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Sociodemographic Moderators of Environment–Physical Activity Associations: Results From the International Prevalence Study

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Background: Associations between the built environment and physical activity (PA) may vary by sociodemographic factors. However, such evidence from international studies is limited. This study tested the moderating effects of sociodemographic factors on associations between perceived environment and self-reported total PA among adults from the International Prevalence Study. **Methods:** Between 2002 and 2003, adults from 9 countries (N = 10,258) completed surveys assessing total PA (International Physical Activity Questionnaire-short), perceived environment, and sociodemographics (age, gender, and education). Total PA was dichotomized as meeting/not meeting (a) high PA levels and (b) minimum PA guidelines. Logistic models tested environment by sociodemographic interactions (24 total). **Results:** Education and gender moderated the association between safety from crime and meeting high PA levels (interaction $P < .05$), with inverse associations found only among the high education group and men. Education and gender also moderated associations of safety from crime and the presence of transit stops with meeting minimum PA guidelines (interaction $P < .05$), with positive associations found for safety from crime only among women and presence of transit stops only among men and the high education group. **Conclusions:** The limited number of moderating effects found provides support for population-wide environment–PA associations. International efforts to improve built environments are needed to promote health-enhancing PA and maintain environmental sustainability.

Keywords: built environment, urban planning, effect modification, global health

A quarter of adults worldwide do not meet the minimal physical activity guidelines (PAG), with older adults, women, and individuals with lower education being the least active, and, therefore, at the highest risk of adverse health outcomes.[1–4] The World Health Organization (WHO) recommends adults engage in a minimum of 150 minutes per week of aerobic moderate- to vigorous-intensity physical activity.[2] Exceeding the minimum PAG can provide additional health benefits, such as preventing unhealthy weight gain.[2] Because physical inactivity is contributing to the high rates of obesity worldwide,[5,6] a clear understanding of the factors influencing physical activity (PA) is warranted. According to ecological models, factors at the individual (eg, biological and psychological), social (eg, social support), and physical (built) environmental levels interact with one another to influence PA.[7–9] Of the possible interactions across levels, those involving environmental factors remain the least understood. Examining interactions between environmental- and individual-level characteristics of residents (sociodemographics) can help inform interventions targeting environments to promote PA equitably across a population.

The neighborhood environment has been of particular focus in PA research given its potential to promote or impede PA, including leisure-time and transport-related PA (walking or bicycling to/from places).[10] For example, neighborhood environmental factors related to total PA include proximity of recreational facilities and neighborhood aesthetics.[9] However, there are inconsistent associations reported for some environmental factors like safety from crime.[11] Such inconsistencies merit further examination, such as testing whether certain characteristics of the population are explaining these variations (ie, sociodemographic moderators). Some studies suggest that associations between neighborhood environmental factors and PA vary by age, gender, and socioeconomic status, but findings have been inconsistent.[12–19] Much of the evidence on interactions between environmental and sociodemographic factors has come from single country studies whose findings are limited by the samples and context under study. Differences in methodology across studies can also contribute to inconsistencies. Multicountry studies that employ comparable measures and protocols across sites can enhance our understanding of the moderating effects of sociodemographic factors on associations between the environment and PA among nationally representative samples from a geographically diverse set of countries.

In 2016, the International Physical Activity and Environment Network (IPEN) examined sociodemographic moderators of associations between perceived environmental factors and accelerometer-based PA among an international sample of adults and found a few moderating effects by gender and age, but not education.[15] The study reported positive associations between perceived environmental factors (eg, safety from crime) and accelerometer-based PA only among older adults and women. Because associations between the environment and PA can depend on the measure of PA (objective or self-report),[20] the sociodemographic moderators of associations of the environment with PA based on accelerometry may differ from those with associations

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involving self-reported PA. As such, to better understand whether and how associations of the neighborhood environment with PA differ systematically by sociodemographic factors, evidence from self-reported and objective PA studies is needed. Consistent findings from both types of studies would support stronger recommendations for interventions and policies.

The present multicountry analyses attempted to replicate findings and extend understanding from the aforementioned IPEN study[15] by examining sociodemographic moderators of associations of perceived environmental factors with self-reported total PA. Replicating or reproducing population health associations is critical for assessing the robustness of research findings among different populations, increasing confidence in findings from previous research, and informing program/policy decisions.[21] The present study used data from the earlier International Prevalence Study (IPS),[22] which involved a different set of countries, samples, and PA measures (total PA) than the IPEN study. We focused on total PA because the frequency of PA in each domain varies greatly between countries (eg, leisure-time PA rates are higher in high-income countries).[23] Thus, total PA allows us to account for those differences.

The aim of the present study was to test whether age, gender, and education moderated associations of perceived environmental factors with self-reported total PA. In line with the findings reported in the IPEN study,[15] we hypothesized positive associations between perceived safety from crime and self-reported total PA only among older adults and women. Although the IPEN study did not find moderating effects by education, such effects were found in 2 other studies from the United States[14] and Australia.[18] Those studies reported positive associations between environmental factors (eg, safety and walkability) and self-reported PA only among adults with higher education, leading to our corresponding hypothesis.

Methods

Study Design

This cross-sectional study used data collected between 2002 and 2003 from IPS. IPS was a collaborative international project whose goal was to obtain nationally or regionally representative prevalence estimates of PA among adults aged 18–65 years from a geographically diverse set of countries. Of the 20 countries approved for IPS, 11 included a perceived environment survey. For the present research, only the 9 countries with comparable measures for PA, perceived environment, and sociodemographics (age, gender, and education) were included in the analyses: Canada, Colombia, Hong Kong (special administrative unit of China), Japan, Lithuania, New Zealand, Norway, Sweden, and the United States. At the time of the study (2002–2003), Colombia was a lower middle-income country, Lithuania an upper middle-income, and the rest high-income countries.[24] The final analytical sample included 10,258 adults. Participants provided informed consent verbally or in writing. All participating centers provided a statement of ethics approval.

Recruitment

Details of IPS's sampling, recruitment, and data collection are described elsewhere.[22] Countries meeting the following criteria were invited to participate: willing to obtain a population sample at least 1500 adults representative of the overall population in a country or significant region within a country (ie, at least 1,000,000), use comparable data collection methods, and use approved cultural translations of the short version of the International Physical Activity Questionnaire (IPAQ-short).[22] The majority of countries used either multistage stratified random sampling or simple random sampling. Only Japan sampled from universities and worksites from different regions of the country. Adults (aged 18–65 y; or 18–40 y in Japan) from each site were selected by random household sampling.

Data Collection

Data were collected in the spring or fall of 2002/2003 to reduce possible seasonal variation in total PA. Participants completed the questionnaires on their own, or via phone or face-to-face interviews with trained interviewers. Prior to data collection, surveys developed in a language other than English were translated and back-translated to English and approved by the investigators. Present analyses were limited to participants living in towns or cities with population sizes of 30,000 or more because the environmental surveys were not suitable for rural environments, consistent with a previous IPS publication.[25]

Measures

Total PA. The 9-item IPAQ-short assessed self-reported total PA in the last 7 days across all domains (ie, combining leisure, domestic, transportation, and occupational)[26] and at 4 intensity levels: vigorous (eg, aerobics), moderate (eg, leisure cycling), walking, and sitting. In a 12-country study with adults, the IPAQ-short showed acceptable test–retest reliability ($\rho = .76$) and fair-to-moderate criterion validity against accelerometers ($\rho = .30$).[26] Total PA measured by IPAQ-short has also been linked to several neighborhood environmental features, such as recreation facilities and locations, transportation environment, and aesthetics.[9] For the present study, we dichotomized self-reported total PA in 2 ways: (a) meeting/not meeting high PA levels and (b) meeting/not meeting minimum PAG. The former outcome was based on categories proposed in the IPAQ scoring protocol,[27] while the latter outcome was based on the WHO's recommendations for aerobic PA.[2]

The WHO recommends at least 75 minutes per week of vigorous-intensity PA, 150 minutes per week of moderate-intensity PA, or an equivalent combination of moderate- and vigorous-intensity PA. Analysis of this outcome allowed for comparison of present results to those of previous studies, including IPS publications.[25] However, because the WHO recommendations[2] are largely based on leisure-time PA and the IPAQ-short measured total PA across all domains, we expected the prevalence of meeting minimum PAG would be overestimated.[25,28] Thus, we used the PA categories proposed in the IPAQ-short scoring protocol[27] to categorize respondents as meeting/not meeting "high PA levels," defined as reporting (a) vigorous-intensity PA on at least 3 days, achieving a minimum of at least 1500 metabolic equivalent-minutes per week or (b) 7 or more days of any combination of walking, moderate- or vigorous-intensity PA, achieving at least 3000 metabolic equivalent-minutes per week. This high PA category equates to approximately 1.5–2 hours of moderate-intensity total PA per day.

Perceived Environment. The Physical Activity Neighborhood Environment Survey[29] assessed perceived environmental factors for walking/bicycling in the neighborhood, defined as the area within a 10- to 15-minute walk from home. The 17-item scale used single items instead of multi-item scales to measure each environmental attribute. Each item has been validated against the abbreviated Neighborhood Environment Walkability Scale with Spearman correlations ranging from .27 to .81.[29] Test–retest reliability of the scale has been evaluated in multiple countries, such as Sweden (intraclass correlation = .36–.98)[30] and Nigeria (intraclass correlation = .43–.91).[31]

The 7 core environmental items assessed across the 9 countries included: (a) main type of residential housing (residential density), (b) having shops and other retail destinations in the neighborhood (mixed land use), (c) presence of transit stops near home, (d) presence of sidewalks, (e) presence of bicycle facilities, (f) access to free/low-cost recreational facilities (eg, parks), and (g) safety from crime at night. Response options for all items except residential housing ranged from 1 (strongly agree) to 4 (strongly disagree) and were recoded as 1 (strongly agree/agree) or 0 (strongly disagree/disagree).[28] Residential housing type was dichotomized to contrast detached single-family homes (lower residential density) from all other housing types (higher residential density).[28]

We computed a neighborhood environment index based on the 6 built environment items, excluding safety from crime.[28] In separate analyses, it was evident that the safety from crime variable reduced the Cronbach's alpha and should be assessed separately from the index.[28] The final built environment index had scores ranging from 0 to 6 and a Cronbach's $\alpha = .55$.[28] We examined the environment index as a continuous variable, with higher scores indicating greater neighborhood walkability and activity supportiveness.

Sociodemographics. Surveys assessed respondents' age, gender, and highest level of education attained. We dichotomized education as <13 years versus ≥13 years of education.[28] Using the median split of age, we grouped respondents into one of the 2 categories: 18–37 versus 38–65 years of age.

Analyses

We computed descriptive statistics for the pooled and weighted sample. Data were weighted to each country's population to account for differential probabilities of sampling within each site. Two separate multivariate logistic regression models adjusted for country site examined the associations of the sociodemographic and perceived environmental factors with each PA outcome. Because the environmental index included scores from 6 of the environmental factors, we fitted additional models with just the environmental index, safety from crime, and sociodemographic variables included. This was done to avoid multicollinearity issues.

To examine whether the environment–PA associations depended on sociodemographic factors, we first tested 2-way interactions of all 3 sociodemographic factors (age, gender, and education) with each environmental factor. With 8 environmental factors, this lead to 8 initial models for each outcome testing 3 two-way interactions between a single environmental factor and each sociodemographic factor, adjusting for country site and all the other sociodemographic and environmental main effects not in the interaction terms. This step allowed us to assess for the presence of multiple sociodemographic moderators of the relationship between a single environmental factor and PA outcome. From these initial interaction models, we identified interaction terms with $P < .10$. This P value was used to minimize type II error. Finally, we tested those interactions with $P < .10$ simultaneously in a full model for each outcome. Using a backward elimination approach, we removed the least significant interaction terms from the full models one at a time until only those terms with $P < .05$ remained. The models involving interactions with the environmental index were adjusted for country site and the safety from crime variables only. For each significant interaction from the full models, we estimated the association between the perceived environmental factor and PA outcome at each level of the sociodemographic moderator. Because the analyses involved multiple hypothesis testing, we also used a Bonferroni adjustment to identify interaction terms with $P < .002$ (ie, .05/24 statistical tests). The Bonferroni adjustment reduces the probability of making a type I error; however, it also increases the chance of committing a type II error.[32] Some researchers view this method as too conservative.[32] For the present analyses, we present results for the models not adjusted for Bonferroni and indicate those that remained significant with the adjustment.

Results

Sample Characteristics

Among the sample [mean age (SD) = 38 (13) y], approximately half were women and respondents with high education (Table 1). The proportion of respondents who met high PA levels was 48% and about 83% met minimum PAG. The majority of respondents reported the environmental factors in question were present in their neighborhoods, except for bicycle facilities (Table 1). Half of respondents reported their neighborhoods were safe from crime.

Table 1 Weighted Characteristics of the Pooled Sample of 10,258 Adults From 9 Countries (IPS: 2002–2003)

Characteristic	
Sociodemographic	
Age, mean (SD), y	37.8 (12.6)
Female, %	50.8
High education (≥13 y), %	48.9
PA	
Meets high PA levels, %[a]	48.0
Meets minimum PA guidelines, %[b]	83.2
Perceived environment[c]	
High residential density, %	64.4
Presence of shops near home, %	78.3
Presence of transit stops near home, %	87.6
Presence of sidewalks, %	82.2
Presence of bicycle facilities, %	47.7
Presence of recreational facilities, %	64.4
Safety from crime, %	52.3
Environmental index (range: 1–6), mean (SD)[d]	4.2 (1.5)

Abbreviations: IPS, International Prevalence Study; PA, physical activity.
[a]Reported vigorous PA on ≥3 days, achieving ≥1500 metabolic equivalent-minutes per week or ≥7 days of any combination of walking or moderate or vigorous PA, achieving ≥3000 metabolic equivalent-minutes per week.
[b]Reported ≥75 minutes per week of vigorous PA, or ≥150 minutes per week of moderate PA, or any equivalent combination of moderate and vigorous PA.
[c]Percentages represent proportion of respondents who somewhat/strongly agreed the environmental factor was present or high.
[d]Average of scores from the perceived environmental factors listed except safety from crime.

Associations of Sociodemographic and Perceived Environmental Factors With PA

There were significant inverse associations of age and being female with both PA outcomes (Table 2). There was also a significant inverse relation between education and meeting high PA levels. Significant positive associations for both PA outcomes were found with the presence of shops or bicycle facilities and a higher built environmental index. Additional significant associations were found for each PA outcome, with an inverse association between high residential density and meeting high PA levels, and a positive association between the presence of sidewalks in the neighborhood and meeting minimum PAG.

Sociodemographic Moderators of Associations of Perceived Environment With PA

For meeting high PA levels, 2 out of 24 interactions were significant at $P < .05$, that is, between perceived safety from crime and both education and gender (Table 2). With the Bonferroni

Table 2 Sociodemographic Moderators of Associations Between Perceived Environmental Factors and PA (IPS: 2002–2003)

	Meets high PA levels[a]		Meets minimum PAG[b]	
	B (SE)	*P*	*B* (SE)	*P*
Models without interactions[c]				
Age[d]	–0.21 (0.02)	<.0001	–0.22 (0.03)	<.0001
Female	–0.22 (0.02)	<.0001	–0.09 (0.03)	.0006
High education	–0.15 (0.02)	<.0001	–0.03 (0.03)	.38
High residential density	–0.07 (0.03)	.005	–0.05 (0.03)	.09
Presence of shops near home	0.06 (0.03)	.03	0.11 (0.03)	.002
Presence of transit stops near home	–0.04 (0.04)	.29	0.01 (0.04)	.74
Presence of sidewalks	0.03 (0.03)	.28	0.18 (0.04)	<.0001
Presence of bicycle facilities	0.13 (0.02)	<.0001	0.07 (0.03)	.03
Presence of recreational facilities	0.04 (0.02)	.11	0.009 (0.03)	.78
Safety from crime	–0.03 (0.02)	.21	0.03 (0.03)	.31
Models for environmental index without interactions[c,e]				
Age[d]	–0.20 (0.02)	<.0001	–0.22 (0.03)	<.0001
Female	–0.43 (0.04)	<.0001	–0.18 (0.06)	.001
High education	–0.29 (0.05)	<.0001	–0.05 (0.06)	.40
Safety from crime	–0.03 (0.05)	.55	0.07 (0.06)	.22
Environmental index[d]	0.11 (0.02)	<.0001	0.17 (0.03)	<.0001
Models with significant interactions[c]				
Age[d]	–0.21 (0.02)	<.0001	–0.22 (0.03)	<.0001
Female	–0.59 (0.06)	<.0001	–0.06 (0.16)	.70
High education	–0.18 (0.06)	.006	–0.53 (0.16)	.0009
High residential density	–0.14 (0.05)	.006	–0.12 (0.06)	.07
Shops near home	0.11 (0.06)	.04	0.22 (0.07)	.002
Transit stops near home	–0.07 (0.07)	.35	–0.16 (0.17)	.34
Sidewalks present	0.06 (0.06)	.31	0.36 (0.07)	<.0001
Bicycle facilities present	0.27 (0.05)	<.0001	0.13 (0.06)	.03
Recreational facilities present	0.08 (0.05)	.10	0.03 (0.06)	.64
Safety from crime	–0.11 (0.07)	.13	–0.09 (0.08)	.26
Safety from crime × education	–0.24 (0.08)	.004	–	–
Safety from crime × gender	0.31 (0.08)	.0002[f]	0.28 (0.11)	.02
Presence of transit stops × gender	–	–	–0.32 (0.16)	.04
Presence of transit stops × education	–	–	0.55 (0.17)	.001[f]

Abbreviations: IPS, International Prevalence Study; PA, physical activity; PAG, physical activity guidelines.
[a]Reported vigorous PA on ≥3 days, achieving ≥1500 metabolic equivalent-minutes per week or ≥7 days of any combination of walking or moderate or vigorous PA, achieving ≥3000 metabolic equivalent-minutes per week.
[b]Reported ≥75 minutes per week of vigorous PA, or ≥150 minutes per week of moderate PA, or any equivalent combination of moderate and vigorous PA.
[c]Models are weighted and adjusted for country site.
[d]Variables were standardized to have a mean = 0 and SD = 1.
[e]Because of multicollinearity with the environment variables, the index was tested in a separate model with the sociodemographic and "safety from crime" variables only.
[f]Interactions significant at Bonferroni-adjusted *P* value of .002.

adjustment, only the interaction between perceived safety from crime and gender was significant ($P < .002$). Probing the interactions showed that perceived safety from crime was significantly related to lower odds of meeting high PA levels only among the high education group [odds ratio (OR) = 0.83; 95% confidence interval (CI), 0.73–0.94] and men (OR = 0.80; 95% CI, 0.70–0.90; Table 3).

For meeting minimum PAG, 3 out of 24 interactions were significant at $P < .05$, that is, between perceived safety from crime and gender as well as perceived presence of transit stops and both gender and education (Table 2). There was a significant positive association between perceived safety from crime and meeting minimum PAG only among women (OR = 1.23; 95% CI, 1.06–1.44). Significant positive associations were found between perceived presence of transit stops and meeting minimum PAG only among men (OR = 1.27; 95% CI, 1.01–1.59) and the high education group (OR = 1.26; 95% CI, 1.03–1.54), but those with lower education had a significant inverse relationship between perceived presence of transit stops and meeting minimum PAG (OR = 0.70; 95% CI, 0.53–0.94).

Discussion

This multicountry study found only a small number of sociodemographic moderating effects, consistent with the overall results of the IPEN study that investigated sociodemographic moderators of associations between perceived environment and objective PA.[15] The only moderating effects found in the present study were for gender and education. The presence of such moderating effects and the direction of the associations appeared to depend on the PA outcome examined. Only gender had a consistent direction of moderating effects on the association between perceived safety from crime and both PA outcomes, with associations in the expected positive direction only among women. Surprisingly, among men and respondents with higher education, higher perceived safety from crime was related to lower likelihood of meeting high PA levels. In addition, among these same subgroups, there were positive associations between the presence of transit stops and meeting minimum PAG.

Table 3 Associations of Perceived Environmental Factors With PA at Varying Levels of the Sociodemographic Moderators (IPS: 2002–2003)

Environmental factor and level of moderator	Meets high PA levels[a] OR (95% CI)[c]	Meets minimum PAG[b] OR (95% CI)[c]
Safety from crime		
Association in low education	1.06 (0.94–1.19)	
Association in high education	0.83 (0.73–0.94)	
Safety from crime		
Association in men	0.80 (0.70–0.90)	0.90 (0.76–1.06)
Association in women	1.09 (0.97–1.23)	1.23 (1.06–1.44)
Transit stops present		
Association in men		1.27 (1.01–1.59)
Association in women		0.84 (0.67–1.06)
Transit stops present		
Association in low education		0.70 (0.53–0.94)
Association in high education		1.26 (1.03–1.54)

Abbreviations: CI, confidence interval; IPS, International Prevalence Study; OR, odds ratio; PA, physical activity; PAG, physical activity guidelines.

[a]Reported vigorous PA on at least 3 days, achieving a minimum total PA of at least 1500 metabolic equivalent-minutes per week or 7 or more days of any combination of walking or moderate or vigorous PA, achieving a minimum total PA of at least 3000 metabolic equivalent-minutes per week.

[b]Reported ≥75 minutes per week of vigorous PA, or ≥150 minutes per week of moderate PA, or any equivalent combination of moderate and vigorous PA.

[c]Models are weighted and adjusted for age, country site, and all other environmental factors in the model.

A previous IPS publication found no significant relationship between perceived safety from crime and meeting minimum PAG.[28] Thus, present analyses extended prior results by showing the associations of perceived safety from crime with meeting high PA levels or the minimum PAG varied by gender and education. Perceived safety from crime was significantly related to higher odds of meeting minimum PAG among women, but lower odds of meeting high PA levels among men. When accounting for the Bonferroni adjustment, only the moderating effects of gender on the relationship between perceived safety from crime and meeting high PA levels was significant. Evidence of gender differences in the relationship between perceived safety (from crime, traffic, etc) and PA was reported in a review of 41 studies from the United States, Australia, and Europe.[11] The review found 5 studies reporting a positive association only among women; none of the studies reviewed reported inverse associations. The IPEN study also found moderating effects by gender on the association between perceived safety from crime and accelerometer-based PA, with a positive association found only among women.[15] Perceptions of feeling less safe from crime tend to be more prevalent among women than men.[33] Our findings suggest women may be more sensitive to perceptions of neighborhood safety than men, which may lend to less engagement in PA in the neighborhood, potentially leading to lower overall activity levels.

Our finding that perceived safety from crime was inversely related to meeting high PA levels among men and those with higher education was unexpected, but we provide a few possible explanations. The gender moderating effect was in line with one US study, which found inverse associations between perceived safety from crime and PA (accelerometer-based moderate- to vigorous-intensity physical activity and self-reported walking for leisure) only among men.[14] That same study also reported a *positive* association between perceived safety from crime and self-reported walking for leisure among the high education group.[14] However, our findings show an *inverse* relationship between perceived safety from crime and meeting high PA levels among the high education group. Because the aforementioned studies used a different operationalization of PA from the present study (ie, domain-specific/accelerometer-based vs self-reported total PA), findings are not directly comparable. Nevertheless, a possible explanation for the inverse associations of perceived safety from crime and high PA among men and the high education group is that they are spending more time outside their neighborhood (eg, at work) and may be less aware of crime activity in their neighborhoods, thereby perceiving it to be safe. People who spend less time in their neighborhoods may be less aware of their neighborhood surroundings.[34] Among those perceiving low levels of neighborhood safety, there may be higher motivation to access gyms/recreational facilities outside their neighborhood. Another possible explanation is that for those with high education, living in a safer but less dense/walkable neighborhood may pose a barrier to PA. In our study, a higher proportion of respondents with high education reported living in neighborhoods with predominantly single-family homes (less dense neighborhoods) compared with those with lower education. Overall, compared with the other perceived environmental factors, associations between perceived safety from crime and PA appeared to be more complex and may depend on contextual factors (eg, location and purpose of PA). Examination of the influence of additional contextual factors was beyond the scope of the present study.

Gender and education also moderated the association between perceived presence of transit stops and meeting minimum PAG. A previous IPS publication found a positive relationship between the presence of transit stops and meeting minimum PAG among the overall sample.[28] In our study, such positive associations were found only among men and the high education group. Among the low education group, the presence of transit stops was inversely related to meeting minimum PAG. A related finding was reported in the IPEN study, which found moderating effects by gender, but not education, on the relationship between land use mix access and accelerometer-based PA.[15] The land use mix access measure assessed the presence of stores/destinations and transit stops in the neighborhood. The authors found a positive association between land use mix access and accelerometer-based PA only among men.[15] Our findings showed that only the presence of transit stops, but not shops, were related to meeting minimum PAG among men. The IPEN study authors explained that land use mix access was mostly related to men's PA because they had a higher prevalence of meeting minimum PAG, while the prevalence was much lower in women, thereby reducing power. We found a similar gender difference in PA levels. Another potential explanation for the positive associations observed among men and respondents with high education may be that these individuals used public transit more often (eg, to get to and from work) and were, therefore, more aware of the presence of transit stops. Individuals who use public transit can achieve 30 or more minutes per day of PA solely by walking to and from transit stops.[35] Although, in the United States, those with lower education and women tend to show higher mean daily minutes of walking to and from transit stops compared with those of higher education and men,[35] respectively, public transit use patterns in other countries may show different patterns. Public transit use is more common in European countries than in the United States and Australia because European cities tend to be more compact and dense and have greater land use mix, greater restrictions on car use, and high costs associated with owning/operating a vehicle (eg, high gasoline prices).[35] Additional research is needed to better understand public transit use patterns in an international context.

Strengths and Limitations

Strengths of the present study include the use of comparable data from a large sample of adults from multiple countries and use of validated questionnaires to assess PA and the perceived environment. Multicountry studies provide greater variability in neighborhood and population characteristics that are often relatively homogeneous in single-country studies. However, our analyses only involved middle- to high-income countries. It is possible that low-income countries would yield different results. Another limitation was use of self-report measures. The IPAQ has been shown to overestimate PA.[36,37] To address the overestimation issue, we also examined associations with meeting high PA levels, which had greater variability than meeting minimum PAG. Self-reported PA measures can introduce recall bias, but they are valuable in assessing activities that standard accelerometer techniques may not capture (eg, biking and swimming). Self-report environment measures are moderately correlated with some objective environment measures, but there are differences for certain factors such as proximity to transit stops.[38] Self-report environment measures can also assess perceptions of the social environment such as safety from crime, which can be challenging to measure using objective tools. The self-report measure of total PA in all domains may have led to underestimating associations with environments because household and occupational PA domains are not expected to be related to neighborhood environment attributes. Our measure of PA was not specific to the neighborhood, potentially weakening associations with the neighborhood environmental factors.

Overall, the present multicountry study found limited evidence for sociodemographic moderators of associations between the perceived neighborhood environment and self-reported total PA, a conclusion consistent with the IPEN study.[15] Consistent conclusions from 2 different multicountry studies (IPS and IPEN) involving a different set of countries, sample selection methods, and measures (objective/self-reported PA) provide strong evidence for population-wide associations between the neighborhood environment and PA on an international basis. The present research demonstrates the importance of replicating and extending published research for assessing the robustness of findings and informing future interventions.[21] Interventions that target the neighborhood environment to make it more activity-supportive and inform the population of the resources and opportunities to be active may help improve residents' perceptions of their neighborhoods, and, in turn, encourage PA in the neighborhood. Prospective studies are needed to examine the mechanisms by which improvements to the environment influence PA behavior change. In conclusion, present findings provide additional support for international recommendations to improve built environments for population-wide benefits for PA, health, and environmental sustainability.[39–41]

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