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Perceived neighborhood built environment and physical activity in urban population in Chile

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Abstract

Background Various indicators of neighborhood environmental perceptions are differently associated with physical activity (PA) domains, with notable variations by sex. However, few studies in Latin America have examined these associations across distinct PA domains. In this study, we analyzed the relationship between neighborhood environmental perceptions and PA in the domains of transportation and leisure among Chilean adults.

Methods This cross-sectional analytical study included 770 participants from the 2014–2016 Latin American Nutrition and Health Survey (ELANS). Perceptions of land use diversity, access to land use, street connectivity, walking and cycling infrastructure, aesthetics, safety from crime, and neighborhood traffic were assessed using the Neighborhood Environment Walkability Scale-Abbreviated (NEWS-A) questionnaire. PA was measured with the International Physical Activity Questionnaire-Long Form (IPAQ-LF), focusing on the transportation and leisure-time domains. Logistic regression and multiple linear regression models were used for the analysis.

Results Logistic regression analysis in men showed no association between neighborhood characteristics and PA in the transportation or leisure-time domains. However, for women, greater perception of facilities for walking or cycling was inversely associated with transportation PA (OR: 0.62; 95%CI: 0.42;0.92). In the multiple linear regression analysis, higher perceived traffic safety was associated with greater PA (min/week) for both transportation (β: 0.098; 95%CI: 0.005;0.192) and leisure time (β: 0.160, 95%CI: 0.012;0.309). For men, higher scores for perceived access to land use were inversely associated with leisure-time PA (β: -0.150, 95%CI: -0.266;-0.034).

Conclusions Different perceived neighborhood characteristics are associated with PA across various domains, with notable gender differences. A better perceived condition of traffic safety would promote urban population to engage in more transportation and leisure-time PA.

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Keywords Neighborhood perception, Physical activity, Built environment, Active transportation, Gender, Chile

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Background

With the growth of urban populations, interest is increasing in understanding new forms of interaction between individuals and their environments, including physical activity (PA) - the focus of this study. According to the World Health Organization (WHO), environmental factors linked to urban development, such as safety, traffic, pollution, and access to parks for recreation and sports, significantly influence decisions related to engaging in PA [1].

According to the WHO, insufficient PA is the fourth leading risk factor for mortality globally, with 1 in 4 adults not achieving adequate activity levels, making it a significant public health concern. As part of the 2030 agenda, a 15% reduction in insufficient PA has been targeted [2]. In 2020, new PA guidelines were introduced, defining an adult as physically active if they engage in at least 150 min of moderate to vigorous PA per week or reach an equivalent of at least 600 METs/min/week. Importantly, all movement now counts as PA, with no minimum duration requirement for activity sessions [3].

A global study analyzed data from 168 countries, examining the prevalence of insufficient PA - defined as less than 150 min of moderate or 75 min of vigorous PA per week or a combination of both—across various domains, including home, work, transportation, and leisure. Using multiple linear regression models to standardize survey data and multilevel mixed-effects models to estimate trends over time, the global prevalence of insufficient PA was estimated at 27.5% among adults [4]. In Chile, the latest National Health Survey (ENS 2016–2017) reported a physical inactivity prevalence of 35.1% among those over 15 years, with rates higher among women than men (38.8% vs. 23.6%) [5]. Additionally, recent research shows that regular leisure-time PA is associated with a 24% reduced risk of all-cause mortality in women and a 15% reduced risk in men compared to physical inactivity [6].

Previous studies on urban development and PA have been conducted globally and in Chile, though few have examined PA from the perspective of residents' neighborhood perceptions as this study does [7–10]. Globally, studies have shown that walkable environments, access to parks and green spaces, and factors such as safety and infrastructure are positively associated with higher PA levels [7, 8]. For instance, a study conducted in the United Kingdom found that PA levels were higher in environments with greater walkability, lower air pollution, greener neighborhoods, and certain sociodemographic characteristics, such as living in rural areas [8]. However, these findings may not fully apply to the Latin American context, where socioeconomic disparities, urban infrastructure, and cultural norms create unique challenges and opportunities. Moreover, research using data from Latin American countries remains limited compared to studies from North America and Europe, underscoring the need for region-specific investigations [7]. A transportation and health study in three Latin American cities found that changes in transportation systems could foster active transportation, highlighting the need for public health systems to play a more active role in transportation planning across Latin America [11]. In 2017, research on active transportation in Latin America revealed significant variability in its prevalence among cities [12]. Recently, the "Latin American Nutrition and Health Study" (ELANS) project explored the perceived environment and PA, finding results that varied by country and gender. ELANS suggested that improving neighborhood perception could support efforts to promote active transportation among Latin Americans [13, 14].

In Chile, infrastructure that supports PA is underdeveloped, influenced by rapid real estate expansion, individual transportation trends, geographical constraints, safety levels, and other factors. However, road culture has shifted in recent years, partly driven by growing environmental awareness in the country [15, 16]. This study aimed to analyze the association between neighborhood environmental perceptions and PA levels in a representative sample of urban adults in Chile.

Methods

Study design and sample

The ELANS study is a multicenter, household-based, cross-sectional survey conducted between 2014 and 2015. It collected data on energy intake, PA, and their relationship with anthropometric profiles in nationally representative samples of urban populations aged 15 to 65 years across Argentina, Brazil, Chile, Colombia, Costa Rica, Ecuador, Peru, and Venezuela [17]. All participants provided informed consent, and the study excluded individuals under 15 or over 65 years, pregnant or breastfeeding women, individuals with physical or mental impairments affecting diet or PA, adolescents lacking parental or guardian consent, those in non-home environments, and those unable to read.

During the first visit, participants were identified, informed consent was obtained, and they completed a sociodemographic questionnaire, a 24-hour dietary recall, and anthropometric measurements. At the second visit, they completed another 24-hour dietary recall, the International Physical Activity Questionnaire-Long Form (IPAQ-LF), and a meal frequency questionnaire. The ELANS protocol was approved by the Western Institutional Review Board (#20140605) and is registered at ClinicalTrials.gov (#NCT02226627). Additionally, the Research Ethics Committee at Pontificia Universidad Católica de Chile approved the ELANS Protocol applied in Chile (ELANS-Chile), and the Ethics Committee of the Faculty of Social Sciences at Pontificia Universidad

Católica de Chile approved the ELANS-Chile project (#14–179). The research has been performed in accordance with the Declaration of Helsinki.

The ELANS study is a descriptive, multicenter, cross-sectional study based on representative samples from urban populations in eight Latin American countries. The study used a complex, multistage sampling design, stratified by age, sex, and socioeconomic level. The present study, based on a cross-sectional analytical design, specifically utilized the ELANS-Chile sample, which included 770 adults with complete and valid data from regions such as Antofagasta, Valparaíso, Metropolitan, Maule, Biobío, Araucanía, and Los Lagos. Adolescents were excluded as the study focuses on adults, and the WHO's PA recommendations differ for adolescents and adults.

Perceived neighborhood built environment.

As shown in Table 1, the perception of neighborhood built environment characteristics was assessed using the Neighborhood Environment Walkability Survey - Abbreviated (NEWS-A) [18]. This tool includes 54 questions organized into seven categories: land use mix diversity, land use access, street connectivity, walking and cycling facilities, aesthetics, traffic safety, and crime. The land use diversity scale measures perceived walking proximity from home to 23 destinations, with responses ranging from 1 to 5 min (coded as 5, indicating high walkability) to over 30 min (coded as 1, indicating low walkability). The other six scales are average scores of items rated on a 4-point Likert scale (1 = "strongly disagree" to 4 = "strongly agree"). The scales are rated to reflect higher walkability and safety, with item reversals where necessary. This scale has been validated both in Chile and internationally [18, 19]. The reliability and validity of the NEWS-A have been documented in several countries, with all included scales showing intraclass reliability correlations greater than 0.50, as measured by Cronbach's alpha [20, 21].

Physical activity

PA was subjectively assessed using the self-reported version of the "International Physical Activity Questionnaire - Long Form" (IPAQ-LF) in its Spanish adaptation for the transportation and leisure time domains, completed during the participant's first home visit [22, 23]. Scores were calculated per the IPAQ-LF scoring system, which includes questions on frequency and duration (in intervals greater than 10 min) of PA in both transportation and leisure time [24]. PA was reported in IPAQ as minutes per day (min/day) for walking and moderate/vigorous PA in leisure time, as well as walking and cycling PA for transportation. For this study, total PA time (min/week) was estimated separately for each domain (transportation and leisure time) and analyzed accordingly. Additional details on PA assessment using the ELANS survey have been published previously [25].

An international study found IPAQ to have reliability and validity comparable to other self-reported PA assessment methods [22]. Evidence suggests an acceptable level of reliability and validity for the IPAQ items on transportation and leisure time PA, with reported correlations between 0.42 and 0.75 [26, 27].

Sociodemographic variables

Table 2 provides sociodemographic data, including age range (18 to 65 years) and sex, collected through standardized questionnaires. Educational level was categorized as elementary, high school, or college, based on questionnaire responses. Body mass index (BMI) was calculated using the formula weight (kg)/height (m^2) and classified into categories: underweight, normal weight, overweight, obese, and morbidly obese [17].

Statistical analysis

Statistical analyses were conducted using SPSS V22 software (SPSS Inc., IBM Corp., Armonk, New York, NY, USA). Descriptive statistics, including median, mean, standard deviation (SD), frequency, and percentage, were calculated to characterize the variables. The proportion of participants meeting WHO PA guidelines (a minimum of 150 min of moderate-to-vigorous PA per week, equivalent to 600 MET/min/week) in both transportation and leisure-time PA was estimated.

To examine the association between neighborhood environmental characteristics, as assessed by the NEWS-A, and PA categories, we applied two different regression models, adjusting for potential confounders such as age, BMI, and educational level. These methods have been utilized in previous ELANS studies [13, 14]. In logistic regression models, odds ratios (OR) with 95% confidence intervals were calculated by dichotomizing PA into physically active and inactive categories. In linear regression models, unstandardized β coefficients, standard error and confidence intervals were determined using the logarithmic transformation (log10) of non-zero PA values. A p-value of < 0.05 was considered statistically significant, representing a 95% confidence interval.

Results

The analysis was conducted using four explanatory models, stratified by sex (men and women) and PA domain (transportation and leisure time), to account for differences in PA levels between sexes [4]. Of the 879 participants in ELANS-Chile, complete data were available for 835 participants (a 5% data loss), with 770 adults included in this analysis. Table 2 shows that 52.7% of the sample were women, with a mean age of 38.1 years (SD: 13.4). Approximately 62.2% of the sample had a basic

Table 1 Summary of environmental scales, items and Cronbach's alpha

Scale	Items	Response Category	Cronbach's alpha
Land use mix-diversity (mean of 23 items– the higher the score, the higher the diversity)	About how long would it take to get from your home to the nearest businesses or facilities listed below if you walked to them? Items: convenience/small grocery store, supermarket, blacksmith, fruit/vegetable market, laundry/dry cleaners, clothing store, post office, library, university/school, other educational centers, book store, fast food restaurant or street food, bakery/coffee shop, bank, non-fast food restaurant, video store, pharmacy/drug store, salon/barber shop, your job or school, public transport stop, park or square, gym or fitness facility	5-point scale: 5 min (5), 6–10 min (4), 11–20 min (3), 20–30 min (2), 30 + min (1)	0.934
Land use mix-access (mean of 5 items)	Stores are within easy walking distance of my home. It is easy to walk to a transit stop (bus, train) from my home. There are many places to go within easy walking distance of my home. The streets in my neighborhood are hilly, making my neighborhood difficult to walk in (reversed). There are major barriers to walking in my local area that make it hard to get from place to place (for example, freeways, railway lines, rivers) (reversed).	4-point scale: strongly disagree (1), disagree (2), agree (3), strongly agree (4)	0.693
Street connectivity (mean of 3 items)	The streets in my neighborhood do not have many cul-de-sacs (dead-end streets). The distance between intersections in my neighborhood is usually short (100 yards or less; the length of a football field or less). There are many alternative routes for getting from place to place in my neighborhood. (I don't have to go the same way every time).	4-point scale: strongly disagree (1), disagree (2), agree (3), strongly agree (4)	0.432
Walking/cycling facilities (mean of 3 items)	There are sidewalks on most of the streets in my neighborhood. Sidewalks are separated from the road/traffic in my neighborhood by parked cars. There is a grass/dirt strip that separates the streets from the sidewalks in my neighborhood.	4-point scale: strongly disagree (1), disagree (2), agree (3), strongly agree (4)	0.614
Aesthetics (mean of 4 items)	There are trees along the streets in my neighborhood. There are many interesting things to look at while walking in my neighborhood. There are many attractive natural sights in my neighborhood (such as landscaping, views). There are attractive buildings/homes in my neighborhood.	4-point scale: strongly disagree (1), disagree (2), agree (3), strongly agree (4)	0.803
Safety from traffic (mean of 4 items)	There is so much traffic along nearby streets that it makes it difficult or unpleasant to walk in my neighborhood (reversed). The speed of traffic on most nearby streets is usually slow (50 km/h or less) Most drivers exceed the posted speed limits while driving in my neighborhood (reversed) There are crosswalks and pedestrian signals to help walkers cross busy streets in my neighborhood.	4-point scale: strongly disagree (1), disagree (2), agree (3), strongly agree (4)	0.191
Safety from crime (mean of 7 items)	My neighborhood streets are well lit at night. Walkers and bikers on the streets in my neighborhood can be easily seen by people in their homes. There is a high crime rate in my neighborhood (reversed). The crime rate in my neighborhood makes it unsafe to go on walks during the day (reversed). The crime rate in my neighborhood makes it unsafe to go on walks at night (reversed). The parks, public squares, green areas and recreation areas in my neighborhood are unsafe during the day (reversed).* The parks, public squares, green areas and recreation areas in my neighborhood are unsafe at night (reversed).*	4-point scale: strongly disagree (1), disagree (2), agree (3), strongly agree (4)	0.805
Proximity of public open spaces* (mean of 3 items)	How long, approximately, does it take you to walk from your home to the following types of public open spaces: metropolitan parks (large, with many green areas), playgrounds, public squares.	5-point scale: 5 min (1), 6–10 min (2), 11–20 min (3), 20–30 min (4), 30 + min (5)	0.695
Proximity of shopping centers* (1 item)	How long, approximately, does it take you to walk from your home to shopping centers?	5-point scale: 5 min (1), 6–10 min (2), 11–20 min (3), 20–30 min (4), 30 + min (5)	-

* items not in the NEWS-A scale

Table 2 Demographic characteristics and physical activity (PA) of participants

Variables	Overall (*n*)	Antofagasta	Valparaíso	Metropolitan	Maule	Biobío	Araucanía	Los Lagos
Sample size (n)	770	28	101	382	45	118	56	40
Age, mean (SD)	38.1 (13.4)	39.3 (12.7)	38.0 (13.1)	37.2 (13.4)	37.0 (13.2)	41.0 (13.1)	36.6 (12.3)	38.9 (11.8)
Sex (%)								
Men	47.2	46.4	50.5	45.5	53.3	49.2	42.9	50
Women	52.7	53.6	49.5	54.5	46.7	50.8	57.1	50
Education level (%)								
Basic	62.2	67.9	69.3	62	62.2	60.2	53.6	60
Secundary complete	25.2	32.1	17.8	24.9	22.2	28	28.6	32.5
Universitary complete	12.6	0	12.9	13.1	15.6	11.9	17.9	7.5
BMI, mean (SD)	28.5 (5.5)	29.9 (5.5)	27.2 (4.2)	28.7 (5.8)	28.3 (5.7)	28.7 (5.1)	28.3 (5.6)	29.1 (5.3)
Physical activity, median								
Transport (min/week)	264.0	57.8	198.0	330.0	346.5	239.3	462.0	247.5
Leisure (min/week)	90.0	10.0	49.5	225.5	15.0	297.0	12.0	10.0

SD: standard deviation; PA: physical activity

Table 3 Overall and city-specific perceived-environment scores

	Overall	Antofagasta	Valparaíso	Metropolitan	Maule	Biobío	Araucanía	Los Lagos
Sample size	770	28	101	382	45	118	56	40
Land use mix-diversity[1] (score 1–5)	2.6 (0.6)	2.3 (0.3)	2.2 (0.4)	2.7 (0.5)	2.5 (0.8)	2.6 (0.5)	2.8 (0.9)	2.6 (0.6)
Land use mix-access (score 1–4)	3.2 (0.4)	2.8 (0.4)	3.1 (0.4)	3.2 (0.4)	3.0 (0.8)	3.5 (0.3)	2.9 (0.5)	2.8 (0.4)
Street connectivity[2] (score 1–4)	2.9 (0.7)	2.6 (0.5)	2.7 (0.8)	3.0 (0.6)	2.6 (0.6)	3.3 (0.7)	2.8 (0.6)	2.9 (0.6)
Walking/cycling facilities (score 1–4)	3.2 (0.6)	2.9 (0.5)	3.3 (0.5)	3.3 (0.6)	3.1 (0.7)	3.3 (0.6)	3.3 (0.9)	3.0 (0.5)
Aesthetics (score 1–4)	2.9 (0.8)	1.9 (0.8)	3.1 (0.9)	2.9 (0.7)	3.0 (0.7)	2.8 (0.8)	2.8 (0.8)	2.8 (0.4)
Safety from traffic[2] (score 1–4)	2.5 (0.5)	2.5 (0.2)	2.2 (0.8)	2.5 (0.4)	2.7 (0.4)	2.5 (0.6)	2.3 (0.4)	2.6 (0.3)
Safety from crime (score 1–4)	2.8 (0.6)	2.3 (0.5)	3.2 (0.7)	2.8 (0.6)	3.1 (0.5)	2.9 (0.6)	2.7 (0.5)	2.7 (0.5)

Results presented as mean (standard deviation)

[1] 5-point scale: 5 min (1), 6–10 min (2), 11–20 min (3), 20–30 min (4), 30 + min (5)

[2] 4-point scale: strongly disagree (1), disagree (2), agree (3), strongly agree (4)

educational level, with similar distributions across the regions studied. Regarding BMI, mean values and standard deviations were presented, with a national average of 28.5 kg/m² (SD: 5.5), showing comparable trends across regions. PA data were reported as median for both transportation and leisure-time domains, with values of 264.0 min/week for transportation and 90 min/week for leisure time across the full sample.

The overall average score of land use mix – diversity (5-point scale from 1 to 5; higher scores reflect more diversity) was 2.6. The overall scores were 3.2 for land use mix – access, 2.9 for street connectivity, 3.2 for walking/cycling facilities, 2.9 for aesthetics, 2.5 for safety from traffic, and 2.8 for safety from crime (4-point scales from 1 to 4; higher scores reflect more activity friendliness) (Table 3).

A multivariate logistic regression model was used to analyze the association between neighborhood characteristics evaluated in the NEWS-A survey and total PA level (including transport and leisure time), adjusted for age, BMI, and educational level for both men and women. Additionally, the relationship between neighborhood variables and PA was explored using a linear regression model with a log10 transformation.

Table 4 presents the results of the multivariate logistic regression model for PA in the transportation domain among men and women (walking or bicycling as transportation), adjusted for age, BMI, and educational level. In this domain, for men, none of the NEWS-A categories was significantly associated with PA level. For women, the logistic regression model revealed that the category related to walking and/or cycling facilities was inversely associated with the likelihood of being physically active in the transportation domain (OR: 0.62, 95%CI: 0.42;0.92). Additionally, multiple linear regression analysis indicated that participants who reported higher perceived safety in traffic (β: 0.098, 95% CI: 0.005;0.192) also reported greater transportation-related PA (min/week).

Table 5 presents the results of the multivariate logistic regression model for PA in the leisure-time domain, which includes leisure-time walking, moderate PA, and vigorous PA. For men, none of the NEWS-A categories were significantly associated with the likelihood of being physically active. In the linear regression model, however, higher perceived street connectedness was linked to lower reported PA during leisure time (β: -0.150, 95% CI: -0.266;-0.034). For women, the different categories of NEWS-A did not correlate with a greater chance of being

Table 4 Regression models for transport-related physical activity

	Logistic Regression[(1)] Any transport-related PA (0 = < 600 MET/min/week, 1 ≥ 600/MET/min/week)		**Linear Regression[(2)] Non-zero reported transport-related PA LOG10 (min/week)**		
Independent variables	**OR (95%CI)**	***p***	**β (95%CI)**	**SE**	***p***
MEN					
Land use mix-diversity (score 1–5) [(3)]	1.16 (0.78–1.72)	0.46	-0.016 (-0.124-0.092)	0.03	0.772
Land use mix-access (score 1–4) [(3)]	0.81 (0.47–1.37)	0.43	0.021 (-0.128-0.171)	0.05	0.781
Street connectivity [(4)]	0.97 (0.67–1.37)	0.84	-0.051 (-0.152-0.050)	0.02	0.324
Walking/cycling facilities (score 1–4) [(3)]	1.17 (0.80–1.72)	0.41	0.089 (-0.018-0.195)	0.05	0.101
Aesthetics (score 1–4) [(3)]	1.11 (0.81–1.51)	0.53	0.079 (-0.010-0.167)	0.01	0.082
Safety from traffic [(4)]	1.49 (0.97–2.30)	0.07	0.088 (-0.033-0.209)	0.02	0.153
Safety from crime (score 1–4) [(3)]	0.91 (0.62–1.34)	0.64	0.011 (-0.096-0.119)	0.03	0.837
WOMEN					
Land use mix-diversity (score 1–5) [(3)]	1.32 (0.89–1.96)	0.16	-0.007 (-0.093-0.079)	0.04	0.875
Land use mix-access (score 1–4) [(3)]	0.82 (0.49–1.38)	0.46	-0.016 (-0.128-0.097)	0.01	0.786
Street connectivity [(4)]	0.79 (0.56–1.12)	0.18	-0.025 (-0.100-0.051)	0.02	0.517
Walking/cycling facilities (score 1–4) [(3)]	**0.62 (0.42–0.92)**	**0.02**	-0.085 (-0.170-0.001)	0.03	0.051
Aesthetics (score 1–4) [(3)]	0.89 (0.66–1.20)	0.43	0.015 (-0.082-0.052)	0.01	0.657
Safety from traffic [(4)]	1.27 (0.82–1.98)	0.29	**0.098 (0.005–0.192)**	**0.04**	**0.040**
Safety from crime (score 1–4) [(3)]	0.70 (0.47–1.04)	0.07	-0.012 (-0.100-0.075)	0.02	0.782

OR: odds ratio; β: regression coefficient; CI: confidence interval; SE: standard error

[(1)] Logistic regression model with transport-related physical activity for men (0=<600 MET/min/week, 1≥600/MET/min/week) as dependent variable, adjusted by age, BMI and education level

[(2)] Linear regression model with transport-related physical activity time (LOG10 (min/week)) as dependent variable in participants with transport-related physical activity ≥10 min/week, adjusted by age, BMI and education level

[(3)] higher scores indicate perception of higher land use mix-diversity, higher land use mix-access, more walking/cycling facilities, better aesthetics, and more safety from crime

[(4)] 4-point scale: strongly disagree (1), disagree (2), agree (3), strongly agree (4)

physically active in the logistic model. Conversely, in the linear regression model, a higher perception score of traffic was associated with increased reported PA (min/week) during leisure time (β: 0.160, 95% CI: 0.012;0.309).

Discussion

In general, this study demonstrated how different perceived neighborhood characteristics are associated with PA across various domains and how these associations differ by gender. Both variables were measured using self-report questionnaires, which, while translated and validated in Spanish, are still susceptible to information biases typical of such instruments [28–30]. Although recent validation of the IPAQ-Short Form Questionnaire has been published [23], it would be beneficial to have further validation for local Spanish in the adult population [19]. The same applies to the NEWS-A, which has been validated for older adults, as there may be challenges in understanding each item that could lead to information bias.

One of the most well-known studies using this methodology is the International Physical Activity Network (IPEN), which encompasses 17 cities across 12 countries, including three Latin American cities: Bogotá, Curitiba, and Cuernavaca. This study reported a positive association between various neighborhood characteristics - such as land use diversity, access to land use, street connectivity, and aesthetics - and transportation-related PA [31].

Although the questionnaire used was the IPAQ-LF, which measures four domains of PA in daily life, only transportation-related PA and leisure time PA were considered in the ELANS study. These two domains were chosen because they exhibit the highest reliability and have a more significant impact on public health [17].

Previous studies have reported inconsistent associations between the environment and transportation-related PA [26], research has indicated that women tend to exhibit a greater preference for risk avoidance compared to men when it comes to using active transportation, particularly when their safety is at stake [32]. Those who had a more favorable perception of their neighborhood's walking or cycling facilities were less likely to engage in PA. This suggests that access to infrastructure alone is insufficient; the willingness to utilize these facilities presents a challenge that requires further investigation [32, 33]. Interestingly, women who reported a better perception of safety in traffic were positively associated with engaging in transportation-related PA, whether walking or cycling.

Table 5 Regression models for leisure-related physical activity

	Logistic Regression[1] Any leisure-related PA (0 = < 600 MET/min/week, 1 ≥ 600/MET/min/week)		**Linear Regression[2] Non-zero reported leisure-related PA LOG10 (min/week)**		
Independent variables	**OR (95%CI)**	***p***	**β (95%CI)**	**SE**	***p***
	MEN				
Land use mix-diversity (score 1–5) [3]	1.22 (0.81–1.83)	0.34	-0.038 (-0.173-0.097)	0.02	0.578
Land use mix-access (score 1–4) [3]	1.72 (0.98–3.01)	0.06	0.104 (-0.093-0.301)	0.03	0.299
Street connectivity [4]	0.85 (0.59–1.22)	0.38	**-0.150 (-0.266–0.034)**	**0.01**	**0.011**
Walking/cycling facilities (score 1–4) [3]	0.75 (0.51–1.20)	0.16	-0.006 (-0.136-0.124)	0.03	0.929
Aesthetics (score 1–4) [3]	1.06 (0.76–1.46)	0.74	0.049 (-0.061-0.159)	0.02	0.377
Safety from traffic [4]	1.22 (0.79–1.89)	0.38	0.004 (-0.142-0.150)	0.01	0.958
Safety from crime (score 1–4) [3]	0.82 (0.55–1.20)	0.31	-0.042 (-0.181-0.097)	0.02	0.548
	WOMEN				
Land use mix-diversity (score 1–5) [3]	1.42 (1.00-2.03)	0.05	0.084 (-0.040-0.208)	0.03	0.185
Land use mix-access (score 1–4) [3]	0.94 (0.59–1.48)	0.78	-0.062 (-0.229-0.105)	0.04	0.467
Street connectivity [4]	0.85 (0.63–1.16)	0.31	-0.028 (-0.144-0.088)	0.03	0.636
Walking/cycling facilities (score 1–4) [3]	0.97 (0.69–1.37)	0.87	0.031 (-0.096-0.158)	0.02	0.634
Aesthetics (score 1–4) [3]	0.87 (0.67–1.14)	0.30	-0.026 (-0.124-0.073)	0.01	0.609
Safety from traffic [4]	0.97 (0.66–1.43)	0.88	**0.160 (0.012–0.309)**	**0.01**	**0.035**
Safety from crime (score 1–4) [3]	0.72 (0.51–1.02)	0.07	-0.041 (-0.166-0.084)	0.03	0.517

OR: odds ratio; β: regression coefficient; CI: confidence interval; SE: standard error

[1] Logistic regression model with leisure-related physical activity for men (0=<600 MET/min/week, 1≥600/MET/min/week) as dependent variable, adjusted by age, BMI and education level

[2] Linear regression model with transport-related physical activity time (LOG10 (min/week)) as dependent variable in participants with transport-related physical activity ≥10 min/week, adjusted by age, BMI and education level

[3] higher scores indicate perception of higher land use mix-diversity, higher land use mix-access, more walking/cycling facilities, better aesthetics, and more safety from crime

[4] 4-point scale: strongly disagree (1), disagree (2), agree (3), strongly agree (4)

In the leisure-time domain, the results indicated that men who perceived better street connectivity in their neighborhoods had lower levels of leisure-time PA. While these findings align with some previous studies (14), most research suggests that street connectivity is positively associated with PA in both men and women [31, 34]. One possible explanation for our results is that the perception of connectivity may be linked to concerns about vehicular congestion or increased pedestrian traffic in the area [35]. Conversely, among women, those who reported a better perception of safety in traffic demonstrated a positive association with leisure-time PA.

Although these results may seem contradictory, similar findings have been observed in previous ELANS studies across Latin America [13]. Regarding traffic safety, perceptions varied by sex, with women appearing more influenced to change their behavior, such as engaging in PA for transportation or leisure. This suggests that a healthy environment should prioritize road safety conditions, such as reducing speed limits in cities, to promote PA and decrease the risk of road accidents [36, 37].

To better interpret the results of this study, it is important to recognize that the variables of interest - such as neighborhood perception and PA - are complex phenomena. As such, interpretations should be approached with caution.

Regarding the outcome variable, it is estimated that questionnaires can overestimate the level of PA by up to 44% compared to data obtained from other measurement instruments, such as accelerometers [28]. These considerations have been analyzed previously in ELANS [29, 30]. Although objective measurement data, such as accelerometer readings, were available, they came from a very small subsample and were not included in the association analysis of the present study. A larger sample measured using accelerometers would have been beneficial.

Concerning the exposure variable, the different categories of the NEWS-A produced similar responses. Although this suggests that the scale may not have effectively identified differences in neighborhood perception, it would have been valuable to gather more information about the urban areas that participated in the survey. The questionnaire was developed in American cities with urban planning contexts that differ from those in Chile, so additional studies are needed to reinforce the reliability of this instrument for the Chilean adult population.

Moreover, given the results, it is important to ask: If being physically active is a behavior, what perceived barriers do people face when trying to engage in such behavior? This necessitates studying variables that act as barriers, which may be internal, sociodemographic, or environmental [38]. A person can overcome internal

barriers through social support and an understanding of the benefits of PA, while external barriers can be mitigated by raising awareness of existing infrastructure [39]. Previous studies have identified lack of motivation and time as the most common external and internal barriers to PA [40]. It is also worth questioning whether people perceive PA as a necessity or a choice, with many likely still opting for the latter [41].

Considering that ELANS-Chile was conducted between 2015 and 2016, it is important to reflect on how the relationship between individuals and their environment may have changed, especially following the confinement due to COVID-19. While some research suggests the pandemic affected leisure-time PA for those who were active pre-pandemic [42], most studies report a decrease in PA during the pandemic, and the role of the built environment during this time remains unclear [43, 44].

The ELANS study was the first of its kind conducted in Latin America concerning nutrition and health, and this particular study is the first to explore the perceived environment and PA. Therefore, it may provide valuable insights for future studies and intervention programs related to urban development and PA in Chile. Additionally, there was a low data loss in this study, with approximately 5% of the total number of adults excluded. However, the study does have limitations, primarily due to the use of self-report surveys to measure both neighborhood perception and PA levels. This reliance on self-reports may lead to recall bias, as respondents might tend to provide socially acceptable answers or be influenced by social desirability bias, resulting in an overestimation of their PA levels [34]. Although neighborhood perception is a subjective measure, it is independently associated with PA compared to other objective methods [35].

In line with the findings of our results, a previous study from China [45] has observed a stronger association of the perceived neighborhood built environment and PA than our current study. Considering the distinct features of Latin American cities, it is not possible to directly translate findings from other countries (e.g., the USA, China or European countries) to this region [14]. This could be due to various reasons specific to the local environment such as area-level socio-economic status or crime rates, factors that were not included in the regression models of land use mix - diversity. Alternatively, the actual level of access to various destinations might have been so high that many respondents could reach destinations with minimal walking. More specifically examining how characteristics of the built environment are associated with PA in Latin American countries provide useful insights for guiding public policies and strategies for PA promotion in this region.

It would be useful to gather information on psychosocial factors that could influence how individuals perceive their environment, as well as to conduct a more detailed evaluation of the NEWS-A categories that were positively associated with PA. These variables could serve as confounding factors rather than controls in the analysis, as they were not part of the study design. Additionally, incorporating data from other PA domains - such as home and workplace activity - and including information from rural populations would enhance the study's comprehensiveness. Finally, as a cross-sectional analytical study, this research can establish associations between variables of interest but has inherent limitations regarding causal inferences, such as reverse causality. Consequently, a positive perception of the neighborhood may be a result of engaging in PA rather than a cause. Longitudinal studies, such as cohort studies, would be ideal for exploring these relationships further.

Conclusion

The study demonstrates that different perceived characteristics of the neighborhood are associated with PA practice in both the transportation and leisure-time domains, with notable differences by sex. For women, a perception of better accessibility for walking or cycling is inversely related to PA for transportation. Additionally, a more favorable perception of traffic safety appears to influence PA practice for both transportation and leisure activities. Conversely, men who perceive better street connectivity engage in less leisure-time PA.

More research is needed to explore how various neighborhood characteristics relate to individuals and to better understand the factors that promote behavioral changes, such as increased PA.

Abbreviations

PA	Physical activity
ELANS	Latin American Nutrition and Health Survey
IPAQ-LF	International Physical Activity Questionnaire-Long Form
OR	Odds ratio
95%IC	95% confidence intervals
Min	Minutes
WHO	World Health Organization
NEWS-A	Neighborhood Environment Walkability Survey– Abbreviated
BMI	Body mass index
SD	Standard deviation

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Author contributions

RFK and GF conceived, designed, and helped to write and revise the manuscript; ARR, were responsible for coordinating the study, contributed to the intellectual content, and revise the manuscript; JCL, BFS and ERdV, interpreted the data, helped to write and revise the manuscript.All authors contributed to the study design, critically reviewed the manuscript, and approved the final version.

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Data availability
Data is provided within the manuscript or supplementary information files.

Declarations

Ethics approval and consent to participate
The ELANS protocol was approved by the Western Institutional Review Board (#20140605) and registered on ClinicalTrials.gov (#NCT022266). Additionally, the Research Ethics Committee at Pontificia Universidad Católica de Chile approved the ELANS Protocol applied in Chile (ELANS-Chile), and the Ethics Committee of the Faculty of Social Sciences at Pontificia Universidad Católica de Chile approved the ELANS-Chile project (#14–179). The research has been performed in accordance with the Declaration of Helsinki.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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