Understanding Environmental Influences on Walking
Review and Research Agenda

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Background: Understanding how environmental attributes can influence particular physical activity behaviors is a public health research priority. Walking is the most common physical activity behavior of adults; environmental innovations may be able to influence rates of participation.

Method: Review of studies on relationships of objectively assessed and perceived environmental attributes with walking. Associations with environmental attributes were examined separately for exercise and recreational walking, walking to get to and from places, and total walking.

Results: Eighteen studies were identified. Aesthetic attributes, convenience of facilities for walking (sidewalks, trails); accessibility of destinations (stores, park, beach); and perceptions about traffic and busy roads were found to be associated with walking for particular purposes. Attributes associated with walking for exercise were different from those associated with walking to get to and from places.

Conclusions: While few studies have examined specific environment–walking relationships, early evidence is promising. Key elements of the research agenda are developing reliable and valid measures of environmental attributes and walking behaviors, determining whether environment–behavior relationships are causal, and developing theoretical models that account for environmental influences and their interactions with other determinants.
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Introduction

Promoting higher levels of participation by adults in regular, moderate-intensity physical activity is a public health priority.[1,2] Recent evidence from Australia suggests that, although public campaigns and other initiatives to increase participation have been underway for more than 10 years, population levels of physical activity have been static and may have declined in some groups.[3] There is a strong case that substantial and long-lasting environmental and policy initiatives are an important opportunity for making physically active choices easier and more realistic choices.[4–6] If advocacy for this public health agenda is to be pursued with confidence, research is needed to determine whether environmental changes (such as providing cycle paths and walkways, or public outdoor recreational settings) do increase the likelihood of more active behavioral choices. However, there are significant conceptual and methodologic challenges in identifying how such physical-environment factors might act to influence such choices.[7] Conceptually, there is a plausible case that environmental influences can play a direct role in shaping habitual behavior patterns. Experimental evidence from several behavioral domains identifies circumstances in which direct environmental influence can be a stronger determinant of behavioral choice than are cognitively mediated influences.[8,9] Because cognitive social theories have been a predominant influence on behavioral studies of physical activity,[10–13] the field has been shaped by assumptions that choices to be active or inactive are conscious and deliberate—that is, consequent upon attitudes, intentions, self-efficacy, and other cognitive mediators of behavioral change.[11,12] Social cognitive models do, however, identify a strong role for environmental influences under some circumstances. Bandura[14] has argued that when behavior is strongly facilitated or constrained by attributes of the environment in which it takes place (and plausibly this is often likely for physical activity), direct environmental influences would be the predominant class of determinants.

Studies of environment–activity relationships, if they are to be of practical use in public health policy, ought to focus on the environmental influences that may

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determine particular behavioral choices.[4,8,9,15] In the context of the public health goal to increase regular, moderate-intensity physical activity, the behavior of most relevance is walking. The public health policy literature has identified walking as the physical activity behavior of adults that should be most amenable to influence.[12,16] Walking is also the most commonly reported physical activity behavior.[16,17] Thus, there is a strong conceptual and practical case for public health research on the environmental determinants of physical activity to focus on the particular behavior of walking.

Humpel et al.[18] reviewed the evidence for environmental influences on physical activity generally. They found that both perceived and objectively determined environmental attributes (particularly aesthetics, convenience, and access) were associated with an increased likelihood of physical activity. Adopting a more specific focus, Saelens et al.[19] synthesized the findings of studies from transportation and urban design and planning research on factors related to walking and cycling for transportation purposes. Much of the transportation literature focuses on vehicular travel. However, human-powered modes of travel such as walking and cycling have also been examined in many studies. Given that most nonwork trips are within walking or cycling distance, findings from this closely related area of research are helpful in identifying objectively measured environmental attributes (particularly mixed land use, residential density, and intersection density[19]) that are relevant to the choice to walk. A conceptual model of the specificity of environmental correlates of walking and cycling resulted from this review.[19] Environmental and policy initiatives to increase physical activity[4] must be informed by such conceptual models and also by a strong body of evidence on the environmental attributes that are related to such particular active behavioral choices.

Here, studies from the public health research literature specifically addressing the environmental correlates of walking are reviewed. The term "correlates" was used advisedly,[7,11] given that much of the evidence available is from studies using cross-sectional designs. Specifically, the focus was on relationships of perceived and objectively assessed environmental attributes with the walking behaviors of adults. The evidence was evaluated on specific environmental attributes associated with subcategories of walking behavior—walking for exercise or recreation, walking to get to and from places, and total walking.

Methods

Quantitative studies examining environmental attributes related to the walking behavior of adults were identified from a previous literature review,[18] from database searches including PsycInfo, Cinahl, Medline, and by using preprints from colleagues of papers that were in press at the time of writing. Studies were included if they used any type of walking as the main outcome variable and if the independent variables included environmental attributes, whether measured objectively or by self-report.

Results

Eighteen studies were identified as meeting the criteria. Sixteen studies used cross-sectional designs, and two studies were prospective. Thirteen used measures of perceived environmental attributes, while 12 included at least one objective measure of environmental attributes. Ten studies examined associations of environmental attributes with walking for exercise or recreation (including "neighborhood" walking). Ten studies examined associations with total walking (including walking sufficiently to meet public health guidelines). Four studies examined associations with walking to get to and from places (including walking for errands, to and from work, during breaks, to and from transit stops). One study examined walking simply for pleasure ("social" walking, such as going for a stroll after dinner). Table 1 summarizes the environmental attributes measured, demographic variables for which the analyses were statistically adjusted, type of walking outcome, and major findings and their direction.

Studies Examining Environmental Relationships with Walking for Exercise or Recreation

Brownson et al.[20] evaluated the use of a new walking trail (Table 1). Among people who reported using the trail, 55.2% had increased their amount of walking. Distance to the trail was not associated with walking, but this may be due to 43% of respondents having to travel ≥15 miles to the trail. An early cross-sectional study by Hovell et al.[21] found that neighborhood environmental attributes (safety and ease of exercising) were associated with walking for exercise. A subsequent prospective study by Hovell et al.[22] examined changes in walking over 2 years and found that the number of convenient facilities reported at baseline was associated with an increase in walking at follow-up, whereas the neighborhood environment was not related to change in walking. A study using an Australian sample of adults[23] found two categories of local environmental attributes to be associated with increased likelihood of walking by residents: an aesthetically pleasing environment (e.g., ratings of pleasant and attractive natural features) and a convenient environment (e.g., stores being nearby, park or beach nearby). One study examined the relationship of environmental attributes with "walking for pleasure."[24] Men who perceived the environment as safest for walking were less likely to walk more for pleasure, and women with moderately positive perceptions of the accessibility of places for walking

were more likely to walk for pleasure. Walking for exercise and recreation and walking for pleasure are likely highly correlated, as enjoyment is often a key attribute and purpose for choosing particular recreational activities.

Giles-Corti and Donovan[25] examined associations of objective and perceived environmental attributes with walking. They found perceptions of an attractive, safe, and interesting neighborhood to be associated with walking for recreation. Sallis et al.[26] found having home equipment and convenient facilities not to be associated with walking for exercise.

Humpel et al.[27] used participants' postal code to identify coastal versus noncoastal place of residence. Living in a coastal location (an objectively determined environmental attribute) was found to be associated with a greater likelihood of neighborhood walking (a particular walking behavior index) for men only. Four categories measuring environmental perceptions were used. Neighborhood aesthetics and traffic not being a problem were associated cross-sectionally with neighborhood walking for men. Convenience of facilities and access to services were associated with walking for both men and women. The participants in this study were also followed up prospectively as part of an intervention trial, and further findings were reported in a subsequent paper.[28] Prospectively, coastal location was associated with men being less likely to increase their neighborhood walking. This may be due to men who were living in a coastal location being already more active, and thus the potential for more walking was limited. An improvement in perceived convenience of the neighborhood environment was associated with an increase of >60 minutes of walking (Table 1). An increase in the perception that traffic was a minor problem resulted in men being less likely to increase their walking.

Studies Examining Relationships with Walking to Get to and from Places

Craig et al.[29] found that a high, positive, neighborhood environment score (observer rating of 18 neighborhood characteristics, such as number of destinations, visual interest) was significantly related to walking to work (Table 1). This association was moderated by degree of urbanization, with higher scores found in urban neighborhoods compared to suburban neighborhoods. Saelens et al.[30] found that living in a highly walkable neighborhood (as defined by higher residential density, more mixed land use, and greater street connectivity) was associated with participants spending more time walking for errands and on breaks at work or school, compared to those living in a low walkable neighborhood. There was no association with walking for exercise or with total walking. Giles-Corti[25] found that objectively verified access to a beach had a strong negative relationship with walking for transportation. This may reflect differences in transportation or destination options in areas adjacent to the coast. Presence of sidewalks, perceptions of traffic safety, and stores within walking distance were positively associated with walking for transport.

Studies Examining Relationships with Total Walking

Berrigan and Troiano[31] used age of respondent's home as a proxy measure of an urban form attribute (Table 1). They proposed that neighborhoods with older homes are more likely to have denser interconnected networks of streets, and to have a mix of business and residential use. Homes built before 1973 were found to be associated with the occupants walking more than 20 times a month for any reason. Other forms of physical activity were not found to be associated with home age. A study by Carnegie et al.[32] also found aesthetics and a "practical" (similar to "convenient") environment to be associated with walking. Giles-Corti and Donovan[25] found access to open spaces and perceived aesthetic attributes were associated with an overall index of walking at levels recommended for health benefits. In a subsequent study,[33] they found that a higher score on a composite objective physical environment measure was associated with walking at recommended levels.

De Bourdeaudhuij et al.[34] developed an extensive instrument to assess environmental attributes. Although some environmental variables were related to walking, this only explained 4% of variance in walking for men and 3% for women. Other variables not found to be correlated with walking included residential density, access to local shopping, safety from crime and traffic, connectivity of streets, worksite environment, home equipment, and convenience of physical activity facilities. Ewing et al.[35] developed "sprawl" indices (low-density residential development; rigid separation of homes, shops, and workplaces) to examine their relationship with walking and physical activity. Both metropolitan and county "sprawl" were negatively associated with minutes walked. Two other recent studies also found associations of environmental attributes with total walking.[36,37]

Synthesis of Findings

Table 2 shows groupings of the environmental attributes with the four categories of walking. These were walking for exercise or recreation (including "neighborhood" walking); walking to get to and from places (including walking for errands, to and from work, during breaks, to and from transit stops); and total walking (including walking sufficiently to meet public health guidelines). Both significant and nonsignificant

Table 1. Characteristics and main findings of studies examining relationships of environmental attributes with a main outcome of walking

Author (year)[ref]	Number, age, gender	Design	Walking outcome	Environmental attributes	Associations with walking outcomes	Statistical adjustment
Ball (2001)[23]	3392 Adults Men 46%	CS, p	For exercise	Aesthetically pleasing environment	Significant (+)	A, G, E
				Convenient environments	Significant (+)	
Berrigan (2002)[31]	14,827 ≥20 years Men 48%	CS, o	≥20 times per month	Age of home	Significant for older homes (+)	A, G, E, Eth, I
Brownson (2000)[20]	1269 Adults Men 35%	CS, o	Increased walking since using trail	Walking trail length	Significant for users of longer trails (+)	None reported
				Trail surface	Significant for users of asphalt trails (+)	
				Distance to trail	Nonsignificant	
Carnegie (2002)[32]	1200 40–60 years Men 43%	CS, p	Total	Aesthetic environment	Significant (+)	A, G, E,
				Practical environment	Significant (+)	
Craig (2002)[29]	Canadian Census, 1996	CS, o	To and from work	Composite environment score	Significant (+)	U, E, I, P
De Bourdeaud huij (2003)[34]	521 Mean=44 years Men 51.7%	CS, p, o	Total minutes in last week	40 Neighborhood items in 12 categories	Availability of sidewalks significant for men (+)	A, E, Em
				41 Recreational items in 3 categories	Land use mix; ease of walk to public transport significant for women (+)	Others not detailed
Ewing (2003)[35]	Total 206,992 18–75 years	CS, p, o	Minutes leisure time walking in past month	Metropolitan sprawl index	More sprawl significant (−)	None reported
				County sprawl index	More sprawl significant (−)	
Eyler (2003)[37]	1816 18–65+	CS, p	Total for usual week categorized as regular, occasional, and never walkers	No sidewalks	Significant with never walkers: no sidewalks (+); no enjoyable scenery (+); no walk/jog trails (+)	A, E, Eth
				Heavy traffic		
				Hills		
				No streetlights		
				Unattended dogs		
				Foul air		
				No enjoyable scenery		
				No walk/jog trails		
				High crime		
Giles-Corti (2002)[25]	1803 18–59 years	CS, p, o	For transport For recreation Meeting guidelines	1. Access to open space	Significant for 1 (+), 2 (−), 4 (+), 5 (+), 6 (+)	A, G, E, I, C, W
				2. Access to beach	Significant for 2 (+), 3 (+)	
				3. Neighborhood aesthetics	Significant for 1 (+), 3 (+)	
				4. Traffic, busy roads		
				5. Sidewalks present		
				6. Stores in walking distance		
Giles-Corti (2003)[33]	1803	CS, o	Meeting guidelines	Composite physical environment score	Significant for high score (+)	A, G, C, E, I

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Table 1. *(continued)*

Author (year)[ref]	Number, age, gender	Design	Walking outcome	Environmental attributes	Associations with walking outcomes	Statistical adjustment
	18–59 years			Access to open space	Significant	
				Minor traffic, some trees	Significant	
				Sidewalk, store	Nonsignificant	
Hovell (1989)[21]	194 adults	CS, p	For exercise	Home equipment	Nonsignificant	A, G
				Neighborhood environment	Significant (+)	
				Convenient facilities	Nonsignificant	
Hovell (1992)[22]	1701	Pros, p, o	Change in walking over 2 years	Neighborhood environment	Nonsignificant	A, G
	Mean=48 years Men 58%			Convenient facilities	Significant (+)	
Humpel (2004)[24]	399	CS, p	1. Neighborhood	Coastal location	Significant for women (+)	A, E, and other categories of environment variables
	Mean=60 years		2. For exercise	Aesthetics	Significant with 1, 2 for men (+)	
	Men 43%		3. For pleasure	Accessibility of facilities for walking	Significant with 1 for men (−) and 3 for women (+)	
			4. To get to places	Safety (personal and traffic)	Significant with 3 for men (−)	
				Weather	Significant with 1, 2 for men (+) and 1, 2 for women (+)	
Humpel (2004)[27]	800 18–71 Years Men 50%	CS, p, o	Neighborhood walking	Coastal location	Significant for men (+)	A, G, E
				Aesthetics	Significant for men (+)	
				Convenience	Significant for men and women (+)	
				Access to services	Significant for men (+) and women	
				Traffic not a problem	Significant for men (−)	
Humpel (2004)[28]	512	Pros, p, o	>60 min increase in neighborhood walking	Coastal location	Significant for men (−)	A, G, E
	18–69 Years Men 49%			Change in aesthetics	Nonsignificant	
				Change in convenience	Significant for men and women (+)	
				Change in access to services	Nonsignificant	
				Change in traffic not a problem	Significant for men (−)	
King (2003)[36]	149 Women	CS, p, o	1. Pedometer steps in 1 week;	Convenience of walking to 11 destinations	Significant with 1, biking or walking trail (+); store(s) (+); park (+); neighborhood rating	None reported
	Mean=74 Years		2. Self-report walking kilocalories per week	Overall quality of neighborhood for walking	Significant with 2, neighborhood rating	

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Table 1. Characteristics and main findings of studies examining relationships of environmental attributes with a main outcome of walking (*continued*)

Author (year)[ref]	Number, age, gender	Design	Walking outcome	Environmental attributes	Associations with walking outcomes	Statistical adjustment
					Significant with 1, 2, total number of perceived convenient destinations (+)	
Saelens (2003)[30]	110	CS, o	For errands outside home	Highly walkable neighborhood	Significant (+)	Unadjusted
	Mean=48 years		On work/school breaks		Significant (+)	
	Men 46.7%		For exercise		Nonsignificant	
			Total walking		Nonsignificant	
Sallis (1997)[26]	110	CS, p	For exercise	Home equipment	Nonsignificant	A, G, Eth, SES
	Mean=21 years			Convenient facilities	Nonsignificant	
	Men 25%			Total neighborhood	Nonsignificant	

(+), positive association; (−), negative association; A, age; C, number of children; CS, cross-sectional; E, education; Eth, ethnicity; Em, employment status; G, gender; I, income; L, location; o, objectively measured; p, perceptions; P, poverty; Pros, prospective; SES, socioeconomic status; U, urbanization; W, work status.

associations with particular environmental attributes are listed for each walking outcome.

Perceptions of the aesthetic nature of the environment have most often been measured. This attribute has been found to be significantly associated with walking for exercise or recreation in four studies and in two studies with total walking, but was not associated with walking to get to and from places (Table 2). Composite convenience of facilities for walking measures has been found to be associated with walking for exercise or recreation in four studies. Specific facilities or destinations (such as convenience of biking or walking trails, stores in walking distance) were associated with total walking.

Access to beach and public open spaces, and having a "highly walkable" neighborhood were found to be significantly related to walking to get to and from places. Perceptions about traffic were found to be associated with walking for exercise or recreation and with walking to get to and from places.

Discussion

The pattern of findings summarized in Table 2 shows a modest but consistent body of evidence indicating patterns of positive relationships of environmental attributes with particular types of walking. What must be highlighted, however, is the number of studies in which some of these relationships were not statistically significant. Also, while studies accounted for only small proportions of variance in physical activity, on a population-wide basis these proportions can be substantial. These findings support the broad conclusions of an earlier review of environment–behavior relationships for all types of physical activity.[18] The findings of the present review support the authors' argument for the use of behavior-specific measures that help identify the particular environmental attributes that might prompt and maintain habitual physical activities.[8,11,12,14,19] Given the small number of studies specific to walking (18 were identified in this review), it would be premature to state definitive conclusions, although there is consistency in the patterns of associations found in these studies (Table 2). Only four studies have thus far examined relationships of environmental attributes with walking to get to and from places; three of these studies have found significant associations[25,29,30] and one found no association.[24] Most studies have found environmental attributes to be associated with walking for exercise, recreation, or total walking. While there was some overlap ("stores in walking distance" being similar to "access to services"), the environmental attributes found to be associated with walking to get to and from places differed from those associated with walking for exercise or recreation (Table 2).

Comparisons of patterns of walking behavior between neighborhoods that differ on objectively assessed

Table 2. Overview of environmental attributes significantly associated with particular types of walking

		Associations reported in studies (Ref nos.)	
Type of walking	**Environmental attributes**	**Significant**	**Nonsignificant**
Walking for exercise or recreation (includes neighborhood and pleasure walking)	Aesthetically pleasant	23, 25, 27 (m) 24 (m)	27 (w) 24 (w)
	Convenient facilities/environment	23, 22, 27, 28	21, 26
	Walking trail length[a]	20	
	Trail surface		20
	Distance to trail[a]		20
	Access to beach[a]		25
	Neighborhood environment	21	
	Coastal location[a]	27 (m), 28, 24 (w)	27 (w), 24 (m)
	Access to services	27	
	Traffic not a problem	27 (m)	27 (w)
	Home equipment		21, 26
	Total neighborhood		26
	Highly walkable neighborhood[a]		30
	Neighborhood environment		22
	Change in aesthetics		28
	Change in convenience	28	
	Change in access to services		28
	Change in traffic not a problem	28 (m)	28 (w)
	Access to public open spaces[a]		25
	Perceptions of traffic, busy roads		25
	Sidewalks present[a]		25
	Stores within walking distance		25
	Accessibility of facilities	24 (w)	24 (m)
	Weather	24	
	Safety	24 (m)	24 (w)
Walking to get to and from places (includes walking to work)	Composite environment[a]	29	
	Access to public open space[a]	25	
	Access to beach[a]	25	
	Perceptions of traffic, busy roads	25	
	Sidewalks present[a]	25	
	Stores in walking distance	25	
	High walkable neighborhood[a]	30	
	Aesthetically pleasing		24, 25
	Accessibility		24
	Safety		24
	Weather		24
Total walking (includes meeting public health guidelines)	Age of home[a]	31	
	Neighborhood/environmental aesthetics	25, 32, 37	
	Practical environment	32	
	Access to public open spaces[a]	25, 33	
	Composite environment score[a]	33	
	Access to beach		25
	Perceptions of traffic, busy roads		25, 37
	Sidewalks present[a]	37	25
	Stores in walking distance		25
	Minor traffic, some trees[a]	33	
	Sidewalk, store[a]	37	33
	High walkable neighborhood[a]		30
	County/metropolitan sprawl[a]	35	
	Convenience of biking/walking trails	36 (w)	
	Convenience of department, discount, or hardware store	36 (w)	
	Convenience of a park	36 (w)	
	Convenience of eight other community destinations		36 (w)
	Overall neighborhood quality	36 (w)	
	Availability of sidewalks	34	
	Land use mix (diversity)	34	
	Easy walk to public transport	34	
	12 other environmental categories		34
	Hills		37
	No street lights		37
	Unattended dogs		37
	Foul air		37
	High crime		37

[a]Objectively assessed environmental attributes. m, men; w, women.

environmental attributes can be particularly informative. Saelens et al.[30] did not find differences between high- and low-walkable neighborhoods in self-reported walking for exercise, self-reported leisure physical activity, and objectively measured vigorous physical activity. Residents of the high- and low-walkable neighborhoods did, however, differ on their walking for errands. This finding parallels those of transportation studies that have found no differences in leisure or exercise walking, but significant differences in walking for transport. Consistent with earlier studies, low levels of other utilitarian walking forms (walking to and from work or school and to or from transit stops) were reported in both neighborhoods.

The Utility of Specific Measures of Walking Behaviors

While there is an insufficient number of studies to reach definitive conclusions, the pattern of findings reviewed here suggests some specific associations of particular environmental attributes with particular walking behaviors. For example, Saelens et al.[30] assessed the minutes spent walking during the past week to and from work or school, during breaks or lunchtime at work or school, as part of errands done outside the household, for exercise, and to and from transit stops. An index of total (sum of the minutes across walking purposes) self-reported walking could be created from these specific indices. Generally, stronger associations with environmental attributes were found for the more particular indices of walking behavior indices.[30] Humpel et al.[27] found a greater likelihood of neighborhood walking (a particular walking behavior index) for those who lived in a coastal location and had positive perceptions of neighborhood aesthetics and convenience of and access to places to walk. Less-strong associations were found for total walking or for total physical activity.[27]

Understanding Environmental Influences on Walking: Research Opportunities

The available research findings that identify environmental correlates of walking include approximately equal numbers of associations for objectively determined and perceived environmental attributes. Few findings from prospective studies are available. To conclude that environmental attributes have a causal role, there is a need to go beyond looking at environmental attributes on their own and to develop multilevel studies that include the strongest individual- and social-level influences on physical activity, such as self-efficacy and social support, ideally using prospective study designs. Multilevel analyses require statistical methods that can take into account the role of possible mediators (intervening variables) and moderators (effect modifiers) in complex causal modeling.[38,39] However, examinations of the relative importance personal, social, and environmental influences on physical activity[33] require the use of well-developed measures of the relevant environmental attributes; these remain to be identified and refined.[6,7,11] It would be premature, for instance, to conclude that individual- and social-level factors (domains where measures are more well established) are more influential than environmental factors (a domain where measures are less well established).

Few of the studies reviewed here reported data on gender differences in the relationships of environmental attributes with walking. Considering the strong gender differences reported in some studies,[21,27,28] future investigations should examine these relationships with walking for men and women separately.

Four key elements of the research agenda relating to environmental influences on walking are reliability, validity, causality, and conception.

Reliability. Reliable measures of environmental attributes are required; this is particularly so for perceptions of environmental attributes such as aesthetics and convenience, but also for reports on specific environmental features such as presence of sidewalks or shade. Humpel et al.[28] examined the test–retest reliability of perceptions of the neighborhood environment and found excellent agreement between tests with intraclass correlations ranging from 0.73 to 0.93 for "aesthetics," "convenience," "access to services," and "traffic" as a problem. Saelens et al.[30] found that the majority of 1-week test–retest values for items used in their Neighborhood Environment Walkability Scale to be $\geq$0.75, a high level of consistency. Individual test–retest intraclass correlations were generally in the 0.60 to 0.80 range for residential density, land use–mix diversity, land use–mix access, street connectivity, walking/cycling facilities, aesthetics, pedestrian/traffic safety, and safety from crime. Kirtland et al.[40] examined 3-week test–retest reliability for items measuring perceptions of the neighborhood and community supports (access, characteristics, barriers, social issues). They found that retest reliability was slightly higher for the neighborhood items, ranging from 0.42 to 0.74 overall. In some circumstances, obtaining measures of perceived environmental attributes may be less costly than objective measures. The inclusion of standardized, reliable self-report measures in multiple studies would help this research field to advance more rapidly. In particular, it would facilitate comparisons of environmental influences across a variety of locations and populations.[34]

Validity. Rated and self-reported environmental attributes should be objectively verifiable, either by independent observation or by objective indices derived from geographic information system (GIS) databases.[19] Saelens et al.[30] assessed the construct validity of environmental attribute measures by comparing subscale scores across two neighborhoods selected to differ

objectively on walkability-related environment characteristics. Residents in the highly walkable neighborhoods perceived greater residential density, closer proximity, easier access to stores and other facilities, better street connectivity, and better neighborhood aesthetics than did residents in low-walkability neighborhoods. Kirtland et al.[40] assessed the validity of items measuring environmental perceptions by comparing them to objective measures using GIS. Overall, low agreement between measures was found for neighborhood and community items (kappa ranged from −0.02 to 0.37). There is a need to improve and refine self-reported measures of environmental attributes that are currently in use, and for more studies that allow direct comparisons of self-reported perceptions of such attributes with objective indices that can be derived from GIS databases and other sources. For example, Pikora et al.[41] developed a framework of potential environmental influences on the specific behaviors of walking and cycling for recreation and for transportation. Items based on findings from the health, transportation, and urban planning literature were used to develop an environmental audit instrument, the Systematic Pedestrian and Cycling Environmental Scan (SPACES),[42] that collected data via observational checklists used by trained observers. If strong patterns of concordance emerge between perceived and objective indices of the same environmental attributes, this will provide support for the validity of the self-reported measures of perceived environmental used in several of the studies that were reviewed here.

Causality. In order to conclude that physical activity behaviors such as walking are influenced by environmental attributes, there is the need to move beyond the description of cross-sectional associations, making use of prospective study designs with multiple observation points as well as intervention study designs.[7,43] While prospective studies with two observation points[28] are informative, they are limited in that no firm conclusions can be reached on the direction of the relationships reported. It is possible that increased levels of walking might influence participants' perceptions of the environment.[28] Future prospective studies need measurements made at a minimum of three time points, in order to gain a clearer view of the direction of these environment–behavior relationships.[38,43]

Conception. The conceptual models and theories on which this research draws require considerable refinement and development. At present, relatively broad conceptual models of putative environment–behavior relationships are being used to guide research.[5,13,19] These models may benefit from considering possible underlying mechanisms that might help to improve their explanatory specificity. For example, Bargh et al.[8,9] argue that many of the actions in which people engage in everyday life are "automatic." There is evidence from a body of experimental studies that features of current environments (people, objects, settings in particular) can drive many habitual behaviors. They argue that behavioral choices can be prompted by the automatic processing of sets of environmental features to which people have been repeatedly exposed, without mediation by conscious reflection or decision making.[8,9] Such a perspective adds potential depth to some of the environmental influences models of physical activity behavior that are broadly guiding current research.[5,13,19]

Conclusions

Research on environmental factors associated with walking shows a promising, although at this stage limited, pattern of positive findings. The aesthetic nature of the local environment, the convenience of facilities for walking (footpaths, trails), accessibility of places to walk to (shops, beach), level of traffic on roads, and composites of environmental attributes have all been found to be associated with walking for particular purposes. However, these findings are primarily from cross-sectional studies and many of the associations reported are based on respondents' perceived ratings of environmental attributes or subjectively identified specific environmental features. Broadly, the research agenda requires a behavior-specific approach, paying particular attention to objectively defined environmental attributes, and requires multilevel modeling approaches to identify how potentially relevant determinants might be acting.[38,39]

From a public health advocacy perspective, the case for "conception"—the conceptual and theoretical models that will be most helpful in explaining the determinants of walking—is of relevance. It is too easily assumed, given the focus of social cognitive models on constructs such as attitudes, self-efficacy, and intentions, that conscious individual decision making is the primary determinant of behavioral choice.[10,14] In the case of physical activity, we have argued that different models are needed that focus primarily on environmentally cued habitual behavior patterns.[4,6,12] In the advocacy context, it is probable that political and administrative decision makers operate from an implicit framework that sees physical activity as "exercising," and thus solely within the domain of individual, consciously made "lifestyle" choices. In this perspective, environmental and policy changes that are needed to promote sustainable increases in physical activity in whole populations[1,2,4] will need concerted advocacy, if they are to be taken sufficiently seriously in political and civic life.

The central challenge in pursuing public health advocacy for physical activity is to build this case on systematic research and theory development to identify the most relevant environmental influences on physical activity. In doing so, it is imperative that this research be used, if possible, to reframe the predominant, implicit model of physical activity as a conscious, dis-

cretionary lifestyle choice. This is particularly important in socioeconomic contexts where prolonged, enforced (or at least strongly reinforced) periods of sedentary behavior in occupational and domestic environments constitute a major public health risk.[13,15,44]

Understanding environmental influences on physical activity is an important and challenging new area of population health research, with many new scientific opportunities.[45] Importantly, it is research that is fundamental to chronic disease prevention, through evidence-based environmental, transportation, urban planning, and public health policy strategies that will promote walking as a more central component of adults' health-enhancing physical activity.[46]

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