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Walkability Drivers for Sustainable Cities: a Pedestrian Behavior Survey

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Abstract

The growth of cities often disordered brings several mobility challenges, both in guaranteeing public transport and creating pedestrian-friendly urban spaces. This paper aims to identify the walkability drivers in urban areas and investigate walkability behavior. The survey was carried out in southern Brazil, with a sample of 439 respondents. Data were subject to factorial analysis, regression analysis, and variance analysis. The analysis revealed four walkability drivers that explain pedestrian behavior: (i) infrastructure, (ii) traffic conditions and behavior, (iii) built and natural environments, and (iv) social relations. The results show that built and natural environments and social relations were the most significant aspects in explaining walkability's overall perception. Concerning socio-demographic aspects, the study points out that (i) men feel safer than women when walking in the neighborhood; (ii) the presence of trees and attractive places along the street increases the walking behavior of non-sedentary people; and (iii) the perception of the neighborhood's beauty increases with age. The research provides contributions regarding understanding the interrelated aspects of walkability behavior. Finally, the study offers relevant evidence for social researchers and urban planners by identifying walkability drivers and supporting political and academic debate elements.

Keywords: sustainable city, pedestrian behavior, walkability, survey, Brazil.

Introduction

Urbanization occurs at an unprecedented rate, with the projection that three-quarters of the world's population will live in urban environments by 2050 (Bibri & Krogstie, 2017). This estimate indicates that cities play critical roles in providing urban environmental quality to the population at a minimum acceptable standard and climate change challenges (Bibri & Krogstie, 2017; Iwan & Poon, 2018). The shape of contemporary cities has been seen as a source of environmental resources and social problems, such as the consumption of around 70% of the world's resources, being large consumers of energy and contributors to the emissions of gases that cause the greenhouse effect (Bibri & Krogstie, 2017).

The challenges related to cities are due to population density and the intensity of economic and social activities related to the inefficiency of environmental resources (Bibri & Krogstie, 2017) and other factors such as inadequate urban projects, social deprivation, mobility, and ineffective accessibility, increased need for transport, public safety, decreasing health, traffic congestion, among others (Bibri & Krogstie, 2017).

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The idea of making cities more sustainable has grown in importance in several fields of knowledge, such as urban planning, environment, and public policy management (Cerutti *et al*., 2019; Jayakody *et al*., 2018). Among the dimensions of a sustainable city, walkability has been identified as one of the central axes of quality of life in sustainable cities (Jayakody et al., 2018). Walkability is one of the strategic elements that are part of urban mobility in general and is characterized both by the study of the physical means that provide walking and by the qualitative aspects about what motivates people to walk in the urban space (Ewing *et al*., 2006; Jayakody *et al*., 2018).

In addition to these two approaches, the nature of walking can be motivated by physical activity or as an active means of transportation (Livi & Clifton, 2004). Regardless of the motivation, improving the walkability of a city has a direct impact in several fields, such as recreation studies (Haq, 2011; Frank *et al*., 2010), urban design (Su *et al*., 2017; Cerin *et al*., 2006), public health, transportation planning (Leslie *et al*., 2005; Cerin *et al*., 2006; Lo, 2009), and quality of life (Macke *et al*., 2018; Lee, 2008; Litman, 2003). For this reason, researchers and public managers are increasingly interested in understanding pedestrians' behavior, perceptions, and attitudes and the relationship of this perception with the physical environment (Livi & Clifton, 2004; Zuniga-Teran *et al*., 2017).

Many researchers have analyzed urban transformations and the impact on walkability (Su *et al*., 2019; Habibian & Hosseinzadeh, 2018; Riggs, 2017), but more work needs to be done on studies that include both objective and subjective data to analyze the individual behavior of pedestrians according to the morphology of the spaces. The tools used to verify walkability have generally been poorly adapted to capture the characteristics of the built environment and attitudes and behaviors about walking, and since they were not originally designed to access pedestrians' perception of these issues (Livi & Clifton, 2004).

The tools that assess walkability fail to access different types of walking behavior, and they do not link pedestrian behavior with the definition of a sustainable city (Su *et al*., 2017). A sustainable city requires improvements in quality and safe access to active mobility, which demands knowledge and understanding of the pedestrians' perception of their walking behaviors and the walkability drivers.

According to socio-demographic features, these gaps and the debate about walkability in sustainable cities lead to this paper's primary objective: to identify the walkability drivers in urban areas and investigate the perception of walkability. The survey was carried out in southern Brazil, in which the attitudes and behaviors about walking of 439 respondents were investigated.

This paper is organized as follows. After this introduction, the theoretical background of walkability is presented. The third section describes the methodological steps, procedures, and criteria. The fourth section presents and discusses the study results. Finally, the conclusion section highlights the study's theoretical and applied contributions.

Walkability

Urban planning is gradually changing, with goals to modify pedestrian streets' landscapes that favor walking and improve urban sustainability (Su *et al*., 2019; Habibian & Hosseinzadeh, 2018; Riggs, 2017). Most research still focuses only on one type of walking: physical activity or walking as a mode of transport, aiming to learn more about one type or another. These surveys' common point focuses on pedestrians' perception (Livi & Clifton, 2004).

In recent years, there has been an increase in popularity and accessibility indexes, creating measures that assess both the built form and residents' needs. Accessibility, or just access, refers to the ability to achieve the desired goods, services, and activities, and walking provides essential mobility; that is, many people depend on walking to access activities, such as medical services, education, and work (Litman, 2003; Ewing *et al*., 2006; Lo, 2009). Accessibility can be assessed using surveys with residents, field surveys, and geographic information systems to determine the portion of essential destinations that can be conveniently reached through travel on foot, in particular by disadvantaged populations (Litman, 2003), which is vital in considering the assessment of the walkability of cities.

Walkability offers various benefits, including accessibility, cost savings for the consumer and public economy, more efficient land use, habitability, public health, and economic development (Litman, 2003; Manaugh & El-Geneidy, 2011). Pedestrians can walk for several purposes: access a destination as a means of transport, exercise, leisure, or some combination (Livi & Clifton, 2004). However, the walking behavior's complexity extends beyond the physical, social, and psychological and motivations, perception of security, ability to move around, personal attributes, income so essential to the decision to walk (Livi & Clifton, 2004).

There are several elements and variables to be considered regarding the walk. As the physical characteristics, qualities of urban design, and individual reactions determine the capacity of the general passage of a street, what we mean by the way people feel about the street as a place to walk (Litman, 2003; Leslie *et al.*, 2005; Ewing *et al.*, 2006; Owen *et al.*, 2007). The main elements of local mobility are proximity and connectivity, with proximity being related to mixed land uses that create shorter distances between homes and destinations such as shops or work, and connectivity is the variety of routes to the destination (Owen *et al.*, 2007; Lo, 2009; Frank *et al.*, 2010; Habibian & Hosseinzadeh, 2018). In several studies analyzed by Lo (2009), many measures overlap when it comes to the analysis of pedestrians' walking capacity, such as maintenance of sidewalks and continuity, connectivity between streets, safety in crossings, absence of heavy traffic and high speed, traffic protection, the density of land use, diversity of land use, presence of vegetation, visual interest and perception of security. Different studies show that it is necessary to consider several drivers for walking, mobility, and pedestrians to enable the subsequent measurement of these items (Litman, 2003; Leslie *et al.*, 2005; Lo, 2009).

However, physical resources individually may not tell us much about the experience of walking down a specific street, as they do not capture people's general perceptions of the environment on the streets, perceptions that can have problematic or subtle relationships with physical characteristics (Leslie *et al.*, 2005; Ewing & Handy, 2009; Manaugh & El-Geneidy,2011). Perception can result from interactions between past experiences, culture, and interpretation of the perceived drivers such as physical characteristics, urban design qualities, and individual characteristics that can influence how an individual feels about the environment as a place to walk (Ewing & Handy, 2009). Thus, it is considered that the attributes of the built environment can be measured both objectively (for example, using data from geographic information systems) and subjectively (for example, using questionnaires (Leslie *et al*., 2005; Cerin *et al.*, 2006; Owen *et al.*, 2007).

A tool that has been used for walkability analysis is the Walk Score, which has been recognized as valid and reliable for estimating access to nearby facilities - a critical component of the physical activity environment. However, there is still no determination whether this tool relates to other components such as connectivity on the streets, access to public transport, residential density, and crime. Even so, these factors can be measured in GIS and correlated to Walk Scores, which offer quick and easy-to-use support for considering neighborhood density and close accesses (Carr*et al.*, 2010; Su *et al.*, 2017). Another study was carried out in neighborhoods in Maryland, where three neighborhoods were assessed. The instrument was designed to make an initial assessment of pedestrian behaviors, including those related to transportation and physical activity, attitudes about walking, perceptions about the built environment, and some demographic information (Livi & Clifton, 2004). This instrument was based on The Partnership for a Walkable America (PWA), which consists of perception issues addressing sidewalks, pedestrian crossings, safety, and fun. This was the model considered for elaborating the questionnaire applied in the study, as it offers considerations of different elements and consideration of people's perceptions.

The study by Adkins and colleagues (2017) analyzed 17 research on the environment versus mobility issue showed that the environment has more effects on walking and physical activity for disadvantaged people than favored groups and that disadvantaged populations face more walking problems tranquility, safety, and health. The research by Moura and colleagues (2017) considered different pedestrian groups (adults, children, the elderly, pedestrians with reduced mobility) and travel purposes (utilitarian and leisure), considering different factors. The results showed that different groups of pedestrians and reasons for travel significantly impact the assessment of walking ability (Moura *et al.*, 2017), so the importance of considering these variables when assessing walkability (Moura *et al.*, 2017; Aghaabbasi *et al.*, 2018).

Emerging evidence supports a link between the built environment in the neighborhood and physical activity, showing that improving the built environment to facilitate and increase physical activity is related to people's health (Livi & Clifton, 2004; Frank *et al.*, 2010). Therefore, walkability is increasingly gaining attention as a critical issue in promoting healthy, environmentally friendly, and socially active practices, as it provides social, environmental, and economic benefits. Besides, in many cases, the only way for people to access daily activities is on foot. Besides, walkability brings life to the streets and makes them habitable, contributing to safer environments (Moura *et al.*, 2017; Habibian & Hosseinzadeh, 2018). These elements make the study of walkability critical in the ever-increasing search for sustainable cities and prioritizing active mobility, such as walking.

Method

Questionnaire design

The questionnaire was adapted from Livi & Clifton (2004), in which walkability is defined "upon the ease of street crossings, sidewalk continuity, local street network characteristics, and topography" (Livi & Clifton, 2004, p. 4). The variable referring to "During the winter, sidewalks are kept clear of snow" was changed for the perception of walkability, considering this weather phenomenon is not common in the region studied. A Likert scale of 5 points (1 = strongly disagree; 5 = strongly agree) was used for the variables for assessing walkability.

The original questionnaire, published in English, was translated into Portuguese, and two translators performed a content validity test. Three researchers from the social theory research group carried out the questionnaire layout adjustments and slight adjustments of the Portuguese language in face-to-face meetings. The pilot test was carried out on ten respondents before the sample was applied, and small semantic adjustments were made to facilitate the respondents' understanding.

The questionnaire was constructed subdivided into two parts: The first part was composed of 31 closed questions on the assessment of walkability; the second contained 11 variables on socio-demographic data (gender, age, the primary mode of transport, possession of a driving license, owns a dog, owns a car, has children under 5, neighborhood and city).

Survey procedures

Data were collected between June and August 2019 by volunteer university students who regularly participate in the research group's activities. The questionnaires were printed, and people were interviewed in public and open places, in squares and parks. The field researchers went through previous training. The 439 respondents interviewed were informed about their voluntary participation, the anonymity of the answers, and the use of the answers only for academic purposes. The average response time of 15 minutes was sufficient to answer the questionnaire.

Data analysis

The answers were initially prepared in an electronic spreadsheet, and, later, they were organized in the SPSS software (Statistical Package for the Social Sciences), version 20 for Windows® for data analysis.

The data were analyzed using descriptive statistics, factor analysis, linear regression, and analysis of variance. Descriptive statistics were used for the socio-demographic characterization of the sample. Factor analysis is used to summarize and reduce data (Hair et al., 2003), and it was used to identify the walkability drivers. Linear regression was used to identify the relative weight of the variables (Hair *et al.*, 2003) in the general perception of walkability. Finally, analysis of variance was used to identify significant differences in mean (Hair *et al.*, 2003) between perceptions according to the respondent's socio-demographic profile.

Results: analysis and discussion

The context: Passo Fundo region in south Brazil

The survey was conducted in the Passo Fundo region, located in the Rio Grande do Sul (the southernmost state in Brazil). The city of Passo Fundo is the principal city in the region (29.61% of respondents). The city has an estimated population of 203,275 people in 2019 and a Municipal Human Development Index (MHDI) of 0.776, according to the IBGE (2019). Cities are considered small and medium-sized, and MHDIs levels are between medium and high (IBGE, 2019). All cities are based mainly on agriculture (especially the small cities). Passo Fundo is the largest city. It is also considered a hub in commerce, industry, education, and health, a nationally recognized medical hub (the city has nine hospitals), and a national capital of culture (having nine higher education institutions).

Identification and analysis of walkability drivers

Descriptive analysis revealed the sample's main characteristics concerning the family: 61.3% are women; 49.5% of respondents are up to 36 years of age (sample mean: 37 years); 17.8% have children under five years old; 57.2% have a dog. Regarding means of transportation: 74.2% have a car; 75.9% have a driver's license; 65.9% have the car as the primary means of transportation, while only 16.9% have walking as the primary means of transportation.

Regarding walking habits, sedentary behavior was defined as less than 20 minutes a day; they represent 54.8% of the sample. Of the total sample (n = 439), 12.1% walk more than 3 km per day. The primary trips are close to home (33.11%) and close to school or work (28.17%).

For 44.1% of respondents, the seasons do not interfere with the habit of walking. Besides, 66.0% usually walk alone, and 38.7% usually walk at night. 55.6% say it is possible to go to work or school on foot, but only 34.62% usually do so. Considering the main reasons for walking: 55.8% walk because it is an opportunity to do physical activity and 18.9% walk for practicality, indicating that urban design favors walkability for this portion of the sample.

Regarding the main reasons that hinder or limit the habit of walking: 54.67% of respondents point out the lack of time as a limiting issue for walking, and 14.58% point out the lack of security as a limiting factor for the practice of walking. When asked what factors would make them walk more: 36.88% would walk more if there were good sidewalks, 31.21% would walk more if there were more and better public lighting on the roads, and 24.15% would walk more if there were more parks and squares.

This research aims to go beyond the walkability assessment made by Livi & Clifton (2004). The data were subjected to factor analysis using PCA (Principal Component Analysis) through the varimax rotation. Missing cases were excluded by listwise treatment (this option means that any case that failed to answer a question is disregarded in the analysis). The index of Kaiser-Meyer-Olkin (KMO) adequacy of the sample was 0.726, and Bartlett's Test of Sphericity (significant to 0.000) indicated the factorability of data (Hair *et al.*, 2003).

The factorial analysis's final model is formed by 12 variables, indicating that six were left out of the model. These variables were removed, one by one, using commonality as a criterion. In addition to the variables provided for in the study by Livi & Clifton (2004), a variable for the general assessment of walkability was added, used as a dependent variable in the linear regression analysis: WALK - "Generally speaking, it is easy to walk in my neighborhood".

The total explained variance of the model was 61,768%, with the "Infrastructure" driver explaining 17,571%; the "Traffic Conditions and Behavior" explaining 16,287%; the "Built and Natural Environments" explaining 15,233% and, finally, the "Social Relations" driver explaining 12,678%. The analysis results converged in 5 iterations, and the Cronbach's alpha for the scale was 0.762, which indicates a satisfactory result for an exploratory study (Hair *et al.*, 2003).

Table 1

Factorial results for walkability

Driver	Items	Loading	Mean	Standard deviation
Infrastructure (0.761)*	INF1–Sidewalks are safe and clear of litter, leaves, poles, and other obstacles.	0.839	2.46	1.114
	INF2 - Sidewalks are safe for people with mobility disabilities.	0.785	2.12	1.024
	INF3–There are enough sidewalks	0.731	2.80	1.214
Traffic conditions and behavior (0.651)*	TCB1 -Drivers drive at a safe speed.	0.700	2.75	0.999
	TCB2–Drivers usually respect pedestrians.	0.691	2.74	1.059
	TCB3–There are sufficient traffic signals and well-marked crosswalks.	0.676	2.78	1.178
	TCB4–Traffic signals allow enough time to cross the street.	0.638	3.16	1.103
Built and natural environments (0.666)*	BNE1–There are trees and attractive places along the street.	0.853	3.39	1.086
	BNE2–There are benches and places to sit.	0.693	3.15	1.217
	BNE3–My neighborhood is attractive and enjoyable to walk in.	0.626	3.52	1.027
Social relations (0.604)*	SOR1–There are commercial areas within walking distance of my residence.	0.818	3.36	1.307
	SOR2–I often see people walking and cycling in my neighborhood.	0.767	3.51	1.109

* Cronbach's Alpha

The Infrastructure driver (M = 2.458; SD = 1.117) includes the variables: (i) "Sidewalks are safe and clear of litter, leaves, poles and other obstacles"; (ii) "Sidewalks are safe for people with mobility disabilities"; and (iii) "There are enough sidewalks". This dimension was the one that presented the lowest averages, which suggests that respondents are not satisfied with sidewalks' infrastructure. In the study by Moura et al. (2017), similar results were found. Pedestrians, representing the elderly and with reduced mobility, were affected by the sidewalk's sufficient width, which does not accommodate this type of population becomes an inconvenience when walking. The study results by Aghaabbasi and colleagues (2018) show that sidewalks are an essential driver in bringing safety, especially for people with reduced mobility. Moreover, Jayakody et al. (2018) found that sidewalks must be free of obstacles and leveled to access people with reduced mobility. Another component pointed out that favored infrastructure environments are more walkable (such as places with adequate sidewalks) than disadvantaged environments (Frank *et al.*, 2005; Adkins *et al.*, 2017 & Lo, 2009), which proves that infrastructure is one of the points to consider making the place more walkable.

The Traffic conditions and behavior driver (M = 2,846; SD = 1,088) embraces the variables: (i) "Drivers drive at safe speed"; (ii) "Drivers usually respect pedestrians"; (iii) "There are sufficient traffic signals and well-marked crosswalks"; and (iv) "Traffic signals allow enough time to cross the street". The averages of three variables are less than three, which indicates that respondents assess that traffic conditions are considered flawed and that drivers do not drive safely, respecting pedestrians. In this line, providing traffic safety is one aspect that needs to be improved, as it is related to the adoption of walking as transportation (Cerin *et al.*, 2006). Cities should consider infrastructure items such as safety and lighting lanes in the traffic safety infrastructure (Cerutti *et al.*, 2019). Less walkable areas have larger blocks, fewer intersections, and greater distance at intersections (Leslie *et al.*, 2005; Lo, 2009), making it difficult to cross the roads.

The Built and natural environments driver (M = 3.356; SD = 1.110) comprises the variables: (i) "There are trees and attractive places along the street"; (ii) "There are benches and places to sit"; and (iii) "My neighborhood is attractive and enjoyable to walk in". Respondents' assessment of this driver was better than that of previous drivers. The presence of resting places, such as seats, is attractive to people, but these are sometimes not used due to a "sense of protection". Still, they are essential to encourage walkability (Jayakody et al., 2018). Another point is that green spaces contribute to people's quality of life, promoting several benefits, such as reducing urban heat, improving air quality, valuing property, and, mainly, psychological benefits, by providing relaxation and recreation (Frank *et al.*, 2005; Haq, 2011; Lo, 2009). Just as respondents noted trees' presence on the streets they walk on, land-use planners must recognize the need to walk spatially the same and the health benefits provided in built environments. Typical approaches to improving street landscapes include providing green belts and sidewalks, building benches and shelters, balancing streets with pedestrian widths, and installing pedestrian crossings (Cerutti *et al.*, 2019; Su *et al.*, 2017).

The Social relations driver (M = 3,438; SD = 1,213) encompasses the variables: (i) "There are commercial areas within walking distance of my residence"; and (ii) "I often see people walking and cycling in my neighborhood". This dimension was the one that presented the highest averages, which suggests that respondents are satisfied with social relations as an element for walkability perception. In the study by Lee (2008), it was found that individuals care more about perceptual perspectives than with environmental perspectives, which goes against what was found in the result above, showing the high degree of relationship in social aspects and not in physical aspects as infrastructure.

Regarding the infrastructure of the neighborhood, Moura et al. (2017) point out that the lack of immediate commerce impacts the convenience of walking to reach these places due to factors such as the concentration of commerce in a few streets and with a predominance of homes and services, that is, the diversity of use of the neighborhood is low, which prevents people from choosing to walk (Frank *et al.*, 2005; Leslie *et al.*, 2005; Ewing *et al.*, 2006; Owen, 2007; Jayakody *et al.*, 2018). Places with active façades, which have shops on the ground floor, are pleasant for pedestrians who travel these places and have a more significant population when they can be reached on foot. The ability to walk dramatically impacts the community's habitability, the streets being an important aspect when they provide places where people interact with their community (Litman, 2003). The social factor is an essential component for people to walk, and, for this reason, the increase in the mix of land use should be a practical approach for the construction of coexistence streets (Su *et al.*, 2017; Su *et al.*, 2019).

In short, as our cities face pressure to run out of cars, the challenge is not merely to create "walkability" but to create great walkable streets that encourage activity, observation and experience, beauty, and visual interest (Riggs, 2017). Therefore, the improved walkability increases accessibility, community livability, improves public health and supports strategic economic development, land use, and equity (Litman, 2003; Su *et al.*, 2019).

The relationship between walkability variables and general perception "In general, walking in my neighborhood is easy" was tested by linear regression using the stepwise method (Table 2). The as-

Table 2

Linear regression model

Model	R	R Square	Adjusted R Square	St. Error of the Estimate	Durbin-Watson
1	0.454[a]	0.206	0.204	0.896	
2	0.566[b]	0.321	0.317	0.830	
3	0.592[c]	0.351	0.346	0.812	
4	0.606[d]	0.367	0.361	0.803	
5	0.613[e]	0.375	0.368	0.799	
6	0,618[f]	0.382	0.372	0.796	1.854

a. Predictors: (Constant), BNE3 – My neighborhood is attractive and enjoyable to walk in.

b. Predictors: (Constant), BNE3 – My neighborhood is attractive and enjoyable to walk in, SOR2 – I often see people walking and cycling in my neighborhood

c. Predictors: (Constant), BNE3 – My neighborhood is attractive and enjoyable to walk in, SOR2 – I often see people walking and cycling in my neighborhood, INF3 – There are enough sidewalks

d. Predictors: (Constant), BNE3 – My neighborhood is attractive and enjoyable to walk in, SOR2 – I often see people walking and cycling in my neighborhood, INF3 – There are enough sidewalks, TCB2 – Drivers usually respect pedestrians

e. Predictors: (Constant), BNE3 – My neighborhood is attractive and enjoyable to walk in, SOR2 – I often see people walking and cycling in my neighborhood, INF3 – There are enough sidewalks, TCB2 – Drivers usually respect pedestrians, INF2 - Sidewalks are safe for people with mobility disabilities

f. Predictors: (Constant), BNE3 – My neighborhood is attractive and enjoyable to walk in, SOR2 – I often see people walking and cycling in my neighborhood, INF3 – There are enough sidewalks, TCB2 – Drivers usually respect pedestrians, INF2 - Sidewalks are safe for people with mobility disabilities, BNE1 – There are trees and attractive places along the street.

g. Dependent Variable: WALK - Generally speaking, it is easy to walk in my neighborhood.

sumptions of homoscedasticity, multicollinearity and normal distribution of errors were achieved for linear regression analysis. The regression results show that six variables in the model are significant for walkability and represent 37.2% ($R2 = 0.372$, $p < 0.05$) of the general perception of the walkability: BNE3 - My neighborhood is attractive and pleasant to walk, SOR2 - I often see people walking and cycling in my neighborhood, INF3 - There are enough sidewalks, TCB2 - Drivers tend to respect pedestrians, INF2 - Sidewalks are safe for people with motor disabilities, BNE1 - There are trees and places attractive to along the street.

The results show that among the model variables, two belong to the walkability driver "Built and natural environments", two variables belong to the driver "Infrastructure", one variable belongs to the driver "Social relations", and one to the "Traffic conditions and behavior". The Durbin-Watson test was used to detect the presence of autocorrelation (dependence) in the residuals of a regression analysis (Hair *et al.*, 2003). The model's test value (1.854) indicates that we can state that the waste is independent with a 95% confidence level.

In other words, the perception of walkability depends significantly on the performance of these variables (**Table 3**). The perception of walkability can be written as follows:

$$\begin{aligned}\mathbf{Walk} &= \mathbf{0.259\,{*}BNE3 + 0.319\,{*}\,SOR2 + 0.104{*}INF3} \\ &\quad \mathbf{+\,0.118{*}\,TCB2 + 0.094{*}\,INF2 + 0.090{*}\,BNE1}\end{aligned} \tag{1}$$

The variable with the most significant weight in the general perception of walkability is "SOR2 - I often see people walking and cycling in my neighborhood" (beta = 0.319; sig. 0.0000). One of the explanations for the presence of pedestrians and cyclists is that for physical activity, no urban element is more important than the streets, as these are where active trips to work, shop, get involved in other daily activities take place (Ewing *et al.* 2006). The bicycle also appears on the

Table 3

Linear regression coefficients

Final Model	Unstandardized		Standardized	t	Sig.
	B	Std. Error	Beta		
(Constant)	0.801	0.193		4.155	0.000
BNE3 – My neighborhood is attractive and enjoyable to walk in	0.253	0.045	0.259	5.639	0.000
SOR2 – I often see people walking and cycling in my neighborhood	0.288	0.038	0.319	7.641	0.000
INF3 – There are enough sidewalks	0.086	0.037	0.104	2.351	0.019
TCB2 – Drivers usually respect pedestrians	0.112	0.040	0.118	2.762	0.006
INF2 - Sidewalks are safe for people with mobility disabilities	0.093	0.044	0.094	2.114	0.035
BNE1 – There are trees and attractive places along the street.	0.084	0.042	0.090	1.994	0.047

a. Dependent Variable: WALK - Generally speaking, it is easy to walk in my neighborhood.

streets as a healthy and sustainable means of transport and physical activity (Kellstedt *et al.*, 2020). When these streets provide the right places (such as sidewalks, bike lanes), there is an incentive for more people to be present on the streets (Zuniga-Teran *et al.*, 2017).

The second variable with the most significant evaluation is “BNE3 - My neighborhood is attractive and enjoyable to walk in” (beta = 0.259; sig. 0.0000). The neighborhood configuration can influence the decision to walk, indicating that the neighborhood’s physical structure is one of the key elements to explain walking patterns (Larrañaga *et al.*, 2009; Nieuwenhuijsen, 2020). Another reason cited by Leslie et al. (2005) was that, in neighborhoods with high walking rates, residents reported that attributes related to residential density, the combination of land use (access and diversity), and the connectivity of the streets have higher values than residents who live in neighborhoods with low circulation. These issues are related to living together since walking becomes a pleasant activity in terms of interaction with people, the natural and built environment, and other pedestrians (Moura *et al.*, 2017).

The other variables - there are enough sidewalks, drivers usually respect pedestrians, sidewalks are safe for people with mobility disabilities, and the presence of trees and attractive places along the street - indicate that the characteristics of the neighborhood influence people’s walks. These results corroborate Zuniga-Teran and colleagues’ (2017) findings, suggesting that a neighborhood that offers traffic safety combined with design elements improves the walking experience, including the nearby green space and easy access to these spaces. Providing commercial destinations near residential areas (diversity of land use) with high residential density can encourage people to walk. Places with good infrastructure attract people, and for that, it is necessary: continuous and preserved sidewalks, the appropriate location of urban furniture, which also contribute so that people with reduced mobility can also enjoy these public spaces, absence of high and high-speed traffic, trees street and landscaping and safety issues, both real and perceived by pedestrians (Larrañaga *et al.*, 2009; Lo, 2009). All these aspects contribute to the streets being quality places for walking.

Identifying statistical differences between the respondents’ averages were carried out through the Analysis of Variance (ANOVA). The purpose of this analysis was to identify differences in behavior according to the different profiles of respondents, especially between the sedentary and active groups. The sedentary profile (walking less than 20 minutes a day) represents 54.8% of the sample. Statistically significant differences ($p < 0.050$) were identified for: sedentary lifestyle, sex, and age group (Table 5).

Table 4

Statistical differences between the respondents' averages through ANOVA

Variable	F	Sig.	Result
Time spent walking per day	1099.89	0.000	Non-sedentary people spend more time walking.
	3.895	0.049	Men spend more time walking.
Distance walking per day	333.10	0.000	Non-sedentary people walk longer distances.
	6.413	0.012	Men walk longer distances compared to women.
Drivers drive at a safe speed	3.243	0.001	The perception that drivers drive at safe speeds increases with age.
Felling safe walking in the neighborhood	11.585	0.001	Men feel safer than women when walking in the neighborhood.
	2.055	0.032	People aged between 28 and 36 years old feel safer than others.
Sidewalks safety for people with mobility disabilities	5.660	0.014	Non-sedentary people consider the sidewalks safer than sedentary people.
	5.281	0.000	People aged between 28- and 36-years old feel consider the sidewalks unsafety.
Presence of benches and places to sit	6.140	0.014	Non-sedentary people agree that there are more benches and places to sit than sedentary ones.
Presence of trees and attractive places along the street	4.430	0.036	Non-sedentary people agree that there are more trees and attractive places to sit than sedentary ones
Beauty of neighborhood area	2.221	0.020	The perception of the beauty of the neighborhood increases with age.
Ease of walking in the neighborhood.	5.710	0.017	Non-sedentary people find walking in the neighborhood easier than sedentary ones.
	4.484	0.035	Men find walking in the neighborhood easier than women.

Both "Time spent walking per day" and "Distance walking per day" showed statistically significant differences regarding sex and physical inactivity (p <0.050): men and active people spend more time walking and travel greater distances per day. Men also perceive that walking in the city is more accessible than women. Regarding physical inactivity, the results show that this driver was the one that presented the most significant number of different perceptions. The perception of active people differs from the perception of sedentary people concerning four aspects (p <0.050): (i) Sidewalk's safety for people with mobility disabilities; (ii) Presence of benches and places to sit; (iii) Presence of trees and attractive places along the street; and (iv) Ease of walking in the neighborhood. In all these aspects, active people have more favorable evaluations than sedentary people, showing that adopting walking habits also improves the city's perception as a space that provides active mobility, social interaction, and quality of life (Leslie *et al.*, 2005).

Regarding the differences in perception according to the age group (p <0.050), the results show that older people have the perception that drivers drive more safely (perhaps because respondents have designed their attitudes in the assessment) and also has a more positive evaluation about urban space since the perception of the beauty of the neighborhood increases with age. The age group between 28 and 36 years old showed a difference in perception in two aspects (p <0.050): (i) they have higher Felling safe walking in the neighborhood, and (ii) they consider sidewalk's unsafety for people with mobility disabilities. The first aspect is related to urban violence, while the second is to perceive the need for pedestrians' infrastructure (Jayakody *et al.*, 2018; Moura*et al.*, 2017; Cerin *et al.*, 2006).

Conclusions

There is growing concern among nations about issues related to sustainability. Researchers and urban planners have sought to identify the variables and methods to measure how sustainable a city is and how it impacts the lives of the people who live there, always seeking to minimize environmental impacts and improve the quality of life and the environment. One way is to consider active mobility, such as walking, which, in addition to not polluting, improves people's health and well-being, but it also needs qualified environments for its encouragement.

Sustainable mobility is a positive indicator of what we all want - replacing pollution, crime, traffic accidents as indicators of what we do not want - and thus becomes a focus for collective action and involvement that recreates the community and takes care of each other and the places they share.

This study aimed to identify the walkability driver in urban areas and investigate walkability drivers according to socio-demographic features. Four walkability drivers were identified: Infrastructure, Traffic conditions and behavior, Built and natural environments, and Social relations. These drivers include both physical and psycho-social aspects linked to walkability. In this way, the study contributed to filling the gap of accessing subjective data to analyze pedestrians' behavior according to the spaces' morphology by identifying attitudes and behaviors about walking.

Regarding respondents' general perception about the ease of adopting walking as active mobility, two aspects were more significant: the attractiveness and pleasure of walking in the neighborhood and the adhesion of more people walking and cycling. This result shows the importance of thinking and designing the neighborhoods, considering the infrastructure and the natural environment that privilege social interaction and active mobility.

Finally, socio-demographic aspects related to walkability were identified: the need to improve public security for women, young people, and the elderly; improve the quality of sidewalks for people with mobility disabilities; increase the presence of benches and places to sit, to encourage people who are sedentary or have reduced mobility; increase the number of trees and attractive places along the street, to encourage coexistence and improve the feeling of security.

Walkability is a central element in planning a sustainable city, and several drivers need to be reviewed. Over the years, walking has taken on an exceptional character, as if it were not a natural alternative for human displacement. Urban spaces are still, for the most part, idealized from the vehicle's perspective, especially in developing countries. As the results pointed out, the design of spaces is fundamental to stimulate coexistence in urban life. Thus, walkability depends on an understanding of walking behavior according to the morphology of the spaces.

In sum, this work contributes theoretically and practically to several approaches. First, it identifies the walkability drivers in urban areas to provide the citizens' perception of walkability as a subjective analysis. Second, it explains socio-demographic aspects related to walkability as a central aspect of a sustainable city. Finally, the study offers relevant evidence for social researchers and urban planners by identifying walkability drivers and supporting political and academic debate elements.

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