Neighborhood Environments And Physical Activity Among Adults in 11 Countries

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Abstract

Background: Understanding environmental correlates of physical activity can inform policy changes. Surveys were conducted in 11 countries using the same self-report environmental variables and the International Physical Activity Questionnaire, allowing analyses with pooled data.

Methods: The countries were Belgium, Brazil, Canada, Colombia, China (Hong Kong), Japan, Lithuania, New Zealand, Norway, Sweden, and USA, with a combined sample of 11,541 adults living in cities. Samples were reasonably representative, and seasons of data collection were comparable. Perceived environmental attributes were categorized "agree" vs. "disagree". Outcomes were meeting health-related guidelines for physical activity. Data were collected in 2002–2003 and analyzed in 2007. Logistic regression analyses evaluated associations with physical activity with environmental attributes, adjusted for age, sex, and clustering within country.

Results: Five of seven environmental variables were significantly related to meeting physical activity guidelines, ranging from access to low cost recreation facilities (OR=1.16) to sidewalks on most streets (OR=1.47). A graded association was observed, with the most activity-supportive neighborhoods having 100% higher rates of sufficient physical activity compared those with no supportive attributes.

Conclusions: Results suggest neighborhoods built to support physical activity have a strong potential to contribute to increased physical activity. Designing neighborhoods to support physical activity can now be defined as an international public health issue.

Introduction

The well-documented health burdens of physical inactivity have led national[1–3] and international[4,5] health agencies to prioritize physical activity promotion. Efforts to motivate and educate individuals can be complemented by creating social and built environments that make physical activity safe and convenient.[6] Authoritative groups found convincing evidence from a few developed countries that people are more active, especially for transportation, when they live in communities characterized by mixed land use (i.e., stores in walking distance of homes), well-connected street networks, and high residential density; compared to people who live in communities designed for automobile-dependent transportation with the opposite characteristics.[7,8] Other reviewers concluded that proximity to recreation facilities, along with pleasing aesthetics, was associated with more recreational physical activity.[9,10]

Limitations of research examining associations of built environments and physical activity are apparent. First, the lack of experimental and prospective studies prevents conclusions about the direction of causality.[8]Second, specific characteristics of neighborhoods related to physical activity need to be identified to guide designers and planners to create more "activity-friendly" environments. Third, most studies examined subcomponents of physical activity, such as transportation or recreation activities, but the contribution of built environments to total physical activity, that should be most strongly related to health outcomes, has seldom been reported.[11–13] Finally, because studies have been conducted within single countries, limited environmental variability may lead to underestimation of true associations with physical activity. Underestimated associations could reduce the apparent relevance of built environment changes as physical activity promotion strategies.

The present study aimed to address all but the first limitation by examining cross-sectional associations of neighborhood attributes with meeting health-enhancing physical activity guidelines among adults in 11 countries. The use of common methods and survey translation/adaptation protocols justified pooling across countries, creating a database with very wide variability in environments and populations.

Method

International Physical Activity Prevalence Study (IPS).

The aim of IPS was to collect nationally representative and internationally comparable prevalence estimates on physical activity from diverse countries. Interested investigators were required to show capacity and intent to follow rigorous guidelines to address known limitations in physical activity prevalence studies (i.e., seasonality, instrument translation and training, data coding, analysis strategy). As described elsewhere,[14] protocols for recruiting population samples and collecting data were established, with some allowances for modifications needed for local contexts. The sample was required to be representative of national populations or a significant region(s) within a country (defined as a population over 1,000,000), with an age range of 18 to 65 years. Households were typically selected at random and individuals within households were selected either randomly or by most recent birthday.

Data collection in Spring or Autumn of 2002/2003 was required to reduce seasonal variations. If data were collected across 12 months, only Spring and Autumn data were used, in most cases. Data were analyzed in 2007.

Of the 20 countries that completed data collection,[14] 11 included an environmental survey: Belgium, Brazil, Canada, Colombia, Hong Kong (China), Japan, Lithuania, Norway, New Zealand, Sweden and USA. Guidelines for survey translation and adaptation had to be followed (www.ipaq.ki.se), and English back-translations of surveys were approved.

Perceived Neighborhood Environment Measure

Neighborhood attributes of relevance to physical activity were measured with seven items from the Physical Activity Neighborhood Environment Survey (PANES; also known as the IPS Environmental Module) that were used by all 11 countries (Appendix A; full survey available at www.ipaq.ki.se and www.drjamessallis.sdsu.edu). Most countries included additional items. Neighborhood was defined as the area within a 10–15 minute walk from home. Each item assessed an environmental attribute shown in previous studies to be related to physical activity for recreation[10] or transportation.[7,8,15] The main type of housing in neighborhoods (e.g., apartment, single family) indicated residential density. Having many stores within walking distance was an indicator of mixed land use. Access to a transit stop was included because transit use involves walking.[16] Presence of sidewalks and bicycling facilities assessed pedestrian and bicycling infrastructure. Presence of free or low cost recreation facilities was assessed. Crime as a barrier to walking at night was an indicator of perceived crime, a social environment variable.

With the exception of the item on the main type of housing, items were phrased as statements about an attribute of their neighborhoods, with the following response options: strongly disagree, somewhat disagree, somewhat agree, strongly agree, don't know/not sure, or refused. For data analysis, responses were combined to create two levels: agree (strongly agree and somewhat agree) and disagree (strong disagree and somewhat disagree). For types of housing, "detached single family" (i.e., low density) was compared to all others. Survey respondents (*n*=754) were excluded from data analysis if they reported "don't know/not sure" or "refused" for any neighborhood attribute item. Most items were taken or adapted from previously evaluated surveys of neighborhood environments.[13,17,18]

Test-retest reliability was evaluated in a separate sample of 135 adults recruited from neighborhoods that varied in income and walkability in Cincinnati, OH, San Diego, CA, and Boston, MA. Intraclass correlations ranged from 0.64 for free or low cost recreation facilities to 0.84 for sidewalks on most streets. Items had similarly high reliability in a Swedish study (except for perceived crime),[19] and reliability was supported in a Nigerian sample.[20]

Neighborhood Environment Index. Analyses with individual environment attributes indicated which items were most strongly related to physical activity. However, individual item results could not estimate the overall effect size of activity-friendly neighborhoods. A Neighborhood Environment Index was constructed by summing the number of favorable "activity-friendly" environmental attributes. Preliminary analyses indicated perceived crime, the only social environment variable, reduced the Cronbach's alpha. Thus, the index was composed of the six built environment items, scores ranged from 0– 6 with higher scores indicating a more favorable built environment for physical activity, and Cronbach's alpha was 0.55. In the separate sample from three U.S. cities, the test-retest reliability for the sum of six items was ICC=0.86, with Cronbach's alpha of 0.92. The difference in alpha coefficients may be due to wider environmental variation in the international sample and high education level of the U.S. reliability sample.

Physical Activity Measure

The short interviewer-administered International Physical Activity Questionnaire (IPAQ) measured the frequency and duration of walking, moderate intensity, and vigorous physical activity for leisure, transportation, and occupational purposes; and inactivity (i.e., sitting) during the past week (except for Sweden which used the self-administered format). For each question, respondents were given country-specific examples of activities and physiological cues for breathing and heart rate to help them recall activities with an appropriate intensity level. Reliability and validity were evaluated with over 2500 adults from 12 countries.[21] One-week test-retest reliability of the short interviewer-administered IPAQ was good (Spearman r=0.70 to 0.97). Criterion validity for the IPAQ total $min \cdot wk^{-1}$ was acceptable as measured against accelerometer total counts (Spearman r=0.23) and for the average correct classification of respondents accumulating ≥150 $min \cdot wk^{-1}$ of physical activity (Spearman r=0.74).[21]

Meeting Guidelines for Physical Activity. The IPAQ was scored using the IPS scoring protocol (available at www.ipaq.ki.se) to classify participants as performing moderate amounts of physical activity, equivalent to meeting physical activity guidelines.[22,23] Meeting guidelines for moderate amounts of physical activity was defined by any of three criteria:

- 3 or more days of vigorous-intensity activity of at least 20 $min \cdot day^{-1}$
- 5 or more days of moderate-intensity activity or walking of at least 30 $min \cdot day^{-1}$
- 5 or more days of any combination of walking, moderate-intensity or vigorous-intensity activities achieving a minimum of 600 MET- $min \cdot wk^{-1}$.

A MET-minute is defined as the MET intensity multiplied by the minutes per week of activity. A MET is the activity metabolic rate divided by the resting metabolic rate, with one MET representing the energy expended while sitting quietly at rest. MET intensity levels used to score the IPAQ were vigorous (8 METs), moderate (4 METs), and walking (3.3 METs).

Analyses

SAS (version 9.1, Cary, NC) was used for data analyses. Data from each country were pooled and weighted to account for differential probabilities of sample selection and post-stratified to the world 2001 population to facilitate comparisons between countries with varying age and sex distributions. Education could not be used as a covariate because it was missing for two countries. Descriptive characteristics of the analysis sample are presented unweighted for each country in Table 1; however, all additional analyses employed sample weights.

Neighborhood environment variables have not been validated for rural residents and may not be relevant, so analyses were conducted only among IPS participants living in towns or cities with populations greater than 30,000. Prevalence of the seven environmental attributes was reported for each country. Odds of meeting guidelines for physical activity were modeled for each neighborhood environment item using PROC LOGISTIC, and models included age, sex, and country as covariates. Data were presented as odds ratios with 95 percent confidence intervals. Strength of association between number of physical activity-supportive environmental attributes (the neighborhood environment index) with physical activity was examined using PROC LOGISTIC. The Wald statistic for the neighborhood index variable was interpreted as a test for a linear gradient, and considered significant at $p<0.05$.

Results

Description of Samples

About 70 percent of total participants (n=11,541) reported living in towns and cities of more than 30,000, ranging from 27.6% (Belgium) to 100% (Brazil, Colombia (Bogota), Hong Kong). All analyses were conducted with the 11,541 participants living in cities, and demographic characteristics of each country sample are shown in Table 1. Sample sizes ranged from 357 (Belgium) to 2674 (Colombia), sexes were well balanced, and age distributions were generally balanced from 20 to 64 years, except for Japan. Percent with more than 13 years of education ranged from less than 20% (Columbia) to more than 60% (Canada and USA).

Table 2 shows substantial variation across countries in the percent of participants who reported presence of the seven neighborhood environment characteristics. For example, having single family homes as the main housing type varied from less than 1% (Hong Kong) to 88% (Brazil), sidewalk availability ranged from 25% (Brazil) to 97% (Hong Kong), and perceived lack of safety due to crime ranged from 16% (Canada and Norway) to almost 75% (Colombia and Lithuania).

Relation of Environmental Attributes to Meeting Health-Enhancing Physical Activity Guidelines

Seventy-seven percent of participants reported meeting guidelines for physical activity. As reported by Bauman and colleagues,[14] physical activity prevalence rates in the IPS were comparable to rates from other studies, especially a recent international study using the short IPAQ.[24] However, the IPAQ is known to produce higher prevalence rates than other self-report surveys,[25–27] in part because IPAQ assesses all physical activity domains.

Physical activity prevalence was significantly related to five of the seven environmental variables (see Figure 1): many shops nearby (OR=1.29, 95% CI=1.15, 1.44), transit stop in neighborhood (OR=1.32, 95% CI=1.16, 1.54), sidewalks on most streets (OR=1.47, 95% CI = 1.32, 1.65), bicycle facilities (OR = 1.21, 95% CI = 1.10, 1.33), and low cost recreational facilities available (OR=1.16, 95% CI=1.05, 1.27). All associations were in the expected direction, and only single family homes and perceived crime were not significant.

Strength of Association

The number of physical activity-supportive built environment attributes was related to meeting guidelines for physical activity (Figure 2). The Wald statistic for the regression coefficient can be interpreted as a test for linear gradient; Wald χ^2=64.86, p<0.0001. There were significant differences in physical activity prevalence for those reporting four, five, and six attributes compared to those reporting zero, and the odds ratio for six supportive attributes was 2.00.

Because education may confound the relation between physical activity and built environment attributes, the analysis was repeated covarying for education, using samples from the nine countries with education data. Only participants with all six favorable neighborhood environment attributes were significantly more likely than those with zero favorable attributes to meet physical activity recommendations. For the score of six built neighborhood attributes, the odds ratio adjusting for education was 1.7 (95% CI; 1.2, 2.4), compared to the original odds ratio of 2.0 (95% CI; 1.4, 2.8)

Discussion

Five of seven neighborhood environment variables were significantly associated with meeting guidelines for physical activity in a study of 11 countries. There was evidence of a linear gradient in the relationship, such that the more supportive built environment attributes reported for the neighborhood, the more likely the person was to be sufficiently physically active. Though adjusting for education reduced the association somewhat, having many favorable neighborhood environment characteristics remained associated with physical activity. Present results demonstrate previous findings linking neighborhood environments with physical activity, based on studies in a few developed countries, can be generalized to a broad range of countries. Designing neighborhoods to support physical activity can now be defined as an international public health issue.

The environmental attribute with the highest odds ratio was having sidewalks on most streets in the neighborhood. This finding may reflect that sidewalks can be used for many common types of physical activity, including walking, jogging, and skating, for both recreation and transportation purposes. Ensuring access to sidewalks may be a practical and effective policy for encouraging physical activity.

The hypothesis that a cluster of activity-friendly attributes would be needed to support higher rates of meeting physical activity guidelines was supported. Though single attributes were associated with 15% to 50% higher rates of meeting guidelines, when all six built environment attributes were present, rates of physical activity were 100% higher, compared to those in neighborhoods with no supportive attributes. After adjusting for education in an analysis of nine countries, the odds ratio was still a significant 1.7. These strong associations contrast with reports that neighborhood environments had weak associations with physical activity.[28–30] Including the full range of environmental variation across countries likely accounts for the stronger associations found in the current study.

The multiple significant individual variables suggest a variety of environmental interventions may affect physical activity, with different environmental variables having particular relevance for physical activity for transportation versus recreation purposes.[31,32] There is substantial interest in crime as a barrier to physical activity, but studies to date have produced inconsistent results,[10,33] and the association was not significant in the present study. More sophisticated measures of crime and domain-specific measures of physical activity are needed to further explore this important topic. All other significant associations with physical activity were consistent with previous findings,[7,8,10,16,34] except the present lack of association with residential density.

The perceived neighborhood environment items may be useful for environmental surveillance, because they revealed substantial variation by country, and the associations with physical activity supported the construct validity of the items. Each country had a unique profile on this set of items (Table 2). Hong Kong appeared to have the most "activity-friendly" built environment on most items, but bicycling facilities were available to few residents. The United States had the lowest access to transit stops and was the only country in which fewer than half of participants were within walking distance of shops. These findings help explain the small percent of trips made by walking and bicycling in the United States.[8] Although the United States has one of the highest violent crime rates in the world,[35] perceived crime was lower than in Lithuania, Colombia, and Brazil. The majority of participants in all countries except Brazil reported having free or low-cost recreation facilities and sidewalks on most streets in their neighborhoods. European countries had the highest access to bicycling facilities.

Strengths of the study included the assessment of large samples of adults in 11 countries using standardized methods. Participating countries provided broad geographical and socio-political diversity, including five continents and some developing nations. Survey items had evidence of good test-retest reliability in multiple countries. Authoritative guidelines[22,23] were used as the criterion for health-enhancing physical activity. However, there were challenges to conducting a multi-country study. Despite efforts to standardize and adapt the survey items, interpretations and meanings of items could vary by country, especially on subjective items such as perception of crime. The number of environmental variables was limited by the multi-purpose survey, so each concept was measured by a single item. The short IPAQ did not provide data on specific domains of physical activity (e.g., transportation, recreation) that may have produced stronger associations with neighborhood characteristics.[31,35] The IPAQ has been shown to overestimate physical activity,[25–27] so actual prevalence rates are likely not as high as those reported here. IPAQ reliability and validity appear to vary by the country's level of development.[21] The cross-sectional design does not allow interpretations about direction of effect, so self-selection of active people into activity-friendly neighborhoods remains a possibility.[8] Inclusion of only people in cities with populations ≥30,000 could be considered a limitation, but the built environmental attributes assessed were not expected to be relevant for rural areas. Reports of environment attributes could be biased if more active persons perceive their environments differently from inactives.

Previous within-country findings that neighborhood environments are related to physical activity[7,8,10,15,31,34] were replicated and extended in the present international study. A variety of neighborhood attributes relevant to physical activity for both transportation and recreation domains were associated with meeting health-enhancing guidelines. These findings suggest that built environment changes may be effective in increasing physical activity, but multiple environmental changes are likely to be needed to have a substantial effect. Prospective and experimental studies are required to strengthen evidence of causality. In the present study, highly supportive environments were associated with a 100% higher likelihood of sufficient physical activity, and a 70% higher likelihood of meeting guidelines after covarying for education. These are large effects for a potential intervention expected to have relatively permanent effects. Each country had a unique profile of environmental supports, so population surveys of neighborhood characteristics can be used for environmental surveillance.

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Table 1. Unweighted sample characteristics of city residents (population ≥ 30,000) by country (Pooled sample N=11,541).

Characteristic	**Total sample**		**Country**									
			Belgium		**Brazil**		**Canada**		**Colombia**		**Hong Kong**	
	n	**%**	***n***	**%**	***n***	**%**	***n***	**%**	***n***	**%**	***n***	**%**
Total [n (%N)]	11541	100	357	100	876	100	619	100	2674	100	990	100
Sex												
Male	5129	44.4	208	52.3	433	49.4	314	50.7	1083	40.5	466	47.1
Female	6412	55.6	149	41.7	443	50.6	305	49.3	1591	59.5	524	52.9
Age (years)												
18– 29	3665	31.8	38	10.6	330	37.7	143	23.1	1052	39.3	186	18.8
30– 39	2894	25.1	79	22.1	227	25.9	152	24.6	668	25.0	271	27.4
40– 49	2512	21.8	103	28.9	174	19.9	165	26.7	517	19.3	305	30.8
50– 65	2470	21.4	137	38.4	145	16.6	159	25.7	437	16.3	228	23.0
Educational attainment												
≤13 years	5625	54.8	-	-	-	-	200	32.5	2174	81.3	769	77.9
>13 years	4633	45.2	-	-	-	-	416	67.5	500	18.7	218	22.1
Meet guidelines by walking												
Yes	7062	61.2	147	41.2	332	37.9	383	61.9	2012	75.2	843	85.2
No	4479	38.8	210	58.8	544	62.1	236	38.1	662	27.8	147	14.9
Meet guidelines for physical activity												
Yes	9147	79.3	203	56.9	571	65.2	527	85.1	2139	80.0	853	86.2
No	2394	20.7	154	43.1	305	34.8	92	14.9	535	20.0	137	13.8

	Country											
	Japan		Lithuania		New Zealand		Norway		Sweden		USA	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
Total n (%N)	442	100	1291	100	803	100	492	100	434	100	2563	100
Sex												
Male	281	63.6	508	39.4	318	39.6	237	48.2	194	44.7	1087	42.4
Female	161	36.4	783	60.7	485	60.4	255	51.8	240	55.3	1476	57.6
Age (years)												
18– 29	356	80.5	538	41.7	190	23.7	128	26.0	111	25.6	593	23.1
30– 39	86	19.5	255	19.8	227	28.3	128	26.0	116	26.7	685	26.7
40– 49	-	-	268	20.8	185	23.0	107	21.8	80	18.4	608	23.7
50– 65	-	-	230	17.8	201	25.0	129	26.2	127	29.3	677	26.4
Educational attainment												
≤13 years	248	56.9	498	38.9	464	57.8	196	41.2	237	54.9	839	32.9
>13 years	188	43.1	782	61.1	339	42.2	280	58.8	195	45.1	1715	67.2
Meet guidelines by walking												
Yes	223	50.5	698	54.1	469	58.4	288	58.5	235	54.2	1432	55.9
No	219	49.5	593	45.9	334	41.6	204	41.5	199	45.9	1131	44.1
Meet guidelines for physical activity												
Yes	289	65.4	1074	83.2	677	84.3	390	79.3	316	72.8	2108	82.3
No	153	34.6	217	16.8	126	15.7	102	20.7	118	27.2	455	17.8

Table 2. Weighted percent of city residents from each country who "agree" with neighborhood environment attributes.

Environmental variable	COUNTRY										
	Belgium (*n*=357)	**Brazil (*n*=876)**	**Canada (*n*=619)**	**Colombia (*n*=2674)**	**Hong Kong (*n*=990)**	**Japan (*n*=442)**	**Lithuania (*n*=1291)**	**New Zealand (*n*=803)**	**Norway (*n*=492)**	**Sweden (*n*=434)**	**USA (*n*=2563)**
Single family houses the main housing type	32.7	88.0	60.9	21.7	0.3	30.0	15.3	74.5	40.6	28.1	60.8
Many shops within walking distance	62.1	85.2	69.0	93.2	88.4	83.2	82.5	74.8	84.1	78.2	59.6
Transit stop within 10-15min from home	74.1	94.8	82.8	96.5	96.4	91.0	91.1	92.1	97.4	97.2	68.0
Sidewalks on most streets in neighborhood	83.9	25.2	77.2	91.1	96.9	59.1	86.7	94.6	76.5	95.7	73.9
Facilities to bicycle in or near neighborhood	78.5	33.9	67.9	45.4	37.2	24.8	47.6	45.7	72.0	78.7	57.4
Low cost rec facilities in neighborhood	78.8	28.3	87.3	50.9	72.9	59.8	54.5	87.0	75.1	78.8	69.8
Crime rate makes it unsafe to walk at night	24.3	65.5	16.1	74.8	36.3	32.9	74.6	39.4	16.3	39.3	31.5

Note: Sample consists of those who reported living in cities with populations ≥30,000

Figure Captions

Figure 1. Results of logistic regression analysis of the relationship of seven perceived neighborhood attributes with meeting physical activity guidelines among city residents only, adjusted for sex, age, and country (Pooled sample N=11,541).

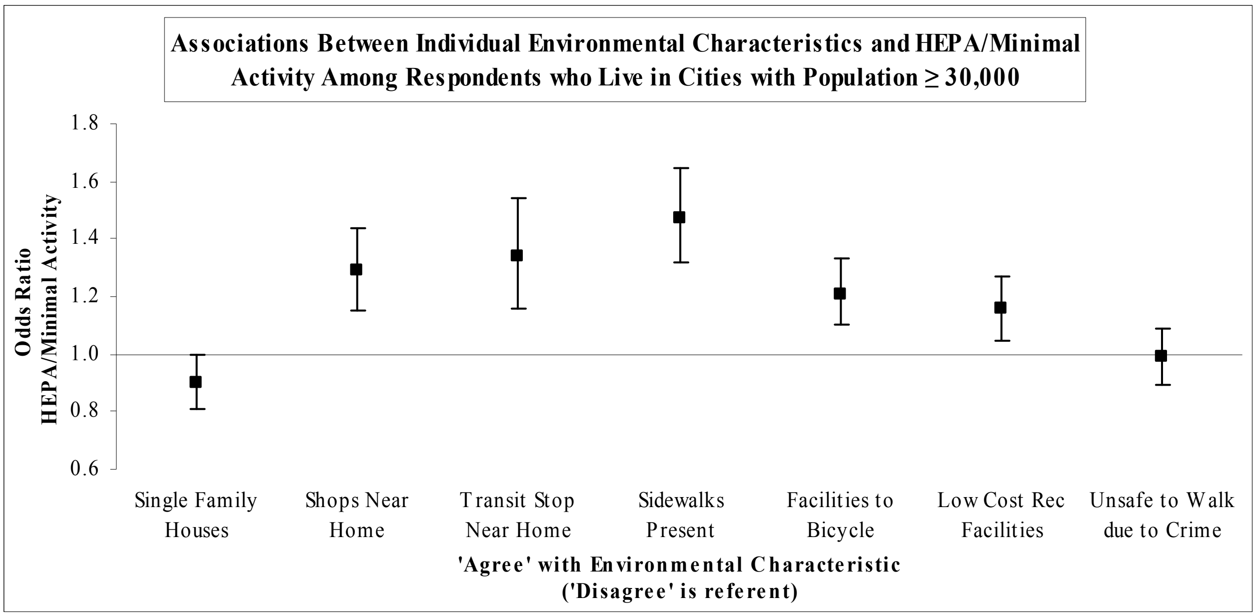

Figure 2. Association between number of "physical activity favorable" built environmental attributes and meeting physical activity guidelines among city residents only, adjusted for sex, age, and country (Pooled sample N=11,541).