

Talking the talk, walking the walk: examining the effect of neighbourhood walkability and social connectedness on physical activity

Andrew T. Kaczynski¹, Troy D. Glover²

¹Department of Health Promotion, Education and Behaviour, Arnold School of Public Health, University of South Carolina, 800 Sumter - Room 216, Columbia, SC 29208, USA

²Department of Recreation and Leisure Studies, University of Waterloo, Waterloo, ON N2L 3G1, Canada

Address correspondence to Andrew T. Kaczynski, E-mail: atkaczyn@mailbox.sc.edu

ABSTRACT

Background Few studies have considered the joint effects of social and physical environments on physical activity (PA). The primary purpose of this study was to examine the compounding effects of neighbourhood walkability and social connectedness on PA.

Methods Data were collected from adults ($n = 380$) in Waterloo, Ontario, Canada. Perceptions of neighbourhood social connectedness and walkability were measured via survey. Minutes of neighbourhood PA for recreation and transportation were captured with a detailed 7-day log booklet. Four groups were created (e.g. high walkability/low social connectedness) and two factorial ANOVAs examined group differences in minutes of recreational and transport-related PA.

Results There were significant differences across the four walkability/social connectedness groups for both recreational ($F = 11.36, P < 0.01$) and transport-related PA ($F = 8.12, P < 0.01$). Participants perceiving both high walkability and social connectedness displayed the greatest levels of both recreational (130.6 min) and transport-related PA (24.5 min). The high walkability/low social connectedness group had greater *transport-related* PA than the two low walkability groups, while the high social connectedness/low walkability group had greater *recreational* PA than the two low social connectedness groups.

Conclusions These findings underscore the relationship between physical and social dimensions of urban form and their association with health behaviours. PA promotion efforts should take into account both physical (e.g. land-use planning) and social (e.g. walking group) environments.

Keywords built environment, neighbourhood, physical activity, social connectedness, walkability

Introduction

Physical inactivity is a significant public health concern and recognition of the complexity of improving population-level activity patterns is reflected in the increasing adoption of social ecological models among researchers and practitioners.^{1–3} Social ecological models posit that health behaviours, such as physical activity (PA), are influenced by a range of individual, social and environmental factors and the interactions between influences at different levels of the model.^{4,5} Numerous studies have examined the relative influence of a variety of PA correlates,^{6–9} yet few studies have explored the compounding effects of enhancing factors at different levels of the social ecological model.^{3,10} For

example, are persons from neighbourhoods endowed with both physical (e.g. street patterns) and social (e.g. trust among neighbours) connections more likely to engage in healthy behaviours than persons from areas with neither or only one of these resources? Exploring such relationships can improve our understanding of the dynamic nature of these models and can lend greater credence to investing in a comprehensive social ecological approach to PA promotion.³ In this study, we examine how social and physical

Andrew T. Kaczynski, Assistant Professor

Troy D. Glover, Associate Professor

dimensions of the neighbourhood are related and potentially work together to encourage PA. The following paragraphs describe associations between PA and each of neighbourhood walkability and neighbourhood connectedness, and how the latter two constructs have been examined in relation to one another.

In recent years, numerous studies have documented significant relationships between neighbourhood walkability factors and residents' active living behaviours. For example, access to a variety of destinations within walking distance is associated with increased amounts of walking and other physical activities.^{11–14} Likewise, residential density and connectivity of streets are often linked to greater walking, especially for transportation.^{15–19} Other studies have used a composite measure of multiple dimensions of walkability to document associations with PA participation.²⁰ Additionally, green space (e.g. parks, trails) in communities can facilitate both recreational and utilitarian PA, while also providing opportunities for social connections among residents.^{21,22}

In addition to the physical dimensions of neighbourhoods and communities, social factors can also significantly impact health behaviours and outcomes. Social capital, a term often used to describe 'those features of social organization—such as networks of secondary associations, high levels of interpersonal trust and norms of mutual aid and reciprocity—which act as resources for individuals and facilitate collective action',²³ has been shown to have significant implications for health.²⁴ Indeed, some research has investigated how constructs related to social capital are associated with PA participation. For example, in a national study of over 62 000 US children at ages of 6–17, those with low perceived neighbourhood social capital had 66% higher odds of being inactive (no days of vigorous PA in past week) and 33% lower odds of being classified as active (3 or more days of vigorous PA in past week) than children with high neighbourhood social capital.²⁵ Additionally, Brennan *et al.*²⁶ constructed an 18-item protective social factors scale based on dimensions such as social participation, cohesion, trust, reciprocity and safety, and found that greater perceptions of protective social factors were related to an increased probability of meeting PA recommendations, especially among lower income people. Other research has likewise reported that greater levels of social capital, community satisfaction and community participation, among other indicators, are related to increased PA participation.^{27,28}

Finally, a few studies have examined the associations between neighbourhood walkability and constructs related to neighbourhood social connectedness. Leyden²⁹ reported that people living in more walkable neighbourhoods, as measured by proximity to nine facilities or services, were more

likely to know their neighbours, participate politically, have greater trust and faith in people and be more socially engaged. Another study looked at environmental variables in exclusively suburban areas and their relationship to residents' responses to a multi-dimensional social capital measure.³⁰ Participants living in a suburban area with a conventional suburban street pattern (i.e. cul-de-sacs and curved layout) had greater social capital than persons living in suburbs with traditional (i.e. predominantly grid-like) or hybrid (i.e. a mix of grid and cul-de-sacs) street patterns. The authors also looked at the number and specific types of destinations nearby and concluded that 'more is not necessarily better and that there may be an optimum number of destinations required to generate feelings of safety and social capital, with greater consideration needed to be given also to the type and quality of destinations rather than simply the quantity' (P. 24). Indeed, Cohen *et al.*,³¹ reported that certain neighbourhood features, such as more parks and fewer alcohol outlets, were associated with individuals' ratings of collective efficacy.

In summary, although several studies have documented independent associations between each of neighbourhood walkability and social connectedness with PA, lesser research has examined the relationship between these two constructs or especially how they may work in concert to influence PA participation. Moreover, examining constructs such as walkability and social connectedness subjectively via self-report can provide insight and a relatively direct link between how residents' perspectives and characteristics (e.g. past experiences, personality traits, standards of evaluation) shape their reported health behaviours (e.g. PA).³² Thus, the purposes of this study were (i) to examine the relationship between perceived neighbourhood social connectedness and neighbourhood walkability and (ii) to examine the compounding effects of neighbourhood walkability and social connectedness in predicting neighbourhood-based PA. Better understanding relationships among these variables can guide strategies for jointly leveraging social and environmental factors to improve population-level PA participation.

Methods

Study setting and data collection

This study was part of the Physical Activity in the Community study, a cross-sectional investigation with adults of individual, social and environmental correlates of PA. The study took place in Waterloo, Ontario, Canada in August 2007 and the methodology is described further elsewhere.³³ Briefly, four neighbourhoods (as designated by

municipal planning boundaries) that were each ~ 1 square mile in size were selected for inclusion in the study. Neighbourhoods were chosen based on their differing ages of construction and land use and street patterns. One that was largely developed in the first half of the 20th century encompassed the downtown area of the city and had substantially diverse land uses (e.g. retail, residential, parkland, etc.), two others were mostly built between the 1950–70s and were primarily residential with some significant commercial and retail activity on their fringes, while construction on the fourth neighbourhood began in the 1990s and included only single-detached and semi-detached housing at the time of the study with almost no retail locations within walking distance. According to the 2001 Canadian census, the median household income levels for the four neighbourhoods ranged from \$40 060 to \$82 738 (Can \$).

Out of 1000 households (250 per neighbourhood) that were randomly selected from municipal property lists, a total of 960 study packages were successfully delivered door-to-door by trained research assistants. Of those, 585 (61%) were returned with useable data. In this paper, to avoid artificial dependence within the data, we analysed only the responses from a single person in each of the 380 unique households that participated in this study.

Measures

Participants completed both a questionnaire addressing various PA correlates and a log booklet in which they recorded all episodes of PA over a period of 7 days. As part of the questionnaire, participants responded to the subscales of the abbreviated version of the Neighborhood Environment Walkability Scale (NEWS),³⁴ which has demonstrated acceptable to high reliability and validity in previous studies.^{35–37} The items and dimensions of the NEWS-A (residential density, land-use mix diversity, land-use mix access, street connectivity, infrastructure and safety for walking/cycling, aesthetics, traffic hazards and crime) were analysed according to procedures described previously³⁵ and summary scores for each dimension were standardized and summed to derive a perceived neighbourhood walkability index.^{20,35}

Neighbourhood social connectedness was measured using the mean of a five-item, five-point scale (e.g. ‘people in this neighbourhood can be trusted’: 1 = strongly disagree, 5 = strongly agree),³⁸ which demonstrated good internal consistency in the present study ($\alpha = 0.83$). Also as part of the questionnaire, participants provided demographic information, including their age, gender, height and weight. Body

mass index (BMI) was calculated using the standard formula for adults [weight (kg)/height(m)²].

As described previously elsewhere,^{18,39} the PA log booklet contained detailed instructions and definitions (e.g. ‘PA includes any activity that requires you to expend energy’) and provided several sample pages for participants’ reference. For each episode > 10 min in duration, participants recorded details such as the location where the PA took place and its purpose. Location data recorded as open-ended responses were coded as: (i) at home, (ii) in the participant’s neighbourhood or (iii) in another location. To maintain theoretical correspondence with the neighbourhood predictor variables examined herein, only episodes within the neighbourhood are of interest to this study.⁴⁰ Neighbourhoods were defined using municipal planning boundaries and episodes falling within those locations (in whole or in part) were determined on a case-by-case basis based on the described locations or streets where the episode occurred.³⁹ Finally, the purpose of each episode—recreation, transportation, household, or job related—was indicated by participants using definitions identical to those developed for the International PA Questionnaire.⁴¹ In this study, only neighbourhood PA episodes engaged in for recreation (‘PA that was done for recreation, sport, exercise or leisure’) or transportation (‘PA that occurs when traveling from place to place, including to places like work, school, stores, movies and so on’) are considered.

Analyses

Initially, we examined the bivariate association between neighbourhood social connectedness and neighbourhood walkability, controlling for age, gender, BMI, education level and neighbourhood of residence. Then, using their self-reported scores, participants were divided at the medians for the walkability and social connectedness variables to create four groups (e.g. high walkability/low social connectedness) in order to examine the compounding effects of walkability and social connectedness. Analysis of covariance (ANCOVA) was used to compare differences in the number of minutes of neighbourhood recreational and transportation-related PA across the four walkability/social connectedness groups, again controlling for age, gender, BMI, education level and neighbourhood of residence.

Results

Table 1 outlines selected socio-demographic characteristics for the study sample ($n = 380$). Overall, the participants in the study were largely representative of the broader

community, except that the current sample contained a slightly higher proportion of female and married persons. Over the 7-day study period, participants reported an average of 88.2 min (SD = 29.6 min) of recreational neighbourhood PA and 13.7 min (SD = 5.5 min) of

transport-related neighbourhood PA. The median value for neighbourhood social connectedness was 3.8 (out of 5) and the median standardized score on the neighbourhood walkability index was -0.24 .

Bivariate analyses using the entire sample revealed a significant, positive relationship between neighbourhood walkability and social connectedness ($r = 0.43$, $P < 0.001$), when controlling for age, gender, BMI, education level and neighbourhood of residence. This association was consistent for both males ($r = 0.36$, $P < 0.001$) and females ($r = 0.49$, $P < 0.001$) and also for participants who were 35–54 years old ($r = 0.47$, $P < 0.001$) and >55 years old ($r = 0.58$, $P < 0.001$), but not for younger adults ages 18–34 years ($r = 0.16$, $P = 0.18$).

As shown in Table 2, ANCOVA tests revealed that several significant differences existed between the four walkability/social connectedness groups (recreational $F = 11.36$, $P < 0.01$; transport-related $F = 8.12$, $P < 0.01$). Participants who characterized their neighbourhood as high in both walkability and social connectedness displayed greater levels of both recreational ($M = 130.6$ min, $SD = 46.2$) and transport-related ($M = 24.5$ min, $SD = 7.7$) PA during the study week than participants in any of the three other groups. However, the high walkability/low social connectedness group had greater transport-related PA ($M = 16.2$ min, $SD = 5.8$) than the two low walkability groups, while the high social connectedness/low walkability group had greater recreational PA ($M = 108.7$ min, $SD = 31.5$) than the two low social connectedness groups.

Discussion

What is already known on this topic

The purpose of this study was to examine (i) the association between neighbourhood walkability and neighbourhood

Table 1 Sample characteristics

Sample characteristic	n	%
Total ^a	380	100.0
Gender		
Male	134	36.2
Female	236	63.8
Age (years)		
18–34	104	28.1
35–54	163	44.1
55+	103	27.8
Marital status		
Married or living with a partner	278	75.2
Single	92	24.8
Education level		
Graduated from college	241	65.1
Did not graduate from college	129	34.9
Employment status		
Employed full-time	195	52.7
Employed part-time	48	13.0
Retired	62	16.8
Other	65	17.5
Weight status		
Underweight or healthy weight	182	49.2
Overweight or obese	188	50.8

^aA total of 380 participants provided valid PA data which were used in this study. However, 10 participants did not provide data for all five variables listed in Table 1. These missing responses are not included in the table such that the percentages in the last column sum to 100%.

Table 2 Minutes of weekly neighborhood recreational and transport-related PA across neighborhood walkability and neighborhood connectedness groups

Walkability/connectedness group	Recreational PA (min)		Transport-related PA (min)	
	Mean	SD	Mean	SD
High walkability/high connectedness	130.6 ^a	46.2	24.5 ^a	7.7
High walkability/low connectedness	55.3 ^c	23.1	16.2 ^b	5.8
Low walkability/high connectedness	108.7 ^b	31.5	9.0 ^c	5.1
Low walkability/low connectedness	59.2 ^c	26.8	7.9 ^c	4.9
<i>F</i>	11.36		8.12	
<i>P</i>	<0.01		<0.01	

Mean minutes values with different superscript letters were significantly different from one another ($P < 0.05$).

social connectedness and (ii) how these two environmental attributes worked jointly to influence recreational and transport-related PA. Some research has demonstrated a link between increased walkability and social connections among residents, but other studies have reported that traditional notions of walkability (e.g. mixed land use, street connectivity) are not supportive of social capital and cohesion. Even so, while several studies have documented associations between PA levels and each of walkability and social connectedness, few studies have examined the compounding effects of physical and social elements of neighbourhoods on health behaviours, including PA.

Main findings of this study

Our analysis began by finding a positive correlation between perceptions of walkability and social connectedness that was consistent across gender and most age groups. While it is unclear why the results for participants aged 18–34 years differed, we suspect this age cohort represents a transitory period in one's lifespan when people are particularly mobile with respect to their living arrangements and therefore either in the process of transitioning away from or into their neighbourhood setting. This process of divestment or investment in a neighbourhood may mean the relationship between social connectedness and walkability is not significant for these individuals. Irrespective of the reason, this finding warrants further investigation.

To be sure though, previous literature has been surprisingly mixed on the relationship between walkability and social connectedness. Some studies report a positive relationship between social capital and walkability,²⁹ whereas others report a negative association.^{30,42} Wood *et al.*⁴² postulated that the negative findings were likely due to what they called the 'stranger hypothesis' whereby denser urban forms characterized by higher levels of mixed use are likely to be associated with the perceived presence of too many visitors and too much traffic, thereby jeopardizing the desire to engage in leisure walking and the development of local connections. Their supposition complements Putnam's⁴³ notion of constrict theory, in which neighbours 'hunker down' when faced with diversity. The community under investigation in our research, a mid-sized city, did not fit these characterizations, though, and so our findings that perceptions of the built and social environment aligned made intuitive sense.

This assertion is particularly relevant if one adopts a relational view of place.⁴⁴ By place, we refer to 'a multidimensional concept that depends on meanings, which in turn are based on experiences with both the physical landscape and

social actors therein' (p.824).⁴⁵ From a place perspective, the built and social environments are inextricably linked. A neighbourhood may appear to be undifferentiated space, but, from a place perspective, it gains meaning as people accumulate experiences within it and personalize it. These experiences, in part, are based on our interpretations of the everyday spaces in which we spend time and the social interactions we have with people in those spaces. Studies that build on our research would thus benefit from adopting a more explicit place-based focus.

Our findings also showed higher levels of both recreational and transport-related PA among participants who rated their neighbourhoods more positively with respect to both walkability and social connectedness. This finding is perhaps not surprising given that numerous previous studies have documented increased PA in areas of higher walkability^{12,18,20} or with greater social connectedness.^{25–27} However, to our knowledge, our investigation of how perceived physical and social environments interact to promote PA is quite novel. Our findings suggest infrastructure and interpersonal needs warrant joint attention when investigating PA. In planning healthy communities, Corburn⁴⁴ underscores the necessity to appreciate context and features of the built *and* social environments 'as key drivers of well-being' (p. 12). Accordingly, he argues healthy places ought to be understood as being 'doubly constructed', both physically and socially. In this sense, it is crucial to connect the material (walkability) and the social (neighbourhood connectedness) if we are to succeed in advancing active living.

At the same time, our findings suggest a strong relationship between neighbourhood social connectedness and recreational PA, and between walkability and transport-related PA. The latter has been sufficiently demonstrated in the literature and therefore does not warrant extensive discussion here, except to say that community design clearly promotes *instrumental* activity. The former, however, has received far less attention and deserves some elaboration. Recreation and leisure activities, whose functions are largely expressive (as opposed to instrumental), are more likely to flourish in socially safe, inviting and welcoming environments, even in cases where such activities are pursued individually.⁴⁶ Recreational PA would appear to be no different. Indeed, one recent study showed that parks with higher levels of social capital had a greater number of users and more energy expended within the park.⁴⁷ Wood *et al.*,⁴² in another example, found sense of community was positively associated with leisurely walking and they revealed seeing neighbours when walking was correlated with sense of community. Their findings resonate with Lund's⁴⁸ observation that strolling trips are positively correlated with sense of

community. Research to date, in other words, strongly suggests that the presence of neighbourhood-level social capital reinforces healthy norms that encourage PA and characterizes a setting in which neighbours feel sufficiently secure to explore their surroundings.

What this study adds

Interestingly, land-use planners, egged on by proponents of active living, have seemingly concentrated their efforts on encouraging active transportation by addressing features of the built environment to make it more walkable. Doing so is perhaps no surprise, given that the built environment is easier to control, adapt, re-design and plan than its counterpart, the social environment of a neighbourhood. However, transportation-related PA represents a relatively smaller realm of PA for many neighbourhood residents than recreational PA. It seems as though attention to the social landscape of a neighbourhood, despite its complexities, poses greater opportunities to increase neighbourhood PA and therefore ought to receive more attention from researchers, planners and elected officials who are serious about advancing active living. For this reason, we join Wood *et al.*,⁴² in their call for researchers to ‘explore in more detail factors that encourage leisure walking and the relationship with sense of community’ (p. 1387).

Limitations of this study

The strengths of this study include the strong response rate, validated measures of walkability and social connectedness, and the fact that it is one of the first inquiries into how social and physical environments jointly influence PA. Nevertheless, our study was subject to several limitations. First, all of our key measures—PA, social connectedness and walkability—were based on self-reported data. This allowed us to capture some increased detail (e.g. purpose of activity), but also potentially introduces certain biases and inaccuracies. Future studies may wish to explore the associations described herein using objective sources for social connectedness (e.g. crime data), walkability (e.g. geographic information systems) and PA (e.g. accelerometers). Further, the location of PA episodes was also self-reported and inferred as occurring within the neighbourhood based on the streets or other destinations described in the log booklet. Global positioning systems, while costly for population-based studies, are starting to be used in research of this nature to provide objective information about PA contexts.^{49,50} As well, our results are based on cross-sectional data and should not be considered causal. Longitudinal studies of the impact of neighbourhood social

connectedness on perceived walkability (and vice versa) would be useful. Additionally, our sample was relatively well educated and drawn from only four diverse neighbourhoods, so future studies may wish to examine the influence of walkability and social connectedness on PA within a broader population. Finally, we did not collect information about participants’ length of residence in their current neighbourhood, which may have affected perceptions of social connectedness or familiarity with walkable destinations.

Conclusion

In conclusion, PA promotion efforts should take into account both the built (e.g. land-use planning) and social (e.g. walking group, neighbourhood interactions) environments, and future research should explore the combined influence of other built (e.g. green space, public space) and social (e.g. crime) factors as well. As suggested, a place-based perspective that melds these two facets theoretically would generate practical findings that would better fit with individuals’ lived experiences in their neighbourhoods. As Mesch and Manor⁵¹ argue, ‘the subjective evaluation of the physical and social environment, such as the presence of open space (parks and playgrounds), the lack of pollution and noise and the kind of people who reside in the immediate area, are characteristics that bind people to place’ (p. 518). To be sure, these bonds warrant exploration in terms of their connection to PA. While future studies ought to further address the differential contribution of the built and social dimensions of the environment, examining their joint implications is crucial to a greater depth of understanding.

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References

- 1 Cochrane T, Davey RC. Increasing uptake of physical activity: a social ecological approach. *J R Soc Promot Health* 2008;**128**:31–40.
- 2 Elder JP, Lytle L, Sallis JF *et al.* A description of the social-ecological framework used in the trial of activity for adolescent girls (TAAG). *Health Educ Res* 2007;**22**:155–65. Epub 19 Jul 2006.
- 3 Sallis JF, Owen N, Fisher EB. Ecological models of health behavior. In: Glanz K, Rimer BK, Viswanath K (eds). *Health Behavior and*

- Health Education: Theory, Research and Practice*, 4th edn. San Francisco, CA: Jossey-Bass, 2008,465–85.
- 4 McLeroy KR, Bibeau D, Steckler A *et al.* An ecological perspective on health promotion programs. *Health Educ Q* 1988;**15**:351–77.
 - 5 Spence JC, Lee RE. Toward a comprehensive model of physical activity. *Psychol Sport Exerc* 2003;**4**:7–24.
 - 6 Bourdeaudhuij ID, Teixeira PJ, Cardon G *et al.* Environmental and psychosocial correlates of physical activity in Portuguese and Belgian adults. *Public Health Nutr* 2007;**8**:886–95.
 - 7 Giles-Corti B, Donovan RJ. The relative influence of individual, social and physical environment determinants of physical activity. *Soc Sci Med* 2002;**54**:1793–812.
 - 8 McNeill LH, Wyrwich KW, Brownson RC *et al.* Individual, social environmental, and physical environmental influences on physical activity among black and white adults: a structural equation analysis. *Ann Behav Med* 2006;**31**:36–44.
 - 9 Wilcox S, Bopp M, Oberrecht L *et al.* Psychosocial and perceived environmental correlates of physical activity in rural and older African American and White women. *J Gerontol* 2003;**58B**:P329–37.
 - 10 Rhodes RE, Brown SG, McIntyre CA. Integrating the perceived neighborhood environment and the theory of planned behavior when predicting walking in a Canadian adult sample. *Am J Health Promot* 2006;**21**:110–8.
 - 11 Cerin E, Lelsie E, Dutoit L *et al.* Destinations that matter: associations with walking for transport. *Health Place* 2007;**13**:713–24.
 - 12 Gauvin L, Riva M, Barnett T *et al.* Association between neighborhood active living potential and walking. *Am J Epidemiol* 2008;**167**:944–53. Epub 2008 Jan 27.
 - 13 King WC, Belle SH, Brach JS *et al.* Objective measures of neighborhood environment and physical activity in older women. *Am J Prev Med* 2005;**28**:461–9.
 - 14 Nagel CL, Carlson NE, Bosworth M *et al.* The relation between neighborhood built environment and walking activity among older adults. *Am J Epidemiol* 2008;**168**:461–8.
 - 15 Besser LM, Dannenberg AL. Walking to public transit: steps to help meet physical activity recommendations. *Am J Prev Med* 2005;**29**:273–80. PMID:16242589.
 - 16 Frank LD, Pivo G. Impacts of mixed use and density on utilization of three modes of travel: single-occupant vehicle, transit, and walking. *Transport Res Record* 1994;**1466**:44–52.
 - 17 Inoue S, Murase N, Shimomitsu T *et al.* Association of physical activity and neighborhood environment among Japanese adults. *Prev Med* 2009;**48**:321–5.
 - 18 Kaczynski AT. Neighborhood walkability perceptions: associations with amount of neighborhood-based physical activity by intensity and purpose. *J Phys Act Health* 2010;**7**:3–10.
 - 19 Oakes JM, Forsyth A, Schmitz KH. The effects of neighborhood density and street connectivity on walking behavior: the twin cities walking study. *Epidemiol Perspect Innov* 2007;**4**:16.
 - 20 Frank LD, Schmid TL, Sallis JF *et al.* Linking objectively measured physical activity with objectively measured urban form: findings from SMARTRAQ. *Am J Prev Med* 2005;**28**:117–25.
 - 21 Kaczynski AT, Henderson KA. Parks and recreation settings and active living: a review of associations with physical activity function and intensity. *J Phys Act Health* 2008;**5**:619–32.
 - 22 Moore S, Gauvin L, Daniel M *et al.* Associations among park use, age, social participation, and neighborhood age composition in Montreal. *Leis Sci* 2010;**32**:318–36.
 - 23 Lochner K, Kawachi I, Kennedy BP. Social capital: a guide to its measurement. *Health Place* 1999;**5**:259–70.
 - 24 Kawachi L, Berkman I. *Social Epidemiology*. New York: Oxford University Press, 2000.
 - 25 Singh GK, Kogan MD, van Dyck PC. A multilevel analysis of state and regional disparities in childhood and adolescent obesity in the United States. *J Community Health* 2008;**33**:90–102.
 - 26 Brennan LK, Baker EA, Haire-Joshu D *et al.* Linking perceptions of the community to behavior: are protective social factors associated with physical activity? *Health Educ Behav* 2003;**30**:740–55.
 - 27 Greiner KA, Li C, Kawachi I *et al.* The relationships of social participation and community ratings to health and health behaviors in areas with high and low population density. *Soc Sci Med* 2004;**59**:2303–12.
 - 28 Kim D, Subramanian SV, Gortmaker SL *et al.* US state- and county-level social capital in relation to obesity and physical inactivity: a multilevel, multivariable analysis. *Soc Sci Med* 2006;**63**:1045–59.
 - 29 Leyden KM. Social capital and the built environment: the importance of walkable neighborhoods. *Am J Public Health* 2003;**93**:1546–51.
 - 30 Wood L, Shannon T, Bulsara M *et al.* The anatomy of the safe and social suburb: an exploratory study of the built environment, social capital and residents' perceptions of safety. *Health Place* 2008;**14**:15–31.
 - 31 Cohen DA, Inagami S, Finch B. The built environment and collective efficacy. *Health Place* 2008;**14**:198–208.
 - 32 Brownson RC, Hoehner CM, Day K *et al.* Measuring the built environment for physical activity: state of the science. *Am J Prev Med* 2009;**36(4S)**:S99–123.
 - 33 Kaczynski AT, Potwarka LR, Saelens BE. Association of park size, distance, and features with physical activity in neighborhood parks. *Am J Public Health* 2008;**98**:1451–6.
 - 34 Saelens BE, Sallis JF, Black JB *et al.* Neighborhood-based differences in physical activity: an environment scale evaluation. *Am J Public Health* 2003;**93**:1552–58.
 - 35 Atkinson JL, Sallis JF, Saelens BE *et al.* The association of neighborhood design and recreational environments with physical activity. *Am J Health Promot* 2005;**19**:304–9.
 - 36 Brownson RC, Chang JJ, Eyler AA *et al.* Measuring the environment for friendliness toward physical activity: a comparison of the reliability of 3 questionnaires. *Am J Public Health* 2004;**94**:473–83.
 - 37 Leslie E, Saelens B, Frank L *et al.* Residents' perceptions of walkability attributes in objectively different neighbourhoods: a pilot study. *Health Place* 2005;**11**:227–36.
 - 38 Sampson RJ, Raudenbush SW, Earls F. Neighborhoods and violent crime: a multilevel study of collective efficacy. *Science* 1997;**277**:918–24.

- 39 Kaczynski AT. Development of a detailed log booklet for social ecological physical activity research. *Env Health Insights* 2012;**6**:1–11.
- 40 Giles-Corti B, Timperio A, Bull F *et al.* Understanding physical activity environmental correlates: increased specificity for ecological models. *Exerc Sport Sci Rev* 2005;**33**:175–81.
- 41 Craig CL, Marshall AL, Sjostrom M *et al.* International physical activity questionnaire: 12-country reliability and validity. *Med Sci Sports Exerc* 2003;**35**:1381–95.
- 42 Wood L, Frank DL, Giles-Corti B. Sense of community and its relationship with walking and neighborhood design. *Soc Sci Med* 2010;**70**:1381–90.
- 43 Putnam RD. E Pluribus Unum: diversity and community in the twenty-first century. *Scand Polit Stud*, 2007;**30**:137–74.
- 44 Corburn J. *Toward the Healthy City: People, Places, and the Politics of Urban Planning*. Cambridge, MA: The MIT Press, 2009.
- 45 Stedman RC. Sense of place and forest science: toward a program of quantitative research. *For Sci* 2003;**49**:822–9.
- 46 Kleiber D, Walker G, Mannell RC. *A Social Psychology of Leisure*, 2nd edn. State College, PA: Venture Publishing, 2011.
- 47 Broyles S, Mowen A, Theall K *et al.* Integrating social capital into a park-use and active-living framework. *Am J Prev Med* 2011;**40**:522–9.
- 48 Lund H. Testing the claims of new urbanism: local access, pedestrian travel, and neighboring behaviors. *J Am Plann Assoc* 2003;**69**:414–29.
- 49 Wheeler BW, Cooper AR, Page AS *et al.* Greenspace and children's physical activity: a GPS/GIS analysis of the PEACH project. *Prev Med* 2010;**51**:148–52.
- 50 Troped PJ, Wilson JS, Matthews CE *et al.* The built environment and location-based physical activity. *Am J Prev Med* 2010;**38**: 429–38.
- 51 Mesch GS, Manor O. Social ties, environmental perception, and local attachment. *Environ Behav* 1998;**30**:504–19.