TÉCNICO LISBOA

PEDESTRIAN ACCESSIBILITY AND ATTRACTIVENESS INDICATORS FOR WALKABILITY ASSESSMENT

EXTENDED ABSTRACT

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ABSTRACT

The aim of this work is to find suitable pedestrian accessibility and attractiveness indicators for walkability assessment. Many benefits have been associated with walking, ranging from reducing traffic congestion and pollution to solving obesity; and being walking also regarded as an essential factor in the creation of "livable communities".

With such associated benefits, critical questions are posed to researchers and urban planners: how and to what extent can the built environment encourage people to walk, and how to measure the intensity of that link, facilitating the progress towards more sustainable, integrated and appealing walking cities. Walkability research is recent and agreement on what to measure and how to measure is still very much in contention. From the multiplicity of urban features that may influence walking, accessibility and attractiveness of the pedestrian environment seem to play a major role.

A walkability assessment model was developed with the aid of multi criteria decision analysis techniques and GIS network analysis, able to address different scales (city, neighborhood and street). The model was applied to case studies (Lisbon, Bairro Alto quarter, and Bairro Alto streets) with results showing a positive correlation between estimated walkability and pedestrian travel patterns.

Keywords: Walkability, Pedestrian; Accessibility; Attractiveness; Measurement; Assessment

INTRODUCTION

Every trip begins and ends with a walking trip, and everyone is a pedestrian at least for a part of its journey. Walking is often the only way that many people can access everyday activities, yet, the streets and public spaces, once meant for pedestrians, struggle with degradation and invasion from private vehicles, with the social live being drawn away from them [1] [2] [3]. Walking is *"the foundation of the sustainable city"* providing social, environmental and economic benefits. [4],

From the social point of view, walking can be seen as the most equitable mean of transportation, as it is cheap, and it needs only basic infrastructure. Walkable environments have been associated with more democratic and "civilized cities", since pedestrian facilities can provide accessibility benefits to a greater portion of the community when compared to road or rail improvements [5]. These benefits are extended not only in terms of population figures but also across classes, including children and seniors, and low income groups who are disqualified from owning or operating automobiles. [4].

Walking also brings life to streets and livable streets contribute to safer urban environments. The contribute of walking to community safety, accessibility and social inclusion has emerged as a particular challenge to the design of the urban environment [6], as over the past century pedestrian access has declined steadily in most cities [4].

From the environmental point of view, walking is a "green" mode of transport, as it has low environmental impact, without air and noise pollution. The presence of walkable environments and transit systems may create alternatives to private car usage, thus reducing traffic congestion, noise and emissions.

Looking at the economic perspective, for the pedestrian walking has a little cost associated. In general terms, it can be associated with less energy and resources consumption when compared to other means of transport. Other economic benefits include thrive of local businesses such as street shopping and tourism and, at a larger scale, public health savings.

Many recent health studies have demonstrated that walking can promote mental and physical health, including cardio-vascular fitness and reduced stress [4], constituting a moderate intensity physical activity. Several countries' public health officials have adopted, over the last years, guidelines to encourage people to accumulate at least 30 minutes of moderate physical activity on preferably all days of the week, but it has been observed that a large proportion (30-60%) of the population maintains a sedentary lifestyle [7]. The consequences of such sedentary lifestyle have been acknowledged by the World Health Organization (WHO), stating the sedentary lifestyle not only as a disease but as "the scourge of the XXI century" [8].

With such associated benefits, one of the most critical questions to be asked is how to encourage people to walk. This question has been particularly addressed to urban planners in terms of the contribution of the urban built environment in encouraging and promoting walking. From one perspective, the relation of the built environment with walking behavior has been mostly intuitive, as there has been little scientific evidence in supporting the extent and intensity of such relation [9]. From another point of view, research has provided sufficient evidence on the link between built environment and walking [10], and focus should be set in identifying and assessing the built environment attributes that make up a pedestrian friendly environment.

Walkability has been recently introduced as a concept that translates the extent to which the urban environment is pedestrian friendly [3]. By assessing (or measuring) it, planning professionals may be able to address the quality of the pedestrian environment, what may facilitate the progress towards more integrated, appealing and walking conductive cities, towards **more sustainable cities.**

OBJECTIVE AND METHODOLOGY

The **objective** of this work is to find suitable pedestrian accessibility and attractiveness indicators for walkability assessment.

This research's **object** is composed by:

- The understanding of the link between the built environment and walking behavior;
- The identification of the relevant environmental features in defining pedestrian friendly environments;
- The comprehension of walkability metrics and techniques;

The research's **motivations** are drawn from the urbanism and territorial planning fields. They are related to the perceived importance of:

- Benchmarking and monitoring of pedestrian accessibility conditions;
- Decision aid factual information for policy makers (for prioritizing interventions, for comparison of alternatives, etc.);
- Cost effective, operational analysis frameworks (for implementation at the resource scarce Portuguese municipal context)

In order to frame the object according to the motivations in achieving the objective, the following methodological steps are taken:

1) **Literature review**, focusing at a first stage in the understanding of the factors influencing walking behavior, at a second stage in defining the walkability concepts and at a third stage in collecting existing walkability measurement tools, models and indicators;
2) **Walkability measurement appreciation**, focusing in the suitability of existing methodologies in achieving this research's proposed objective;
3) **Conceptual development** of a walkability assessment model suitable for use at municipal planning offices (therefore mainly operational).
4) **Operational development** of the model, concerning its structure and formulations;
5) **Testing** of the model, with application in real world cases;
6) **Validation and discussion** of the obtained results

THEORETICAL FRAMEWORK

The relations between the built environment and the walking behavior have been studied from different perspectives, and although being a quite recent field of research, it has been gaining growing attention from the different research fields: transportation, public health and urban planning.

The public health field has been researching actively the environmental variables correlated to physical activity (where walking is included) and has contributed greatly to the finding that built environment does affect walking behavior. Transportation and urban planning studies also have provided evidence that urban features and transportation systems are related to walking behavior. And researchers in both public health and the urban planning and transportation fields have highlighted the importance of using objective measures to help better understand the relations between the environmental attributes and the walking behaviors [11]

In any of the cases, the interest in the role of the built environment in explaining walking behavior has been relatively recent. Research has proven convincing evidence of a link between the built environment and physical activity but provided less convincing evidence of what built environment features were most associated with physical activity and a firm causal relationship could not be established. Certain patterns have however been observed, tending to suggest specific relationships between the built environment and physical activity, namely: [10].

- Accessibility, measured in various ways, emerges most clearly from both literatures as a strong correlate of away-from-home physical activity;
- The importance of design variables in explaining active travel or physical activity was somewhat more ambiguous, in both literatures;
- Design may prove more important for other physical activity than for active travel and distance more important than design for active travel;
- Individual and interpersonal factors are potentially more important than the built environment in explaining physical activity;
- Supportive built environment is not enough on its own to ensure physical activity but it does facilitate physical activity.

The relations between built environment and physical activity (that includes walking for recreation and walking for active travel) are not **consensual.** Evidence has been produced in proving such relations but the extent to which the built environment does, in fact, influence travel behavior in terms of encouraging or deterring walking is still unclear.

Research has also shown that finding the particular attributes of the built environment that might be more important in influencing walking remains a challenge. One factor that contributes to this challenge has been identified as the **co-linearity** between the environmental attributes like neighborhood densities, mixed land use and pedestrian amenities [12], as the observed denser neighborhoods tend to have a greater variety of land uses and a suitable pedestrian network. Such "spatial multicolinearity" has suggested that some of the relations between the built environment and walking are, in fact, **complementary**. For this reason the interpretation of the relative contribution of each factor may result extremely challenging [13].[14]

The sole evidence of the connection between built environment and walking (or even its assumption) has led to a field of work specifically interested in assessing and measuring that connection, has led to the **walkability** research.

WALKABILITY

The walkability of a community has been conceptualized as *"the extent to which characteristics of the built environment and land use may or may not be conductive to residents in the area walking for either leisure, exercise or recreation, to access services, or to travel to work"* [11], or in simpler terms, ***"the extent to which the built environment is walking friendly"*** [3].

The latter definition is used in the scope of this research, implying the clarification of what can constitute a "walking friendly" environment. This question has been addressed in the work by Transport for London [15], where the pedestrian concern and needs were classified under 5 main factors. These factors have been referred to as the **5Cs** and have been considered in accordance to the concept of walkability. The five "Cs" are Connected; Comfortable; Convenient; Convivial and Conspicuous.

Given the particular importance of addressing factors related to 1) pedestrian safety from traffic and traffic impacts on the public space and 2) policy level pedestrian promotion, this research proposes two new walkability dimensions to be addressed: Coexistence and Commitment.

The resulting set of proposed walkability dimensions forms the **7Cs layout:**

- **Connectivity:** The extent to which the pedestrian environment is linked; interfaced; joined; attached; networked.
- **Convenience:** The extent to which the pedestrian environment is appropriate; useful; proper; suitable; time-saving.
- **Comfort:** The extent to which the pedestrian environment is easy; pleasant; protected; relaxed; sheltered; untroubled.
- **Conviviality**: The extent to which the pedestrian environment is entertaining; lively; pleasant; sociable.
- **Conspicuous:** The extent to which the pedestrian environment is obvious; clear; discernible; distinct; perceptible.
- **Coexistence:** The extent to which the pedestrian and other transport modes can exist at the same time and place with order and peace.
- **Commitment:** The extent to which there exists engagement, liability and responsibility towards the pedestrian environment.

WALKABILITY MEASUREMENT

The assessment of the walking environment has been done using various methods. These methods include audit tools; checklists; inventories; level-of-service scales and surveys.

The measurements have bound to be performed **quantitatively** or **qualitatively** and there have been techniques developed to address to different scales, from the neighborhood **area** to the street **segments** and even intersections.

A group of walkability measurement methodologies has been appreciated in this research, revealing that there is a generalized lack of consensus in walkability measurement. Several major issues have been identified, relating to the usage of more objective or more subjective metrics; to the model validation; to the usage of methods outside the areas object of research.

A multiplicity of indicators has been used in the literature but, again, more research was considered needed in order to understand their relative importance.

To date, there has not been a walkability measurement methodology fairly accepted and implemented in planning offices. The different methodologies analyzed by this research could most probably be used in the Portuguese urban environment for walkability estimation. However, given the prevailing local conditions, this research aims to propose a new walkability measurement model, applicable to the Portuguese municipalities' context.

CONCEPTUAL DEVELOPMENT

Walkability has multidisciplinary concerns. The different perspectives are to be taken in consideration, meaning **all the different dimensions of walkability** should be assessed.

Walkability **is not definable as a single entity**. The built environment factors that affect walking likely differ according to other factors, namely by the user itself (if young, old, male, female, fit, unfit) and by the walking purpose (if for transportation, if for recreation) [10][16]. The environmental correlates of walking may also differ according to the time of the day (day trips, night trips), or by the region where the walking takes place (if it has harsh climate conditions) and by other environmental and cultural variables.

For the purpose of this research, the model to be developed and tested is a **base model,** a model suited for the adult pedestrian, not impaired, walking for transportation purposes during the day in a mild climate region (Mediterranean climate).

The main objective of the model is to assess the built environment factors that contribute to a pedestrian friendly environment, to a walkable urban environment. To do so, two main qualities of the built environment associated with walking are assessed: its **accessibility and its attractiveness.**

OPERATIONAL DEVELOPMENT

For the structuring phase, the insights drawn from MCDA [17] allowed to decompose the two main qualities of the built environment associated with walking, accessibility and its attractiveness, into a family of key-concerns or fundamental viewpoints. The key-concerns were then related to elementary viewpoints (understood as the measurable and operational components) and for each of the elementary viewpoints a descriptor was selected to act as measurement scale.

In the scope of this research, the walkability indicators (or descriptors) were drawn from the literature, forming a table of several dozens of possible indicators. A screening process was applied in order to achieve a **consensual, exhaustive, non-redundant and concise** table of elementary viewpoints and their descriptors.

In this research both quantitative and qualitative analysis were used. Each indicator is given at least two performance levels – the “base” or “neutral” value and the “good” or “goal” value. These values work in practice as anchors for the value scales and are given the standard values of 0 and 100 respectively. In the case of qualitative analysis other impact levels are created, corresponding to plausible performances.

Each of the key-concerns was assigned a similar weight, as very little is known about the relative importance of each individual factor. The assigned weight was distributed equally among each key concern’s elementary viewpoints. The simple additive model was used to combine the various criteria.

In terms of data analysis and calculations, Esri ArcGis Network Analyst extension was used to perform network analysis, mainly area coverage.

TESTING

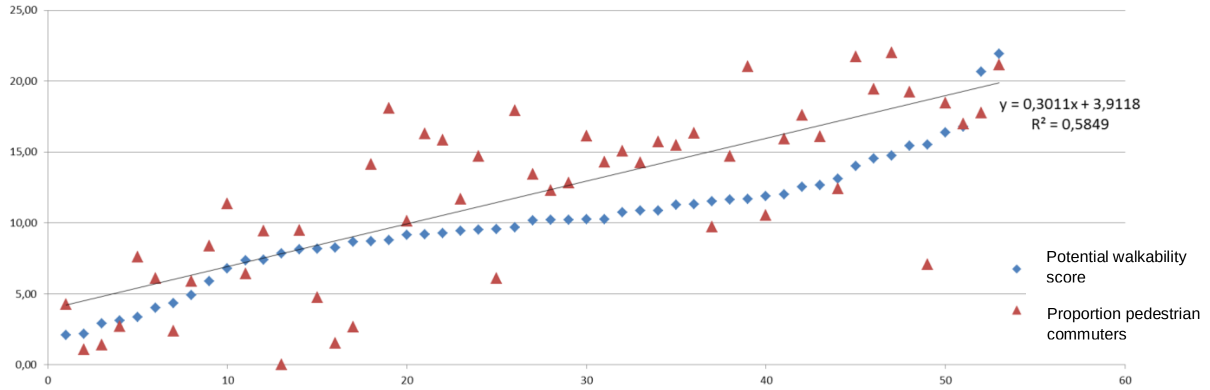
The proposed base model was developed for application in 4 different work scales: the global scale;, the macro scale; the meso scale and the micro scale. The model was tested in three of them: the city of Lisbon (global scale); the Bairro Alto quarter (macro scale) and along a path composed by 3 street portions in Bairro Alto (micro scale).

Global Scale

The global scale walkability assessment makes use of the following derived expression for the calculation of the *"Potential Walkability":*

$$Potential\ Walkability = (z.score)Land\ Use\ Mix + (z.score)Gross\ Residential\ Density + (z.score)Street\ Density$$

The potential walkability was calculated for all Lisbon's parishes, and at this scale, the availability of statistical information regarding commuting travel patterns (CENSUS 2001) allowed confronting the model's results with the resident's transportation modal choices.



Evidence 1: Correlation of walkability potential and pedestrian commuting, Lisbon case study

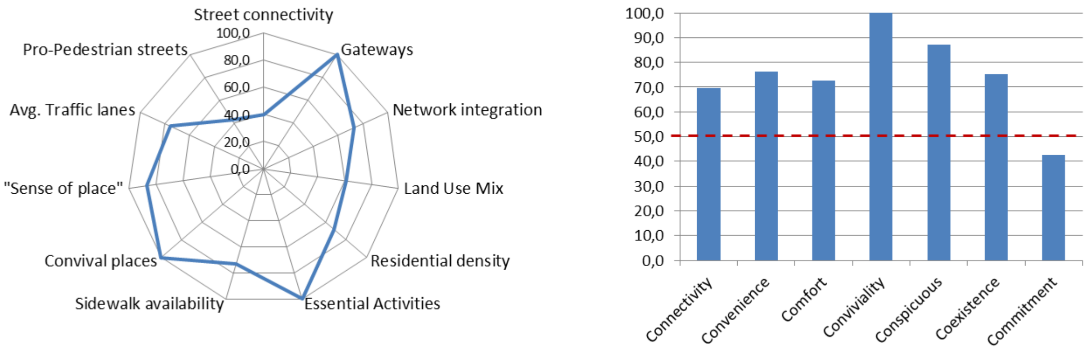
A positive correlation (R^2= 0,34) was found between the "potential walkability" of Lisbon's 53 parishes and the proportion of residents who reported travelling by foot and/or public transportation in their daily commuting. A positive and more significant correlation (R^2=0,58, Pearson's r=0,73) was found between the "potential walkability" and the proportion of residents who reported walking as a sole commuting means of transport.

Macro Scale

The parish with the highest proportion of pedestrian commuting residents (39%) was selected for macro scale analysis (Encarnação parish) and within this parish; the Bairro Alto quarter was analyzed. The macro scale assesses quantitatively 11 environmental attributes, resulting in a score of 0 to 100:

$$Walkability_{MACRO} = 0.0476 * Street\ connectivity + 0.0476 * Public\ transport\ coverage + 0.0476 * Network\ integration + 0.0476 * Land\ use\ mix + 0.0476 * Residential\ density + 0.0476 * Essential\ land\ use\ coverage + 0.1429 * Pedestrian\ infrastructure\ coverage + 0.1429 * Convivial\ points\ coverage + 0.1429 * Sense\ of\ place + 0.1429 * Traffic\ capacity + 0.1429 * Pedestrian\ friendly\ street\ proportion$$

The application of the macro scale base model reported a walkability score of 75.,0 (max 100), being the individual contribution of each of the 7 walkability dimensions assessable in the output.



Evidence 2: Output from macro scale walkability assessment, Bairro Alto case study

By applying the model to other urban areas it would be possible to compare results and to draw more comprehensive conclusions on the validity of the walkability scores from the macro area model. Additional measurements and evaluations need to be done in future research developments.

Micro Scale

The micro scale assesses qualitatively 13 environmental attributes, resulting in a score of 0 to 100:

$$
\begin{aligned}
Walkability_{micro} &= 0.1428 * Pesdestrian\ network\ continuity + 0.1428 * Sidewalk\ available\ width \\
&+ 0.0357 * Amenities + 0.0357 * Trees + 0.0357 * Climate\ protection + 0.0357 \\
&* Lighting + 0.0714 * Blind\ buildings + 0.0714 * Transparent\ buildings + 0.1428 \\
&* Path\ enclosure + 0.0714 * Conflicts + 0.0714 * Sidewalk\ buffer\ width + 0.0714 \\
&* Maintenance + 0.0714 * Cleanlines
\end{aligned}
$$

A short path (220m) was audited for the micro scale walkability model. The path was formed by 10 sidewalk segments in 5 street segments of 3 different streets. Each segment is scored independently and each segment's score is weighted according to its lengths for the calculation of the path score, being the segments of each side of the path street are added together.

Along one of the sides of the path the score was 69.6 (in 100) and the other side scored 72.3. Combining them, it would add up to an average walkability score of 71. A model validation exercise, other than field observation, has not been undertaken for this analysis scale. Follow-on research could focus on more objective validation methods.

$Walkability_{micro}$:PathSide_0 =

$$\frac{\sum_i Segment\ score_i \times length_i}{\sum segment\ length\ (side\ 0)} = 69.6$$

$Walkability_{micro}$:PathSide_ 1 =

$$\frac{\sum_j Segment\ score_j \times length_j}{\sum segment\ length\ (side\ 1)} = 72.3$$

$Walkability_{micro}$ Path = (69.6 + 72.3) / 2 = 71

Evidence 3: Micro scale output and results, Bairro Alto case study

Validity and Validation

On the meaning, or interpretation, of the results, a higher walkability score in one area or in one street does not necessarily mean more people walk there or will walk there. It means that the area, or the street, meet a certain set of requirements to a certain extent. In other words, it means that certain built environment attributes which are believed to promote a pedestrian friendly environment are more present or more evident in one area/street than in other.

Limitations

The major internal limitations of the model are believed to be related to the lack of scientific evidence supporting the choice of the indicators and their threshold.

In terms of limitations external to the model, the most relevant was found to be the lack of information regarding travel behavior and travel patterns. Without travel behavior data the validation of the model is fairly limited (although still possible by other means).

Applicability

The outputs from the global scale may be useful in characterizing whole urban areas in terms of their potential walkability, and in comparing urban settings. In terms of planning, they may be useful at master plan level studies

The outputs from the macro scale may be useful in classifying existing or proposed neighborhoods in terms of their walkability. In terms of planning, this may be useful for identifying critical intervention areas, for assessment of urbanization impacts and for benchmarking/monitoring purposes.

The outputs from the meso scale may be useful in addressing the pedestrian accessibility of public services and facilities (schools, health centers, sport and recreation) or for real estate prospection. They may also be useful for transportation planning.

The outputs from the micro scale may be useful in identifying intervention needs and in providing a reference for benchmarking. In terms of urban design it may be useful in rating intervention alternatives.

CONCLUDING REMARKS

Walkability assessment is relevant as it provides factual data for decision aid, benchmarking and monitoring processes. Walkability and its measurement should not be seen as a “one fits all” concept. It is necessary to understand what type of walking is going to be assessed (if walking for transportation if walking for recreation or exercise), what pedestrian group is to address (adult, enfant, elderly, less able), where and when.

A model for walkability assessment was development, conceptually designed to fit the Portuguese municipal context. It made use of GIS analysis features in combination with MCDA techniques. The MCDA techniques allowed a clearer comprehension of what was to be assessed and by which means. The model was applied to the city of Lisbon, to the Bairro Alto neighborhood and to some of its streets. Results were encouraging, as a positive correlation was found between estimated walkability and pedestrian travel patterns. Further developments will undoubtedly contribute to the understanding and validation of walkability scores.

Today, more than ever, walking matters.

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