urban science

MDPI

Article

Toward Resilient Urban Design: Pedestrians as an Important Element of City Design

Diego Ros-McDonnell [1], María Victoria de-la-Fuente-Aragón [1], Lorenzo Ros-McDonnell [1,*] and Manuel Cardós [2]

[1] Industrial Engineering Research Group, Universidad Politécnica de Cartagena, 30202 Cartagena, Spain; diego.ros@upct.es (D.R.-M.); marivi.fuente@upct.es (M.V.d.-l.-F.-A.)

[2] Department of Business Administration, Universidad Politécnica de Valencia, 46076 Valencia, Spain; mcardos@omp.upv.es

* Correspondence: lorenzo.ros@upct.es; Tel.: +34-699961166

Abstract: Including pedestrians in urban design is vital so that they prefer walking over motorized transport. Motorized mobility, which mainly involves automobiles, has conditioned urban design, pedestrian movement, sustainability, and urban resilience. Studies of walkability in cities have recently been conducted, and they can be classified into those that use a qualitative observer-perception-based approach and a second approach based on the measurement of observable variables. This work aims to develop a tool that allows for walkability in public spaces to be evaluated based on directly observing reality while considering both approaches: those related to perceiving the environment and physical reality. Walking is one of the main ways of moving around and achieving sustainable urban mobility. The conditions of public spaces are fundamental for people in their preference for moving around by walking. A literature review related to walkability revealed that previous works included a variety of viewpoints, scales, tools, variables, and approaches. This study included a developed tool by modeling a definition of working areas, processing walkability data, and determining the Walkability Index (WI). The reliability of the data observed from the walkability variables was verified, and the tool's usefulness for urban planning was demonstrated. Pedestrian-centered urban design promotes cities' sustainable mobility, sustainability, and resilience. People's conduct reveals how the urban environment is perceived. The developed WI evaluates the existing reality and allows for its evolution to be monitored.

Keywords: pedestrian; urban management; urban resilience; sustainable mobility; walkability

Citation: Ros-McDonnell, D.; de-la-Fuente-Aragón, M.V.; Ros-McDonnell, L.; Cardós, M. Toward Resilient Urban Design: Pedestrians as an Important Element of City Design. *Urban Sci.* **2024**, *8*, 65. https://doi.org/10.3390/urbansci8020065

Academic Editor: Mike Hynes

Received: 20 February 2024
Revised: 28 May 2024
Accepted: 4 June 2024
Published: 7 June 2024

1. Introduction

The process of designing urban environments must not ignore the fact that designing an available space for pedestrians is vital if citizens are to prefer walking over using motorized transport. Urban planners must consider how to set up and develop citizens' rights to walk regardless of their disabilities, physical condition, age, job, etc. This work presents a way to measure walkability on a street or in a district that incorporates how citizens use the space.

A city contains two types of spaces: public spaces and private spaces. These surface areas are exclusive and complementary. Public spaces comprise linear elements whose categories and importance differ; these are urban routes and surface elements, which are basically squares and green spaces, and their level of relevance also varies. Public spaces belong to the community. They are collective places, providing the main environment for human relationships, and they are, to a certain extent, essential elements of a city. Public space is continuous; citizens have free to access to it, but they must stick to rules related to its use, particularly those set by local authorities. One of public space's many functions is to support different categories of the movement of people and things, and this is one of its most important missions. Ever since automobiles emerged, different spaces have been assigned for motorized vehicles to move around and others for people. Today, however, the distribution of spaces must take other types of mobility, such as traditional and electric bicycles, skateboards, delivery tricycles, and cleaning machinery, into consideration.

Throughout the 20th century, motorized traffic has occupied an ever-growing portion of the public space, mostly for automobiles to move around and park. Looking at today's use of public space, almost 70% of it is either directly or indirectly designed for motorized vehicles. Moreover, 64% of the kilometers driven by motorized vehicles are actually in an urban environment [1]. The urban design praxis has prioritized the mobility of vehicles by prioritizing speed and machines and has reduced the surface area by assigning people to two narrow lateral strips called sidewalks for longitudinal traffic; their narrowness makes other activities difficult, limits them, or even makes them impossible. Public space makes sense thanks to people; the citizens who move around a city walk about, observe, converse, shop, work, play, rest, interact with others, and perform an endless list of activities that should be encouraged by providing suitable spaces for them to do so [2].

The many activities performed in a city not only require a great deal of resources but also generate different types of waste and conditions that negatively impact the urban system and its environment. Between the end of the last century and the start of this century, concerns about these circumstances have marked the search for more sustainable cities by developing policies and initiatives for public transport, green spaces, community amenities, etc. to deal with social, environmental, and economic impacts by means of urban planning and city management [3–5]. Such actions contribute to increasing a city's resilience [6].

Concern about the sustainability of urban areas in the social, environmental, and economic dimensions influences urban design, especially when outlining spaces according to citizens' new expectations. The fact that public space is gradually more occupied by motorized means of transport to the detriment of pedestrian areas has conditioned the way that people use common spaces. The degree of occupation by motorized vehicles has significantly reduced the variety of, time taken to, and area occupied to perform social activities in public spaces and negatively impacts urban resilience. Sustainable urban design has included the community's perception, the cost of housing, energy use, security against crime, environmental responsibility, etc. [7]. Walking is acknowledged as the main and oldest form by which human beings move around, and it contributes physical and mental benefits. Given its individual and social implications, it is becoming a relevant urban planning issue to be considered [8,9]. Compact walkable cities collaborate in conserving natural resources and reducing the costs of using infrastructures [10]. Walkable cities encourage their inhabitants' social interaction by generating a sense of community and improving their mental health [11,12]. The different activities performed by pedestrians in public spaces can be synchronic or take place over time. The wider the variety of simultaneous or successive activities is, the greater is the plurality of the pedestrian uses that will take place in a public space. Thus, a city's vitality, strength, and durability will increase, and, basically, the urban system's resilience will grow.

In this resilient and sustainable city scenario, the local authorities play a key role because, among other aspects, they must set up new mobility policies for cities that encourage more sustainable mobility and less motorized traffic, and promote social cohesion to favor people's presence in public space by improving conditions for pedestrian mobility and increasing the activities that citizens can perform in this space. This urban scenario allows for the following questions to be raised:

- How can the walkability of an urban environment be evaluated based on the physical reality and considering the human factor?
- If evaluating walkability were possible, would such a method be reliable?

The tools proposed in this work are intended to positively answer the above questions to allow the following: on the one hand, the evaluation of the suitability of the urban environment for walking in accordance with the circumstances of the physical reality according to the pedestrians who use it; on the other hand, the monitoring of the evolution of an urban fabric's walkability.

Having identified urban walkability, the Introduction stresses the relevance of sustainability problems in urban areas, the pros and cons of walking, and the connection between mobility and accessibility. The Bibliographic Review Section offers a brief general description of the research on these issues by describing problematic matters, and discusses the research design. Section 3 presents a three-stage walkability methodology. The three stages are described in detail, along with their characteristics and the Walkability Index (I_w). Section 4 offers the results and a discussion about the reliability of walkability in urban systems. The independent variables included in the I_w for urban design are shown. Section 5 indicates the limitations of this research. The "Conclusions" Section provides the final generalized conclusions that were reached while work was underway. The Appendix A details the evaluation of all of the street auditing variables presented in Section 3.

2. Bibliographic Review

2.1. Urban Mobility and Walkability

Urban mobility, which is understood as the different ways and modes that people employ to travel and move goods around a city, is a paradigm of current urban policies. In 2003, given the relevance of the right to mobility, Southwork and Ben-Joseph [13] indicated the need to consider all mobility alternatives and means for citizens and goods by paying special attention to systems that use less energy, orient the supply of infrastructures, and manage the urban space by focusing on pedestrian mobility. In addition, the quality of the pedestrian environment is a key factor for encouraging people to walk rather than use vehicles [14].

Historically, urban design has sometimes not taken environmental quality and users' perceptions into account and has even negatively estimated pedestrians because they slow down vehicle traffic [15]. To build a city that adapts to pedestrians in the automobile era, it is necessary to promote a change in point of view by doing away with the approach that completely favors motorized vehicles to encourage other forms of moving around that foster pedestrian mobility and bicycle traffic in the urban fabric. This new approach of moving around by walking or cycling, along with public transport, is an excellent alternative that can improve urban mobility while also increasing a system's sustainability. A city's stakeholders can promote all of this by making changes in infrastructures, new rules to protect pedestrians and cyclists, and sustainable urban planning decisions [16–19].

When applied to an urban environment, the concept of walkability—understood as the conditions of the public space in this environment so that people can walk around it—is not only related to using the public space and inhabitants' attitudes [19] but also impacts many aspects; for instance, the influence of choosing a way to travel short distances be-cause a suitable, pleasant, and safe public space for walking around stimulates non-motorized modes of traffic as opposed to motorized ones. Another example is making areas that provide good conditions for walking and encouraging it as an available healthy activity, physical exercise, leisure, etc. Despite these and other possible related aspects, and bearing in mind the criteria established by Krambeck [20], this work studies the aptitude for walking in an urban space by evaluating different directly observable items that quantify distinct aspects of walkability to allow the so-called Walkability Index (I_w) to be estimated.

Clearly, the walkability of an urban space significantly influences a city's sustainability and resilience. Determining an urban design according to pedestrian mobility reduces the use of resources, which leads to their conservation [21]. It is worth considering that the I_w is a useful criterion for estimating an urban environment's degree of sustainability. The walkability paradigm emphasizes a new vision of the city fabric because its objectives seek to observe citizens' response to the existing urban design and, up to a point, to determine inhabitants' perceptions based on how pedestrians employ the place to determine if it is necessary to newly organize the environment by modifying reality based on social behavior.

In Spain [22], pedestrian travel to work represents between 14% and 26% of all traffic. Moreover, pedestrian zones with an appealing public transport service and access regulated by the delivery of goods help the volume of the commercial business in the area to grow. Introducing the concept of walkability into urban design involves considering urban displacements at different levels:

- Planning models and managing urban mobility, including urban sustainable mobility plans.
- The urban mobility of social groups with special needs—particularly at-risk groups:
    - Groups with specific needs (the elderly, those with disabilities, etc.);
    - Displacements: modes and motivation (work, leisure, etc.);
    - Connectivity of means of transport/infrastructures;
    - Flexibility and access costs.
- Urban logistics.

Walking is a basic way for people to move. Even people who habitually use a motorized vehicle walk more or less long distances. Non-motorized transport modes are ecological, economical, and reasonably quick for distances shorter than 3.5 km [23]. As previously indicated, walkability in an urban area is a fundamental factor of a sustainable city. Increasing the quality of the public space for walking is a key factor in encouraging people to walk; in other words, people opt for sustainable mobility modes. The I_w indicates the interaction between the public space and pedestrians [9] and answers pedestrians' questions, such as the following:

- Does the public space offer comfort?
- What degree of security does the pedestrian mode offer?
- Does it allow destinations in the city to be reached in a reasonable time/with reasonable effort?
- Does the urban landscape—the city's image—arouse pedestrians' interest? Is it pleasant?

The process of designing an urban environment must not ignore the fact that making a space suitable for pedestrian demands is vital for encouraging people to walk rather than resorting to motorized transport. Urban designers must bear in mind how pedestrians perceive their urban environment, as well as the view, smell, sound, textures, and even taste perceptions that characterize it. The sensations that an environment makes people feel determine its quality and clearly influence how people choose their mobility options.

2.2. Factors Influencing Walkability in Urban Areas

As opposed to the Anglo-Saxon spread city model [24], the compact city model [25], which promotes a wide range of uses in the urban fabric based on the compatibility and succession of activities, is more significant as a sustainable city paradigm. This latter city type stimulates the use of bicycles and public transport; that is, a city without motorized vehicles [26,27]. In the diffuse city model, different activities (e.g., human, residential, industrial, commercial, administration, etc.) are physically separated and generate large sectors with a limited number of tasks.

Conversely, the compact city is characterized by its density, continuous multifunctional fabric, and heterogeneous activities. This compact model is the basis of united social life and a competitive economic platform, with fewer land uses, lower energy use, and the use of fewer material resources than a diffuse city, where farming and natural systems are less affected by urban development. A compact city is also a system that allows the better conservation of neighborhoods, public spaces, and historic/cultural buildings [26,28,29]. Over time, the development of compact cities has led to different areas appearing in them. The oldest parts, the historic centers, were built to meet the typical needs, circumstances, and possibilities of the time; in such areas, generally, few rules apply, and the local authorities scarcely intervene. Likewise, areas that have undergone urban expansion, which are known as "ensanches" in Spain, were devised in the 19th and 20th centuries, and they developed according to the trends of that time. Contemplating both forms of growth came before sustainability criteria, as such were drawn up and were, logically, not taken into account, even though compact cities participate in them to a greater extent than diffuse cities do.

In urban design, it is necessary to consider that "the city is a complex set of interactions in which contradictory logics are faced" [30]. Any urban sprawl, regardless of if it is diffuse or compact, is continuously evolving and is a social manifestation that results from the actions of citizens who, on the whole, form or have formed part of society. The main factors to consider are the physical reality, the population, the government system, and economic activities [31].

The improvement in urban design and its consolidation according to walkability contribute benefits from the points of view of both the environment and comfort of urban areas; in addition, they increase the rendering of services and promote necessary regeneration [32]. Urban areas that allow citizens to walk intrinsically have an economic value because they favor economic transactions and social exchange [33,34]. Urban fabrics with a pattern of large housing blocks in pedestrian-oriented neighborhoods have the effect of increasing property values and, unlike in the previous case, have an impact by lowering property values in vehicle-oriented neighborhoods [35]. A broad consensus has been reached by urban designers about the importance of considering and including land use mixes, transport systems, and environmental policies toward sustainable development in urban design decision-making [36].

It is generally agreed that walkability is affected by the design of the built environment and its features [37]. In 2011, Pivo and Fisher [38] concluded that if the I_w value rises in an urban area when employing different walkability variables, such as metrics, such a rise can be associated with property values increasing up to 9%. The I_w has been well studied in several countries, such as Australia, New Zealand, India, and the USA [39–42]; for example, in Europe, research on "global microscale walkability ratings and rankings", which have been applied to 59 city centers, has been performed [43]. Compact cities, which can be found in European countries such as Spain, Italy, France, and Greece, cities, especially city centers and historic areas, which are made up of short, narrow streets with difficult access, and services, are not always available. Toward the end of the last century, many historic centers started to lose inhabitants because they moved to the cities' outskirts. For conservation purposes, this is why these urban fabrics need to adopt stimulation policies that particularly bear the positive characteristics of this conservation in mind.

2.3. Literature Review

With the intention of establishing an initial framework, a search for "walkability" was conducted on the Web of Sciences. In the past four decades, walkability has been analyzed using a wide range of scales, tools, variables, and approaches (applications). The works by Wang and Yang [37], Blečic et al. [44], Hasan et al. [45], and Singla et al. [46] were taken as a basis for the literature review by introducing the classification proposed by these authors into our study. The analysis of the literature related to walkability indicated that studies on this theme came from five continents (see Table 1).

Table 1. Works about walkability from five continents.

Region or Continent Where the Work on Walkability Was Carried Out	Examples of Walkability Studies That Were Performed
Africa	[47,48]
Americas	[41,49–52]
Asia	[15,20,39,40,53–57]
Australia	[42,58–61]
Europe	[9,36,42,62–65]

Likewise, it is worth indicating that walkability has been studied in the urban context at different levels (see Table 2).

Table 2. Works about walkability at different levels.

Level of the Studied Urban Design	Some Examples of the Walkability Studies Performed
Regional or provincial level	[50,51,66]
City level	[39,54,60]
District or neighborhood level	[49,58,59,63,65,67,68]
Street level	[1,9,23,53–56,62,64,69–71]

The methods that they applied to observe walkability varied, and they included interviews and surveys, GIS-based analyses, the auditing of physical reality, and the use of images and instruments [72]. They were performed in different research settings—mostly urban and rural planning, transport, and public health. The first works began with a basic walkability index that combined the net residential density, intersection density, the retail floor area ratio, and the land use mix. The studies that followed included other environmental elements or attributes of walkability [14,67], such as pedestrian infrastructures, green zones, and street furniture. They even considered perceptions of public space, such as travel satisfaction, wellbeing, safety, and security [59,73–75].

According to the variables making up walkability that are used to measure it, beginning with the analyses performed by Hasan et al. [76] and Wang and Yang [37], a classification was established based on the following different approaches:

- A perception-based approach in which studies collect the perceptions of users/pedestrians, the researcher, or a panel of experts [39,47,58,62,67,77–79];
- A measurement-based approach that includes the use of physical auditing [32,52,60,80], images [72,81], and GIS-based studies [47,49,51,55,56,82,83];
- A mixed approach [54,58,59,65,84,85].

We conclude from this review that walking is an urban outdoor activity [85], and 90% of public transport in cities includes a minimum of two pedestrian-covered distances. Thus, understanding how the urban environment influences the walking experience allows walking to be encouraged by means of planning and urban design. It must be stressed, as the introduction pointed out, that there is now a current in the 21st century that seeks to "return the city to citizens" [86] by orienting urban policies to promote the pedestrian/citizen/tourist figure from the point of view of sustainable mobility [87], which favors urban resilience.

To develop a methodology that includes the presence of pedestrians, it is necessary to identify which attributes are proposed in the literature about walkability. To do so, factors related to the design of infrastructures, accessibility, closeness to amenities, demographic characteristics, land use, security, convenience, and, finally, aesthetics were grouped (see Table 3).

The urban environment influences people as they walk and frequently does so unconsciously. Pedestrians often describe the characteristics of this environment and mention if they like, dislike, or are indifferent to its attributes for walking [85]. When pedestrians decide to move around on foot, their choice of route is conditioned by what citizens perceive that they can find in the environment [88]. Logically, in such circumstances, people prefer to walk around places with better attributes. This work includes the presence of pedestrians as a weighting factor of the environment's influence on walkability, and a tool that included two approaches (the perception-based approach and the measurement-based approach) was developed by studying reality. The developed method confers work teams with independence, as they can perform such analyses themselves because this method allows the human factor to be estimated by means of citizens' conduct.

Table 3. Factors of walkability.

The Factors Considered to Evaluate Walkability	Examples of Studies That Were Performed
Design of infrastructures	[1,23,51,52,54–56,59,63,64,69]
Accessibility	[9,49,52,54,55,58,60,63]
Demographic characteristics	[1,49,51,52,54,59,63,64]
Security factors	[9,23,47,52,54–56,59,60,62,64]
Convenience factors	[1,9,23,47,54,56,59,62,64,69,70]
Aesthetic factors	[9,23,52,58,60,64,70,73]

3. Materials and Methods

3.1. Modeling Cities Using Walkability

The main confirmatory research objective herein was to build a walkability index with mixed (qualitative and quantitative) variables that can be applied to the urban environment to seek to correct observer subjectivity. This research work intended to directly evaluate walkability, an intrinsically unobservable variable, as a metric for dealing with urban design by starting from the existing physical reality and the presence of citizens in public space.

The I_w, which is employed as a working method to evaluate the unobservable variable of walkability in an urban environment, is obtained by determining an urban space's characteristics through direct observation and aggregating these values. This method offers a simple procedure for determining the suitability of an urban space for pedestrian displacements in a city by estimating the observable items making up the I_w of the studied area.

Walkability reflects the urban environment's health status, its economy, and, above all, an area's habitability [40]. The main objective of calculating the I_w is summarized as follows:

1. Raising awareness of the importance of walkability for a city's development;
2. Providing local authorities with an instrument to deal with aspects of walkability;
3. Helping urban designers to understand the importance of conditions for pedestrians in different cities;
4. Offering urban designers the necessary information to identify deficiencies in the existing reality in relation to pedestrians.

In the different methodologies for analyzing walkability, the need to model a city by considering pedestrians is inferred; that is, making an abstraction of the existing reality that is not only representative but also allows its operation to be understood. The system used to model the urban fabric should be sufficiently flexible to devise different urban morphologies, and, if at all possible, it should contain a different level of detail. Up to a point, the intention is to search for a method that allows both a local study of the elements in public space, on a street, or on a stretch of street and a sectorial study of the environment, the urban fabric, and both streets and housing blocks.

The present work used a street audit tool that contains nine items to analyze walkability and its evaluation (Table 4). These variables allowed a large dataset to be obtained and walkability in the public space to be estimated by using the Global Walkability Index (GWI) as a starting point and applying it to compact cities in Europe, as well as by making street-level observations for urban design estimation (Section 3.3).

For data collection purposes, non-probabilistic sampling was applied by selecting three historic compact cities in the Mediterranean Region with similar population sizes. In these cities, working areas with clearly defined limits covering approximately 1 km^2 were established. The area of all three cities was divided into two or three working areas depending on their morphological characteristics. After selecting the urban areas where variables were to be observed, it was necessary to choose streets for data collection purposes.

To do so, the criterion followed was that all of the street types were represented in the sample (pedestrian streets, main roads, slow roads, thoroughfares, internal roads, etc.), and the observed stretches had uniform characteristics. A street was divided into stretches if this last condition was not met. This allowed 236 urban stretches to be selected (Section 3.2). The research team made all of the observations.

Table 4. The items of the Walkability Survey [adapted from 20].

Items	Description
Conflicts while walking	The extent of conflict between pedestrians and other modes on streets, such as bicycles, motorcycles, vans, etc.
Availability of sidewalks	Maintenance and cleanliness. Availability and conditions of sidewalks.
Availability of crossings	The availability and length of crossings
Degree of crossing safety	Exposure to other modes when crossing streets and time spent crossing streets
Motorists' behavior	Motorists' behavior toward pedestrians as an indicator of pedestrians' environment
Amenities	The availability of amenities, such as benches, lights, toilets, and trees, which greatly enhance the surrounding area
Disability infrastructure	The availability, positioning, and maintenance of infrastructure for the disabled
Obstructions	The presence of permanent and temporary obstructions on pedestrian pathways and effective pedestrian pathway width
Security against crime	The general feeling of security against crime on a certain road section

Apart from these observations, the number of pedestrians found on roadways (collected by the research team when directly observing the number of people) and the roadway length were quantified by measuring them directly on city maps. These two values were included in the construct calculation; that is, the implemented walkability index employed pedestrian use to weight the importance of the walkability variables of public space [85].

Measurements were taken on different days and at distinct times but with the same characteristics for the urban system that was being analyzed. The set formed by the observed data on urban stretches, which allowed the walkability index variable to be calculated, needed to be reliable and valid. Such characteristics were studied based on the application of Cronbach's alpha [89] and McDonald's omega [90] (Section 4) to the set of nine items that formed the construct (Appendix A). Likewise, the contribution of each item to the I_w according to the same indicators was studied.

To do this, a three-stage method was developed to determine the walkability of the urban morphologies that corresponded to compact cities. This adaptation eliminated subjective aspects and incorporated density into the pedestrian use of roadways as a city's resilience factor:

- Stage 1: Delimiting areas and determining the (j) urban observation elements; j = {1, 2, 3, . . .n}.
- Stage 2: Walkability data matrices $\left(\gamma_{i\,j}\right)$.
- Stage 3: The Walkability Index, "I_w"; pedestrian influence.

3.2. Study Areas

The aim of Stage 1 was to delimit sufficiently relevant urban environments and to select the elements in public space that allow walkability to be evaluated. To this end, three cities were chosen: Alcantarilla, Cartagena, and Molina de Segura. In all of them, seven work elements corresponding to an urban morphology of a compact city were delimited.

Each place had its own characteristics. The study of these seven systems was intended to identify the likenesses and differences that validated the I_w. This index was employed as an urban design metric that can contribute to the evaluation of sustainability policies in a city by identifying places that tend to encourage urban life more.

Cartagena, Zones 1 and 2. The first studied zone (urban system 1, Table 5), the historic center of Cartagena, is a compact urban area with short and narrow streets, most of which are pedestrian. Buildings tend to have a ground floor and three or four upper floors. The second zone (urban system 2, Table 5), which is formed by a large part of the Cartagena Extension, is a compact city with a high population density due to the urban development that took place in the decades from 1960 to 1980. The urban outline of this sector appeared at the beginning of the 20th century. The initial buildings, made up of isolated two-floor buildings, were replaced with buildings among dividing partitions with more floors as of the 1960s. Its urban routes are wide and straight with paved sidewalks and roadways. The buildings are between 6 and 10 floors high. The number of road sections selected for this study of Cartagena came to 50 in both zones.

Table 5. Characterization of the studied urban systems.

Urban System	City/Town Name	Urban Morphology	City Typology	Urban System Surface Area	Population
1	Cartagena	Harbor city, historic city center, and tourist area	Compact city	1.1 km^2	43,266 inhabitants
2	Cartagena	Harbor city and extension built in the 20th century	Compact city	0.9 km^2	
3	Alcantarilla	Inland town 10 km from the capital city of the province. A city of services crossed by a railway line (north–south) that divides it into two parts—west zone	Compact city	0.8 km^2	41,095 inhabitants
4	Alcantarilla	Inland town 10 km from the capital city of the province. A city of services crossed by a railway line (north–south) that divides it into two parts—east zone	Compact city	1.3 km^2	
5	Molina de Segura	A post-industrial inland town with many services—historic city center	Compact city	0.5 km^2	46,043 inhabitants
6	Molina de Segura	A post-industrial inland town with roadways on a gentle slope, limited by a fluvial watercourse, with an extension built in the 20th century—east zone	Compact city	0.9 km^2	
7	Molina de Segura	A post-industrial inland town with roadways on a high slope, an urban area with traffic connections between the urban area and the industrial estate, and an extension built in the 20th century—west zone	Compact city	1.2 km^2	

Alcantarilla, Zones 3 and 4. The third studied zone (urban system 3, Table 5) corresponded to the extension of the industrial town of Alcantarilla. This zone's limits are the following: to the east, a railway line that divides the place from north to south; to the south, the Andalusia railway line; to the north and west, the city's ring road. The streets in this zone are wide and straight with sidewalks and large open pedestrian zones, a high population density, and four-floor buildings. Zone 4 (urban system 4, Table 5) has similar features to Zone 3, but it is the oldest part of the city of Alcantarilla and has short narrow streets. The urban morphology is conditioned by railway lines bordering the south and west. Buildings are four floors high. The numbers of road sections for the study of Alcantarilla came to 24 for Zone 3 and 15 for Zone 4.

Molina de Segura, Zones 5, 6, and 7. The city owes its name to the fact that it lies on the banks of the River Segura, which was, in the past, where important milling companies were concentrated (molina = mill town). Zone 5 (urban system 5, Table 5) corresponds to the historic center of Molina de Segura (Figure 1). Its streets are short and narrow, and its buildings are four to six floors high. Some parts of this zone have been recently restyled with the widening of streets by setting back urban alignments when old buildings were about to be replaced with newly built ones. As a result of this, the zone contains some larger-sized streets, squares, and parks. Buildings are six floors high. Urban Zone 6 (urban system 6, Table 5) corresponds to this town's urban growth, which took place between the 1960s and 1980s. Urban growth coincided with the rise and fall of the city's industrialization. Urban roadways are formed by wider and straighter paved streets. Buildings are 6 to 10 floors high. Finally, Zone 7 (urban system 7, Table 5) is an urban system located between the residential urban fabric and the city's industrial estate. Development in this zone is recent. It contains not only two-floor dwellings but also buildings between partitions, and the number of floors ranges between two and five. The number of road sections selected for the study of Molina del Segura came to 34 for Zone 5, 43 for Zone 6, and 20 for Zone 7.

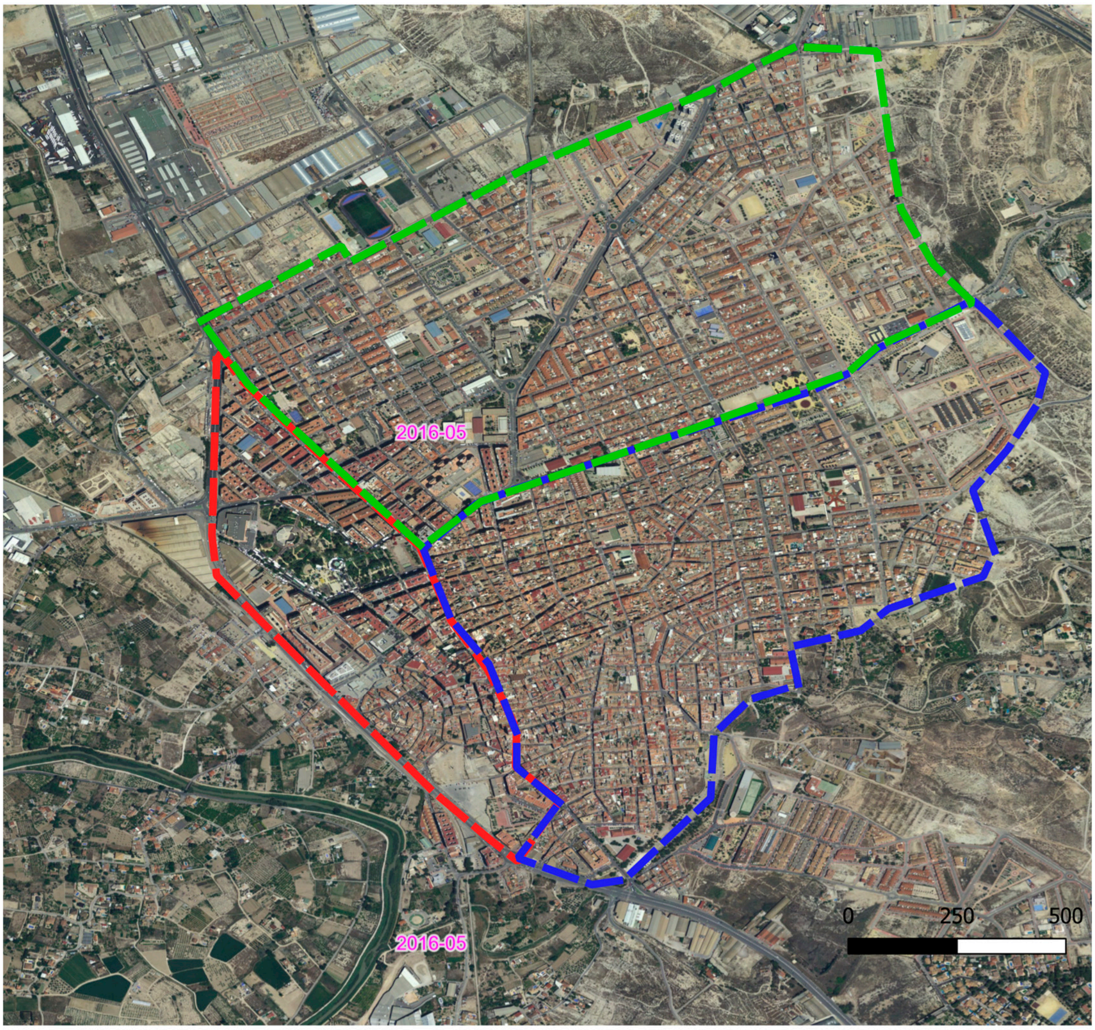

Figure 1. Graphic example of the studied urban systems corresponding to "Molina del Segura": urban systems 5 (red), 6 (blue), and 7 (green).

Having established the work areas, it was necessary to specify the observation places. The number and location of the urban elements to be observed had to be representative to explain how inhabitants used each zone. For this purpose, observation points were selected while bearing in mind the spatial criteria by seeking a uniform distribution in the urban environment to be studied. The considered aspects included the following: the relation to the main urban routes of the urban fabric, the function, the position in relation to the zone and city, continuity with other elements of adjacent public space, relevance, size, and section.

Basically, the selected elements were urban routes: streets. However, the streets had to be somewhat homogeneous to be able to give each walkability variable a specific value. If there were considerable variations in the characteristics of a road, it was divided into street sections with a similar or uniform configuration [91].

3.3. Data Collection—Walkability Data Matrices

Stage 2 aimed to determine the value of the walkability variables in all of the aforementioned elements and then design walkability data matrices. The numerous qualitative variables used to evaluate walkability enabled different aspects of the public space in the studied urban environment to be considered. Some noteworthy ones were existing conditions for pedestrians, the environment's characteristics, commercial spaces and buildings, urban furniture, obstructions on thoroughfares, etc. An evaluation of the set of employed walkability items allowed pedestrians' preferences to be identified and local authorities' policies to be assessed [92]. All of this enabled city areas requiring improvement to be located by paying attention to urban stakeholders and by taking citizens' perceptions of the conditions that the city offered for them walking around it as a starting point.

The evaluation of the walkability variables was performed using a numerical Likert scale from 1 to 5, where 1 was the minimum value (not met) of the studied walkability variable and 5 was its maximum value (met) [91]. Measurements were taken by members of the research team. Table 6 provides an example of the evaluation criteria. All of the values of the variables appear in the Appendix A.

Table 6. Item: sidewalks: definition and score (source: adapted from Krambeck [20]).

Item 1—Conflicts while walking and possible conflicts with other forms of mobility, such as bicycles, motorcycles, private cars, and vans: What is the level of conflict you face while walking along sidewalks or roadways?	
SCORE	CONDITION
Value 1	High risk of accidents, conflicts with other forms of mobility.
Value 2	Walking is possible, but with many inconveniences.
Value 3	Walking is possible, but with certain levels of inconvenience caused by other means of transport.
Value 4	No conflicts with motorized vehicles but with slower vehicle types, such as bicycles.
Value 5	No conflicts with other means of transport. The walking experience is a relaxed one.

Initially, the above-cited walkability variables were presented as a table. The first column expressed the walkability items that each row represented. The upper rows in the table detailed the type, name, and general number of the observation elements. By way of example, Table 7 partly shows a representation of the walkability data from one of the studied zones in this format.

Next, by using the data obtained with the walkability variables in the urban observation elements, streets, and stretches of streets, a walkability data matrix was built with the data of all of the studied urban zones. The walkability data matrices of each urban environment ($\gamma i\ j$) had the same number of rows (nine), which corresponded to the walkability items that were employed, but they had different numbers of columns, which fell in line with the numbers of observation elements determined for each zone.

$$\left(\gamma_{ij}\right) = \begin{pmatrix} \gamma_{11} & \gamma_{12} & \cdots & \gamma_{1n} \\ \gamma_{21} & \gamma_{22} & \cdots & \gamma_{2n} \\ \vdots & \vdots & & \vdots \\ \gamma_{91} & \gamma_{92} & \cdots & \gamma_{9n} \end{pmatrix} \quad (1)$$

Table 7. Example of a walkability data matrix [85].

City Center						
Studied Urban Sections	**50**	**1.06**	**km²**			
	Street 1			**Street 2**	**Street 3**	**Street 4**
γ(i, j)	**A**	**B**	**C**			
Items for measuring walkability	1	2	3	4	5	6
1. Conflicts while walking	3	2	2	1	1	3
2. Availability of sidewalks	3	3	3	1	3	5
3. Availability of crossings	1	1	2	1	3	3
4. Degree of crossing safety	4	3	3	1	2	3
5. Motorists' behavior	3	2	2	2	2	2
6. Amenities	1	1	1	1	2	2
7. Disability infrastructure	2	2	1	1	4	4
8. Obstructions of sidewalks	3	2	2	1	3	4
9. Security against crime	4	2	3	1	3	3
Sum of the items of each studied urban section	24	18	19	10	23	29

3.4. The Walkability Index (I_w)

Stage 3 aimed to calculate the I_w of all of the delimited working areas. To do so, the values corresponding to the walkability data of all of the observation elements that were established according to the Likert scale were transformed into a centesimal scale, which was then weighted using the objective data.

With the dataset of the variables at each observation point on the centesimal scale (V_{ij}) (Table 8), the values of the walkability items in each zone (V_i) were initially calculated.

$$V_i = \frac{\sum_{j=1}^{n} V_{ij}}{n} \text{con} j = \{1, 2, \ldots, n\} \quad (2)$$

During data collection, in addition to estimating the characteristics related to the walkability items of the urban routes set out in Section 2.3, the number of people observed on each one (P_j) was counted, and the street length or stretch of street length (L_j) was measured. Logically, the number of determinations corresponded to the number of observation elements (n) in each studied zone.

$$\left(P_j\right) = \left(P_1 P_2 \ldots P_n\right)\left(L_j\right) = \left(L_1 L_2 \ldots L_n\right) \quad (3)$$

Given the difference in the length of the observation elements, it was necessary to harmonize the obtained data to be able to work with values that could be compared with one another. For this purpose, a new parameter called the "linear presence of pedestrians" (D_j) was designed; this involved determining the ratio between the people present in an observation element and its length.

Table 8. Values of the items corresponding to each studied area.

Mean Value of Each Item or Variable (V_i)	**Urban Systems**						
	1	**2**	**3**	**4**	**5**	**6**	**7**
V_1. Conflicts while walking	77.20	85.20	84.17	84.00	71.18	78.14	72.00
V_2. Availability of sidewalks and walking areas	76.80	67.20	75.83	74.67	70.59	69.30	71.00
V_3. Availability of crossings and zones to cross roads	69.60	40.00	80.00	85.33	75.88	74.88	78.00
V_4. Degree of crossing roads and safety at crossings	85.20	69.60	81.67	81.33	57.06	51.63	57.00
V_5. Motorists' behavior	59.60	44.80	63.33	65.33	70.00	51.16	56.00
V_6. Amenities and equipment for walking (shaded areas, benches, etc.)	43.20	44.80	44.55	44.00	48.82	35.35	42.00
V_7. Disability infrastructure	60.80	54.80	64.17	72.00	64.12	59.07	62.00
V_8. Obstructions on sidewalks	64.00	68.80	69.17	61.33	57.06	66.05	58.00
V_9. Security against crime	68.00	76.00	65.00	62.67	67.65	50.23	60.00

D_j established the number of pedestrians present per unit of length of each observation element, street, or stretch of street to allow them to be compared. It indicated citizens' preference for using public space and the space's importance in the set, and it hierarchized the elements observed in the studied area in accordance with pedestrian use. It also enabled the verification of whether the area's modeling adapted to how people used it, a circumstance that provided the process with feedback.

$$D_j = \frac{P_j}{L_j} \quad (4)$$

Finally, the I_w of each urban system was calculated (Table 9) as the media of the walkability values of each road section according to its use.

$$I_w = \sum_{j=1}^{n} \frac{D_j}{\sum_{J=1}^{n} D_j} * \frac{\sum_{i=1}^{9} V_{ij}}{9} \quad (5)$$

Table 9. The Walkability Index values corresponding to each studied area.

Mean Value of Each Walkability Ratio	**Urban Systems**						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Walkability Index (I_w)	77.00	61.22	75.20	77.92	77.52	62.11	66.43

After obtaining the I_w, it was worth considering the following urban policies if the aspects to be dealt with were known: restoration or renovation actions in areas with low I_w values; improvement actions in those with medium or acceptable I_w values; consolidation or conservation actions in those with high I_w values. The I_w results for Zones 1, 3, and 5, which corresponded to the studied historic centers, were significantly higher than those for other parts of the city. This circumstance indicates that pedestrian policies of public spaces (city centers) that have been set up by local authorities in recent times have improved conditions for pedestrians. Initially, however, the validation of the reliability and consistency of the observed variables is required to determine the values of the walkability variable.

4. Results and Discussion

In this study, the I_w is intended to quantify the expression of a construct or variable that is not directly observable and is impossible to explicitly or directly measure (synthetic variable). To measure it, a set of intermediate variables or items are used; each one contributes to the quantification of some trait of the concept whose magnitude is to be synthesized. When measuring an indirectly observable quality or characteristic, such as an urban environment's walkability, the observable "i" variables are measured by assuming a priori that the variables are related to the unobservable magnitude that is intended to be measured.

The fundamental properties that a synthetic variable must meet are reliability and validity. The reliability of values is related to the possibility of repeatedly reproducing results with the same instrument; that is, it is a matter of measurement stability. Moreover, an instrument's validity refers to the degree to which it measures what is intended to be measured.

The results obtained in the study, which correspond to each walkability item and are presented in Table 4, can be graphically represented (e.g., urban systems 5, 6, and 7 are represented in Figure 2). The employed figure represents the items that constitute the synthetic "walkability" variable and were used for urban systems 5, 6, and 7 (Table 5).

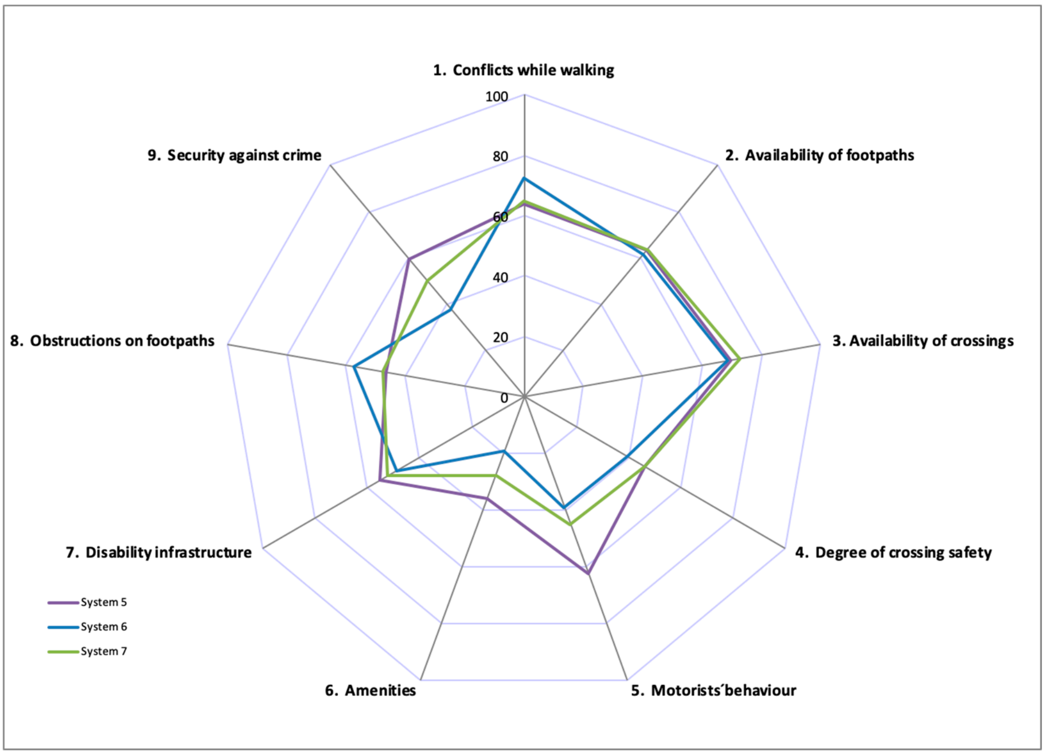

Figure 2. Value of each variable making up the Walkability Index and corresponding to urban systems 5, 6, and 7 (Table 5).

As previously mentioned, the internal consistency method allows a measurement instrument's reliability to be estimated by means of a set of items that are expected to measure the same construct or a single theoretical dimension of a latent construct. When the data take a multidimensional structure, the internal consistency value is low. In other words, no consistency is seen in the scores that form the theoretical construct to be measured.

Cronbach's alpha coefficient [89] and McDonald's omega [90] are internal consistency models based on the average of the correlations among items. Cronbach's alpha allows a measurement scale's reliability level to be quantified for an unobserved magnitude built from n studied roadways [89]. This coefficient had two basic uses: first, as an instrument for measuring the globally evaluated internal homogeneity of "walkability", thus taking an intrinsic value; second, analyzing what each particular observed item contributed to the homogeneity of "walkability". This contribution was measured by comparing the value of the coefficient obtained when all of the items were employed to that obtained when making a calculation after having eliminated an item. That is, if alpha significantly increased after eliminating a specific item, then excluding this item would increase the homogeneity of the scale, and vice versa.

As previously mentioned, the internal consistency method allows the reliability of a measurement instrument to be determined by means of a set of items that are expected to measure the same construct or a single theoretical dimension of a latent construct. When data are multidimensional, the internal consistency value will be low. In other words, no consistency is observed in the scores that form the theoretical construct that is to be measured. Cronbach's alpha coefficient and McDonald's omega are internal consistency models based on the average of the correlations between items.

It is a good thing for variables to highly correlate with one another to create a reliable scale. The maximum correlation level is achieved when the values of items {V1, V2, . . ., V9} are equal. The expression of Cronbach's alpha is as follows:

$$\text{Cronbach's alpha} = \frac{\mathrm{I}}{\mathrm{I}-1} * \left| \frac{1-\mathrm{S}_\mathrm{t}^2}{\mathrm{S}_\mathrm{n}^2} \right| \tag{6}$$

$$\text{with } \mathrm{S}_\mathrm{t}^2 = \sum_{\mathrm{i}=1}^{\mathrm{k}} \mathrm{S}_\mathrm{i}^2$$

where

- S_i^2 is the variance of variable i.
- S_t^2 is the sum of the variance of all of the variables.
- S_n^2 is the variance of the sum of the observed values.
- n is the number of observed streets or roads.
- I is the set of the observed variables.

The closer Cronbach's alpha is to 1, the greater is the internal consistency of the analyzed items; that is, it is assumed that items measure the same dimension. Conversely, if items are completely independent and show no type of relation to one another, the alpha value will equal 0. Cronbach's alpha was calculated for all seven studied urban systems (see Table 10).

Table 10. The values of Cronbach's alpha and McDonald's omega for each studied system.

Urban System	1	2	3	4	5	6	7
Cronbach's alpha	0.867	0.604	0.894	0.823	0.930	0.601	0.741
McDonald´s omega	0.881	0.677	0.908	0.831	0.938	0.637	0.757

The reliability of all of the observed values was studied to determine the construct reliability, and a value of 0.840 was obtained for Cronbach´s alpha. Likewise, Cronbach's alpha was calculated by ruling out all of the variables that reflected the cohesion or contribution of each variable to the construct (Table 11).

As a general criterion, George and Mallery [93] proposed the following intervals to evaluate the values of Cronbach's alpha coefficient (the same recommendations apply for McDonald's omega coefficient):

- An alpha coefficient of >0.90 to 0.95 is excellent.
- An alpha coefficient of >0.80 is good.
- An alpha coefficient of >0.70 is acceptable.

- An alpha coefficient of >0.60 is questionable.
- An alpha coefficient of <0.50 is unacceptable.

Table 11. The values of Cronbach´s alpha of the entire urban set after ruling out each variable of the construct.

Walkability Variables	V_1	V_2	V_3	V_4	V_5	V_6	V_7	V_8	V_9
Cronbach's alpha if the variable (item) is ruled out	0.816	0.811	0.811	0.823	0.837	0.828	0.827	0.828	0.829

Notwithstanding, the minimum value that is generally accepted for Cronbach's alpha is 0.7 [94–96]. However, values up to 0.6 can be accepted for exploratory research purposes [97].

The internal measurement consistency measured with Cronbach's alpha assumes that items (measured on a Likert-type scale) measure the same construct and are highly interrelated [98]. Therefore, it is worth bearing in mind that using Cronbach's alpha might not be right when the nature of the response scale is of an ordinal kind because one of the assumptions of this coefficient is the continuous nature of the variables; in such a case, applying Likert-type response scales makes sense, and there are response intervals that are comparable with one another [99].

All response scales that apply a Likert-type scale are polydomous; that is, they have more than two response alternatives. They are ordered or graduated response scales, and assigning whole numbers to different response options indicates an ordinal scale. By using the scores obtained for the different roadways on the same item, inferences can be made as to the more or less favorable reality that each one offers, but it is not possible to determine the distances between the realities with different alternatives for their responses. Strictly speaking, this is not a matter of an interval response scale because these are actually ordinal scales. Thus, in general, if response options include six or fewer alternatives, opting for omega [90] is recommended. In any case, it is necessary to check if the tau-equivalence of items occurs.

Unlike the alpha coefficient, McDonald's omega coefficient is calculated with factor loadings, which are a weighted sum of standardized variables. This transformation makes calculations stable and reflects the true level of reliability irrespective of the number of observations. Its mathematical expression is as follows:

$$\omega = \frac{\left(\sum_{1}^{i} \lambda_i\right)^2}{\left(\sum_1^i \lambda_i\right)^2 + \left(\sum_1^i 1 - \lambda_i^2\right)} \quad (7)$$

where

- ω is the symbol of the omega coefficient.
- λi is the standardized factor loading of variable "i".

The reliability of the whole set of observed values was studied to determine the construct reliability, which resulted in a value of 0.856. Similarly, McDonald's omega was calculated by ruling out each variable, which reflected the cohesion or contribution of each variable to the construct (Table 12).

For the Walkability Index (I_w) presented here, the results showed not only a high consistency for the nine variables considered to measure "walkability" (a synthetic variable) in five urban systems but also acceptable consistency for the other two (Table 7). This means that these are reliable metrics and shows how the observed variables outline a suitable way to measure the synthetic variable. The high Cronbach's alpha values in urban systems 1, 3, and 5 correspond to the historic parts of cities. The lower values (urban systems 2 and 6) refer to the urban expansion areas developed in the 20th century. It would be suitable to apply the developed tools to other European cities so that they can realize their limitations.

Table 12. Values of McDonald's omega for the entire urban set after ruling out each variable of the construct.

Walkability Variables	V_1	V_2	V_3	V_4	V_5	V_6	V_7	V_8	V_9
McDonald's omega when a variable (item) is ruled out	0.839	0.819	0.819	0.843	0.853	0.848	0.847	0.848	0.853

Mediterranean cities, which are a particular kind of European city, are formed from districts or areas with different and inhomogeneous built environments (street width, building height, shaded streets, amenities, etc.). As set out in a previous paragraph, the proposal here (I_w) is especially suitable for application to the study of a traditional Mediterranean city.

Studying walkability in urban systems involves analyzing the degree of homogeneity of pedestrians using urban routes. Table 13 shows the mean value of the presence of pedestrians on all of the urban stretches and the standard deviation of the set of values and indicates the concentration or dispersion of people in public space. The standard deviation measures the dispersion of data and offers information about the mean dispersion of people coinciding per kilometer in the study area.

Table 13. Mean values and standard deviations of the presence of pedestrians for all seven studied systems.

Urban System	1	2	3	4	5	6	7
Mean value of the linear presence of pedestrians (people/km)	132.11	94.84	92.30	92.97	140.98	45.95	78.56
Standard deviation of the linear presence of pedestrians σ (D_j)	118.69	72.62	139.18	169.63	138.52	51.33	79.94

The walkability study conducted here allows not only the areas in the city that need to be improved but also pedestrian preferences to be identified. Replicating the study also allows the repercussions from making changes to the city to be followed up and monitored to improve sustainable mobility. This falls in line with the objective of developing a city model for citizens [5,85]. In this study, a check was performed to verify that the methodology that was followed to evaluate pedestrianized streets improved the I_w by increasing the number of pedestrians present on them [100]. The number of pedestrians observed on a street influences the methodology that is used to calculate walkability in the studied urban system but not in other identified urban systems.

The proposed tool is useful for planners before drawing up an urban project and after it has been undertaken. Before an urban project begins, this tool not only contributes to the knowledge of the extent to which public spaces are suitable for walking but also allows the category, object, and scope of interventions to be determined. When such work has been finished, conducting a new walkability study will allow changes to be made, the proposed purpose to be fulfilled, and the repercussions of the undertaken project on citizens' conduct to be assessed [101].

5. Limitations

To summarize the proposed methodology for measuring walkability in urban areas, the following pros and cons were identified.

Pros

- The methodology incorporates quantifiable information, such as the number of pedestrians.
- After including the number of pedestrians, it incorporates the effect of the environment on encouraging pedestrians to walk around public spaces.
- When pedestrians are present, the influences of streets on the I_w are stratified according to pedestrian use.
- Observations do not represent interferences with the observed phenomenon of interest.
- Observations offer a real-time measurement of pedestrian conduct and one that is less exposed to randomness than surveys.
- The methodology includes the (sometimes unconscious) influence of pedestrians' experience.
- This is a planning and urban design method that centers on pedestrians using public space.

Cons

- Observations do not provide information about all of the aspects of walkability.
- The methodology does not discriminate between pedestrians' use of streets and their use of public space (work, leisure, active transportation).
- Observations are sporadic. The methodology does not incorporate increases or decreases in the number of pedestrians in the studied public space.

The following limitations affected the Walkability Index that was applied to the three compact cities studied here: the uniformity of the results when collecting some of the observed data; the evaluation of the number of pedestrians is an objective variable even though it is subject to the evaluation being made on one day of the week or another, and the time at which measurements are taken affects it, as does the time of year. Nevertheless, the number of pedestrians affects the methodology during its process of determining "pedestrian density". To obtain the I_w of an urban system, it is important to maintain the measurement criteria on the different streets in the urban system under study.

In future research, the Walkability Index can be enriched with more variables, such as the specific characteristics of zones for walking (ramps, sidewalks with limitations, etc.) or of the environment to be walked in, such as street slopes. It is also possible to develop tools that allow the number of people on a studied stretch of street to be measured.

Moreover, modeling the environment under study confers flexibility for adapting to urban planners' requirements. Among other possibilities, it allows an urban area to be modeled to homogeneously study it. Likewise, it permits a limited number of roadways to be selected according to criteria pertaining to an urban motorway, such as road hierarchy, as well as the creation of a pedestrian circuit. It is also possible to assess the importance of a given street in the study area.

6. Conclusions

Citizens' mobility in an urban environment is subject to many facets that, in line with a sustainable and resilient approach, require the formulation of solutions that focus on the people who live in and move around the urban fabric, that is, one that centers on pedestrians. Modeling a city and, consequently, conceiving urban design based on the I_w significantly facilitates the optimization of processes and procedures of sustainable and resilient urban mobility.

When applied to an urban environment, walkability strongly impacts a city's sustainability. Establishing an urban design in accordance with pedestrian mobility reduces the use of resources, which means that they last longer. Thus, it is worth considering that walkability is a useful criterion for estimating an urban environment's degree of sustainability.

The walkability paradigm emphasizes a new vision of the city fabric because its objectives include observing citizens' conduct when faced with designing an existing urban public space. Up to a point, it can be used to determine how the inhabitants of an urban environment perceive it by observing the place's pedestrian use. An urban design that favors walking around a public space by increasing the number, variety, and extension of social activities improves a city's resilience.

The I_w provides data systematization for urban planners. This study analyzed urban functioning in both streets and stretches of streets in an urban area. Walkability was proven to be valid for evaluating the urban fabric's morphology in a compact city. The people responsible for making municipal decisions can use walkability to complement the distribution of transport modes and urban scenarios or to improve environmental conditions with the goal of creating a sustainable city. This concept can also be used to identify areas in a city with deficiencies that require actions to improve the urban conditions, and analyses can be carried out with it as a tool for monitoring walkability improvements in a city.

In future work, we foresee the generalization of this method to urban environments at different levels (street, district, and city), the investigation of the relation between walkability and real estate property values, and the validation of the method in other types of cities.

Author Contributions: Conceptualization, L.R.-M. and M.V.d.-l.-F.-A.; methodology, L.R.-M.; validation, M.C.; formal analysis, D.R.-M.; investigation, M.V.d.-l.-F.-A. and L.R.-M.; resources, M.V.d.-l.-F.-A.; data curation, M.C.; writing—original draft preparation, L.R.-M.; writing—review and editing, D.R.-M., M.V.d.-l.-F.-A. and L.R.-M. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Data Availability Statement: The data for each urban system can be found at Mendeley Data V1. https://doi.org/10.17632/ydn9xmwn6w.1.

Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A

Observable variables of the qualitative observer-perception-based approach to calculating the Walkability Index (WI; I_w) were created by adapting the compact city model of Krambeck (2006) [20]. The Global Walkability Index (GWI) was adapted to individually evaluate each urban element (street, square, etc.) and to incorporate the quantitative variables of length and pedestrians to obtain the I_w of the studied urban systems.

The tables indicate the numerical values of the evaluation options for the nine variables for each stretch of street to be studied.

Variable 1. Conflicts while walking. The aim is to determine the level of difficulty for pedestrians when walking along a path or a sidewalk.	
Significant vehicle problems that interfere with pedestrians walking. A very high risk level for having an accident.	1
Vehicle problems with a high risk level for having an accident, but it is possible to walk.	2
Walking is possible, but with a significant level of inconveniences caused by motorized vehicles or other mobility systems.	3
Conflicts with other slow vehicles such bicycles or electric scooters.	4
No conflicts with other forms of mobility—a relaxed walking experience.	5
Variable 2. Availability of sidewalks. There are areas to walk that are limited to pedestrians. If they exist, their conditions for cleaning, maintenance, etc. are considered.	
Areas or sidewalks are needed for pedestrians, but they do not exist. An unpleasant environment.	1

Sidewalks are in bad condition or are not continuous. An unpleasant environment. Bad conditions may derive from their not being wide enough or being slippery when wet.	2
There are areas to walk, and they can be used despite needing to be cleaned and maintained.	3
There are sidewalks or areas to walk that are cleaned and well maintained, and they are made with non-slip materials.	4
There are pedestrian areas and exclusive sidewalks for pedestrians.	5
Variable 3. Availability of crossings (they can be on a different level/the same level). Are crossings suitable or useful? Do pedestrians use them?	
No crossings exist.	1
Crossings have distances of more than 500 m between them, and the vehicle speed limit is over 50 km/h.	2
There are crossings every 300 m, and the vehicle speed limit is over 30 km/h.	3
There are walking areas with distances shorter than 100 m with a mean vehicle speed limit of 30 km/h.	4
They are safe and can be crossed at any point because of slow-moving traffic.	5
Variable 4. Degree of crossing safety. It is important to know not only if crossings exist but also the quality of these crossing points. Are crossings really safe? Do pedestrians use them?	
Unsigned crossings. Neither zebra crossings nor vertical signs on roads.	1
Crossings are at different levels, but there are no stairs or elevators, and they are not easily used by the elderly or the disabled.	2
Crossings are used by many people with long waiting times. The place where pedestrians wait to cross is too small and is even packed at times. There is not enough time allowed for pedestrians to cross.	3
There is a crossing on a different but safe level with amenities for the elderly or the disabled or a crossing on the same level with a sign indicating where pedestrians cross.	4
Pedestrians can safely cross the street at any point. There is a pedestrian zone or very slow-moving traffic.	5
Variable 5. Motorists' behavior. To determine walkability, determining motorists' behavior toward pedestrians in the city is important.	
Considerable lack of respect for pedestrians by motorists; they invade pedestrian zones (sidewalks, designated pedestrian zones, paths, etc.).	1
Motorists do not slow down for pedestrians and even beep their horns at them.	2
Motorists sometimes slow down when pedestrians are present.	3
Motorists slow down only when there are many pedestrians or they walk as a group. Motorists also frequently slow down when pedestrians are present in the city.	4
Motorists respect pedestrians and always slow down in pedestrian-priority zones.	5
Variable 6. Amenities. Services are important for pedestrians when they feel tired, when it is very hot, or when it rains. Urban amenities such as lighting, shaded areas, signs with information, clean and toilets improve the pedestrian experience.	
There are no amenities or toilets. A very unpleasant walking experience.	1
There are some trees, but they are set far apart. There are no suitable shaded areas for pedestrians. Benches cannot be used. The light intensity is poor (night). A very unpleasant walking experience.	2
There are signs, benches, and shaded areas on sidewalks, but they block pedestrians' way. Unpleasant.	3

There are some signs, shaded areas, and lighting, but they are insufficient. Signs, lighting, and shaded areas are available, but they can improve with a better location.	4
Benches are located beneath trees that provide shade; lighting is sufficient; signs with directions and guidance are available.	5
Variable 7. Disability infrastructure. This is used to determine how agreeable a street is for people with special needs, including ramps, handrails, tactile sidewalks, and signs that can be heard.	
There is no infrastructure for pedestrians with special needs to access. An unfriendly city.	1
There is insufficient infrastructure and a shortage of infrastructure that is not properly maintained. Infrastructure is present but not in good condition or is badly planned.	2
Infrastructure is present and in good condition, but is not usable.	3
Infrastructure is in good condition and cleaned but could be better located/maintained.	4
Amenities and infrastructure are well placed and in excellent condition.	5
Variable 8. Obstructions. Analysis of invasions: parked vehicles, supplies being delivered, and other situations that interfere with pedestrian mobility.	
Permanent obstructions in pedestrian zones, such as large trees, posts, signs, and litter bins.	1
Pedestrian zones are less than 1 m wide or have points of sale or bar/restaurant terraces occupying most of the space so that pedestrians can barely walk past.	2
Temporary obstructions. Parked vehicles that block pedestrian zones. Available pedestrian zone are more than 1 m wide but have some obstructions.	3
Available pedestrian zones are more than 1.5 m wide but have a few obstructions.	4
There are neither obstacles nor obstructions.	5
Variable 9. Security against crime. This variable measures a street's vulnerability due to poor lighting, high walls, vehicle speed, and invaded spaces.	
Feeling extremely vulnerable to crime. Uninhabited streets with no lighting, no trade, and fast-moving vehicles.	1
Feeling vulnerable to crime because of scarce planning, high building walls, and tainted windows.	2
Feeling insecure after sunset, with barely any other pedestrians present, poor lighting, and hardly any activity taking place. Marginal security, slow traffic, buildings from which the street cannot be seen, or hardly any economic activities taking place.	3
Feeling secure because other pedestrians, salespersons, discontinued walls, and good lighting are present.	4
Feeling very secure because there are many people on the street, with open building facades, trading areas, etc. There is plenty of activity taking place on the street, and vehicles drive slowly.	5

References

1. Mazzulla, G.; Eboli, L.; Forciniti, C. Do women perceive pedestrian path attractiveness differently from men? *Transp. Res. Part A Policy Pract.* **2024**, *179*, 103890. [CrossRef]
2. Perez-Ilzarbe, I.; Rivas, C.; Zuza, M. *WCT: Walkability City Tool, una Herramienta De Análisis de Caminabilidad*; II Congreso Ciudades Inteligentes: Madrid, Spain, 2016.
3. Sarté, S.B. *Sustainable Infrastructure: The Guide to Green Engineering and Design*; John Wiley & Sons: Hoboken, NJ, USA, 2010.
4. Kenworthy, J.R. Ten key dimensions for eco city development in theory and practice. *Int. Soc. City Reg. Plan. Rev.* **2016**, *12*, 16–47.
5. UN HABITAT. *The ABC for Sustainable Cities. A Glossary for Policy Makers*; UNEP: United Nations Environment Programme: Nairobi, Kenya, 2016.

6. Abastante, F.; Lami, I.M.; La Riccia, L.; Gaballo, M. Supporting resilient urban planning through walkability assessment. *Sustainability* **2020**, *12*, 8131. [CrossRef]
7. Bautista-Puig, N.; Benayas, J.; Mañana-Rodriguez, J.; Suarez, M.; Sanz-Casado, E. The role of Urban Resilience in research and contribution to sustainability. *Cities* **2022**, *126*, 103715. [CrossRef]
8. Baobeid, A.; Koc, M.; Al-Ghamdi, S.G. Walkability and its relationships with health, sustainability, and liveability. Elements of physical environment and evaluation frameworks. *Front. Built Environ.* **2021**, *7*, 721218. [CrossRef]
9. Mendzina, E.; Vugule, K. Importance and planning of pedestrian streets in urban environment. *Landsc. Archit. Art* **2020**, *16*, 80–86. [CrossRef]
10. Norman, J.; Maclean, H.; Kennedy, C. Comparing high and low residential density: Life-cycle analysis of energy use and greenhouse gas emissions. *J. Urban Plan. Dev.* **2006**, *132*, 10–21. [CrossRef]
11. Leyden, K.M. Social capital and the built environment: The importance of walkable neighbourhoods. *Am. J. Public Health* **2003**, *93*, 1546–1551. [CrossRef] [PubMed]
12. Ferdman, A. Walking and Its Contribution to Objective Well-Being. *J. Plan. Educ. Res.* **2019**, *43*, 294–304. [CrossRef]
13. Southworth, M.; Ben-Joseph, E. *Streets and the Shaping of Towns and Cities*; Island Press: Washington, DC, USA, 2003.
14. Southworth, M. Designing the walkablr city. *J. Urban Plan. Dev.* **2005**, *131*, 246–257. [CrossRef]
15. Crosby, A.; Silvia, A.; Tifani, C.; Imantaka, M.E. Counter-mapping Surabaya: Designing 'cities within the city'. *Cities* **2024**, *145*, 104675. [CrossRef]
16. Dragović, D.; Krklješ, M.; Slavković, B.; Aleksić, J.; Radaković, A.; Zećirović, L.; Alcan, M.; Hasanbegović, E. A Literature Review of Parameter-Based Models for Walkability Evaluation. *Appl. Sci.* **2023**, *13*, 4408. [CrossRef]
17. Ahvenniemi, H.; Huovila, A.; Pinto-Seppä, I.; Airaksinen, M. What are the differences between sustainable and smart cities? *Cities* **2017**, *60*, 234–245. [CrossRef]
18. Toli, A.M.; Murtagh, N. The Concept of Sustainability in Smart City Definitions. *Front. Built Environ.* **2020**, *6*, 77. [CrossRef]
19. Hellberg, R.; Guaralda, M.; Rinchumphu, D. Urban walkability profiles in Brisbane. *Int. Rev. Spat. Plan. Sustain. Dev.* **2021**, *9*, 1–15. [CrossRef] [PubMed]
20. Krambeck, H.V. The Global Walkability Index. Master's Thesis, Massachusetts Institute of Technology (MIT), Cambridge, MA, USA, 2006.
21. Hutabarat, L. Walkability: What is it? *J. Urban. Int. Res. Placemaking Urban Sustain.* **2009**, *2*, 145–166. [CrossRef]
22. IDAE. *PMUS: Guía Práctica para la Elaboración e Implantación de Planes de Movilidad Urbana Sostenible*; Instituto para la Diversificación y Ahorro de la Energía: Madrid, Spain, 2006.
23. Zhang, S.Y.; Liu, N.X.; Ma, B.N.; Yan, S.R. The effects of street environment features on road running: An analysis using crowdsourced fitness tracker data and machine learning. *Environ. Plan. B Urban Anal. City Sci.* **2024**, *51*, 529–545. [CrossRef]
24. Tsai, Y.H. Quantifying urban form: Compactness versus "sprawl". *Urban Stud.* **2005**, *42*, 141–161. [CrossRef]
25. Mouratidis, K. Is compact city livable? The impact of compact versus sprawled neighbourhoods on neighbourhood satisfaction. *Urban Stud.* **2017**, *55*, 2408–2430. [CrossRef]
26. Rueda, S. La ciudad compacta y diversa frente a la conurbación difusa. *Biblioteca CF+S* **1998**, *19*, 69–83.
27. Rueda, S. Modelos urbanos y sostenibilidad. In *I Congreso de Ingeniería Civil, Territorio y Medio Ambiente*; Colegio de Ingenieros de Caminos Canales y Puertos: Madrid, Spain, 2009.
28. Navarro, J.R.; Ortuño, A. Aproximación a la génesis de la contribución de la densidad de "ciudad compacta". *EURE* **2011**, *37*, 23–41. [CrossRef]
29. Krause, A.L.; Bitter, C. Spatial econometrics, land values and sustainability: Trends in real state valuation research. *Cities* **2012**, *29* (Suppl. 2), S19–S25. [CrossRef]
30. Panerai, P.; Mangin, D. *Proyectar la Ciudad*; Ediciones Celeste: Madrid, Spain, 2002.
31. Yin, C.; Cao, J.; Sun, B.D.; Liu, J.H. Exploring built environment correlates of walking for different purposes: Evidence for substitution. *J. Transp. Geogr.* **2023**, *106*, 103505. [CrossRef]
32. Bulkeley, H.; Betsill, M.M. Rethinking sustainable cities: Multilevel governance and the "Urban" politics of climate change. *Environ. Politics* **2005**, *14*, 42–63. [CrossRef]
33. Litman, T.A. Economic value of walkability. *Transp. Res. Rec.* **2004**, *1828*, 3–11. [CrossRef]
34. Leinberger, C.B.; Alonzo, M. *Walk This Way: The Economic Promise of Walkable Places in Metropolitan*; The Brookings Institution: Washington, DC, USA, 2012.
35. Li, X.H.; Yang, Z.Q.; Qian, X.W.; Guo, Y.T.; Yang, C. Investigating the Impacts of Property Walking Accessibility on Housing Affordability and Equity: Evidence from Shanghai, China. *J. Urban Plan. Dev.* **2023**, *149*, 05023035. [CrossRef]
36. Murgante, B.; Valluzzi, R.; Annunziata, A. Developing a 15-minute city: Evaluating urban quality using configurational analysis. The case study of Terni and Matera, Italy. *Appl. Geogr.* **2024**, *162*, 103171. [CrossRef]
37. Wang, Y.; Yang, Y. Neighbourhood walkability: A review and bibliometric analysis. *Cities* **2019**, *93*, 43–61. [CrossRef]
38. Pivo, G.; Fisher, J.D. The walkability premium in commercial real estate investments. *Real Estate Econ.* **2011**, *39*, 185–219. [CrossRef]
39. Cerin, E.; Macfarlane, D.J.; Hin-Hei, K.; Kwok-Cheung, A.C. Measuring perceived neighborhood walkability in Hong Kong. *Cities* **2007**, *24*, 209–217. [CrossRef]
40. Luadsakul, C.; Ratanvaraha, V. The Study of Walkability Index: A Case Study in Nakhon Ratchasima Province. *Int. J. Emerg. Technol. Adv. Eng.* **2013**, *3*, 471–476.

41. Lynch, A.J.; Mosbah, S.M. Improving local measures of sustainability: A study of built-environment indicators in the United States. *Cities* **2017**, *60*, 301–313. [CrossRef]
42. Minhas, P.; Poddar, A. Walkability index by Global Walkability Index method. *Int. Res. J. Eng. Technol.* **2017**, *4*, 2957–2963.
43. Bartzokas-Tsiompras, A.; Bakogiannis, E.; Nikitas, A. Global microscale walkability ratings and rankings: A novel composite indicator for 59 European city centres. *J. Transp. Geogr.* **2023**, *111*, 103645. [CrossRef]
44. Blečić, I.; Congiu, T.; Fancello, G.; Trunfio, G.A. Planning and design support tools for walkability: A guide for urban analysis. *Sustainability* **2020**, *12*, 4405. [CrossRef]
45. Hasan, M.M.; Oh, J.S.; Kwigizile, V. Exploring the trend of walkability measures by applying hierarchical clustering technique. *J. Transp. Health* **2021**, *22*, 101241. [CrossRef]
46. Singla, T.; Karki, T.; Mishra, V. Walkability: Bibliometric analysis and review. *AIP Conf. Proc.* **2024**, *2986*, 020032.
47. Amouhadi, R.; Balali, V.; Zuidgeest, M.; Heydarian, A. Measuring Walkability Using a Mobile Phone Sensors and Applications. In Proceedings of the Transportation Research Board 98th Annual Meeting, Washington DC, USA, 13–17 January 2019.
48. Abusaada, H.; Elshater, A. Cairenes' storytelling: Pedestrian scenarios as a normative factor when enforcing street changes in residential areas. *Soc. Sci.* **2023**, *12*, 278. [CrossRef]
49. Creatore, M.; Booth, G.; Glazier, H. Neighbourhood environments and resources for healthy living—A focus on diabetes in Toronto. In *Ethnicity, Immigration and Diabetes, ICES Atlas*; Institute for Clinical Evaluative Sciences: Toronto, ON, Canada, 2007.
50. Smart, M.J. Walkability, transit, and body mass index: Is there a connection? In Proceedings of the Transportation Research Board 97th Annual Meeting, Washington, DC, USA, 7–11 January 2018. [CrossRef]
51. Doyle, S.; Kelly-Schwartz, A.; Schlossberg, M.; Stockard, J. Active community environments and health: The relationship of walkable and safe communities to individual health. *J. Am. Plan. Assoc.* **2006**, *72*, 19–31. [CrossRef]
52. Day, K.; Boarnet, M.; Alfonzo, M.; Forsyth, A. The Irvine–Minnesota inventory to measure built environments: Development. *Am. J. Prev. Med.* **2006**, *30*, 144–152. [CrossRef]
53. Leather, J.; Herbert, F.; Sudhir, G.; Alvin, M. *Walkability and Pedestrian Facilities in Asian Cities: State and Issues*; Working Paper Series N° 17; Asian Development Bank: Manila, Philippines, 2011.
54. Krambeck, H.V.; Shah, J. Evaluating the quality of pedestrian infrastructure and service in Chinese cities. In Proceedings of the First International Symposium on Transportation and Development Innovative Best Practices, Chongqing, China, 29 June–1 July 2012.
55. Erath, A.; Van Eggermond, M.A.B.; Axhausen, K.W. Introducing the Pedestrian Accessibility Tool: Walkability Analysis for a Geographic Information System. *J. Transp. Res. Board.* **2017**, *2661*, 51–61. [CrossRef]
56. Gu, P.; Han, Z.; Cao, Z.; Chen, Y.; Jiang, Y. Using open source data to measure street walkability and bikeability in China: A case of four cities. *Transp. Res. Rec.* **2018**, *2672*, 63–75. [CrossRef]
57. Kamel, M. Encouraging walkability in GCC cities: Smart urban solutions. *Smart Sustain. Built Environ.* **2013**, *2*, 288–310. [CrossRef]
58. Giles-Corti, B.; Donovan, R.J. Relative influences of individual, social environmental, and physical environmental correlates of walking. *Am. J. Public Health* **2003**, *93*, 1583–1589. [CrossRef] [PubMed]
59. McCormack, G.; Shiell, A.; Giles-Corti, B.; Begg, S.; Veerman, J.; Geelhoed, E.; Amarasinghe, A.; Emery, H. The association between sidewalk length and walking for different purposes in established neighborhoods. *Int. J. Behav. Nutr. Phys. Activ.* **2012**, *9*, 92. [CrossRef] [PubMed]
60. Pikora, T.; Fiona, C.L.; Bull, F.; Konrad, K.; Matthew, M.; Giles-Corti, B.; Rob, B. Developing a reliable audit instrument to measure the physical environment for physical activity. *Am. J. Prev. Med.* **2002**, *23*, 187–194. [CrossRef] [PubMed]
61. Kim, I.; Kang, H. A study of delay-based level of service on pedestrian facility. In Proceedings of the Australasian Transport Research Forum 2013, Brisbane, Australia, 2–4 October 2013.
62. Kelly, C.E.; Tight, M.R.; Hodgson, F.C.; Page, M.W. A comparison of three methods for assessing the walkability of the pedestrian environment. *J. Transp. Geogr.* **2011**, *19*, 1500–1508. [CrossRef]
63. Ribeiro, A.; Hoffmann, E. Development of a neighbourhood walkability index for Porto metropolitan area. How strongly is walkability associated with walking for transport? *Int. J. Environ. Res. Public Health* **2018**, *15*, 2767. [CrossRef] [PubMed]
64. Beltsiou, V.; Gemenetzi, G.; Manetos, P. Assessing walkability: Index construction and application to a medium-size Greek city. *E3S Web Conf.* **2023**, *436*, 12003. [CrossRef]
65. Moura, F.; Cambra, P.; Gonçalves, A. Measuring walkability for distinct pedestrian groups with a participatory assessment method: A case study in Lisbon. *Landsc. Urban Plan.* **2017**, *157*, 282–296. [CrossRef]
66. Frank, L.; Sallis, J.; Saelens, B.; Leary, L.; Cain, K.; Conway, T.; Hess, P. The development of a walkability index: Application to the neighborhood quality of life study. *Br. J. Sports Med.* **2010**, *44*, 924–933. [CrossRef]
67. Shaaban, K. A Simple Assessment Method for Measuring Sidewalk Walkability in Developing Countries. In Proceedings of the Transportation Research Board 98th Annual Meeting, Washington, DC, USA, 13–17 January 2019.
68. Clifton, K.; Smith, A.; Rodriguez, D. The development and testing of an audit for the pedestrian environment. *Landsc. Urban Plan.* **2007**, *80*, 95–110. [CrossRef]
69. Yin, L.; Cheng, Q.; Wang, Z.; Shao, Z. "Big data" for pedestrian volume: Exploring the use of Google Street View images for pedestrian counts. *Appl. Geogr.* **2015**, *63*, 337–345. [CrossRef]
70. Ewing, R.; Connors, M.; Goates, J.; Hajrasouliha, A.; Neckerman, K.; Nelson, A.; Greene, W. Validating Urban design measures. In Proceedings of the Transportation Research Board 92nd Annual Meeting, Washington, DC, USA, 13–17 January 2013.

71. Wang, Y.; Chau, C.K.; Ng, W.Y.; Leung, T.M. A review on effects of physical built environment attributes on enhancing walking and cycling activity levels within residential neighborhoods. *Cities* **2016**, *50*, 1–15. [CrossRef]
72. Lu, Y. Using Google Street View to Investigate the Association between Street Greenery and Physical Activity. *Landsc. Urban Plan.* **2018**, *191*, 103435. [CrossRef]
73. Ahmed, T.; Moeinaddini, M.; Almoshaogeh, M.; Jamal, A.; Nawaz, I.; Alharbi, F. A new pedestrian crossing level of service (PCLOS) method for promoting safe pedestrian crossing in urban areas. *Int. J. Environ. Res. Public Health* **2021**, *18*, 8813. [CrossRef]
74. Rukus, J.; Warner, M.E. Crime rates and collective efficacy: The role of family friendly planning. *Cities* **2013**, *31*, 37–46. [CrossRef]
75. Steels, S. Key the characteristics of age-friendly cities and communities: A review. *Cities* **2015**, *47*, 45–52. [CrossRef]
76. Hasan, M.M.; Oh, J.S.; Kwigizile, V. Impact of walking environment on the walkability measures. In Proceedings of the Transportation Research Board 100th Annual Meeting, Washington, DC, USA, 21–22 January 2021.
77. Park, S.; Deakin, E.; Lee, J.S. Perception-based walkability index to test impact of microlevel walkability on sustainable mode choice decisions. *Transport. Res. Rec.* **2014**, *2464*, 126–134. [CrossRef]
78. De Vos, J.; Lattman, K.; van der Vlugt, A.; Welsch, J.; Otsuka, N. Determinants and effects of perceived walkability: A literature review, conceptual model and research agenda. *Transp. Rev.* **2023**, *43*, 303–324. [CrossRef]
79. Hoehner, C.M.; Ivy, A.; Ramirez, L.K.B.; Handy, S.; Brownson, R.C. Active neighborhood checklist: A user-friendly and reliable tool for assessing activity friendliness. *Am. J. Health Promot.* **2007**, *21*, 534–537. [CrossRef] [PubMed]
80. Rundle, A.G.; Bader, M.D.; Richards, C.A.; Neckerman, K.M.; Teitler, J.O. Using Google street view to audit neighborhood environments. *Am. J. Prev. Med.* **2011**, *40*, 94–100. [CrossRef] [PubMed]
81. Xia, Z.; Li, H.; Chaen, Y. Assessing neighborhood walkability based on usage characteristics of amenities under Chinese metropolises context. *Sustainability* **2018**, *10*, 3879. [CrossRef]
82. Klein, O.; Gutiérrez, G.; Escobar, F. A55 GIS based walkability index for urban contexts. Application to Luxembourg. *J. Transp. Health* **2015**, *2*, S33. [CrossRef]
83. Ewing, R.; Handy, S. Measuring the unmeasurable: Urban design qualities related to walkability. *J. Urban Des.* **2009**, *14*, 65–84. [CrossRef]
84. Su, S.; Zhou, H.; Xu, M.; Ru, H.; Wang, W.; Weng, M. Auditing street walkability and associated social inequalities for planning implications. *J. Transp. Geogr.* **2019**, *74*, 62–76. [CrossRef]
85. Hillnhütter, H. Stimulating urban walking environments—Can we measure the effect? *Environ. Plan. B Urban Anal. City Sci.* **2022**, *49*, 275–289. [CrossRef]
86. Tian, D.W.; Wang, J.; Xia, C.Y.; Zhang, J.; Zhou, J.; Tian, Z.H.; Zhao, J.; Li, B.X.; Zhou, C.X. The relationship between green space accessibility by multiple travel modes and housing prices: A case study of Beijing. *Cities* **2024**, *145*, 104694. [CrossRef]
87. Muñoz, J.P.; Simon, C.; Jimenez, I.C. Empirical study on the use of public transport in the Community of Madrid as a key factor in sustainable mobility. *Cuad. Econ.* **2016**, *37*, 112–124. [CrossRef]
88. Lynch, K. *The Image of the City*; Harvard-MIT Joint Center for Urban Studies Series; The MIT Press: Cambridge, MA, USA, 1964.
89. Cronbach, L.J. Coefficient alpha and the internal structure of tests. *Psychometrika* **1951**, *16*, 297–334. [CrossRef]
90. McDonald, R.P. *Test Theory: A Unified Treatment*; Lawrence Erlbaum Associates Inc.: Mahwah, NJ, USA, 1999.
91. Ros-McDonnell, L.; de la Fuente Aragon, M.V.; Ros-McDonnell, D. *Mendeley Data, Version 1*; Walkability Item Measurements Spanish Cities; Elsevier: Amsterdam, The Netherlands, 2022. [CrossRef]
92. Weinstein, A.; Schlossberg, M.; Irvin, K. How Far, by Which Route and Why? A Spatial Analysis of Pedestrian Preference. *J. Urban Des.* **2008**, *13*, 81–98. [CrossRef]
93. George, D.; Mallery, P. *SPSS for Windows Step by Step: A Simple Guide and Reference, 11.0 Update*, 4th ed.; Allyn & Bacon: Boston, MA, USA, 2003.
94. Sekaran, U.; Bougie, R. *Research Methods for Business: A Skill Building Approach*; John Wiley & Sons: Haddington, UK, 2010.
95. Nordin, N.; Deros, B.M.; Wahab, D.A. A Survey on Lean Manufacturing Implementation in Malaysian Automotive Industry. *Int. J. Innov. Manag. Technol.* **2010**, *1*, 1467–1476.
96. Eswaramoorthi, M.; Kathiresan, G.R.; Prasad, P.S.S.; Mohanram, P.V. A survey on lean practices in Indian machine tool industries. *Int. J. Adv. Manuf. Technol.* **2011**, *52*, 1091–1101. [CrossRef]
97. Panizzolo, R. Applying the lessons learned from 27 lean manufacturers: The relevance of relationships management. *Int. J. Prod. Econ.* **1998**, *55*, 223–240. [CrossRef]
98. Welch, S.; Comer, J. *Quantitative Methods for Public Administration: Techniques and Applications*; Brooks/Cole Publishing Co.: Pacific Grove, CA, USA, 1988.
99. Elosua, P.; Zumbo, B. Coeficientes de fiabilidad para escalas de respuesta categórica ordenada. *Psicothema* **2008**, *20*, 896–901.
100. Hussein, N. The pedestrianization and its relation with enhancing walkability in urban spaces. *J. Contemp. Urban Aff.* **2018**, *2*, 102–112. [CrossRef]
101. Tarek, M.; Hassan, G.F.; Elshafer, A.; Elfayoumi, M. Investigating built environment indicators to develop a local walkability index. *J. Contemp. Urban Aff.* **2021**, *5*, 235–251. [CrossRef]