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How the built environment characteristics shape parents' perception of active commuting norms

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A B S T R A C T

Active commuting to school (ACS) is a promising strategy to increase physical activity among adolescents. While characteristics of the built environment influence commuting behaviors, they may also shape parents' perceptions of social norms related to ACS. This study analyses how subjective and objective built environment characteristics, at both micro- and macro-scale, are associated with parents' perceptions of the social norm. When the built environment was considered as whole in a multivariable model, only the density of sports facilities (a macro-scale measure) was linked to parents' perception of social norms, while subjective and micro-scale characteristics were not. These findings imply that environments with visible opportunities for physical activity, such as sports facilities, may shape parental perceptions of ACS as normative behavior. The presence and design of such facilities could be considered in planning, with macro-scale variables emerging as the most informative measure capturing associations with the social norm.

1. Introduction

Physical inactivity is a major public health issue worldwide, and estimations show that only about 20% of adolescents are meeting the recommended levels of 60 min daily physical activity (Guthold et al., 2020). To counter this negative trend, active commuting to school (ACS), mainly involving walking or cycling to and from school, has been proposed as a specific strategy to increase daily physical activity (Prince et al., 2021). Overall evidence suggests that ACS has the potential of contributing with almost half of the daily recommended physical activity in children and adolescents (Campos-Garzón et al., 2023). In addition, previous research has shown that ACS provide various benefits for both children and society, including improved cardiovascular health, enhanced academic performance, reduced air pollution, a safer traffic environment and lower greenhouse gas emissions (Alfaro et al., 2025; Larouche et al., 2014; Mizdrak et al., 2019; Smith et al., 2015). Unfortunately, many European countries have experienced a declining trend in ACS over the past decades (Haug et al., 2021). More specifically, in Spain, it has been estimated that just over half of all children and

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adolescents engage in ACS (Gálvez-Fernández et al., 2021). Since physical activity habits often form early and track into adulthood, promoting ACS in younger years is especially important to encourage lifelong active lifestyles (Telama et al., 2014; Yang et al., 2013). However, while children may gain greater independence as they grow older (Huertas-Delgado et al., 2017), parents are still a main influencer of their children's mode of commute to school.

1.1. Literature Review

Emerging studies indicate that social norms seem to play an important role in parents' decision concerning ACS (Forsberg et al., 2020, 2021; Melin et al., 2024; Schuster et al., 2015, 2016). Social norms shape behavior on a more or less conscious level, by people looking to others for guidance on how to act (Lapinski & Rimal, 2005). This process is driven by our basic need to belong, leading us to adopt behaviors of our reference groups (Rhodes et al., 2020; Rimal & Lapinski, 2015). Various types of norms exist, and research has shown that a form of descriptive norm seems to play a significant role in parents' decisions regarding ACS (Forsberg et al., 2024; Melin et al., 2024; Ross & Wilson, 2021). To illustrate, the descriptive norm differs from for example the injunctive norm, because it refers to "what is done", rather than "what should be done" (Rivis & Sheeran, 2003). Also, according to Rivis and Sheeran (2003) the descriptive norm seems to take on importance in behaviors that include some kind of risk. Thus, safety factors are well-established and central concerns in parents' decision-making around ACS (Aranda-Balboa et al., 2020). However, previous research has shown that parents feel more comfortable allowing for example children's free play, that is, play without parental supervision, when more people are out and about in the neighborhood, as this creates "more eyes on the street", and therefore it is perceived as safer (Jacobs, 1961; Holt et al., 2015). In the specific context of ACS, previous studies have shown that when parents observed others talking or waving, and saw other children walking in the neighborhood, this increased the likelihood of ACS use among their children, provided that driving was not perceived as the most convenient option (Ross & Wilson, 2021). Ultimately, this underscores how perceptions of social norms may not only promote ACS behaviorally but also align with and potentially alleviate parental safety concerns (Pang et al., 2017; Ross & Wilson, 2021).

The built environment is a key factor influencing adolescents' travel behavior when walking to and from school (Wong et al., 2011). Evidence suggests that more direct routes are associated with a higher likelihood of walking to school. In a study in which route directness was measured using the Pedestrian Route Directness (PRD) index—defined as the ratio between the shortest network distance and the straight-line distance between home and school—children and adolescents were more likely to walk to school when routes were more direct (Campos-Sánchez et al., 2020). This measure provides an indication of the shape of the street network through which people move (Dill, 2004). At the same time, research indicates that when adolescents do walk, they may choose longer routes instead of the shortest, most efficient path, preferring routes with more intersections and higher residential density (Díaz-Carrasco et al., 2025a).

Moreover, previous research suggests that other route features such as connectivity, traffic conditions, and infrastructure influence whether parents allow their children to use ACS (Frank et al., 2010). Wang et al. (2017) emphasized the importance of analyzing the interaction between built environment characteristics and psychosocial factors, particularly in the context of ACS. In addition, objective measurements of these features are often considered more reliable than the subjective ones (Ding et al., 2011). There is also a lack of studies using objective built environment measurements at both micro- and macro- scale (Menardo et al., 2022; Wang et al., 2017). However, while objective measurements of the built environment may be more reliable, parents' decisions often seem to be influenced more by how they perceive the environment than by its physical reality (Kerr et al., 2006). For instance, prior studies have demonstrated that children's ACS is more closely linked to parents' perceptions of the neighborhood environment than to objective measurements of it (McMillan, 2007). Beyond influencing active commuting behavior directly, the built environment may shape the visibility of walking and cycling within a neighborhood. Built environment characteristics operate within a broader ecological system influencing health behaviors (Sallis et al., 2006). Walkable and connected street networks have been associated with greater pedestrian presence and neighborhood social interaction (Leyden, 2003; Ewing & Cervero, 2010), potentially increasing exposure to others' commuting behaviors. As described by Jacobs (1961), pedestrian presence and "eyes on the street" can influence perceptions of safety, and parents report greater comfort allowing independent mobility when more people are present (Holt et al., 2015). Increased visibility of commuting behaviors may, in turn, inform descriptive norms—perceptions of what others typically do (Rivis & Sheeran, 2003; Lapinski & Rimal, 2005). Thus, supportive built environments may contribute not only to behavior itself but also to parents' perceptions of normative commuting practices. In summary, previous research has examined how both subjective and objective measurements of the built environment are related to physical activity and ACS in children and adolescents (Ding et al., 2011; McMillan, 2007; Menardo et al., 2022; Wang et al., 2017). However, to the best of our knowledge no previous study has examined how the built environment is associated with parents' perception of the social norm. Therefore, this study aimed to explore how subjective and objective built environment characteristics, at both micro- and macro- scale, are associated with parents' perception of the social norm.

2. Methods

This cross-sectional study is part of two projects: the PACO (Pedalea y Anda Colegio [Cycle and walk to school]) and CiudActiva (Active City). The main objectives of these projects are to promote cycling and walking to school and respectively to analyse the influence of the built environment on physical activity behaviours among adolescents.

2.1. Participants

The present study included 16 public schools located in the cities of Granada, Jaén, Valencia, Toledo and Almeria (Spain). The self-reported family questionnaire used in this study was developed at the University of Granada by the PROFITH research group and was administered to parents through their adolescents at school between January 2019 and June 2021. The inclusion criteria for participation in this study were complete data on: 1) Social norm 2) City and educational center 3) Parents and adolescents sociodemographic background characteristics 4) Subjective built environment characteristics 5) Objective built environment characteristics (family postal address). In total 362 parents responded to the questionnaire and out of these, 223 parents were included when the three first criteria were applied. Out of these 223 parents, three subsamples were extracted when applying the fourth and fifth criteria. One subsample was based on the subjective built environment characteristics using ALPHA: (Assessing Levels of Physical Activity and Fitness) (n = 220) (Spittaels et al., 2010). Two subsamples were based on objective built environment characteristics: MAPS (Microscale Audit of Pedestrian Streetscapes) Global (n = 199) (Cain et al., 2018), and GIS (Geographic Information System) (n = 202), capturing the micro- and macro-scale respectively (Fig. 1). The study was approved by the Research Ethics Committee of the University of Granada under references 162/CEIH/2016 and 359/CEIH/2020.

2.2. Measures

2.2.1. Social norm

Parents' perception of the social norm was assessed using one question adopted from a previous study by Chillón et al. (2014) which has been found to have satisfying reliability in the Spanish context (Forsberg et al., 2024). The question was phrased as following: "How many adults in the neighborhood go and/-or return accompanying their children on foot or by bike to school?" Answer options

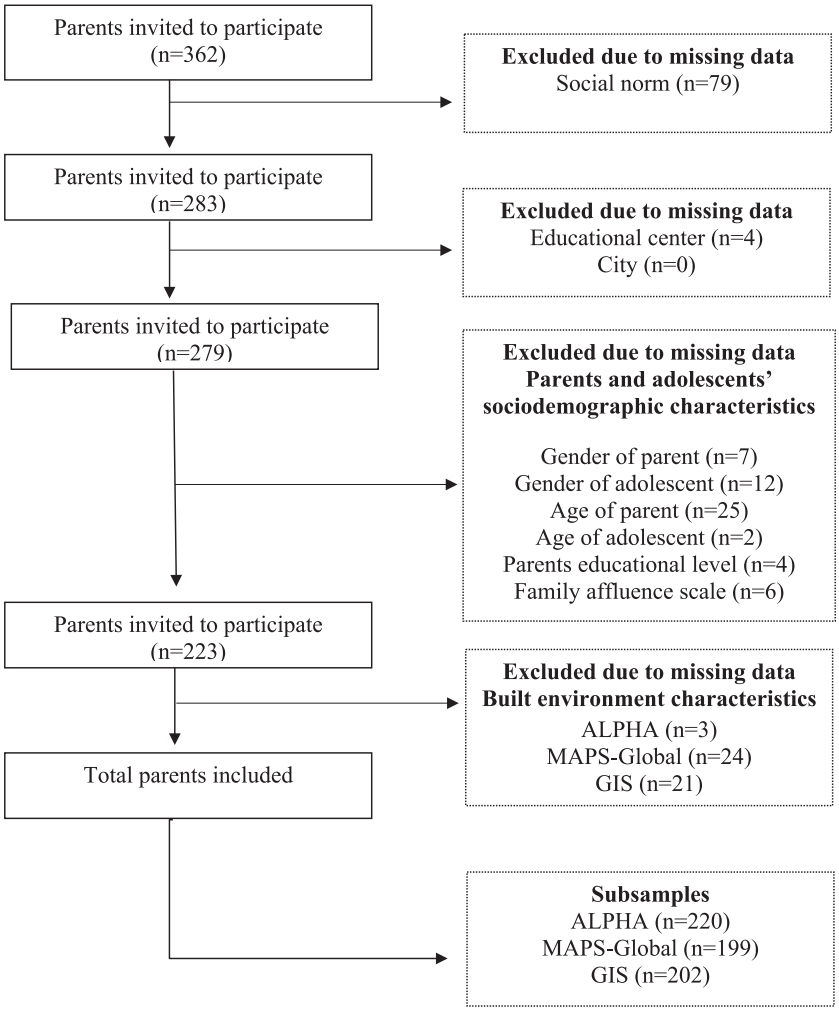

Fig. 1. Parents included in the study.

ranged from “none”, “few”, “plenty”, to “everybody”. Due to a low number of respondents selecting “everybody” (n = 2), the variable was recategorized from four response options to three, with option “everybody” being merged with the category “plenty”, forming the category “plenty”. The final answer options thus ranged from 1 to 3, including “none”, “few” and “plenty”.

2.2.2. Family sociodemographic characteristics

Parents reported their family sociodemographic characteristics including gender, age, school city and school. The educational level of parents was assessed using one question “What is the highest educational level that you have”. Answer options were, without studies and primary, categorized as “primary”. High school education and vocational training was categorized as “secondary”, and university was categorized as “university”. The family affluence scale was used to assess socio-economic status using four questions. (Torsheim et al., 2016). 1) “Does your child have their own room” (answer options: “yes” and “no”) 2) “Do you have internet access” (answer options: “yes” and “no” 3) “How many computers does your family own” (answer options: “none”, “one”, “two”, and “two or more” and 4) “Do you have a four-wheel motorized vehicle at home” (answer options:”no”, “yes one”, “yes two”, and “yes more than two”. These four questions were summarized as a continuous variable ranging from 0 to 7, indicating the lowest to the highest socioeconomic status.

2.2.3. Subjective built environment characteristics

How parents perceived the built environment for walking and cycling was assessed using four questions from the validated and reliable European environmental questionnaire- ALPHA (Spittaels et al., 2010). These questions reflect how pleasant the neighborhood is for walking and cycling: 1) “My local neighborhood is a pleasant environment for walking and cycling” 2) “The buildings are clean and free from markings (graffiti)” 3) “There are trees along the streets in my neighborhood” and 4) “In my neighborhood, there are badly maintained, unoccupied, or ugly buildings” Answer options were: “strongly disagree”, “somewhat disagree”, “somewhat agree”, and “strongly agree”. In accordance with ALPHA (Spittaels et al., 2010) these four questions were summarized as a continuous variable assessing the perceived satisfaction, ranging from 4 to16. The perceived aesthetics was assessed by summing all questions except one of them (“My local neighborhood is a pleasant environment for walking and cycling”) ranging from 3 to 12. To ensure consistency in scoring direction, the item 4)”In my neighborhood, there are badly maintained, unoccupied, or ugly buildings” was reverse coded before they were summarized.

2.2.4. Objective built environment characteristics

Parents reported their family postal address in the family questionnaire. This data was exported to Excel and used as the basis for objectively assessing the built environment with both MAPS Global and GIS.

To assess microscale built environment characteristics, the MAPS Global tool was used (Cain et al., 2018). MAPS Global is a standardized and internationally validated observational instrument designed to capture detailed street-level features relevant to walking and cycling across age groups and settings (Cain et al., 2018; Cain et al., 2014; Millstein et al., 2013). Unlike macro-level GIS indicators, MAPS Global assesses observable environmental attributes directly experienced by residents through structured auditor-based observation. Such features may function as visible social cues shaping expectations regarding walking and cycling within a neighborhood context. The instrument has demonstrated good validity and reliability, including for online assessments using Google Street View and Google Earth (Queralt et al., 2021). The tool includes four analytical components: route, segments (street sections between two intersections), crossings, and cul-de-sac. However, in the Spanish version, cul-de-sac is included as an item in the crossing section. Although MAPS Global allows assessment of “home”, “school”, and “home-to-school” routes, this study focused on the residential home block, considered the most relevant spatial unit for capturing routine social exposure to everyday mobility behaviors and neighborhood-level normative cues. Using the same spatial unit across participants also reduced variability in the extent of the area assessed. Blocks were assessed online using Google Street View and Google Earth following standardized MAPS Global procedures. Assessments were conducted clockwise, beginning at the participant’s main entrance and continuing until the entire block was covered. Ten researchers completed standardized training and certification prior to independent coding, requiring assessment of at least four routes and achieving > 95% agreement (Millstein et al., 2013). Observed items were aggregated according to the standardized MAPS Global scoring protocol (Cain et al., 2018) and summarized into 10 composite domain scores, each reflecting a specific aspect of the built environment. Domains consist of defined sets of observable street-level characteristics coded using standardized categorical or ordinal response options. For example, the pedestrian infrastructure domain includes sidewalk presence and continuity, sidewalk width, separation from traffic, curb ramps at crossings, and absence of major obstructions. Items were coded as supportive or unsupportive for walking and cycling and combined by summing positive attributes and subtracting negative attributes when applicable. Some domains consist primarily of supportive attributes and therefore yield nonnegative score ranges, whereas others include both supportive and unsupportive components combined as positive minus negative scores. Consequently, theoretical score ranges differ across domains and may include negative values. The possible score ranges were: streetscape (0 to 29), destinations and land use (–10 to 111), aesthetics and social environment (–6 to 4), street segment (–13 to 45), crossings (–2 to 25), pedestrian infrastructure (0 to 27), pedestrian design (0 to 22), grand score for active transport (0 to 210), grand score for leisure physical activity (0 to 56), and bike facilities (0–11). Higher scores indicate a more supportive built environment for walking and cycling.

To assess the built environment on a macro-scale level, GIS was performed using ArcGIS 10.3 (ESRI, Redlands, CA, USA). The home-built environment was defined as the area within a 1350-meter street network buffer from the home (original point), as this distance has been identified as the threshold within which urban Spanish adolescents are willing to walk to school (Rodríguez-López et al., 2017). Several databases were used to attain data which were: Spatial reference data of Andalusia (DERA), National Statistics Institute (INE), Unified Digital Street Map of Andalusia (CDAU), RT and Carto Ciudad from the National Geographic Institute (IGN), ATOM

Inspire Cadastral Database, and Open Street Map (OSM). In this study, a total of nine macro-variables were included which were: residential density, intersection density, land use mix, walkability index, service density, trees density, park density, sport facilities density and open public spaces density. All macro-scale variables were calculated as densities, except for land use mix and walkability, which were calculated as an index. An overview, including descriptions and calculations of the variables, is provided in Supplementary file 1 (Table S1).

2.3. Data analysis

In the first step, descriptive statistics were calculated for each variable. Categorical variables were reported using frequencies and percentages, while continuous were reported as means and standard deviations. In the second step, the necessity of a multilevel approach was assessed. Thus, we calculated the Intraclass Correlation Coefficient (ICC) using a null (empty) linear mixed model to assess the proportion of variance attributable to the grouping structure (city and educational center). This model included only the dependent variable (social norm) with random intercepts for both city and educational center. The analysis yielded an ICC of 0.016 for educational center and 0.012 for city, indicating that the proportion of variance attributable to each grouping level was low (<5%). The low between-group variance justified proceeding with a single-level approach. Given that the outcome variable (social norm) was measured on an ordinal scale with three ordered categories, cumulative logit ordinal regression models (proportional odds models) were fitted using the *ordinal* package in R. Thus, in the third step, we conducted separate bivariate ordinal regression models for each built environment characteristic (entered as independent variables), with the social norm as the dependent variable. These results are presented as crude associations (Supplementary file 1, Table S2). In the fourth step, the bivariate models were adjusted for gender of parents and adolescents, socioeconomic status and parents' educational level (Forsberg et al., 2024). Variables identified in the adjusted bivariate analyses, using a liberal significance threshold of $p < 0.20$, were considered for potential inclusion in the multivariable models (Gropp et al., 2012). Finally, multivariable models were conducted, adjusted for the same covariates as in the bivariate models, and these analyses form the basis for the main results and interpretations. The ordinal regression models were specified using a cumulative logit link function as follows:

$$\text{logit}[P(Y_i \leq k)] = \theta_k - (\beta_1 X_{1i} + \beta_2 X_{2i} + \cdots + \beta_{pi} X_{pi})$$

Table 1
Family sociodemographic characteristics of the participants and parents' perception of the social norm according to the subjective and objective built environment characteristics subsamples.

	Subjective environment	**Objective built environment**	
	(n = 220)	Micro-scale MAPS Global (n = 199)	Macro-scale GIS (n = 202)
Gender [a]			
Parents gender			
Mother	165 (75)	148 (74.4)	154 (76.2)
Father	55 (25)	51 (25.6)	48 (23.8)
Adolescents gender			
Girl	122 (55.5)	109 (54.8)	110 (54.5)
Boy	98 (44.5)	90 (45.2)	92 (45.5)
Age (years) [b]			
Parents age	46.3 (4.7)	46.4 (4.6)	46.3 (4.6)
Adolescents age	14.3 (0.6)	14.3 (0.6)	14.3 (0.5)
Parents educational level [a]			
Primary	13 (5.9)	12 (6)	10 (5)
Secondary	98 (44.5)	90 (45.2)	87 (43.1)
University	109 (49.5)	97 (48.7)	100 (52)
Family socioeconomic status [b]			
	5.4 (1.3)	5.4 (1.3)	5.4 (1.3)
Social norm [a]			
None	106 (48.2)	93 (46.7)	93 (46.0)
Few	86 (39.1)	81 (40.7)	83 (41.1)
Plenty	28 (12.7)	25 (12.6)	26 (12.9)

Note: ALPHA = Assessing Physical Activity Levels and Fitness, MAPS = Microscale Audit of Pedestrian Streetscapes, GIS = Geographic Information System, Social norm= See other adults walking/cycling in the neighborhood to/from school with child.
[a] Number (%).
[b] Mean (SD).

where Y_i represents the ordinal social norm outcome for participant i, k denotes the category thresholds, θ_k are the intercept cut-points, and X_{pi} represents the independent variables included in each model, comprising: (i) single built environment predictors in crude bivariate analyses; (ii) built environment predictors plus adjustment covariates (parental and child gender, socioeconomic status, and parental educational level) in adjusted bivariate analyses; and (iii) predictors meeting the inclusion criterion ($p < 0.20$) together with covariates in the final multivariable models. Before finalizing the models, collinearity among predictors was tested using the *car package* to prevent multicollinearity issues, and the distribution of residuals was evaluated using the *DHARMa package* to ensure that model assumptions were met. All statistical analyses were performed using R software (4.3.3.), and inferential statistics were evaluated at a significance threshold of $p < 0.05$.

3. Results

Table 1 displays the sociodemographic characteristics and social norm reported by parents across the subsamples according to the subjective and objective built environment characteristics subsamples. In the three subsamples, 74.4–76.2% of respondents were mothers, indicating a consistently higher representation than fathers. Adolescents' gender was quite evenly distributed among girls (54.5–55.5%) and boys. The mean age of parents was approximately 46.3 years (SD ± 4.6–4.7). The mean age of adolescents was 14.3 (SD ± 0.5–0.6). University education was the most reported educational level among parents, ranging from 48.7% to 52% across subsamples. The average socioeconomic status was classified as medium–high, with a mean score of 5.4 (SD ± 1.3). Most parents (46–48.2%) reported not seeing adults walking or cycling with children to and/or from school, indicating a low perceived social norm. Table 2 displays the means and standard deviations for the built environment characteristics.

Fig. 2 displays the results from the adjusted bivariate ordinal regression analyses examining associations separately between built environment characteristics and parents' perception of the social norm (See Supplementary file 1, Table S3 for detailed data). None of the subjective built environment characteristics showed a statistically significant association with the social norm (all, $p > 0.05$). Among the objective built environment characteristics, several micro-scale variables were significantly associated with decreased odds of the social norm. This included destinations and land use (OR = 0.93, CI: 0.88–0.99) pedestrian design (OR = 0.90, CI: 0.82–0.99) and grand score for active commuting (OR = 0.97, CI: 0.95–0.99). Several of the macro-scale variables were significantly associated with increased odds of the social norm, which included residential density (OR = 1.43, CI: 1.08–1.93), walkability index (OR = 1.19, 1.04–1.37), park density (OR = 1.45, CI: 1.10–1.92), sport facilities density (OR = 1.87, 1.40–2.54), and open public space density (OR = 1.68, 1.25–2.29).

Fig. 3 displays the results of the multivariable analysis (See Supplementary file 1, Table S4 for detailed data), retaining the objective built environment characteristics that were significantly associated with the social norm on a liberal level in the bivariate analysis ($p < 0.2$). Due to multicollinearity, the macro-scale variables residential density, intersection density and land use mix were excluded from this model. The final findings showed that a higher density of sports facilities was associated with increased odds of the social norm (OR = 1.84, CI: 1.26–2.74).

Table 2
Means and standard deviations for the built environment characteristics.

	Mean (SD)
Subjective built environment characteristics (n = 220)	
Satisfaction	12 (2.1)
Aesthetics	8.9 (1.6)
Objective built environment characteristics	
Micro-scale (n = 199)	
Streetscape	2.1 (1.9)
Destinations and land-use	6.3 (4.7)
Aesthetics and social	−2.6 (0.8)
Segment	14.9 (6.2)
Crossings	6.8 (3.6)
Pedestrian infrastructure	7.5 (2.2)
Pedestrian design	8.5 (2.8)
Grand score for active commuting	32.9 (11.6)
Grand score for leisure activity	9.6 (3.2)
Bike facilities	0.3 (0.7)
Macro-scale (n = 202)	
Residential density	12,117 (5528)
Intersection density	215 (88.7)
Land use mix index	0.4 (0.1)
Walkability index	0.2 (2.1)
Service density	61.8 (45)
Trees density	756 (1371)
Park density	11.2 (5.8)
Sport facilities density	27 (11.4)
Open public spaces density	75.2 (30.5)

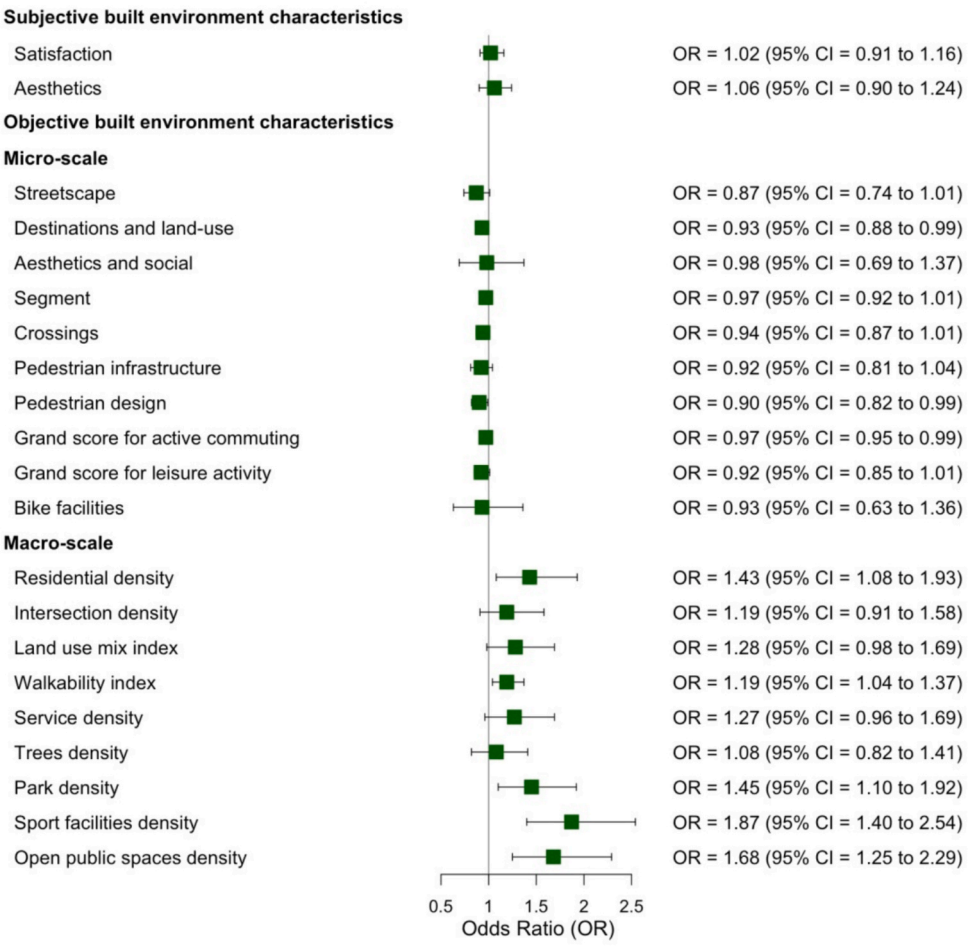

Fig. 2. Bivariate ordinal regression between the built environment characteristics and parents' perception of the social norm, adjusted for parents and adolescents' gender, socioeconomic status and parents' educational level, OR = odds ratio, CI= Confidence interval (significance level of < 0.05).

4. Discussion

The aim of this study was to explore how subjective and objective built environment characteristics, at both micro- and macro-scale, were associated with parents' perception of the social norm. When the built environment was considered as a whole in a multivariable model, the main finding was that parents living in neighborhoods with a higher density of sports facilities were more likely to observe other adults walking or cycling to school with their children. (i.e., social norm). Nevertheless, in the adjusted bivariate models, when the macro-scale variables were considered separately, apart from sport facilities, a higher residential density, as well as a higher density of parks, and open public spaces along with greater walkability in the home neighborhood, were all significantly associated with increased odds of the social norm. In contrast, the findings showed that none of the micro-scale variables were associated with the social norm in the multivariable model. However, in the bivariate model destinations and land-use, pedestrian design and grand score for active commuting in the home block, were significantly associated with decreased odds of the social norm. Interestingly, the subjective built environment characteristics showed no association with the social norm.

Parents whose home neighborhood had a higher density of sports facilities were almost two times more likely to perceive other parents and their children engaging in ACS in their neighborhood. Interestingly, and consistent with our findings, previous studies have identified recreational facilities such as soccer fields and basketball courts within the home neighborhood (2 km buffer) as important for adolescents' weekday physical activity (Loh et al., 2020). Similarly, recent reviews have found that parents' perceptions of access to sports and recreational facilities in their neighborhood are positively associated with adolescents' physical activity levels (Xing et al., 2025). Thus, a higher density of such facilities could increase the likelihood of parents observing others walking, cycling, or engaging in sports, providing cues about what is perceived as common and normal behavior. Indeed, previous research suggests that when parents perceive that other children are walking and cycling in their neighborhood, they become more likely to let their own child do the same, since frequent public activity may also convey a sense of safety (Forsberg et al., 2024; Melin et al., 2024; Ross & Wilson, 2021; Zeng et al., 2023). Beyond their direct role in supporting physical activity, our findings underscore how sports facilities

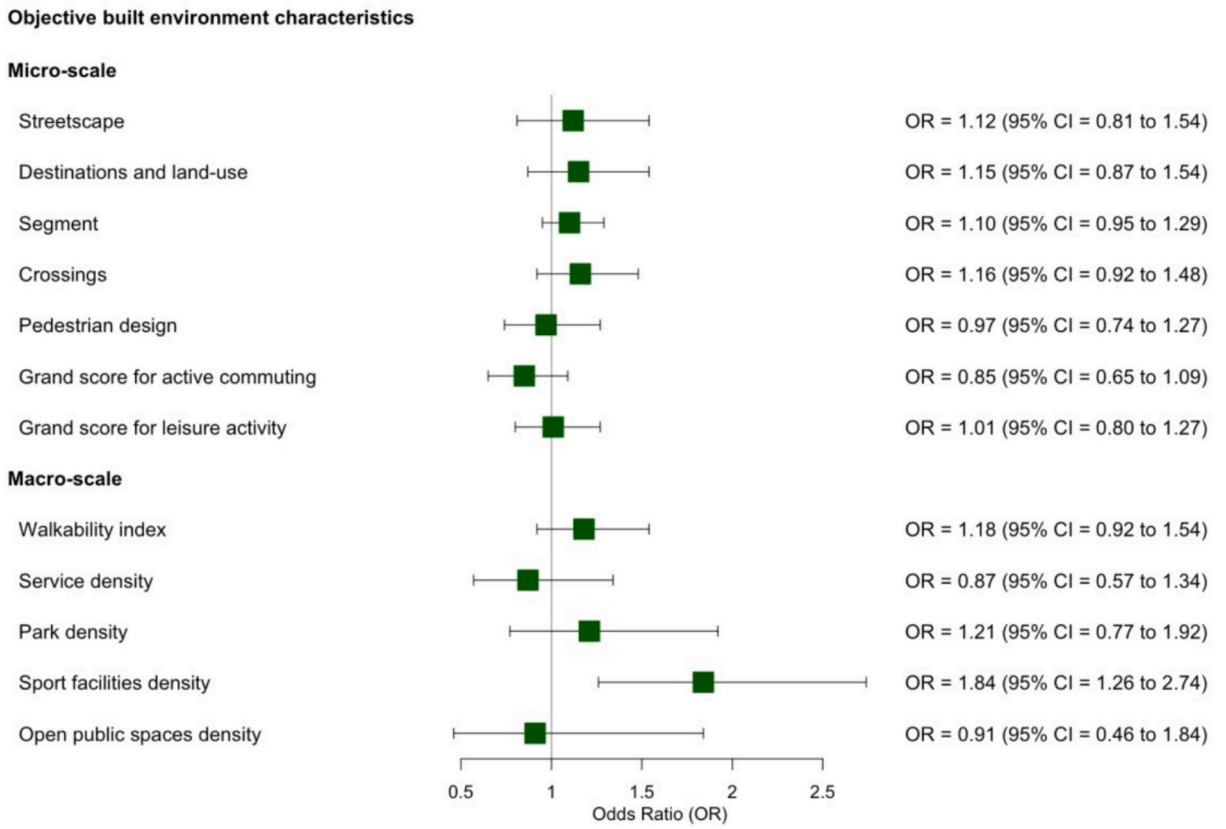

Fig. 3. Multivariable ordinal regression between the built environment characteristics and parents' perception of the social norm, adjusted for parents and adolescents' gender, socioeconomic status and parents' educational level, OR = odds ratio, CI= Confidence interval (significance level of < 0.05).

may help shape ACS-related social norms.

Although based on bivariate analyses, several built environment variables, including park density, residential density, walkability, and open public spaces, were associated with parents' perception of the social norm, broadly aligning with previous research linking such features to children's physical activity (Althoff et al., 2025; Buck et al., 2019; Queralt & Molina-García, 2019; Yi et al., 2021). However, some micro-scale variables showed counterintuitive negative associations, which contrasts with previous research suggesting that walkable environments support children's active commuting (Ikeda et al., 2018). Importantly, none of these associations persisted in the multivariable models when all environmental variables were considered simultaneously. This suggests that the observed bivariate associations do not reflect independent effects and should be interpreted with caution. While these findings may indicate potentially relevant environmental factors, further research is needed to examine their role in other contexts.

The absence of an association for the subjective built environment characteristics contrasts with the objective ones, at both the micro- and macro-scale, which did show a relationship in this study. This is in line with previous studies showing that objective measurements have performed better in explaining physical activity behavior such as leisure, walking and transportation (McGinn et al., 2007). This discrepancy highlights that subjective measurements of the built environment do not always align with its actual characteristics (Menardo et al., 2022). One possible explanation is that subjective built environment characteristics are shaped by personal attitudes, experiences, or social context, which may not accurately reflect the physical environment's potential to influence behavior (Panter et al., 2008). Furthermore, it has been suggested that subjective measures may be less sensitive or too general to capture the specific environmental cues (Menardo et al., 2022). This may explain why the subjective built environment characteristics were less effective in explaining social norms, suggesting that objective measurements may be more useful for this type of outcome.

It was also noteworthy to observe the differences between the micro- and macro- scale variables used in this study. Whereas the macro-scale variables showed stronger associations with parents' perception of the social norm, than the micro-scale variables. One possible explanation for these differences may lie in the spatial scale of the tools. Macro-scale variables capture broader neighborhood-level characteristics, offering a more comprehensive view of the surrounding environment (Campos-Sánchez et al., 2020; Wong et al., 2011). Meanwhile, the narrower geographic focus in micro-scale variables captures features in a limited single-block such as intersection design and land-use (Cain et al., 2018; Vanwolleghem et al., 2016). The differences between these two in our results may therefore reflect that parents' perception of the normativity of ACS likely stems from observing others being active in patterns across the neighborhood rather than from a single street segment (Ross & Wilson, 2021). This in turn, may explain the weaker associations in

micro-scale variables, and how macro-scale variables may be more suitable for analyses with broader psychosocial constructs such as social norms.

4.1. Implications

Policymakers could consider the importance of designing neighborhoods that visibly support active lifestyles as such built environments may provide social cues and reassurance to parents. In this sense, developing a built environment with greater possibility of being active through the presence of sports facilities within residential areas and everyday settings could be related to the sense of more people around, potentially contributing to perceptions that active behaviors are common and socially supported. Consequently, providing and promoting accessible facilities for physical activity may increase the presence of adolescents and adults in the community, which could help strengthen social norms around active behaviors. In practical terms, municipalities could incorporate considerations of neighborhood- level density and spatial distribution of sport facilities into land-use planning processes, development plans, and long-term infrastructure strategies. Ensuring visibility and everyday integration of such facilities may reinforce their potential social signaling function. Further, this study demonstrates the utility of macro-level measurements in relation to psychosocial perspectives to better understand and design environments that promote physical activity. Integrating macro-level environmental measures with psychosocial constructs in planning and evaluation processes may strengthen future physical activity promotion strategies.

4.2. Methodological strengths and limitations

The major strength of this study is the use of measures capturing subjective and objective built environment characteristics at both the micro- and macro-scale. This approach provides a rich and detailed understanding of how the built environment characteristics shape parents' perception of the social norm. These measurements were standardized, reliable, and validated, with rigorous inter-rater reliability procedures and high-quality spatial data (Cain et al., 2018; Forsberg et al., 2024; Millstein et al., 2013; Spittaels et al., 2010). Despite these strengths, some methodological considerations should be taken into account when interpreting the findings. First, it should be noted that although the MAPS Global measures are described as objective, this designation refers to their independence from participants' perceptions and does not imply complete absence of human judgement in the assessment process (Cain et al., 2018). In addition, the micro-scale assessment was limited to the residential home block. While this aligns with the outcome measure and captures routine neighborhood-level exposure, it does not account for environmental characteristics beyond the immediate residential context. Second, the distance to the city center was not included as a macro-scale indicator of urban centrality. While GIS-based indicators captured structural characteristics of participants' residential neighborhoods, incorporating a centrality measure may have provided additional contextual information regarding broader urban spatial structure. Also, the macro-scale built environment was defined using a 1,350-meter street-network buffer based on empirically identified walking thresholds among Spanish adolescents (Rodríguez-López et al., 2017). However, recent systematic reviews indicate that smaller buffers (e.g., 800 m or 1,000 m) are more commonly used in studies of school neighborhood environments (Díaz-Carrasco et al., 2025b). Nevertheless, we chose this buffer size to better reflect the specific Spanish context. Third, family socioeconomic status was assessed using the family affluence scale (Torsheim et al., 2016), which includes car ownership but does not capture emerging opportunities for mobility such as bicycle or e-bike ownership. The social norm was assessed using a single-item measure capturing parents' perceptions of what other adults do in the neighborhood. While the item reflects a key aspect of descriptive norms, it may not capture the full complexity of social norms (Forsberg et al., 2024). In addition, the cross-sectional design precludes conclusions about causality. The somewhat skewed sample, including more mothers than fathers, may also limit the generalizability of the results.

5. Conclusion

The findings of this study highlight that, when the built environment was considered as a whole in a multivariable model, the density of sports facilities, measured as a macro-scale variable, emerged as important for parents' perception of the social norm. Meanwhile, subjective and micro-scale characteristics showed no associations. This may imply that environments offering visible opportunities for physical activity, such as sports facilities, provide social cues that shape parental perceptions of ACS as normative and socially supported behavior. Indicating that the presence and design of sport facilities should be considered in planning-built environments that promote physical activity behaviors, such as ACS. Taken together, the findings also suggest the importance of measurement choice, with macro-scale variables emerging as the most informative approach for capturing associations with parents' perceptions of the social norm.

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CRediT authorship contribution statement

Hanna Forsberg: Writing – original draft, Software, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Pablo Campos-Garzón:** Writing – review & editing, Visualization, Software, Methodology, Formal analysis, Data curation. **Ana Ruiz Alarcón:** Writing – review & editing, Investigation. **Iris Díaz- Carrasco:** Writing – review & editing, Investigation. **Sergio Campos-Sánchez:** Writing – review & editing, Investigation, Funding acquisition. **Palma Chillón:** Writing – review & editing, Validation, Supervision, Methodology, Funding acquisition, Conceptualization. **Francisco Javier Huertas-Delgado:** Writing – review & editing, Validation, Supervision, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Statement.

During the preparation of this work Hanna Forsberg used ChatGPT 5.0 in order to improve the readability and language of the manuscript. After using this service, the author reviewed and edited the content as needed and take full responsibility for the content of the published article.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.trd.2026.105406.

Data availability

Data will be made available on request.

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