Building the Evidence—International Approaches

Environmental Correlates of Physical Activity in a Sample of Belgian Adults

Ilse De Bourdeaudhuij, James F. Sallis, Brian E. Saelens

Abstract

Purpose. *This study investigated the variance in sitting, walking, and moderate and vigorous physical activity explained by neighborhood design and recreational environmental variables above and beyond the variance accounted for by individual demographic variables.*

Design. *Cross-sectional analyses of self-reported survey data.*

Setting. *A random sample of inhabitants of Ghent, Belgium, aged 18–65 years, was drawn.*

Subjects. *Five hundred twenty-one adults completed questionnaires (52.1% response rate). The average age of the sample was 41 years, and 48.2% were female.*

Measures. *A questionnaire developed to assess neighborhood design and recreational environmental variables with a total of 81 items was administered. The environmental questionnaire showed acceptable to good reliability and acceptable validity. The previously validated International Physical Activity Questionnaire (IPAQ) was used to quantify physical activity in the past 7 days. Additional demographic information was also obtained.*

Results. *Regression analyses showed that environmental variables were related to all types of physical activity in both sexes. However, the range of variance explained by the models including demographic and environmental variables was low, only 5% to 13%. Minutes of walking and of moderate-intensity activity were related to quality of sidewalks and accessibility of shopping and public transportation. Vigorous physical activity was related to presence of activity supplies in the home and number of convenient activity facilities outside the home.*

Conclusions. *Both neighborhood design and recreational environment variables had small but significant associations with multiple types of physical activity in a sample of Belgian adults. (Am J Health Promot 2003;18[1]:83–92.)*

Key Words: Environment, Physical Activity, Walkability, Community Design, Prevention Research

INTRODUCTION

The need to increase physical activity is a public health priority,[1,2] but intervention approaches should be based on empirical research that identifies correlates and potential influences on behavior.[3] Demographic, psychological, and social correlates of physical activity have been widely studied in adults[4] and youth,[5] but physical environmental variables have been much less studied. Principles based on ecological models of behavior posit that it is important to understand multiple levels of influences on health behaviors.[6] There is reason to believe that physical environmental variables play an especially important role in physical activity because physical activity occurs in specific settings[7] and psychosocial and sociodemographic variables explain limited variance in physical activity. Environmental interventions for physical activity have been evaluated only minimally to date.[8,9]

Research is accumulating in two disparate fields supporting the contention that physical environments have significant associations with physical activity. Humpel, Owen, and Leslie[9] reviewed studies in the health and behavioral sciences literature. The authors concluded that accessibility to recreational facilities, opportunities for physical activity, and aesthetic attributes were consistently and significantly related to physical activity. Weather and safety were less consistently associated with the behavior. In the 19 studies included in the review, the environment was often measured with one or a few specific variables, which were related to recreational or total physical activity.[9]

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Another review paper examined a completely separate set of studies from the transportation and urban planning fields.[10] Fourteen studies were identified that evaluated the association between neighborhood built environment variables and residents' rates of walking and cycling for transportation. Virtually all reported significant associations, whether environments were assessed objectively or by self-report. The physical environment characteristics associated with more walking and cycling were mixed residential and commercial uses (as opposed to separated uses), high connectivity of the street network (characterized by a grid pattern as opposed to a pattern that includes many cul-de-sacs), and higher residential density. Residents of neighborhoods with these characteristics reported on average making more than twice as many walking/cycling trips per week than residents of neighborhoods lacking these characteristics. Preliminary evidence suggests that these differences in neighborhood environment also are related to differences in overall physical activity.[11]

The consistency of associations between physical environmental variables and physical activity in two distinct literatures enhances confidence in the relations and tends to validate the emphasis of ecological models on environmental factors. However, the studies to date provide an incomplete picture of environmental correlates of physical activity. There are many hypothesized environmental correlates that have not been tested,[4,12–15] so the present study included assessments of previously unexplored variables. There is a need to simultaneously evaluate variables believed by transportation researchers to be related to walking and cycling for transportation, as well as variables believed by health researchers to be related to leisure-time physical activity.[16] Although most studies on these topics have been conducted in the United States, international studies suggest a need to examine the great variation in environmental factors related to walking and biking across countries.[17,18] Thus, it is important to conduct studies of environmental correlates of physical activity in countries other than the United States.

The aim of the present study was to investigate the variance in sitting, walking, and physical activity of moderate and high intensity explained by a wide range of community design and recreational environmental variables above and beyond the variance accounted for by individual and group demographic variables.

METHOD

Design

A cross-sectional design was used, analyzing self-reported survey data collected from a mailed questionnaire. Variables of interest were neighborhood environmental variables believed to be related to walking and cycling for transportation and leisure; environmental factors believed to be related to recreational physical activity; and minutes of sitting, walking, moderate-intensity, and vigorous-intensity activities.

Sample

A random sample of 1000 residents of Ghent, Belgium, was drawn for the age group 18–65 years. The local government randomly selected this sample from the pool of all residents of Ghent, a city in the northern part of Belgium with 224,000 inhabitants and consisting of a city center, suburbs, and countryside.

A seven-page questionnaire was mailed with a letter explaining the purpose of the study, addressed to the randomly selected person who was requested to answer to questionnaire. A prepaid and preaddressed envelope was provided to return the questionnaire. Fourteen questionnaires were returned because people no longer lived at the address. After 6 weeks, 417 questionnaires were received, and a second letter to ask for participation was sent. After another 6 weeks, a total of 529 questionnaires were sent back, of which eight were incomplete. No incentive was provided for participation.

Descriptive characteristics for the sample and the reference population are presented in Table 1. The final sample consisted of 521 participants (52.8% response rate). Mean age was 41 (±12.22) years, and 48.3% were female. In the final sample, 70.1% were working, 31.9% as blue collar workers and 68.1% as white collar workers; 43.8% had a technical education or vocational training, and 56.2% had obtained a general or higher education. Only 7.9% still lived in the parental home, 34.1% with their partner, 43.2% with (partner and) children, and 14.3% alone. Mean body mass index (BMI) was 23.5 (±4.0) for women and 25.1 (±3.6) for men. In the sample, 39.3% lived in the city center, 54.9% in the suburbs, and 5.9% in the countryside. Although no information (e.g., demographics) was available regarding the specific individuals who were nonrespondents, respondents appear to have better jobs, to have a higher education, and to be more often employed compared to the Flemish reference population.

Measures

The questionnaire consisted of three parts to obtain information on (1) the environmental correlates of physical activity, (2) physical activity (sitting, walking, moderate, and vigorous), and (3) demographic variables.

Environment Questionnaire. To measure the hypothesized environmental correlates of physical activity, two existing questionnaires were combined. The scales, scale composition, sample items, and response categories are listed in Table 2. First, a modified version of a new questionnaire developed to assess neighborhood environmental variables believed to be related to walking and cycling for transportation and leisure was used (40 items).[11] Neighborhood environmental variables assessed included residential density, land use mix (diversity of uses), land use mix (access to local shopping), ease of access to a public transportation stop, availability of sidewalks, availability of bike lanes, neighborhood aesthetics, perceived safety from crime, perceived safety from traffic, connectivity of the street network, satisfaction with neighborhood services, and satisfaction with neighborhood (Table 2A). Saelens, Sallis, Black and Chen[11]

Table 1

Descriptive Characteristics (Percentages or Means and Standard Deviations) for the Sample and Reference Populations

	Sample	Reference*
Sex (%)		
Female	48.3	51.1
Male	51.7	48.9
Age (mean years ± SD)	41.0 (±12.2)	40.7
Education (%)		
Lower (technical and vocational)	43.8	64.0
Higher (general and higher)	56.2	36.0
Employment status (%)		
Employed	70.1	57.4
Not employed	29.9	42.6
Occupation (%)		
Blue collar	31.9	49.7
White collar	68.1	50.3
Living situation (%)		
With parents	7.9	—†
With partner	34.1	24.8
With (partner and) children	43.2	47.5
Alone	14.3	27.7
Body mass index (mean ± SD)		
Females	23.5 (±4.0)	24.4
Males	25.1 (±3.6)	25.3
Living environment (%)		
City center	39.3	—
Suburbs	54.9	—
Countryside	5.9	—

* The total Flemish (Dutch-speaking part of Belgium) population was taken as the reference population. Only data available from the National Institute for Statistics were included.
† Only data within households available.

found strong support for the reliability and validity of this survey.

Second, a questionnaire assessing environmental factors believed to be related mainly to recreational physical activity was used (41 items). Scales included characteristics of the worksite environment, physical activity equipment in the home environment, and convenience of physical activity facilities (Table 2B). The psychometric properties were published previously.[19]

Reliability and Validity Testing of the Environment Questionnaire. A separate study was executed to assess reliability and validity of the combined environmental questionnaire in a Belgian sample. The surveys were translated into Flemish and pretested with a small sample to ensure clarity of the items. Forty subjects within different age and sex groups were randomly selected from a rural area and the city center. Test-retest reliability was analyzed by subjects completing the questionnaire twice within a 14-day interval. To test validity, the perceived environmental scores (reports on the questionnaire) were compared with an ''objective'' rating of the environment. The environment was defined as an area within a 5-minute walk around the respondent's home. The objective rating was executed by two independent raters (interrater reliability was high to very high with single-measure intraclass correlations between .80 and .90). Raters visited the neighborhoods of participants and rated the characteristics independently. Police reports were used to obtain an indication of the crime rate in the neighborhoods of the participants. Pearson correlation coefficients were calculated for each item between the subjective reports of the subjects and the mean of the objective scores of the researchers. Validity was not computed for worksite environment, supplies in the home environment, or satisfaction with the neighborhood.

Reliability and validity results are provided in Table 2. Single-measure test-retest reliability intraclass correlation coefficients ranged between .40 and .97. The lowest coefficients were found for perceived safety from traffic, because of a lack of consistency in the item on reported speed of traffic, and for neighborhood aesthetics, because of differences in the item assessing litter in the neighborhood. Validity coefficients ranged between .21 and .91. The smallest validity score was found for perceived safety from crime during the day, with participants reporting inconsistent and much higher crime compared to more objective assessments of crime (on the basis of police reports). For convenience of physical activity facilities, in addition to the Pearson correlation for the total scale, kappa coefficients were computed for the separate items given the yes/no response structure of the items. The lowest and only nonsignificant kappa coefficient was found for the convenience of walking trails, probably because of the confusion about the nature of a ''walking trail'' in the translated questionnaire.

Physical Activity. To obtain information on physical activity, the International Physical Activity Questionnaire (IPAQ) was used. This questionnaire was developed by a working group initiated by the World Health Organization (WHO) and the Centers for Disease Control and Prevention (CDC). The purpose of the questionnaire is to provide a common instrument that can be used internationally to obtain physical activity surveillance data. Validity and reliability results in 12 countries demonstrate that the IPAQ has comparable reliability and validity to other self-re-

Table 2

Summary of Environmental Items, Scales, Intraclass Correlations (ICC, Reliability), and Pearson Correlations (Validity)

Scale (Composition)	Item	Response Category	Reliability (ICC)	Validity (Pearson *r*)
A. Neighborhood variables				
Residential density (3 separate items)	How common are each type of residence listed below in your immediate neighborhood?	3-Point scale None/some/a lot		
	Detached single-family residence		0.93	0.85
	Row house		0.93	0.73
	Apartment		0.97	0.90
Land use mix Diversity (sum of 13 items)	About how long would it take to get from your home to the nearest business or facilities listed below if you walked to them?	5-Point scale*	0.96	0.58–0.93
	List of 13 facilities: grocery store, supermarket, baker, butcher, clothing store, post office, library, elementary school, secondary school, bank/credit union, video store, pharmacy, bus or trolley stop. (Reversed)			
Access to local shopping (sum of 2 items)	I can do most of my shopping at local stores.	4-Point scale†	0.78	0.73–0.75
	Stores are within easy walking distance of my home.			
Ease of walk to public transportation stop (1 item)	It is easy to walk to a transit stop (bus, trolley) from my home.	4-Point scale†	0.63	0.38
Availability of sidewalks (1 item)	There are sidewalks on most of the streets in my neighborhood.	4-Point scale†	0.82	0.81
Availability of bike lanes (sum of 2 items)	There are bike lanes on most of the streets in my neighborhood.	4-Point scale†	0.80	0.60–0.72
	It is safe to ride a bike in or near my neighborhood.			
Neighborhood aesthetics (sum of 4 items)	There are trees along the streets in my neighborhood.	4-Point scale†	0.58	0.48–0.80
	My neighborhood is generally free from litter.			
	There are many attractive natural sights in my neighborhood (such as landscaping, views).			
	There are attractive buildings/homes in my neighborhood.			
Perceived safety from crime (sum of 2 items)	The crime rate in my neighborhood makes it unsafe to go on walks during the day. (Reversed)	4-Point scale†	0.75	0.21–0.72
	The crime rate in my neighborhood makes it unsafe to go on walks at night (Reversed)			
Perceived safety from traffic (sum of 4 items)	There is so much traffic along the street I live on or nearby that it makes it difficult or unpleasant to walk in my neighborhood. (Reversed)	4-Point scale†	0.40	0.69–0.73
	The speed of traffic on the street I live on nearby is usually slow (40 km or less).			
	Most drivers exceed the posted speed limits while driving in my neighborhood. (Reversed)			
	When walking in my neighborhood, there are a lot of exhaust fumes (such as from cars, buses). (Reversed)			
Connectivity (sum of 2 items)	The street design in my neighborhood has few, if any, cul-de-sacs.	4-Point scale†	0.63	0.66–0.89
	There are many four-way intersections in my neighborhood.			
Satisfaction with neighborhood services (sum of 2 items)	I am satisfied: with the access to the bus and trolley system in my neighborhood.	7-Point scale‡	0.81	
	with the access to shopping in my neighborhood.			

* Five-point scale: 1–5, 6–10, 11–20, 20–30, >30 min.
† Four-point scale: strongly disagree, somewhat disagree, somewhat agree, strongly agree.
‡ Seven-point scale from 1 (strongly disagree) to 7 (strongly agree).

Table 2, continued

Scale (Composition)	Item	Response Category	Reliability (ICC)	Validity (Pearson *r*)
Emotional satisfaction with neighborhood (sum of 4 items)	I am satisfied: with how many friends I have in my neighborhood. with how easy or pleasant it is to walk or bicycle in my neighborhood. that my neighborhood is a good place to raise children. that my neighborhood is a good place to live.	7-Point scale‡	0.85	
B. Recreational variables				
Worksite environment (sum of 10 items)	Are there exercise facilities at work?	Yes/no	0.89	
	Are there regular exercise programs at work?	Yes/no		
	Are there shower facilities at your work?	Yes/no		
	Is an exercise specialist or activity coordinator available for employees at your work?	Yes/no		
	Are there policies at your work that encourage exercise?	Yes/no		
	Are the stairs at your work			
	accessible?	Yes/no/not applicable		
	safe?	Yes/no/not applicable		
	pleasant?	Yes/no/not applicable		
	Does your employer provide any paid time for you to exercise?	Yes/no		
	Does your employer encourage commuter cycling?	Yes/no		
Physical activity equipment in home environment (sum of 13 items)	Please indicate which items you have in your home, yard, or apartment complex. (List of 13 items: stationary aerobic equipment, bicycle, trampoline, running shoes, swimming pool, weight lifting equipment, aerobic workout video or audiotapes, step aerobics, skates, sports equipment, surf or boogie or windsurf board, canoe or row boat or kayak, skis.)	Yes/no	0.92	—
Convenience of physical activity facilities (sum of 18 items)	For each of these places where you can exercise, please indicate if it is on a frequently traveled route (e.g., to and from work) or within a 5-min drive from your work or home. (List of 18 facilities: dance studio, basketball court, beach or lake, bike lane or trails, golf course, health spa/gym, martial arts studio, soccer field, public park, public recreation center, squash court, running track, skating rink, sporting goods store, swimming pool, walking trails, tennis courts, fitness studio.)	Yes/no	0.80	0.95 (kappa: 0.13–0.60)

port measures of physical activity.[20] The short (self-administered, seven items), last-week version of the IPAQ was administered, asking about the time spent being physically active in the last 7 days. Minutes of sitting, walking, moderate-intensity (walking not included), and vigorous-intensity activities were computed for the last week. Although the long version of the IPAQ could provide more detailed information on physical activity in different settings and situations, the participant burden associated with this longer questionnaire precluded it as an option. The IPAQ questionnaires, including definitions of moderate and vigorous activity, are available at www.ipaq.ki.se.

Demographic Variables. Demographic variables assessed included sex, age, education, living situation, working situation, height, weight, and body mass index (BMI, calculated as kg/m).[2] Dichotomous variables were constructed for education (lower: vocational or technical training; higher: general education or college), living situation (with children or without children), and working situation (working or nonworking).

Analyses

Independent sample *t*-tests were used to analyze differences in environmental variables by education level, working situation, and living situation. Pearson correlations were executed to investigate relations between environmental variables and age and BMI.

Before running the regression analyses, all variables (demographic and environmental) with low bivariate correlations with a given type of physical activity ($p > .10$) were omitted. The alpha value of .10 was chosen rather than the more stringent .05 value for the bivariate correlation analyses because, from a health promotion perspective, all variables that might have some influence on physical activity are reasonable to include in the regression analyses. Because previous studies showed sex differences in the types of correlates as well as in the level of physical activity,

Table 3

***T*-Values for Differences in Environmental Variables and Pearson Correlations with Age and BMI**

Environmental Variables	Education (*t*-Values)†‡	Working Situation (*t*-Values)†§	Living Situation (*t*-Values)†‖	Age (Pearson *r*)	Body Mass Index (Pearson *r*)
Residential density					
Detached single-family residence	ns	−2.8**	ns	ns	ns
Row house	ns	2.3*	ns	ns	ns
Apartment	ns	ns	3.2***	ns	ns
Land use mix					
Diversity	ns	ns	ns	ns	ns
Access to local shopping	−2.0*	ns	2.2*	ns	ns
Ease of walk to public transportation stop	−3.7***	ns	ns	ns	ns
Availability of sidewalks	ns	ns	2.5*	ns	ns
Availability of bike lanes	ns	ns	ns	−0.10*	ns
Neighborhood aesthetics	ns	−2.3*	ns	0.10*	ns
Perceived safety from crime	−4.8***	−2.1*	ns	−0.12**	−0.11*
Perceived safety from traffic	−2.2*	−2.4*	ns	−0.09*	ns
Connectivity	ns	ns	ns	ns	ns
Worksite environment	−3.1**	—	ns	−0.18***	ns
Physical activity equipment in home environment	−3.1**	−3.8***	−4.7***	−0.26***	−0.15***
Convenience of physical activity facilities	−2.3*	−3.3***	ns	−0.26***	−0.11*
Satisfaction with neighborhood services	ns	ns	ns	ns	ns
Emotional satisfaction with neighborhood	ns	ns	−2.1*	ns	ns

† Negative *t*-values show higher mean scores for higher education, working, and having children.
‡ Education variable 1 = higher, 0 = lower.
§ Working situation variable 1 = working, 0 = nonworking.
‖ Living situation variable 1 = with children, 0 = without children.
* $p \leq 0.05$.
** $p \leq 0.01$.
*** $p \leq 0.001$.

separate analyses were executed by sex.

Multiple regression analyses were conducted to determine variance explained in the four dependent variables, including demographics variables as a first block in the regression, followed by the environmental variables as a second block. This allows an estimation of the independent contribution of the environmental variables above and beyond the variance accounted for by demographic variables. The tables present the semipartial correlations after all blocks were entered, along with the adjusted R^2 values. Conforming to similar studies,[21–24] a logarithmic transformation was used to improve the normality of the distribution for minutes of walking and for minutes of physical activity of moderate and vigorous intensity. After this transformation, the assumptions for executing multiple regression analyses were adequately met for all dependent and independent variables. A $p \leq .05$ was considered to be significant in the multiple regression analyses. Analyses were carried out using SPSS 10.0 software.

RESULTS

Relationship Between Demographic and Environmental Variables

Table 3 summarizes significant differences in environmental variables by education, working situation, and living situation. Higher educated participants reported better access to local shopping, more ease to walk to public transportation stop, more safety from crime, more safety from traffic, more possibilities to be active in the work environment, more physical activity equipment in the home environment, and more convenient physical activity facilities compared to participants with a lower education. Respondents engaged in paid work reported more detached single-family residences, fewer row houses, better aesthetics in their neighborhood, more safety from crime and from traffic, more physical activity equipment in the home environment, and more convenient physical activity facilities compared to respondents not engaged in paid work. Participants living with children in their homes reported fewer apartments in their neighborhoods, less access to local shopping, less availability of sidewalks, more physical activity equipment in the home environment, and more emotional satisfaction with their neighborhood compared with participants without children in their homes.

Correlations between the environmental variables and the age of the respondents (Table 3) showed that older people reported less availability of bike lanes, better neighborhood aesthetics, less safety from crime, less safety from traffic, less possibility to be physically active in the work envi-

Table 4

Regression Analyses of the Contribution of Demographic (Block 1) and Environmental (Block 2) Variables to Different Types of Physical Activity

Dependent Variable	Male			Female		
	Significant Correlates	Semipartial Correlate	R^2	Significant Correlates	Semipartial Correlate	R^2
Sitting	Demographic variables		0.00	Demographic variables		0.09
	Environmental variables		0.07	Age	−.28**	
	Perceived safety from crime	−.22**		Children in the home	−.15*	
	Land use mix (access to local shopping)	.15**		Environmental variables		0.12
	Land use mix (diversity)	.14*		Emotional satisfaction with neighborhood	−.15*	
Walking	Demographic variables		0.01	Demographic variables		0.01
	Working	.12*		Education	−.13*	
	Environmental variables		0.05	Environmental variables		0.04
	Availability of sidewalks	.14*		Land use mix (diversity)	.15*	
				Ease of walk to public transportation stop	.16*	
Moderate activity	Demographic variables		0.01	Demographic variables		0.03
	Environmental variables		0.10	BMI	−.16*	
	Presence of physical activity equipment in the home	.28**		Environmental variables		
	Satisfaction with neighborhood services	.15*		Land use mix (access to local shopping)	.16*	0.07
				Emotional satisfaction with neighborhood	.13*	
Vigorous activity	Demographic variables		0.04	Demographic variables		0.00
	Age	−.14*		Environmental variables		0.07
	Environmental variables		0.13	Presence of physical activity equipment in the home	.15*	
	Presence of physical activity equipment in the home	.26**		Convenience of physical activity facilities	.14*	
	Convenience of physical activity facilities	.11*		Worksite environment	.12*	

* $p \leq 0.05$.
** $p \leq 0.01$.
*** $p \leq 0.001$.

ronment, less physical activity equipment in the home environment, and fewer convenient physical activity facilities. Participants with a higher BMI reported less safety from crime, less physical activity equipment in the home, and fewer convenient physical activity facilities. Only one sex difference was found for the environmental variables. Men reported more safety from crime in their neighborhood compared to women.

Variation in Physical Activity and Inactivity Explained by Demographic and Environmental Variables

Results of regression analyses are summarized in Table 4. Seven percent of the variance in *sitting* was explained in males. None of the demographic variables, but three of the environmental variables, were significant correlates of sitting time among males. Amount of sitting was related to higher perceived criminality in the neighborhood, longer distances to shops and businesses (land use mix, diversity), and more convenience of shopping in local stores (land use mix, access to local shopping). Twelve percent of the variance in sitting was explained in females. Nine percent was explained by the demographic variables of lower age and the absence of children in the home. An additional 3% of sitting was explained by the environmental block, particularly less emotional satisfaction with the neighborhood.

For *walking,* 5% of the variance was explained in males. One percent was explained by working (more walking among workers), and an additional 4% by the environmental block of variables, particularly greater availability of sidewalks. Four percent of the variance in walking was explained in females. One percent was explained by education (less walking among higher educated women), and an additional 3% was explained by the environmental block of variables. More walking was related to a greater ease of the walk to a public transportation stop and to longer distances to shops and businesses (land use mix, diversity).

For physical activities of *moderate intensity,* 10% of the variance was explained in males. No demographic variables reached significance. More activity of moderate intensity was re-

lated to the presence of more physical activity equipment in the home environment and to more satisfaction with neighborhood services. Seven percent of the variance in moderate-intensity physical activity was explained in females. Three percent of the variance was explained by a higher BMI. An additional 4% was explained by the environmental block. More activity of moderate intensity was related to better access to shopping in local stores and more emotional satisfaction with the neighborhood.

For physical activities of *vigorous intensity,* 13% of the variance was explained in males. Five percent was explained by a lower age and the rest by the presence of more physical activity equipment in the home and more convenient physical activity facilities. Seven percent of the variance in vigorous activity was explained in females. No demographic variables reached significance. Again, more activity of high intensity was related to the presence of more physical activity equipment in the home and more convenient physical activity facilities. In addition, a supportive worksite environment was related to more activity of high intensity in women.

DISCUSSION

Environmental variables were significantly related to all types of physical activity in both sexes. However, it was clear that neither demographic nor environmental variables explained large proportions of variance. Psychosocial variables generally have explained more of the variance, generally 25% to 30%, but sometimes up to 50%.[25] In the present study, the range of variance explained by the models was small, 5% to 13%, with environmental variables adding 3% to 9% of variance above and beyond the variance accounted for by demographic variables. However, even if environmental variables explain relatively small amounts of variance, the implication is that changing environments has the ability to affect entire populations on a relatively permanent basis. This is in contrast to the typical psychosocial intervention that affects a limited number of people on a temporary basis, although the temporary effects are sometimes initially robust.[26]

It is useful to consider how different environmental variables were related to different types and intensities of physical activity. Vigorous, presumably leisure-time, physical activity was related to presence of recreational resources, but not to aspects of neighborhood design. These results are in line with previous studies.[7–9,27,28] For women, the presence of more opportunities to be physically active in the worksite environment was related to more activity of high intensity. It is possible that the availability of facilities at work is more important for women because it enables them to incorporate physical activity into their daily routines, without interfering with other duties, such as household and child care.

Minutes of walking and of moderate activity were related to accessibility of shops, facilities, and public transit in women and to the availability of sidewalks in men. The relationship between accessibility of destinations and physical activity is consistently found in transportation studies.[10,29,30] Loutzenheiser[31] also suggested that public transportation facilities that are surrounded by greater mixed use tend to promote more walking trips to public transport. Moreover, public transport can also facilitate nonmotorized travel at trip ends. Taking transit to work or shopping requires walking between subsequent destinations rather than using a car. All of these environmental factors are hypothesized by urban planners to stimulate walking,[13,14] and present results support that view. Somewhat unexpectedly, a longer distance to shops and businesses in women was related to more walking. A possible explanation is that walking for recreation or for exercise, rather than walking for transport, accounted for this association. Thus, the finding could mean that women were more likely to walk for recreation in the suburbs or countryside than in the middle of town, where shops are more close by but exercise walking is more challenging. The questionnaire used in the present study did not distinguish between walking for transportation or for recreation. A different interpretation is related to the relatively high levels of mixed use in Belgium, in comparison to the United States, where most previous studies have been conducted. If many people live very close to shops, it is those who live farther away who will have to walk more to get to their destinations. This issue needs additional study, ideally on an international basis. Furthermore, emotional satisfaction with the neighborhood was related to more moderate physical activity and less sitting among women. It is not surprising that emotional comfort with the neighborhood was more related to walking and inactivity in women because of women's more social orientation compared to men.[4]

Other environmental variables expected to be related to walking or moderate activity were not, such as residential density, availability of bike lanes, neighborhood aesthetics, perceived safety from crime and traffic, and street connectivity. A more specific study of the environmental correlates of walking for transportation will be necessary to extend the results of the transportation literature. The nonspecific walking measure used in the present study makes it difficult to interpret some results. It is also possible that there are critical or threshold levels above or below which these environmental variables are related to physical activity in the form of walking and/or biking trips and that the studied environments generally did not reach these threshold levels. There is evidence that residential density is not linearly related to walking trip frequency.[32,33] The same might be true for connectivity, perceived crime, and traffic safety.

In men, more convenience of shopping in local stores was related to more sitting. This relationship was not only unexpected, it was also in contrast to a finding that a greater distance from shops and businesses was related to more sitting in men. It is possible that for men, who are typically not the primary shopper of the family, ''convenience'' of shopping in local stores was irrelevant for daily activity.

The significant differences in environmental variables found for educa-

tion and working situation suggests an important relationship between socioeconomic status, environmental variables, and physical activity. Especially for the environmental variables related to vigorous activity, a higher socioeconomic status was related to a more ''activity-friendly'' environment. Moreover, higher scores were found for access to local shopping, ease of the walk to a public transportation stop, and perceived safety from crime and from traffic—environmental variables that could potentially be related to walking or moderate activity—in higher educated participants. These observations are consistent with the hypothesis that physical activity–related environmental characteristics can mediate some of the often-reported associations between socioeconomic status and physical activity.[1] Furthermore, age differences were found in environmental variables, with older people reporting less activity-friendly environments, such as less safety, less availability of bike lanes, and fewer convenient physical activity facilities. It is possible that this reflects perception differences rather than differences in the environment. It also highlights the importance of continuing to examine individual factors in exploring the relations between environment and physical activity.

In the present study, environmental variables contributed to the variance explained in physical activity, even when adjusting for sociodemographic variables, but the analysis strategy could have underestimated the variance explained by environmental variables. This is because any shared variance between sociodemographic and environmental variables was assigned to sociodemographic variables, which were entered first in the regression models. Given the significant relations found between sociodemographic and environmental variables, it could be suggested that the percentage of variance explained by environmental variables in the present study is understated. Further research needs to disentangle the relationships between sociodemographic factors, environmental variables, and physical activity.

The reliance on self-reported information for physical activity and environmental variables, though assessed through validated questionnaires, is a limitation of this study.

Vigorous physical activity is recalled more accurately than lower intensity activities,[34] which might explain the higher percentage of variance accounted for in vigorous physical activity. More accurate measures of physical activity of low to moderate intensity, such as accelerometers, need to be included in future studies. The health literature[9] and transportation and planning literatures[10] indicate that both objective and perceived environmental measures are significantly associated with physical activity. The present study supports the value of assessing perceived environment, in that most significant findings were consistent with expectations. However, it is still essential to use objectively measured environmental variables to enhance understanding of environmental influences on physical activity. The use of perceived environmental measures and a cross-sectional design means that the direction of causality cannot be addressed. A second limitation is that the study was conducted in one city. In any geographic region, there is limited variation in environments. Cross-national studies are needed to evaluate the full range of environmental and physical activity variables.[18] A third limitation is that causal relations cannot be determined from cross-sectional studies such as this. Because a consensus is developed on the most promising environmental correlates of physical activity, they should be evaluated in prospective studies. Fourth, as is often the case in population studies, the sample was somewhat too highly educated, with more white-collar workers and with an underrepresentation of people living alone. However, because within-subject relationships were investigated, this might not necessary limit the generalizability of the findings. Fifth, the lack of context-specific physical activity measures was a major limitation because different environmental variables can be related to walking for transportation or leisure and to moderate activity for household, child care, transportation, or sport. However, the short IPAQ did not differentiate between the purpose or context of the activity. This could limit our interpretation of the effect of the built environment on walking/cycling. Future research is needed to test more specific hypotheses about the relation of multiple environmental variables to activities within domains such as transportation, work, household, and leisure time. The long version of the IPAQ might be a valuable instrument for this purpose.[20]

Finally, it is clear that the variance explained was small. However, this does not mean that environmental variables are of little importance because small changes in relevant environmental factors could influence daily physical activity patterns of large populations over long periods of time. Future research should study the relative importance of individual and environmental variables in the explanation of physical activity of different purposes and intensities.

Present results indicated activity-specific relations with environmental variables. Walking and moderate-intensity activities were related to sidewalks and access to shops and public transportation facilities, highlighting the importance of community design. Vigorous physical activity was related to access to activity supplies and recreational facilities. Thus, the study indicates that environmental characteristics related to both community design and recreational resources must be considered in explaining physical activity. Even though the cause-effect relationship is not clear, many of these environmental characteristics are difficult or impossible to evaluate in randomized controlled trials. Thus, prospective research is necessary to investigate the temporal relations among environmental variables and physical activity, for example, by examining the change in physical activity among individuals moving from one environment to a different environment.

Researchers need to refine hypotheses about how specific environmental variables might be related to particular types and purposes of physical activity. Policy makers need to consider how to build communi-

ties so they facilitate physical activity for transportation, recreation, and other purposes.

SO WHAT? Implications for Health Promotion Practitioners and Researchers

This study seems to indicate that also in Belgium: (1) walking and moderate-intensity activities were related to sidewalks and access to shops and public transportation facilities and (2) vigorous physical activity was related to access to activity supplies and recreational facilities. Combined with other research, there seems to be support for the assertion that environmental characteristics related to both design and recreational resources can explain part of the variance in physical activity. However the variance explained by environmental variables above and beyond demographic variables remained small.

If this assertion holds true, researchers need to refine hypotheses about how specific environmental variables might be related to particular types and purposes of physical activity. In addition, policy makers need to begin to consider how to build communities so they facilitate physical activity for transportation, recreation, and other purposes. However, it is not clear yet which changes in environments have the ability to affect the physical activity of the population on a relatively permanent basis.

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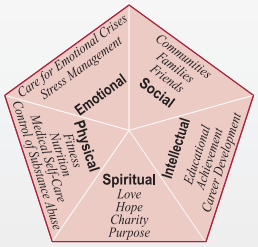

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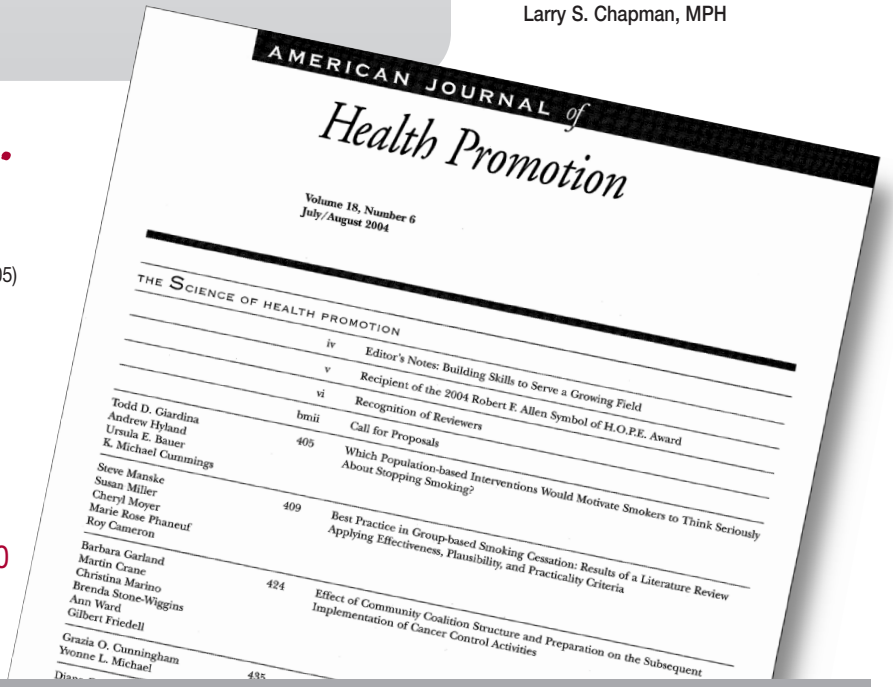
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