



Perceived neighborhood environmental attributes associated with leisure-time and transport physical activity in Mexican adults



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ABSTRACT

Environmental factors have been associated with specific physical activity domains, including leisure-time and transport physical activity, in some high income countries. Few studies have examined the environmental correlates for domain-specific physical activity in low- and middle-income countries, and results are inconsistent. We aimed to estimate the associations between perceived environment and self-reported leisure-time walking, moderate-to-vigorous leisure-time physical activity and transport physical activity among adults living in Cuernavaca, Mexico. A population-based study of adults 20 to 64 years old was conducted in Cuernavaca, Mexico in 2011 ($n = 677$). Leisure and transport physical activity was measured using the International Physical Activity Questionnaire – Long Form. Perceptions of neighborhood environment were obtained by questionnaire. Hurdle regression models estimated the association between environmental perceptions and participation and time spent in each physical activity domain. High perceived aesthetics were positively correlated with participation and time spent in leisure-time walking and moderate-to-vigorous physical activity. SES differences existed for aesthetics in relation to participation in leisure-time walking. Participation in transport physical activity was positively associated with easy access to large parks, while closer distance to large parks was a negative correlate for participation and time-spent in this physical activity domain. Results suggest that perceived environmental characteristics related with physical activity are domain specific. High perceived aesthetics were an important correlate for leisure-time activities among Mexican adults, suggesting that policy strategies aimed at improving this environmental perception may be warranted. Patterns of associations between environmental correlates and transport physical activity differed from those reported in commonly studied high income countries.

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1. Introduction

Non-communicable diseases constitute the leading causes of death globally, with nearly 80% of these deaths occurring in low- and middle-income countries (Anon., 2011a). Since physical inactivity is a major risk factor for chronic diseases, (Lee et al., 2012) effective interventions are needed to increase population levels of physical activity

(PA) (Anon., 2011a). Ecological models of PA emphasize the importance of considering multiple levels of influence when developing interventions (Sallis et al., 2008). In addition to individual and interpersonal factors, certain environmental factors may be associated with specific PA domains, such as PA for leisure or transport (Sallis et al., 2008).

Evidence suggests that the relations between neighborhood environmental attributes and PA are domain-specific (Sugiyama et al., 2012; Van Dyck et al., 2012, 2013). While availability and access to retail and service destinations, street connectivity, residential density, and sidewalk availability have been positively related with walking for transport, (Sugiyama et al., 2012; Van Dyck et al., 2012) other features, such as availability and accessibility of recreational facilities (e.g., parks) and aesthetics, have been associated with leisure-time walking (Sugiyama et al., 2012; Van Dyck et al., 2013). However, to date most of the available evidence on these relations is from some high-income

Abbreviations: PA, Physical activity; SES, Socioeconomic status; IPEN, International Physical Activity and the Environment Network; IPAQ, International Physical Activity Questionnaire; ANEW, Abbreviated Neighborhood Environment Walkability Scale.

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countries from the “Global North”, such as the United States, Canada, the United Kingdom, Australia and Northern European countries.

Environmental characteristics have been measured using objective and perceived (self-reported) measures (Arango et al., 2013; Leslie et al., 2007; Salvo et al., 2014a). Perceived measures may play an important and distinct role in influencing PA, and allow for assessing relevant aspects of the built environment that are difficult to measure objectively (e.g., aesthetics and safety) (Arvidsson et al., 2012; Brownson et al., 2009). Little is known about the association between perceived environment and domain specific PA in Mexico and the Latin American region at large, and the available evidence suggests differences with findings reported from those commonly studied high income countries (Arango et al., 2013). Due to the cultural (Anon., 2011b) (Sivak and Schoettle, 2013), social, economic (Knox and McCarthy, 2012; Poumanyvong et al., 2012) and structural (Dodman, 2009) differences between commonly studied high income countries and Latin America, differences in associations between the built environment and physical activity are expected.

Previous reports from our research team show that in Mexico, objective and perceived measures of residential density, land use mix diversity, and street connectivity, are either not related, or inversely related to accelerometer-based physical activity (Jauregui et al., 2016a; Salvo et al., 2014c).

The objective of this study was to estimate the associations between perceived neighborhood environmental features and self-reported leisure-time walking, moderate-to-vigorous leisure-time PA, and transport PA among adults from Cuernavaca, Mexico.

2. Materials and methods

2.1. Study design and setting

This study was part of the International Physical Activity and the Environment Network (IPEN) – Mexico project (Kerr et al., 2013). IPEN is a study exploring the relationships between the built environment and physical activity among 12 culturally- and environmentally-diverse countries, including Mexico. IPEN-Mexico is a cross-sectional, population-based study that was carried out in the city of Cuernavaca, Mexico. Cuernavaca is a mid-sized (total area of 150 km², 365,000 inhabitants) city with human activity localized in the central business district (Anon., 2016). The city has many steep slopes and is carved up by a system of 46 gorges. Public transportation is highly available and provided by a system of feeder-buses stopping whenever and wherever a potential rider signals the driver to do so (Adams et al., 2014; Baik et al., 2006). IPEN-Mexico collected data in 2011, when Mexico was enduring a period of very high crime, and Cuernavaca was one of the most affected cities (Anon., 2012; Ortega, 2015) of the country. Data collection for the IPEN-Mexico study took place in 2011–2012, and analyses are ongoing.

2.2. Neighborhood selection and recruitment

A representative sample of adults was selected using Census tracts as sampling units. Census tracts were stratified in four levels of socioeconomic status (SES) and two levels of objectively measured walkability (high and low walkability, via median split) (Frank et al., 2010). Eight Census tracts per stratum were randomly selected, yielding 32 (out of 123) study Census tracts. Seven blocks were randomly selected per census tract and two to four households were selected per block (Salvo et al., 2015). Data was collected in person via two home visits. Eligible participants were aged 20 to 65 years, able to walk, and permanent residents of that household (Salvo et al., 2015). Participants signed informed consent forms before data collection. The study was approved by the institutional review boards of Emory University and the Instituto Nacional de Salud Pública of Mexico.

2.3. Physical activity

Self-reported PA was measured using the International Physical Activity Questionnaire–Long Version (IPAQ, 2005). Validation studies in Latin America suggest that the IPAQ has high reliability (Spearman's rho ~0.8) and moderate criteria validity in comparison with accelerometers (Craig et al., 2003; Hallal et al., 2010b). The Colombian (Spanish) version of IPAQ was adapted for a Mexican audience, using culturally appropriate wording and examples. Frequency (number of days in the last seven days) and duration (minutes per day) of PA in leisure and transport PA were queried (Hallal et al., 2010a). Only bouts of at least ten minutes were reported. Using this information, weekly minutes of leisure-time walking, leisure-time moderate-to-vigorous PA, and transport PA (walking and bicycling) were derived (IPAQ, 2005). The proportion of participants meeting PA recommendations (150 min per week of moderate to vigorous PA) per PA domain was calculated (WHO, 2010).

2.4. Perceived environment

Perceived neighborhood environment was measured using the Latin American version of the Abbreviated Neighborhood Environment Walkability Scale (ANEWS) (Salvo et al., 2014b). ANEWS consists of 58 items divided into ten subscales (Cerin et al., 2013): residential density, land use mix diversity, land use mix access, street connectivity, few cul-de sacs, no major physical barriers for walking, pedestrian infrastructure, aesthetics, traffic safety, and safety from crime. High test-retest reliability (intraclass correlation coefficient > 0.75) has been reported for most of these subscales (Leslie et al., 2005; Oyeyemi et al., 2013; Saelens et al., 2003). This version included characteristics of the built environment present in Latin American urban settings such as hilliness, proximity to public transportation, park safety, and easy access and proximity to small and large parks (Salvo et al., 2014b). Variables were calculated as per the ANEWS protocol (Supplementary Table) (Cerin et al., 2013). All measures were scored such that higher values were expected to be positively related to PA domains.

2.5. Covariates

Self-reported sociodemographic variables including age, sex, education level, marital status, individual-level SES (based on 25 questions on household characteristics and assets (Gutierrez et al., 2012)) and motor vehicle ownership were collected.

2.6. Data analysis

Descriptive statistics (means, proportions and 95% confidence intervals) were computed for all variables. Weekly minutes of leisure-time walking, leisure-time moderate to vigorous PA, and transport PA were log-transformed to improve the normality of the distribution for the dependent variables.

All PA variables had a distribution with a large number of zeros (between 10 and 65% of participants did not accumulate any PA within specific domains), and a continuous right-skewed non-zero part. To account for the large number of zeros we estimated hurdle models of participation and time spent in each domain. Hurdle models recognize that decisions about PA participation are made in two steps: 1) The decision to participate in a determined PA domain (e.g. leisure-time walking), and 2) The decision on the duration of such activity, given participation (Humphreys and Ruseski, 2015). This distinction allows factors that affect participation and factors that affect duration of PA to have different signs (Humphreys and Ruseski, 2015). Additionally, these models may account for correlated error terms between participation and duration equations. We specified the participation decision by using a probit model and the duration decision by using a log-normal model. To account for potential correlated errors in both equations, we introduced the inverse Mills ratio in all models. Since ratios' *p* values were >0.05

and coefficients did not differ by introducing this ratio, we present the models assuming no correlation between error terms in equations. Based on previous reports from Mexico and other middle income countries, we adjusted models for individual variables (sex, age, marital status, SES, motor vehicle ownership, and educational attainment), and theoretically relevant environmental variables (aesthetics, safety from crime, access and proximity to large and small parks, pedestrian infrastructure, land-use mix diversity, traffic safety, and proximity to transit stops) (Arango et al., 2013; Ding et al., 2013; Ortega, 2015; Parra et al., 2011; Salvo et al., 2014a). Other environmental factors were only included in final models if associations with a *p* value <0.05 were observed in single-environment (independent)-variable models, adjusting for individual variables (see above). We tested for all possible interactions between environmental variables and gender as well as SES, but only interactions with a *p* < 0.05 were included in the models. The antilogarithms of the regression coefficient estimates (exp(*b*)) of all models were calculated and reported. All analyses accounted for the complex multistage clustered design and were weighted for probability of selection. Analyses were carried out using Stata v.14.0 (StataCorp, College Station, Texas) survey procedures (e.g. *svy*).

3. Results

Of the 677 participants, nine had incomplete perceived environmental data, leaving 668 participants for analysis. No differences in demographic characteristics were found between the analytic and the full sample. Among adults in Cuernavaca participants are 42.0 (95% CI: 40.7–43.2) years old on average, 51.2% are women, and 54.8% own a motorized vehicle (Table 1). Car ownership was higher among high SES participants (95.6%) than among low SES participants (24.3%). Most (90.2%) participate in transport PA, whereas 34.1% and 36.6% engage in walking and MVPA during leisure-time, respectively. Overall, 46.9%, 14.1% and 30.2% meet PA recommendations through transport, leisure-time walking, or leisure-time moderate-to-vigorous PA. A total

of 70.6% respondents reported low residential density (score < 50), 93.0% reported high land use mix diversity, and 99.6% reported a transit stop within ≤10 min walking distance (Appendix Table 2). Reported perceptions of the built environment did not vary by socioeconomic status (data not shown).

3.1. Leisure-time walking

The adjusted models showed that participation in leisure-time walking was positively associated with aesthetics only among adults of low SES: Each unit increase in perceived aesthetics was associated with a 123% (43–249%) more participation in leisure-time walking. This relationship decreased in the upper three quartiles of SES (Table 2, Fig. 1). Conditional on participation, duration of leisure-time walking was positively associated with aesthetics: Regardless of SES status, each unit increase in perceived aesthetics was associated with a 92% (18–213%) increase in time spent in this PA domain (Table 2).

Leisure-time moderate to vigorous physical activity

The adjusted models showed that aesthetics were associated with both participation and duration of leisure-time moderate to vigorous PA (Table 3). Each unit increase in perceived aesthetics was associated with 33% (4–70%) more participation in this domain. Conditional on participation, each unit increase in perceived neighborhood aesthetics was associated with a 67% (12–149%) increase in duration of leisure-time moderate to vigorous PA.

3.2. Transport physical activity

The adjusted models showed that participation in transport PA was negatively associated with shorter perceived walking distances to large parks (exp[B] = 0.78, 95% CI = 0.63–0.97), while perceived easy access to large parks was a positive correlate (exp[B] = 1.69, 95% CI = 1.18, 2.41) of participation in transport PA (Table 4). Additionally, conditional on participation, duration of transport PA was negatively associated with shorter perceived walking distances to large parks: each additional unit of perceived proximity to large parks was associated with a 31% (12–46%) decrease in the time spent in this PA domain.

Table 1
Sample characteristics among Mexican Adults. Cuernavaca, Mexico, 2011.^a (n = 668).

Variable	n	%	95% CI
Gender (%)			
Female	366	51.2	(44.1, 58.2)
Male	302	48.8	(41.7, 55.9)
SES (%)			
Low	196	30.9	(23.7, 39.2)
Medium	163	24.0	(20.5, 27.8)
Medium-high	197	29.1	(24.5, 34.2)
High	112	16.0	(12.9, 19.7)
Education (%)			
Elementary school or less	102	15.1	(12.2, 18.6)
Some or complete middle school	162	25.2	(21.4, 29.4)
Some or complete high school	186	27.2	(23.8, 30.9)
Some or complete college	176	27.0	(23.4, 30.9)
Post-graduate	42	5.5	(3.7, 8.2)
Motor vehicle ownership (%)			
Car	359	53.4	(46.8, 59.9)
Motorcycle	30	4.8	(3.3, 6.9)
Either	367	54.8	(48.1, 61.4)
Marital status (%)			
Single	165	24.7	(21.9, 28.7)
Married or living with someone	430	64.4	(60.5, 69.1)
Separated or divorced	56	8.4	(5.7, 9.8)
Widower	17	2.5	(1.3, 4.3)
Meeting physical activity guidelines (%) ^b			
Transport PA	300	46.9	(44.0, 62.0)
Walking for leisure	93	14.1	(10.4, 18.9)
Leisure time MVPA	196	30.2	(25.9, 34.8)

SES = Socioeconomic Status; CI = Confidence Interval; PA = Physical activity; MVPA = Moderate to vigorous physical activity.

^a Weighted for survey design.

^b Meeting 150 min per week of moderate to vigorous PA per PA domain (20).

Table 2
Perceived environmental correlates of participation and time spent in walking for leisure among Mexican adults. Cuernavaca, Mexico, 2011. (n = 668).

Environmental correlate	Participation ^{a,b}			Duration ^a		
	Exp(B)	Exp (95% CI)		Exp(B)	Exp (95% CI)	
Aesthetics ^c				1.92	1.18	3.13
Low SES	2.23	1.43	3.49			
Medium SES	1.53	0.95	2.44			
Medium-high SES	1.27	0.73	2.19			
High SES	0.89	0.58	1.36			
Land use mix diversity	1.04	0.80	1.34	1.08	0.70	1.69
Pedestrian infrastructure	0.95	0.67	1.34	1.00	0.58	1.75
Traffic safety	1.16	0.93	1.46	1.33	1.18	3.13
Safety from crime	1.02	0.88	1.18	1.02	0.92	1.92
Proximity to small parks	1.01	0.92	1.12	1.03	0.77	1.35
Park access	1.19	0.86	1.64	1.23	0.87	1.22
Proximity to large parks	0.99	0.82	1.21	0.98	0.68	2.21
Access to large parks	0.97	0.70	1.34	0.85	0.72	1.34
Proximity to transit stops	0.88	0.71	1.09	0.77	0.50	1.44

SES = Socioeconomic status; CI = Confidence Interval.

^a Regression coefficients estimated using a Hurdle model. Both equations are adjusted for sex, age, marital status, individual socioeconomic status, motor vehicle ownership, educational attainment, all perceived environment variables listed in the table and the survey design. Exp(B) is to be interpreted as the proportional increase in total minutes per week of moderate to vigorous physical activity associated with a 1 unit increase on the independent variable.

^b Equation additionally adjusted for the interaction term SES quartile X aesthetics.

^c Significant interaction by SES. The sliced associations are presented. See Fig. 1.

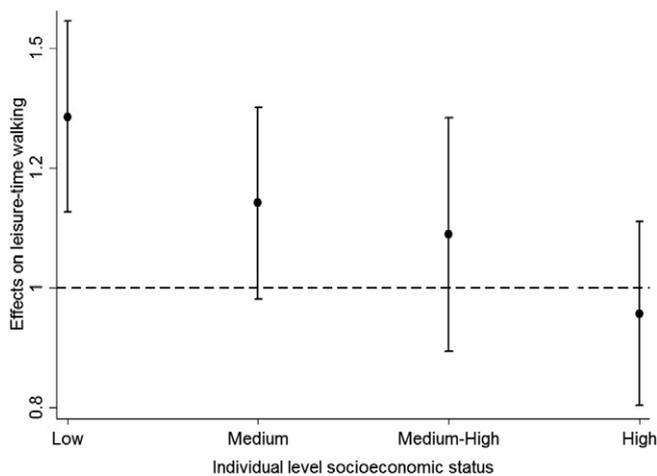


Fig. 1. Associations between aesthetics and participation in leisure time walking by socioeconomic status level. Cuernavaca, Mexico, 2011. Adjusted predictions and 95% confidence intervals were estimated after running a Hurdle model. The participation equation is adjusted for sex, age, marital status, individual socioeconomic status, motor vehicle ownership, educational attainment, all perceived environment variables, the interaction term socioeconomic status quartile X aesthetics, and the survey design.

4. Discussion

Our study explored associations between perceived neighborhood environment and domain-specific PA among adults in Cuernavaca, Mexico. Our results indicate that certain perceived environmental characteristics are correlated with some PA domains, but not with others; (Arango et al., 2013; Sugiyama et al., 2012; Van Dyck et al., 2012, 2013) While perceived aesthetics were a positive correlate for leisure-time activities, proximity and access to large parks were identified as correlates for transport PA among Mexican adults.

Aesthetics were an important correlate for participation and duration in both leisure-time activities studied (walking and moderate to vigorous PA). Previous reports on this relationship from other Latin American countries have been inconsistent (Arango et al., 2013). Aesthetics are hypothesized to encourage engagement in leisure-time PA by providing clean and well-maintained infrastructure, attractive buildings and natural elements (Saelens and Handy, 2008). Interestingly, aesthetics were associated with participation in leisure-time moderate-to-vigorous PA among the full sample, but only with participation in leisure-time walking among participants from the low SES. Similar SES differences have been previously reported for accelerometer based

Table 3
Perceived environmental correlates of participation and duration of leisure-time moderate to vigorous physical activity among Mexican adults. Cuernavaca, Mexico, 2011. ($n = 668$).

Environmental correlate	Participation ^a		Duration ^a		
	Exp(B)	Exp (95% CI)	Exp(B)	Exp (95% CI)	
Aesthetics	1.33	1.04 1.70	1.67	1.12	2.49
Land use mix diversity	0.97	0.81 1.16	0.95	0.69	1.31
Pedestrian infrastructure	0.79	0.58 1.09	0.60	0.36	1.01
Traffic safety	1.09	0.87 1.37	1.26	0.81	1.95
Safety from crime	1.02	0.84 1.24	1.06	0.74	1.51
Proximity to small parks	1.07	0.99 1.16	1.04	0.99	1.08
Park access	0.95	0.76 1.18	0.88	0.59	1.32
Proximity to large parks	1.03	0.90 1.18	1.08	0.85	1.39
Access to large parks	1.05	0.80 1.37	1.02	0.62	1.67
Proximity to transit stops	0.86	0.69 1.083	0.69	0.45	1.05

CI = Confidence Interval.

^a Regression coefficients estimated using a Hurdle model. Both equations are adjusted for sex, age, marital status, individual socioeconomic status, motor vehicle ownership, educational attainment, all perceived environment variables listed in the table and the survey design. Exp(B) is to be interpreted as the proportional increase in total minutes per week of moderate to vigorous physical activity associated with a 1 unit increase on the independent variable.

Table 4
Perceived environmental correlates of participation and duration of transport physical activity among Mexican adults. Cuernavaca, Mexico, 2011. ($n = 668$).

Environmental correlate	Participation ^a			Duration ^a		
	Exp(B)	Exp (95% CI)		Exp(B)	Exp (95% CI)	
Aesthetics	1.23	0.85 1.77		1.27	0.94	1.73
Land use mix diversity	0.86	0.66 1.12		0.82	0.61	1.08
Pedestrian infrastructure	0.84	0.53 1.34		0.97	0.61	1.55
Traffic safety	0.91	0.72 1.16		1.15	0.88	1.50
Safety from crime	1.06	0.91 1.24		1.11	0.88	1.41
Proximity to small parks	1.02	0.89 1.17		1.09	0.95	1.24
Park access	0.75	0.49 1.14		0.82	0.57	1.17
Proximity to large parks	0.78	0.63 0.97		0.69	0.54	0.88
Access to large parks	1.69	1.18 2.41		1.41	0.89	2.22
Proximity to transit stops	1.04	0.83 1.30		0.98	0.75	1.29

CI = Confidence Interval.

^a Regression coefficients estimated using a Hurdle model. Both equations are adjusted for sex, age, marital status, individual socioeconomic status, motor vehicle ownership, educational attainment, all perceived environment variables listed in the table and the survey design. Exp(B) is to be interpreted as the proportional increase in total minutes per week of moderate to vigorous physical activity associated with a 1 unit increase on the independent variable.

moderate-to-vigorous PA in this dataset (IPEN-Mexico) (Jauregui et al., 2016a). The difference in the way aesthetics are associated with leisure time activities has two important implications. The first being that aesthetics may play a different role in deciding whether or not to engage in different types of leisure activities (i.e. walking versus moderate to vigorous). While aesthetics may not be a relevant environmental feature for walking, particularly for higher SES individuals, it may play a more relevant role for participation in moderate-to-vigorous PA. The second implication, is that low SES individuals may be more susceptible to environmental influences on PA. Since low SES Mexican adults engage in more transport activities and are therefore out in the neighborhood more often, (Salvo et al., 2015) they may be more aware of their neighborhood surroundings and therefore may be more susceptible to aesthetic influences on PA. Previous analyses of these data exploring associations between objective and perceived measures of the built environment show that sufficiently active non-motor vehicle owners (two factors associated with transport PA) have a better awareness of their neighborhood. Future studies exploring perceived aesthetics, PA domains and SES differences in Latin America and other low-to-middle income settings could help elucidate these relations. Since for now this study provides the best available evidence, improving aesthetic qualities of the built environment should be considered a potential intervention to increase PA among Mexicans. Studies conducted in high income countries suggest that aesthetic quality is linked with perceived naturalness, order and upkeep, as well as unobstructed views (Kaplan and Kaplan, 1989; Nasar, 1994). Formative research and community-based participatory research with Mexicans are needed to identify the environmental factors that matter in PA promotion in order to improve the perceived aesthetics of a neighborhood.

The patterns of association between environmental correlates and transport PA differed from what has been reported in commonly studied high income countries (Sugiyama et al., 2012; Van Dyck et al., 2012). In Mexico, most transport PA is accounted for by walking, whereas cycling is almost inexistent (Anon., 2015; Kerr et al., 2016). Proximity to parks was a negative correlate for participation and time spent in transport PA; in contrast, access to large parks was a positive correlate for duration of this PA domain. These relations were unexpected, first because parks are generally thought to be important environmental features for leisure-time PA but not for transport PA, (Cohen et al., 2007) and second because they suggest contradictory findings. These findings could be explained in part by a lack of differentiation between leisure and transport trips among participants. Given that 90.2% of individuals reported participating in transport PA, this could be especially true for multi-purpose trips. Additionally, proximity and access to large parks may be measuring distinct environmental constructs. Proximity to

large parks provides information on the distance from home to the park. Large parks in Mexico generally have few access points and in some circumstances may represent a barrier to get from home to transit stops or other destinations, explaining the negative relations observed. Additionally, the negative relationship between close proximity to large parks and transport PA could be due to residual confounding. In Mexico, neighborhoods close to large parks are also those with higher income and availability of public transportation. Our statistical models were adjusted for individual socioeconomic status and motor vehicle ownership, eliminating the potential confounding effect of income. Models were also adjusted for perceived proximity to transit stops. However, previous findings comparing objective and perceived measures of proximity to transit stops among Mexican adults indicate that this self-reported variable is not a good proxy for its objective measure in Cuernavaca (Jáuregui et al., 2016b). As for access to large parks, this variable was retrieved by asking participants if they could easily walk to the park. Although A-NEWS is intended to measure how walkable the environment surrounding the participant's home is, this may not necessarily reflect the walkability of neighborhoods surrounding parks, especially for those large parks located at longer distances. In such cases, access to large parks may be a better proxy for walkability surrounding the park. This, along with the increased access to transit stops close to large parks, may explain the positive relation between access to large parks and duration of transport PA. Future studies exploring the relationship between transport PA, access to transit, and proximity and access to large parks are needed to better elucidate these relationships.

Most of the environmental factors measured in this study were not associated with either leisure or transport PA. In contrast, previous findings evaluating associations between perceived environmental factors and accelerometer-based PA in this same population, identified more environmental correlates (e.g. safety from crime, not many cul-de-sacs) for PA (Jáuregui et al., 2016a). As noted above, it is possible that environmental factors included in the questionnaire are not as relevant in Mexico. A-NEWS was derived from studies conducted mainly in the US. The lack of variability of certain environmental features (i.e. proximity to transit stops and land use mix access) may also help explain in part this lack of associations. Given the differences in urban planning and transportation systems between countries, it has been suggested that developing locally-specific instruments for evaluating environmental correlates for PA is needed (Arango et al., 2013). The quality of the infrastructure could also be playing a role in the lack of detection of correlations, which could help explain the differences between our results and previous reports from certain high-income countries. Future studies should explore the role that the quality of physical activity infrastructure has in the relation between the built environment and physical activity. Additionally, although IPAQ is a valid and reliable instrument for PA measurement, (Craig et al., 2003; Hallal et al., 2010b) it is subject to more measurement error compared to objective measures. This might attenuate estimates on the relationship between environmental attributes and PA (Celis-Morales et al., 2012; Nusser et al., 2012).

4.1. Limitations

This is the first study to examine perceived environmental correlates of domain-specific PA in a Mexican city and builds upon evidence from other Latin American countries. Limitations include the cross-sectional design which does not allow determination of causality. Self-report measures of environmental attributes may not accurately reflect objective measures, however they are still relevant since objective and perceived environmental attributes may be independently associated with PA (Arvidsson et al., 2012). Additionally, for some attributes, such as aesthetics, environmental perceptions may be considered as criterion measures (Brownson et al., 2009). The principal strengths of this study are its population representativeness, and the use of cross-validated, comparable measures of perceived environmental attributes

(Cerin et al., 2013). Advanced analytical methods were employed to examine associations, taking into account the nature of participation and duration of PA.

5. Conclusion

Our results suggest that perceived environmental characteristics and their relationship with PA are domain specific. High perceived aesthetics were an important correlate for leisure-time activities, suggesting that policy strategies aimed at improving this environmental perception may be warranted for enhancing leisure-time PA among Mexican adults. Patterns of associations between transport PA and environmental features differed from those reported in commonly studied high income countries, underscoring the relevance of the considering contextual factors when analyzing the relationship between PA and environmental features. Future studies exploring locally-specific environmental correlates for PA are needed to better elucidate these relationships.

Supplementary data to this article can be found online at <http://dx.doi.org/10.1016/j.yjpm.2016.11.014>.

Transparency document

The [Transparency document](#) associated with this article can be found, in the online version.

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