Test–retest reliability |
|---|---|---|
| | Lots of exhaust fumes from cars and buses | .71 |
| Safety from crime | Streets are well lit at night | .56 |
| | Lots of petty crime in local area (e.g., vandalism, shoplifting) | .71 |
| | Lots of major crime in local area (e.g., armed robberies, break-ins, attacks) | .67 |
| | Crime in local area makes it unsafe to walk during day | .63 |
| | Crime in local area makes it unsafe to walk in at night | .61 |
| | Feel safe walking home from bus or train stop at night | .59 |

*Notes*: *N=71*, All item test–retest reliability values $p<0.01$, with the exception of 'slow speed of traffic on nearby streets' with $p<0.05$, —, there was not enough variability in responses to evaluate reliability.

were very similar. In both studies, the greatest difference between high- and low- walkable neighbourhoods was in land-use mix diversity, and the smallest difference was in street connectivity. This suggests perhaps some consistency in the magnitude of differences in walkability factors between neighbourhoods across metropolitan areas in Australian and the USA.

The test–retest reliability findings reported here for most constructs are comparable to the findings from the USA reported by Saelens et al. (2003a), with the USA study reporting test–retest reliabilities (intra class correlations) for the subscales ranging from 0.58 to 0.80, and our study ranging from 0.62 to 0.88. Some of the differences observed for specific subscales may be the result of minor modifications made to wording to reflect the Australian context, the differences in the neighbourhood environments explored, and to inclusion of attributes related to walking and not to bicycle use.

Kirtland et al. (2003) examined 3-week test–retest reliability for items measuring perceptions of 'neighbourhood' and 'community' supports for activity. They found retest results slightly higher for their neighbourhood items, with reliability coefficients ranging from 0.42 to 0.74 overall. The higher values found for the neighbourhood compared to the community items may be due to the definitions of distance used, which were 'within a 10 min walk of home' and 'within a 20 min drive of home', respectively. Our study had individual test–retest values of 0.26 to 0.91 and used the definition of '10–15 min walk from home' to define local neighbourhood. The use of shorter distances in these surveys may result in more accurate recall of environmental attributes (Kirtland et al., 2003).

Limitations of our study include the use of a convenience sample (participants willing to complete the survey) not matched on individual respondent demographic characteristics that may be potential modifiers of environmental perceptions. Participants were recruited from only two neighbourhoods at the extremes of walkability and it may be that these particular neighbourhoods also had other, unmeasured, characteristics that influenced residents' perceptions of their neighbourhood environment. Although it is not known what the educational or socio-economic levels of participants were, the two areas selected were chosen to be similar on census-based data for age and income. While both groups had high levels of car ownership, participants in Norwood (the high-walkable neighbourhood) may be likely to use public transport more regularly (due to a greater number of bus routes traversing their neighbourhood) and may therefore have had more exposure to environmental attributes, than would those residents in the more car-oriented Hawthorndene neighbourhood. This may have been a factor in residents' perceiving their neighbourhood attributes accurately.

GIS databases are increasingly being used in studies of the role of space, place and distance in the study of health and disease (Ricketts, 2003; Rushton, 2003). However, the complexity and availability of objectively derived data means that for population monitoring and for the purposes of other research studies, measures of perceived environmental attributes may be useful, particularly where objective indices are not available or feasible. Valid and reliable measures of these perceived attributes may also be useful as covariates in evaluations of intervention effects in future research studies (Humpel et al., 2004a). It is not yet clear whether objective or perceived measures of walkability constructs are more or less related to actual physical activity behaviour. Further, it is unknown what individual factors make a given respondent a more or less accurate reporter of his or her neighbourhood environment.

Understanding how neighbourhood physical environment attributes are associated with physical activity behaviour has practical and policy implications. If supportive community environment attributes do increase physical activity, this greatly strengthens the public health case in support of transportation, urban planning and environmental protection or initiatives to increase walking and bicycle use (Sallis et al., 2004). However, the challenge for research is to demonstrate that the associations of environmental attributes with physical activity behaviour are causal (Saelens et al., 2003b; Sallis et al., 1998).

Thus far, research studies on the possible environmental determinants of physical activity behaviour have generally used cross-sectional designs (Humpel et al., 2002). Future studies will require the use of prospective or intervention designs to determine whether the environment–behaviour associations that we and others have documented, are actually causal relationships (Saelens et al., 2003b; Humpel et al., 2002). While causality will certainly remain the central focus of this emerging area of inquiry, it is important to note that research also documents a latent, or unmet, demand for more walkable environments where adults can self-select to be more physically active (Levine et al., in press). This finding operates on the notion that there is an emerging undersupply of walkable environments in most newly developed regions of the western world. For the past 50 years, these residential regions have been built largely to meet the physical requirements of the motor vehicle. In light of these considerations which operate at the person and community levels, it will be particularly important to ascertain how physical environment attributes might act to moderate or mediate physically active behavioural choices, in a context where individual-level or social determinants are also relevant causal influences (Bauman et al., 2002; Giles-Corti and Donovan, 2002a; Owen et al., 2000; Sallis and Owen, 2002).

There is a new and challenging research agenda to understand how environmental factors might operate to influence habitual physical activity in local community environments (Humpel et al., 2002; Owen et al., 2004; Saelens et al., 2003b). Sallis et al.'s recent review (2004) summarizes 11 studies that use a high- and low-walkable community comparison design, with rates of walking as the outcome. Consistently higher numbers of walking trips have been found to be related to living in high-walkable compared to low-walkable areas. Research in this area and in related studies in the urban planning field are identifying new and challenging research questions (Frank et al., 2003; Kitamura et al., 1997; Krizek, 2000). Our study and that of our colleagues in the USA suggest that it is feasible to assess environmental attributes relevant to walking, using both objective and self-report methods. Such measurement advances will help to underpin future research. In the shorter term, they might also provide practical tools that can be integrated into population monitoring and surveillance. Future research could test these items in less extreme neighbourhoods to ascertain whether residents can perceive more subtle differences in environmental characteristics.

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