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Association between built environment and physical activity in Latin American countries: a multicentre cross-sectional study

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ABSTRACT

Objective To assess the association between the physical activity level and the built environment by accessibility, microinfrastructure and security in Latin America (LA).

Design We conducted a multicentre cross-sectional study to collect physical activity and built environment data. The levels of physical activity were calculated through the International Physical Activity Questionnaire survey. Using the Neighbourhood Environment Walkability Scale-Abbreviated, characteristics of the built environment were measured through three domains: accessibility, microinfrastructure and security. To estimate the association of the built environment and physical activity, we used mixed effects logistic regression analysis. In addition, likelihood ratio test to account for clustered effect within countries and/or cities was used.

Setting Eight countries in LA.

Participants Adults aged 15–65 years (n=9218) living in urban areas and consented to participate of the Latin American Study of Nutrition and Health.

Results Most of the population in LA had access to a grocery store (97.2%), public transport stop (91.5%) and children's playground (81.6%). Metropolitan parks were more accessible in Ecuador (59.8%) and Colombia (59.2%) than in Venezuela (33.5%). Individuals located within 20 min of walking from sport facilities or children's playground areas were more likely to perform moderate-to-high physical activity OR 1.20 (95% CI 1.06 to 1.36) and OR 1.25 (95% CI 1.02 to 1.53), respectively. Only 14.5% of the population from the region considered that their neighbourhood had an adequate design for walking or cycling. Likewise, among adults living in LA, only 39.75% had the perception of living in a safe neighbourhood.

Conclusions This multicentre study shows that currently, LA built environment does not promote physical activity in the region. Our findings provide the rationale to push forward, at regional and national levels, policies and interventions that will help to achieve a safe, healthy and friendly built environment to encourage participation in active recreation and sports in leisure time.

Trial registration number NCT02226627.

Strengths and limitations of this study

- This is the first study to report detailed country-built environment domains (accessibility, microinfrastructure and security) and to assess their relationship with physical activity in countries in Latin America.
- Consistent findings based on representative samples of eight participating countries.
- We used comprehensive and consistent metrics regarding healthy urban environments proposed by WHO to assess the built environment.
- Our estimates did not include children or the elderly.
- Findings apply only to urban settings in Latin America.

INTRODUCTION

One of public health's main goals is people's development of healthy habits such as regular physical activity (PA).[1] However, according to WHO, approximately 30% of the world's population does not carry out the necessary PA to maintain its well-being.[1 2] This translates that one in four adults and three in four adolescents do not satisfied WHO global recommendations of PA.[2] This is a worrisome statistic considering that physical inactivity is the fourth-leading cause of global mortality and represents approximately INT$54 billion per year in direct healthcare costs.[2 3] Further, a sedentary lifestyle increases the risk of diseases such as coronary heart disease, diabetes, colon cancer and breast cancer and is therefore responsible for approximately 9% of worldwide premature mortality or about 5.3 million deaths per year.[4] A healthy environment is one of the cornerstones for good health and promoting PA. Thus, one of the four pillars of the recently WHO's global

action plan to promote PA during 2018–2030 rest on the creation of active environments.[2]

Currently, cardiovascular disease and diabetes are the leading causes of mortality and morbidity in Latin American (LA) countries, medical conditions highly preventable with regular PA and proper diet.[4 5] It has been reported that 39.1% of the LA population has insufficient PA and only 24.6% performs moderate/vigorous PA.[3 4] The lack of PA in the LA region could be driven by key built environment (BE) factors such as overpopulation, increase in poverty and crime, high traffic density, poor air quality, lack of parks, sidewalks and sports and recreational facilities as reported in other world regions.[1–4] Yet, despite this scenario, comprehensive and detailed descriptions of the impact of BE by country, age and sex on PA in LA countries are not available except for Mexico, Brazil and Colombia.[6 7]

An evaluation of the impact of the BE on PA is essential to inform and implement national and regional policies, establish priorities and guide interventions in LA. To address this key gap in knowledge, we used population-based data from eight countries in LA collected in 2015 from the Latin American Study of Nutrition and Health (ELANS) project. This study seeks to determine the association between BE and the level of PA in male and female populations between 15 and 65 years living in urban areas of eight LA countries.

METHODS

Study design

The ELANS project is a multicentre, cross-sectional study of nutrition and health surveillance.[8] The study's aim is to evaluate the nutritional intake, PA levels and anthropometric data of its participants. The ELANS project was simultaneously conducted in male and female residents from urban areas of eight LA countries as follows: Argentina, Brazil, Chile, Colombia, Costa Rica, Ecuador, Peru and Venezuela. These samples are representative of the population between 15 and 65 years old in each country.[8]

Study sample

In order to capture a representative sample across the eight participating countries, the ELANS project used random sampling, complex, multiple stages and stratified participants by geographical area, gender, age, socioeconomic status (SES) and body mass index (BMI).[8] The regions and cities with the higher population were considered for each country. The sample size of 9218 adolescents and adults were calculated with a confidence level of 95%, and a maximum error of 3.49%. In order to avoid sample bias, the recruitment rates were country weighted based on their population; thus, the largest and lowest recruitment rate were for Brazil and Costa Rica, 22.2% and 8.8%, respectively. The inclusion criteria required not presenting any underlying disease or acute pathology that limited PA or food intake and exclusion criteria were the following: pregnancy, breast feeding, individuals under 15 or over 65 years old, adolescents without the consent of a parent or legal guardian, people living in any residential environment other than a home (eg, hospitals, regiments and nursing homes), and people who could not read.[8] The information was obtained from questionnaires and objective measurements. Prior to their participation, all participants signed an informed consent agreement.[8]

Measures

Physical activity

The level of PA was determined through the IPAQ-long survey (International Physical Activity Questionnaire), a self-reported questionnaire that measures the PA levels of an individual in the last 7 days. It is calculated based on the metabolic equivalent of task (MET) measures in minutes per week (min/week).[8] The IPAQ-long version is designed for its application in epidemiological investigations as described elsewhere.[8 9] This tool has been used extensively across different countries and is recommended by WHO.[9] The validity and reproducibility of this questionnaire were studied in 12 countries,[10] and these studies found a reproducibility of 0.80,[11] and an acceptable validity with an average r value of 0.33.[11] The IPAQ-long version allows an assessment of PA based on three dimensions: intensity, frequency and duration. Thus, activity is considered moderate if it causes an increase in heart and respiratory rate, but the ability to speak is maintained; examples include brisk walking (at least 2.5 miles per hour), social dancing, gardening and slow cycling (less than 10 miles per hour). On the other hand, activities are considered vigorous when they require greater effort, leading to a thermal rise and sweating. The ability to talk a lot is lost, but they do not lead to shortness of breath; examples of vigorous activity include running, swimming, aerobic dance and jump rope.[12] For IPAQ, these activities must be maintained for at least 10 continuous minutes to be considered as moderate or vigorous PA. The registration in METs-min/week is used to measure the weekly PA. The reference values were calculated based on the compendium of PA of Ainsworth *et al*,[13] for which average MET scores were obtained for each type of PA—walking, moderate activity and vigorous activity. Therefore, the results: (1) walking: 3.3 METs, (2) moderate PA: four METs and (3) vigorous PA: eight METs.[14]

Perceived neighbourhood BE

The perceived neighbourhood BE was measured using data from the Neighbourhood Environment Walkability Scale-Abbreviated (NEWS-A) adapted for the ELANS project.[15] The scale adaptation also includes items to safety from crime, items to measures the proximity of shopping centres and items that evaluated the proximity to public open spaces. The NEWS-A validity and reliability has been shown previously with all included scales.[16 17]

The questions selected for this study were grouped in three dimensions based on the NEWS-A subcales: accessibility to services (Land use mix-diversity), microinfrastructure features (Land use mix-access, street connectivity,

walking/cycling facilities and safety from traffic) and security features (Safety from crime).[6 8]

Accessibility to services

Accessibility was objectively measured by the proximity to destinations of daily living commodities such as grocery store (neighbourhood store or supermarket), gymnasium, work or school and public transport stop.[18] According to Giles-Corti *et al*, the average walking time must not be longer than 15 min for a place within a neighbourhood to be considered accessible.[18] The NEWS questionnaire uses the following time categories: 1–5 min, 6–11 min, 11–20 min, 21–30 min and more than 30 min.[14 18] In order to assess environmental accessibility, these five time categories were collapsed into two categories: adequate accessibility (1–3 time categories, ie, up to 20 minutes) and inadequate accessibility (4–5 time categories, ie, more than 20 min). Accessibility to outdoor recreation was defined using the same approach as for destinations of daily life commodities. Further, accessibility information by public transport was included in the analysis. Access to a destination was categorised as adequate if less than thirty minutes away by this form of transportation.[18]

Microinfrastructure features

Two microscale parameters for the urban environment were examined: the structural design of the neighbourhood (inadequate or suitable to walk), and pedestrian safety (insecure or secure). The NEWS-A questions that provided more information were selected based on previous studies or urban design projects, to assess these dimensions.[18–21] To assess structural design, we evaluated the presence of slopes and/or steep climbs, obstacles that make walking difficult (barracks or rivers), roads with no way out or closed streets, short pedestrian crossings (100 m or less), presence of sidewalks and lighting.[20 21] In relation to pedestrian safety, we evaluated the space between the sidewalks and the tracks of vehicular traffic, the presence of a high flow of cars, the established speed for vehicular traffic at residential areas (50 km/hour or less), whether drivers exceed the legal speed, and the presence of traffic lights.[20 21] Each question had four possible answers as follows: totally disagree, in disagreement, in agreement or totally agree. These answers were grouped as a dichotomous variable as follows: inadequate to walk or perception of unsafety (if the participant were in partial agreement or totally agreed with the characteristics for inadequate to walk or the presence of insecurity) and suitable to walk or perception of being safe (otherwise).[18 19]

Security features

Questions from the the NEWS-A were used to assess the security of the neighbourhood and the parks. Each question had four possible answers regarding the perception of security.[14] One of the questions assessed the perception of high crime rate in the neighbourhood. The other questions evaluated the perception of insecurity during the morning and at night, independently, in the neighbourhood and in the parks. These answers were grouped in dichotomous categorical variables (totally disagree, in disagreement, in agreement or totally agree) as follows: perception of security (if they partially disagreed or totally disagreed with the presence of insecurity) or perception of insecurity (otherwise). These questions have been used in another BE studies in LA.[22] However, in this research, each question was analysed separately.

Patient and public involvement

No patient involved.

Statistical analysis

Data were analysed using RStudio program for Windows V.4.0.4. Descriptive statistics were used to summarise the baseline characteristics of the participants countries. Continuous variables are described as mean±SD, and categorical variables as counts and percentages. Pearson's χ^2 test was used to assess the association between PA categories on the distribution of baseline variables by country. Cumulative link mixed models for ordinal regression was used to assess the association between PA levels and baseline characteristic variables and with BE (microinfrastructure and security). The significance of the association is tested using likelihood ratio test accounting for clustered effect of countries and/or cities. In addition, mixed effects logistic regression was used to model the association between accessibility with binary PA level (low vs moderate/high categories) adjusted for age, sex, ethnicity, level of education and SES in the clustered data. Further, we modelled accessibility with level of PA by active transport and leisure time domains. Measures of association are presented as OR with their 95% CI. A two-tailed $p<0.05$ was considered to claim statistical significance. Two-way interactions are not found as significant. Sensitivity analysis addressing the missing data via multiple imputation gives similar results.

RESULTS

The study population for this multicentre cross-sectional analysis consisted of 9218 individuals, distributed as follows: Argentina, 13.7% (1266/9218); Brazil, 21.7% (2000/9218); Chile, 9.5% (879/9218); Peru, 12.1% (1113/9218); Colombia, 12.3% (1230/9218); Costa Rica, 8.7% (798/9218); Ecuador, 8.7% (800/9218) and Venezuela, 12.3% (1132/9218). The average age was 36±1.1 years, sex distribution showed a slight predominance of females (52.2%). Regarding the ethnic group, most participants self-identified as mestizos (46%) or whites (34.9%). The most frequent socioeconomic level was the middle status (42.8%). The majority of the sample (60.1%) reported less than 6 years of schooling. 37.1% of the study population was categorised as having a normal weight (BMI: 18.5–24.9 kg/m^2) (table 1).

PA distribution by sociodemographic variables in LA

According to the IPAQ, 5350 (58%) participants were classified as having low level of PA, 2472 (26.8%) participants

Table 1 Characteristics of the study population at baseline by country

Characteristic/countries	Argentina (n=1266)	Brazil (n=2000)	Chile (n=879)	Peru (n=1113)	Colombia (n=1230)	Costa Rica (n=798)	Ecuador (n=800)	Venezuela (n=1132)	Missing data
Age, mean±SD	37±13.9	36±13.8	36±14.2	34±13.6	37±14.6	35±13.9	34±14	35±13.8	N/A
Gender, n (%)									N/A
Female	693 (54.7)	1058 (52.9)	454 (51.6)	590 (53.0)	627 (51.0)	404 (50.6)	403 (50.3)	580 (51.2)	
Race, n (%)									465 (5.0)
Mestizo	301 (23.8)	366 (18.3)	397 (45.2)	978 (87.9)	698 (56.8)	263 (33.0)	701 (87.6)	536 (47.4)	
Indigenous	20 (1.6)	45 (2.3)	18 (2.1)	7 (0.6)	39 (3.2)	15 (1.9)	17 (2.1)	17 (1.5)	
White	859 (67.9)	797 (39.9)	279 (31.7)	96 (8.6)	290 (23.6)	394 (49.4)	39 (4.9)	462 (40.8)	
Black (Afro-American)	1 (0.1)	398 (19.9)	0 (0.0)	8 (0.7)	93 (7.6)	15 (1.9)	26 (3.3)	44 (3.9)	
Mulato	2 (0.2)	244 (12.2)	0 (0.0)	1 (0.1)	21 (1.7)	81 (10.2)	14 (1.8)	47 (4.2)	
Asian/Gypsy/others	13 (1.0)	81 (4.1)	12 (1.4)	2 (0.2)	4 (0.3)	3 (0.4)	2 (0.3)	7 (0.6)	
Socioeconomic level, n (%)									N/A
High	65 (5.1)	705 (35.3)	80 (9.1)	225 (20.2)	67 (5.5)	108 (13.5)	104 (13.0)	62 (5.5)	
Middle	585 (46.2)	1034 (51.7)	388 (44.1)	355 (31.9)	384 (31.2)	428 (53.6)	582 (72.8)	190 (16.8)	
Low	616 (48.67)	261 (13.1)	411 (46.8)	533 (47.9)	779 (63.3)	262 (32.8)	114 (14.3)	880 (77.4)	
Education, n (%)									N/A
No schooling	3 (0.2)	82 (4.1)	0 (0.0)	1 (0.1)	11 (0.9)	1 (0.1)	2 (0.3)	7 (0.6)	
Primary (≤6 years)	952 (75.2)	886 (44.3)	572 (65.1)	256 (23.0)	788 (64.1)	650 (81.5)	662 (82.8)	770 (68.0)	
Secondary or tertiary incomplete (7–12 years)	257 (20.3)	864 (43.2)	208 (23.7)	747 (67.1)	294 (23.9)	101 (12.7)	84 (10.5)	142 (12.5)	
Tertiary (≥13 years)	54 (4.3)	168 (8.4)	99 (11.3)	109 (9.8)	137 (11.1)	46 (5.8)	52 (6.5)	213 (18.8)	
BMI, n (%)									10 (0.1)
Underweight	37 (2.9)	87 (4.4)	5 (0.6)	24 (2.2)	59 (4.8)	27 (3.4)	28 (3.5)	39 (3.5)	
Normal weight	493 (38.9)	749 (37.5)	271 (30.8)	414 (37.2)	548 (44.6)	267 (33.5)	288 (36.0)	390 (34.5)	
Overweight	399 (31.5)	664 (33.2)	332 (37.8)	422 (37.9)	419 (34.1)	260 (32.56)	287 (35.9)	384 (33.9)	
Obesity	303 (23.9)	448 (22.4)	238 (27.1)	228 (20.5)	189 (15.4)	210 (26.3)	183 (22.9)	278 (24.6)	
Morbid obesity	34 (2.7)	52 (2.6)	33 (3.8)	15 (1.3)	15 (1.2)	34 (4.3)	14 (1.8)	41 (3.6)	

The BMI classification was made based on WHO specifications.
Source, Database of the eight countries participating in the ELANS project.
BMI, body mass index; IPAQ, International Physical Activity Questionnaire; N / N/A, no applicable.

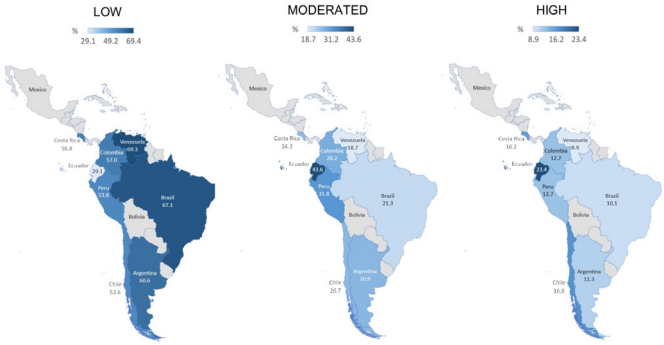

Figure 1 Country distribution of physical activity by level in eight countries in Latin America in 2015. The scale is based on the percentage of physical activity measured in 2015 through the IPAQ-long survey. Countries in grey were not included in the study. Missing data 190 (2.1%). IPAQ, International Physical Activity Questionnaire.

as having moderate level of PA and 1206 (13.1%) participants as having high level of PA (online supplemental table S1). Among LA countries, the prevalence of low-level of PA ranged from 29.1% in Ecuador to 69.4% in Venezuela, and the highest rates of PA were in Ecuador (23.4%), Chile (16.8%) and Costa Rica (16.2%). There were many similarities as well as significant heterogeneity across the countries (figure 1).

PA was inversely related to age among both men and women in the region. The age groups with the highest PA levels were adolescents (15–19 years) and young-aged adults (30–34 years) (online supplemental table S1). In Chile and Costa Rica, they represent more than the 70% of the high PA group. The group aged ≥55 years represented less than the 4% of the high PA level in Costa Rica (3.33%) and Brazil (3.38%). Further, the highest level of PA was more prevalent in males compared with females (61.4% vs 38.6%; p<0.001) (online supplemental table S1).

Regarding SES, low SES category performed less PA compared with the highest SES category (43.7% vs 15.4%; p<0.001). It is notable that people with middle SES had higher levels of moderate (44.9% vs 14%), and high (47.4% vs 18.2%) PA compared with high SES category (online supplemental table S1). Among ethnic groups, there were many differences in the PA level among countries (online supplemental tables S2-S9). Overall, in LA, people with obesity perform less PA than people with normal weight (27.3% vs 45.3%; p<0.001) (online supplemental table S1). More than 30% of people with a low level of PA were overweight (online supplemental tables S2-S9). Furthermore, in Brazil and Ecuador more than 30% of the people with a low level of PA were obese (online supplemental tables S4 and S7).

Distribution of BE-specific features in LA

Accessibility

Most of the population in LA had access to a grocery store (97.2%) and to a public transport stop (91.5%) by walking 20 min or less. The lowest rates of accessible grocery store were in Brazil (93.1%) and Venezuela (95.7%). Rates of accessible public transport stop were lowest in Venezuela (83.4%) and Brazil (89.1%). On average, 35.1% of the people were living further than twenty minutes by walking from their school or job, especially in Chile (45.6%), Argentina (41.9%) and Venezuela (41.2%). 50.6% of people had an accessible gym or sport centre; Argentina had the highest rate (62%) and Venezuela the lowest (38.2%) (table 2).

Among LA countries, the access rates to recreational facilities such as metropolitan parks and children's playgrounds were 49.2% and 81.6%, respectively. Metropolitan parks were more accessible in Ecuador (59.8%) and Colombia (59.2%) than in Venezuela (33.5%). Chile had the highest rate of accessibility to children's playgrounds (98.2%) and Venezuela had the lowest (62.8%) (table 2). Table 3 shows that individuals located at less than 20 min of walking for sport facilities had higher odds of performing moderate/high PA, OR 1.20 (95% CI 1.06 to 1.36). Likewise, people within 20 min walking distance of children's playground performed 25% more moderate/vigorous PA, than individuals living at >20 min walking distance or <30 min by public transportation.

Further, no evidence was found for association between accessibility to different destinations and level of PA in active transport or leisure time domains (online supplemental tables S10 and S11).

Microinfrastructure

Across LA, 14.5% of the population considered that their neighbourhood had an adequate design for walking or cycling, and 85.5% considered that there were many steep slopes, obstacles in the sidewalks, dead ends and large intersections. Furthermore, there was little illumination at night and a lack of sidewalks. The countries with the highest prevalence for inadequacy to walk were Brazil (91.5%) and Ecuador (90.3%) (figure 2A). Regarding the perception of pedestrian safety due to microinfrastructure features, only 3.1% of the population considered their area as secure. The country with the highest prevalence of perceived pedestrian safety was Chile 7.5% compared with the lowest pedestrian safety rate observed in Venezuela (1.2%) (figure 2B).

Security

Among adults living in LA, 39.75% had the perception of living in a safe neighbourhood. The highest perception of crime safety was found in Chile (61.7%) and the lowest in Venezuela (24.7%). People felt more secure during morning than at night-time, 60.1% vs 31.9%, respectively. This same trend was seen with perceived safety at recreational facilities. The countries with the lowest perception of safety at recreational places at night are Venezuela (15.9%), Argentina (23.2%) and Brazil (25.8%) (table 4). The aspect of safety feature most strongly associated with moderate to high PA levels was the perception of a safe neighbourhood during the morning time (p<0.05).

Table 2 Accessibility to main daily destinations and to outdoor recreation by country

Accessibility/country	General (n=9218)	Argentina (n=1266)	Brazil (n=2000)	Chile (n=879)	Peru (n=1113)	Colombia (n=1230)	Costa Rica (n=798)	Ecuador (n=800)	Venezuela (n=1132)
Walking to main daily destinations									
1–20 min, n (%)									
Food cellar/neighbourhood store/supermarket/butcher shop	8960 (97.2)	1246 (98.4)	1862 (93.1)	873 (99.3)	1098 (98.7)	1216 (98.9)	786 (98.5)	795 (99.4)	1084 (95.8)
Your school or job	2993 (32.5)	409 (32.3)	674 (33.7)	197 (22.4)	398 (35.8)	487 (39.6)	286 (35.8)	252 (31.5)	290 (25.6)
Public transport stop	8432 (91.5)	1177 (93.0)	1782 (89.1)	839 (95.5)	1043 (93.7)	1133 (92.1)	737 (92.4)	776 (97.0)	945 (83.5)
Gym or sports facilities	4666 (50.6)	785 (62.0)	956 (47.8)	460 (52.3)	427 (38.4)	744 (60.5)	440 (55.1)	422 (52.8)	432 (38.2)
>20 min, n (%)									
Food cellar/neighbourhood store/supermarket/butcher shop	197 (2.1)	11 (0.9)	119 (6.0)	3 (0.3)	10 (0.9)	9 (0.7)	3 (0.4)	5 (0.6)	37 (3.3)
Your school or job	3237 (35.1)	531 (41.9)	649 (32.5)	401 (45.6)	319 (28.7)	404 (32.9)	215 (26.9	252 (31.5)	466 (41.2)
Public transport stop	421 (4.6)	45 (3.6)	105 (5.3)	33 (3.8)	42 (3.8)	60 (4.9)	24 (3.0)	15 (1.9)	97 (8.6)
Gym or sports facilities	1783 (19.3)	171 (13.5)	328 (16.4)	220 (25.0)	229 (20.6)	186 (15.1)	155 (19.4)	145 (18.1)	349 (30.8)
To outdoor recreation centres									
1–20 min walking or <30 min by public transportation, n (%)									
Metropolitan park	4534 (49.2)	711 (56.2)	732 (36.6)	423 (48.1)	617 (55.4)	728 (59.2)	465 (58.3)	478 (59.8)	380 (33.6)
Small playground for children	7521 (81.6)	1045 (82.5)	1376 (68.8)	863 (98.2)	958 (86.1)	1076 (87.5)	745 (93.4)	747 (93.4)	711 (62.8)
>20 min walking or >30 min by public transportation, n (%)									
Metropolitan park	4123 (44.7)	509 (40.2)	1214 (60.7)	411 (46.8)	307 (27.6)	470 (38.2)	250 (31.3)	303 (37.9)	659 (58.2)
Small playground for children	1431 (15.5)	188 (14.9)	545 (27.3)	15 (1.7)	134 (12.0)	113 (9.2)	36 (4.5)	49 (6.1)	351 (31.0)

Source, database of the eight countries participating in the ELANS project.
ELANS, Latin American Study of Nutrition and Health.

Table 3 Association between accessibility to different destinations and level of physical activity (moderate/high vs low) in LAC countries†‡§

Walking accessibility to main daily destinations	N (%)	Unadjusted OR (95% CI)	Adjusted OR (95% CI)
Food cellar/neighbourhood store/supermarket/butcher shop			
>20 min	18 (0.2)	1.00¶	1.00¶
1–20 min	8491 (99.8)	1.33 (0.46 to 3.82)	1.42 (0.48 to 4.20)
Your school or job			
>20 min	3011 (51.9)	1.00¶	1.00¶
1–20 min	2796 (48.1)	1.00 (0.90 to 1.12)	1.05 (0.94 to 1.17)
Public transport stop			
>20 min	381 (4.6)	1.00¶	1.00¶
1–20 min	7854 (95.4)	1.08 (0.86 to 1.36)	1.05 (0.84 to 1.32)
Gym or sports facilities			
>20 min	1642 (27.4)	1.00¶	1.00¶
1–20 min	4357 (72.6)	1.22 (1.07 to 1.38)*	1.20 (1.06 to 1.36)*
Accessibility to outdoor recreation centres			
Metropolitan park			
>20 min walking or >30 min by public transportation	1790 (25.0)	1.00¶	1.00¶
1–20 min walking or <30 min by public transportation	5381 (75.0)	0.98 (0.87 to 1.11)	0.96 (0.85 to 1.08)
Small playground for children			
>20 min walking or >30 min by public transportation	573 (7.1)	1.00¶	1.00¶
1–20 min walking or <30 min by public transportation	7488 (92.9)	1.30 (1.06 to 1.59)*	1.25 (1.02 to 1.53)*

*P<0.05; **p<0.01; ***p<0.001.
†The dependent variable is the level of moderate/high vs low physical activity, and the independent variable is accessibility by walking between 1 and 20 min and accessibility by walking in >20 min for daily living destinations. For outdoor recreation centres the independent variable is accessibility by walking between 1 and 20 min or <30 min by public transport and accessibility by walking in >20 min or >30 min by public transport.
‡P <0.05 was considered statistically significant. All models are adjusted for age, sex, ethnicity, level of education, socioeconomic status and BMI.
§Participants who did not have information on their level of physical activity were excluded from the analysis (n=190).
¶Reference group.
.BMI, body mass index; LAC, Latin America and Caribbean.

DISCUSSION

Results of this study highlight the impact of the BE on PA in eight countries in LA. Overall, low PA was the most prevalent category (58%) in the region. Men had higher rates of PA than women, and younger populations had a higher level of PA than older populations. Among the individual BE dimensions examined, we found that individuals located within 20 min walking distance of sport and children's playground facilities were more likely to perform more moderate/vigorous PA than other common daily destinations. Most of the population across the region considered there neighbourhood inadequate, poorly accessible and unsafe for PA. Only 39.7% of the population in the region had the perception of living in a safe neighbourhood. These results provide insight into the heterogeneities in PA levels and the interaction of PA levels with the BE (accessibility, microinfrastructure and security) across the LA region and emphasise country-specific priorities for public health policy and urban planning that would be expected to increase PA and prevent the development of diseases linked to low levels of PA.

Comparison with other studies

Consistent with the literature, this research found that the LA population performed low levels of PA, with the lowest levels found among women and aged adults.[3 23 24] There are several possible explanations for these results. First, during the last decade LA has achieved significant economic growth,[25] resulting in an increased population purchasing power and accelerating the transition towards more sedentary occupations and personal motorised transportation.[3] Second, nearly 80% of the population in LA countries lives in cities and a large percentage of this population resides in poorly developed areas with high rates of crime and violence.[23] Third, cultural norms, traditional roles and lack of social and community support could explain the finding that women engage in

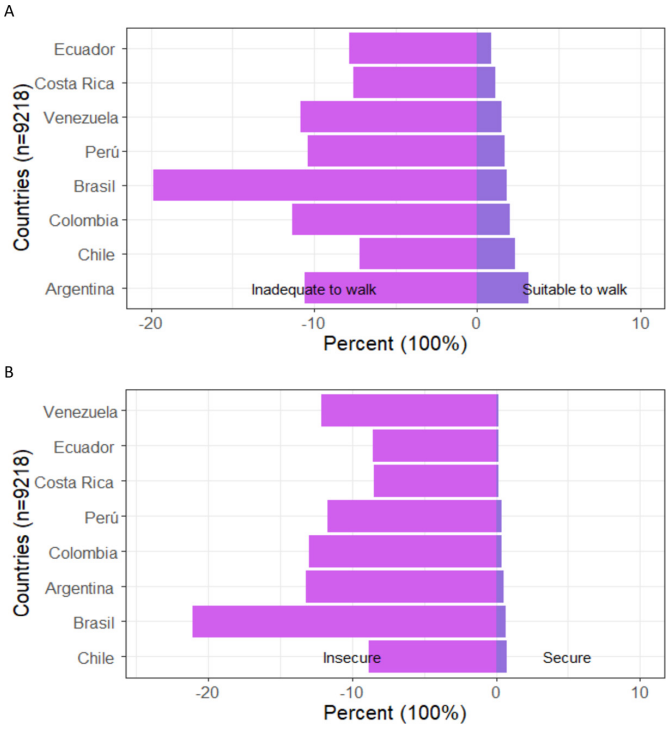

Figure 2 National distributions of the infrastructure features of the urban environment in eight countries in Latin America and Caribbean. (A) shows the distribution of the urban environment by the structural design of the neighbourhood and (B) shows the distribution of the urban environment by pedestrian safety.

leisure PA less than men.[3] Fourthly, health-related issues could explain the higher prevalence of low PA among aged adults. As people get older, they are less motivated to improve their health by activities such as performing PA.[26]

This study advances current understanding of the impact of BE on PA among LA countries in several ways. We present country-specific distributions of PA according to three BE domains (accessibility, microinfrastructure and security). Previous literature on the association of BE and PA in the region provided information on only the domain of accessibility.[6] This research provides estimates using country-level data from eight LA countries; previous research analysed only three Latin American cities (Curitiba, Brazil; Bogotá, Colombia; and Cuernavaca, Mexico).[6 27] Further, this study estimates accessibility to different living commodities using a walking time metric while a prior study solely allocated ranks to the most frequently reported places for PA.[27]

In spite of some methodological differences with a prior study,[27] our findings are consistent with results of Salvo *et al*: individuals with higher access to public-access places for PA are more likely to performed moderate-to vigorous-intensity PA (MVPA). Studies assessing infrastructure (accessibility and safety) of the LA BE and its impact on PA levels among adults appear non-existent. A study conducted in Curitiba (Brazil) using the 'walkability index' as a proxy for this domain showed positive

Table 4 Perception of security of the neighbourhood and parks by country

Security/country	General (n=9218)	Argentina (n=1266)	Brazil (n=2000)	Chile (n=879)	Peru (n=1113)	Colombia (n=1230)	Costa Rica (n=798)	Ecuador (n=800)	Venezuela (n=1132)
Safe neighbourhood perception, n (%)	3664 (39.8)	406 (32.1)	653 (32.7)	542 (61.7)	561 (50.4)	527 (42.9)	346 (43.4)	350 (43.8)	279 (24.7)
Perception of safe neighbourhood in the morning, n (%)	5535 (60.1)	640 (50.6)	1030 (51.5)	715 (81.3)	856 (76.9)	777 (63.2)	532 (66.7)	546 (68.3)	439 (38.8)
Perception of safe neighbourhood at night, n (%)	2943 (31.9)	305 (24.1)	527 (26.4)	423 (48.1)	471 (42.3)	498 (40.5)	257 (32.2)	269 (33.6)	193 (17.1)
Perception of security in parks, public squares, green areas and neighbourhood recreation sites in the morning, n (%)	5497 (59.6)	643 (50.8)	1031 (51.6)	689 (78.4)	855 (76.8)	795 (64.6)	521 (65.3)	531 (66.4)	432 (38.2)
Perception of security in parks, public squares, green areas and neighbourhood recreation sites at night, n (%)	2867 (31.1)	294 (23.2)	516 (25.8)	384 (43.7)	472 (42.4)	498 (40.5)	239 30.0)	284 (35.5)	180 (15.9)

Source, database of the eight countries participating in the ELANS project.
ELANS, Latin American Study of Nutrition and Health.

associations between commuting walking and leisure-time MVPA and infrastructure.[27] However, our findings of poor accessibility and relative lack of safe infrastructure in the region have been reported in other regions such as South-east Asia and Africa.[27] Hence, in most developing countries, pedestrians are the most vulnerable to accidents among road users.[27] Surprisingly, no association was found between accessibility to different destinations and level of PA using active transport and leisure time domains as other studies conducted in the USA or Europe.[28] A possible explanation for this might be due to the inherent LA's characteristics. For instance, LA region has high population density, disorganised traffic and transportation, and high air pollution. Further, this region posses a high-income inequality which translates in high levels of poverty and crime rate.[29 30]

Sixty per cent of the population in the region have the perception of living in an unsafe neighbourhood due to interpersonal violence and crime.[31] Literature reports that 33% of the world's homicides occur in LA, often as part of everyday violence on suburban street corners.[31 32] Thus, in addition to poor microinfrastructure, the unsafe environment helps to explain the low levels of PA found in the region. A study in England reported that a fall in the crime rate from the 75th to the 25th percentile would lead to an average 10 min increase in walking.[33]

We found heterogeneities in the build environment domains among the evaluated countries. Venezuela is the country with the lowest rate of accessibility, microinfrastructure and perception of safety at recreational places. Currently, Venezuela is one of the most violent countries in the world with a homicide rate of 61.9 per 100 000 people.[33] This could explain our finding that it is the country in the region with the highest rate of low level of PA. On the other hand, Ecuador and Chile obtained the highest rates of vigorous PA, 23.4% and 16.8%, respectively. In the case of Ecuador, this finding is difficult to explain as there have been no policy evaluations studies in the country. By comparison, in Chile a comprehensive policy to develop PA was implemented at the end of 1999 and embedded in the country's general health promotion policy.[34] Strategies in Chile's policy include preparing printed guidelines to perform PA, mass media education, establishing regulatory measures, conducting research, reclaiming public spaces for recreation and implementing incentives for PA in the workplace.[34] Another successful example of promoting PA comes from Colombia. In an effort to increase accessibility to public parks and PA among its population, Colombia implemented 'The Ciclovía-Recreativa' programme across the country.[35] Evidence shows that this programme has contributed substantially to meeting PA guidelines and improving quality of life among the Colombian population.[23 35]

Strengths and limitations

Our investigation has several strengths. To our knowledge, this is the first study to report detailed country-BE domains (accessibility, microinfrastructure and security) and to assess their association with PA in countries in LA. We used comprehensive and consistent metrics regarding healthy urban environments proposed by the WHO to assess the BE.[36 37] Further, ELANS uses a common protocol which ensures valid comparisons can be made across the eight participating countries.[20] The current work uses best practice analysis to accommodate the clustering effect of countries and/or cities. Limitations of the current work must also be considered. The most important limitation of this study is inherent to its cross-sectional design, which does not allow to claim causality. However, recent evidence in the form of longitudinal data and natural experiments evaluations were generally consistent with cross-sectional results.[28 38] The IPAQ and parts of the NEWS-A instruments capture self-reported data so the risk of recall bias cannot be discounted. Nevertheless, the IPAQ instrument has been widely used and adapted previously in LA populations.[23 39 40] NEWS-A scale has previously been validated as an alternative method of assessment of BE.[15] Our estimates did not include children or the elderly; future efforts should include these groups to assess the impact of BE and PA in the younger groups and in the rapidly expanding elderly population. Furthermore, we do not evaluate the potential effect modification action by country. Future studies should take this into account to better inform policies in LA.

Implications of the findings

This study has important implications for the region in relation to the United Nations' Sustainable Development goals (SDGs), UN-habitat-3 and the WHOs initiative for accessible and safe cities.[41] Specifically, our findings support the need to push forward national policies to make cities inclusive and safe (SDG 11).[42] In addition, having a BE that promotes PA would assist with the goal of healthy lives and well-being for all at all ages (SDG 3).[42] Some of the benefits of having a suitable BE include lower cardiovascular disease and stroke mortality; less stress with better mental health[41 43]; better cognitive development in children; prevention of non-communicable diseases and better mobility and health in the elderly.[44 45] In light of our results, policies and interventions are needed, at regional and national levels, to encourage non-motorised transportation, such as walking and cycling, and to promote participation in active recreation and sports in leisure time.[3 34 41] Currently, policy evaluations and longitudinal studies regarding BE and its impact on PA in the region are largely absent. Further research is needed to fill these gaps in knowledge, with the aim of reducing the development of diseases linked to low levels of PA.

CONCLUSION

In summary, we assessed the impact of BE on PA in eight LA countries. The results highlight, at both national and regional levels, patterns and heterogeneities in PA level related to accessibility, microinfrastructure and security

domains. Individuals located within 20 min of walking from sport facilities and children's playground are more likely to perform moderate/high PA. In addition, most of the population studied considered the infrastructure areas to be poorly accessible and unsafe for PA. Our findings provide the rationale to push forward national policies, which will help to achieve a safe, healthy and friendly BE in the region.

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