Investigating the Walkability Index of a Commercial City Center Using Simulation and Surveys: The Juiz de Fora Case Study

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Abstract. Although the positive impacts of the urban experience are perceptible when the population occupies public spaces, it is notable that the pedestrian loses more space to motorized transportation every day. The cities are often adapted or even built for the circulation of automotive, which increasingly decreases the walkability in urban areas. However, several studies note that the vitality of a path directly benefits local commerce and safety. This argument encourages the implementation of pedestrian paths and mechanisms that benefit people's permanence in urban centers. Considering these issues, this article aims to investigate the walkability of the commercial center of Juiz de Fora (MG), a neighborhood that has a peculiar morphology with commercial galleries and that has been encouraged in recent decades to create pedestrian paths. This research method comprises three main steps: computational simulations, interviews and assessment of the Walkability Index (ITDP, 2018). The simulation experiments consist of the construction of a spatial syntax, through the Depthmap program, which processes the path possibilities within the studied region. Its use includes the analysis of network passages configured by commercial galleries, which have an important function for mobility. The interviews were conducted, within the sample space, with questions based on important criteria for the classification of a livable city. Finally, the Walkability Index, based on six criteria (i.e., sidewalk, mobility, attraction, road safety, public safety and the environment), was assessed. Based on the results, there is evidence that the commercial center of Juiz de Fora provides essential characteristics for the quality of mobility for pedestrians, highlighting the importance of the urban form for walkability in commercial centers. Future studies considering other urban centers could benefit from the insights gained from this study as well by applying the proposed research method.
1. Introduction
Urban streets are more than areas intended for the circulation of people and goods and often by highlight the cultural, social and economic constitution of each society. The streets represent the city landscape, and this is where the urban dynamics are evident. They are places of symbolic exchange that show the social and political organization [1, 2].

Although the positive impacts of the population are notable when occupying public spaces, pedestrians lose more space for motorized transport every day [3]. The reduction of sidewalks, the dispersion of services and the increase of traffic accidents constitute a hostile environment for those who choose non-motorized use. Thus, there is a great loss in the liveliness of places that depend on people in acceptable conditions of accessibility. Consequently, environments conducive to social interaction can contribute to more sustainable cities with a focus on quality of life, especially for pedestrians.

Based on this idea, the present article aims to investigate the walkability and its applicability. For this purpose, the commercial center of Juiz de Fora (MG, Brazil) was defined as a reference study. This city began its development in the late nineteenth century, having as its main area of expansion the current commercial center, which is characterized for its diversity of services, commerce, institutions, and residences. Its current urban morphology is configured by parallel streets (some exclusive to pedestrians) interconnected by covered pedestrian galleries. Such galleries function as network passages and assume an important influence on the displacement of people, as will be presented in this paper. Hence, the importance of studying the walkability of this neighborhood, where streets interact with cultural and historical dimensions of this place is notable.

2. Theoretical Background

2.1. Walkability e Indicators
Walkability refers to characteristics of the environment that motivate and encourage people to occupy public spaces. Studying these characteristics is essential for understanding travel patterns and accessibility conditions. This information is essential for diagnosing the conditions in which people on the streets are subjected. If these conditions are met, it is understood that walking in the region is prosperous, resulting in mobility and a livelier city.

Several characteristics of the environment contribute to the increase of walkability. One of these aspects is identified by the sense of security provided by "eyes on the street", which consist of the activities of cities that interact with public spaces [4]. Such activities act as "natural watchers" of the space and provide a feeling of greater comfort to those who attend them. Therefore, it is necessary to study these effects and how they can be perceived by the population.

To analyze these characteristics, several indicators are used to address the main attributes, such as safety and comfort, linked to walkability. The first walkability index [5] adopts ten multiple choice questions, including not only the attributes exemplified above, but also dimensions related to density.

Other walkability indices that can be highlighted are those generated by the Institute for Transportation and Development Policy (ITDP) [6]. Its most current version (2018) is composed of six categories: sidewalk, mobility, attraction, street safety, public safety and environment, where there is, in each, a set of indicators that contain the main attributes of walkability. This indicator acts in a micro scale, generating results for each section of street to finally reach an overall result about the region. This version was also used as a basis for analyzing the region investigated.

2.2. Axial Syntax
One of the factors that influence walkability is connectivity, recognized as one of its attributes from the research conducted by the London Planning Advisory Committee, that defines a multidimensional 5Cs format, also composed for convenience, comfort, conviviality and conspicuousness, updated later to the 7Cs Layout, with the addiction of coexistence and commitment [7]. Also, Randal and Baetz [18] develop a study of Pedestrian Connectivity, which presents the positive effects of good connection of
routes in the sustainability of the cities. For these reasons, connectivity plays an important role in pedestrian mobility, as a connected region that allows a greater variety of paths and can give pedestrians several number of routes to choose from, improving comfort and safety. Jane Jacobs (2000) [4], for example, argued that urban liveliness was only possible in areas with short blocks and mixed uses that encouraged pedestrians to walk.

To analyze connectivity, the axial syntax can be used. This syntax consists of a map of the study region composed of axial lines that represent the street sections. By the use of the Depthmap program, presented in the actual work, it is possible to generate connectivity and choice results from the intersection of these lines. The importance of Connectivity is to define which streets are more or less connected in the axial map. Furthermore, the Choice values measure the degree to which the line exerts control neighboring lines. These values are essential to comprehend the possibilities of routes that could be used inside the axial map, the relation of the possibilities with each axial line and the influence of the structure of the study region on the flow of pedestrians. Thus, through these analyzes, it is possible to establish criticism about the network and its influence on walkability.

3. Case study
The urban setting chosen for this research was the commercial center of the city of Juiz de Fora, MG, Brazil. It is considered an average city including a population of approximately 560 thousand inhabitants [10] and the fifth largest GDP of Minas Gerais [11]. It has an HDI of 0.778 [12], which places this municipality in the High Human Development range.

Historically, the city's development is associated with the Gold Rush and broad coffee activity (foundation in 1850). In the twentieth century it had a great industrial development, mainly encouraged by the textile industry [13]. Nowadays, the city still has great development focused on commerce and services and is considered a pole of attraction for neighboring municipalities.

The development of the central nucleus of the city is characterized by its commerce and was planned in the early twentieth century [14]. The region is characterized by a triangle formed by three avenues: Av. Barão do Rio Branco, Av. Getúlio Vargas and Av. Presidente Itamar Franco. Within this boundary are defined eleven streets parallel to Av. Pres. Itamar Franco and two parallel to Av. B. do Rio Branco. In addition, there are fifteen galleries that connect these roads to each other. Some of these roads have been turned into pedestrian streets and the main and oldest of them is Halfeld Street (Fig. 1 and Fig. 2).

**Figure 1.** Morphology arrangement of the Commercial Center of Juiz de Fora. Source: adapted Google Maps, 2019.

**Figure 2.** Principal Boardwalk of the Commercial Center of Juiz de Fora (Halfeld St.). Source: personal assortment, 2019.
Not only commercial and service exchanges, but also symbolic exchanges are quite present in the center which is considered by many to be an “open-air mall” [13]. The intertwining of galleries and streets (many exclusive for pedestrians) favors tranquility and urban liveliness, mainly because the region has mixed use with housing, services (health, education, etc.), commerce and leisure.

Currently, the city is undergoing a decentralization process and has other commercial nucleus under development and some already consolidated [15], but the urban center is still the scene of greater concentration and diversity of people.

4. Methodology
As previously presented, the work methodology is composed of three phases: construction of a spatial syntax, interviews and application of the Walkability Index developed by ITDP [6]. The objective of using three different steps was to generate discussions from different points of view of the same study region: the spatial syntax for comprehending the effects of the localities of the galleries, the surveys to include of the pedestrians' perception and travel patterns and the Walkability Index to understand the infrastructure as a way to guarantee a broader discussion of the area.

The construction of a spatial syntax aims to classify the streets by means of a depth analysis, which relates the distances of each other to define characteristics such as connection and control. For this, an axial map was developed, composed only of lines, that represent the roads of the studied region, using the AutoCAD software. The map was then analyzed using the DepthMap program, which generates values for connection and choice. The purpose of this analysis is to generate results of such values by comparing a map that includes the galleries and one that excludes them.

Considering the intention of investigating the walking conditions for pedestrians, interviews play an important role in understanding the space. It happens because, through these, there is the inclusion of popular opinion and search for understanding the travel patterns and characteristics of the population profile. Thus, it is possible to develop solutions that involve not only the urban infrastructure, but the social demands.

Therefore, a questionnaire was developed to assess the population’s perception of the Commercial Center of Juiz de Fora. In order to gather reliable responses from a representative sample, a minimum number of questionnaires was determined using the Glauber Santos’ Sample Calculation program [16], which consists of the following equation (1):

\[
\text{n} = \frac{N \times Z^2 \times p \times (1-p)}{Z^2 \times p \times (1-p) + e^2 \times (N-1)}
\]

where n: calculated sample; N: population; Z: standardized normal variable associated with confidence level; p: true probability of the event; e: sampling error

This formula can be calculated through an online tool provided by the author, where the reliability considered was 95% and the margin of error 10%, defined according to the use of higher reliability of the research, thus generating a sample of 88 questionnaires [16].

From these data, interviews were conducted at three times: April 12th, 2019 from 12:00 pm to 5:00 pm, April 13th, 2019 from 9:00 pm to 12:00 pm and May 3, 2019 from 4:00 pm to 7:00 pm.

The questions were designed to assess the population profile and travel patterns. Thus, three questions were defined as the basis of population characteristics, nine regarding travel patterns and five the quality of elements associated with walking.
Table 1. Data demanded in the surveys with the pedestrians

| Population Characteristics |  |
|----------------------------|---|
| Age                        |  |
| Gender                     |  |
| Scholarly                  |  |

| Travel Patterns                  |  |
|----------------------------------|---|
| From what neighborhood do you come from? |  |
| How often do you come to the Commercial Center? |  |
| What kind of activity, or activities, do you do develop here? |  |
| What time of the day do you usually come? |  |
| How do you come to the Commercial Center? |  |
| Do you use the same or different paths to get to the activity? |  |
| Do you usually get lost in the Center? |  |
| Do you go to the galleries? What kind of activities do you do in them? |  |
| Name a reference point or points to locate in the neighborhood |  |

| Quality of Walking               |  |
|----------------------------------|---|
| Day displacement                 |  |
| Night displacement               |  |
| Lightning                        |  |
| Day security                     |  |
| Night security                   |  |

Source: authors, 2019

As a way to comprehend the diversity characteristics and urban form of the studied region, the work uses, as a basis, the indicators provided by ITDP Brazil, which brings, in its document ITDP Tools - Version 2.0, a series of evaluators arranged in six categories: sidewalk, mobility, attractiveness, street safety, public safety and the environment. As an example of its use, there is a pilot application in the Center of Rio de Janeiro [19], which applies these indicators in different stretches and define diagnosis for the space. Considering that the study region is a Commercial Center, also from a Brazilian city, this study defines that the ITDP index was also suitable for the present situation.

5. Results and Discussion

5.1. Axial Simulation Results

Understanding the urban mesh is essential for the analysis of walkability. The connectivity between the streets is a factor of great importance, since its good form allows greater possibilities of path to reach an activity, which interferes with the accessibility and comfort of those who walk [7].

Considering the particularity of the galleries in the center of Juiz de Fora with potential for widening the connectivity and redistribution of pedestrian flows, situations were analyzed with and without the galleries composing the network using the Depthmap program. The representation of the axial lines in the program can be found in Figure 3.
Figure 3. Axial lines (a) without galleries e (b) with the galleries  
Source: Developed by the authors through the DepthMap program

The data generated from the analysis aims to associate the connectivity and choice of the sections. The choice values used for analysis were found for a radius of two topological steps, which are those considered for two knot encounters from one stretch. Choice rates assume the maximum value of 1, which characterizes a line that has control over all others, while the value of 0 indicates the total lack of it. Consequently, Table 2 presents the connectivity and choice data between the main streets.

| Streets  
Analysis | Connection  
Without Galleries | Without Galleries | With Galleries | With Galleries |
|------------|------------------|------------------|---------------|---------------|
| Baixo do Rio Branco Avenue | 16 | 16 | 0,79 | 0,40 |
| Getúlio Vargas Avenue | 14 | 14 | 0,70 | 0,37 |
| Afonso Pinto da Mota St. | 2 | 2 | 0,00 | 0,00 |
| Mal Floriano Peronoto St. | 3 | 3 | 0,00 | 0,00 |
| Mr. Moore St. | 2 | 4 | 0,00 | 0,03 |
| Mal. Deodoro da Fonseca St. | 3 | 9 | 0,00 | 0,16 |
| Halfeld St. | 4 | 13 | 0,13 | 0,37 |
| Baixo de São João Nepomuceno St. | 3 | 9 | 0,00 | 0,22 |
| Santa Rita St. | 4 | 5 | 0,03 | 0,03 |
| Braz Bernardino St. | 2 | 4 | 0,00 | 0,03 |
| Espírito Santo St. | 4 | 6 | 0,01 | 0,09 |
| Oscar Vidal St. | 3 | 3 | 0,01 | 0,01 |
| Barista de Oliveira St. | 10 | 11 | 0,19 | 0,27 |
| Barbosa Lira St. | 3 | 4 | 0,00 | 0,03 |
| Henrique Surerus St. | 3 | 3 | 0,01 | 0,01 |

Table 2. Relation between connection and choice, considering the principal routes of the system

Source: Developed by the authors through the DepthMap program
Among the data presented, it is notable the relationship between the number of connections in the streets Marechal Deodoro da Fonseca, Halfeld and Barão de São João Nepomuceno, which is tripled when compared to the situation of the study region in which the galleries are not considered. These values allow for more path possibilities, with a greater number of inputs and outputs for pedestrians to use as they travel to reach their activity.

In addition to this, the presence of the galleries is perceived as a possibility for the redistribution of pedestrian flow. The Choice data indicates the influence of a section in relation to the paths that can be developed within the study region. Therefore, there is a reduction in control of Avenida Rio Branco and Avenida Getúlio Vargas, being more distributed with the streets Halfeld, Batista de Oliveira, Barão de São João Nepomuceno and Marechal Deodoro.

5.2. Interview Results
The interviews were conducted with a total of 89 people through the streets of Juiz de Fora Center. Sections from Halfeld, Marshal Floriano Peixoto, Baron of St. John Nepomuceno, Espirito Santo, as well as Rio Branco and Getúlio Vargas avenues were chosen. The choice of sections was made in order to ensure greater diversity in responses, so that there was no greater influence of characteristics of any specific street. The graphs for the analysis were then developed from these data.

5.2.1. Characteristics of the population
The analysis of population characteristics encompasses the gender, education and age of the people interviewed. The answers to these questions are presented in Figure 4 (a, b and c).

From the analysis of the graphs, there is a majority of adults in the streets, followed by the number of young people and, finally, the elderly, who made up less than 10% of respondents for the research. Such factors are essential for the evaluation of the space, since an elderly person may require better accessibility conditions than an adult [17]. Still, the research finds some limitations regarding the application of interviews mostly with the female audience.

In addition, almost half of the respondents have a graduate degree and around 20% did not finish high school. Given this, there is a diversity as to the level of education achieved, which may reflect the type of jobs and the diverse socioeconomic conditions presented by people attending the center of Juiz de Fora.

5.2.2. Travel Patterns
Moreover, the analysis of travel patterns seeks to understand the characteristics of the trip, including its motivation, schedule, the modes of transport used. As an answer to these questions the actual work presents the data in Figure 5 (a, b, c, d, e, f, g, h, i, j).
Data from the graphs suggest that the origin of the people who come to the Center is very diverse. The Commercial Center is located in the Central zone of the city, which leads the origin of trips. In turn, those originating in the North Zone account for just over 20% of these trips, followed by the South and East regions, with over 13% each. In addition, 38.2% originated from the trip come from the Central Zone, which reflects the trips made by foot to the Center, which reach 21.9%. Considering the issue of the mobility to the center, it is clear that most people use public transport, but still, more than 20% opt for individual transport by their own car or use of mobility app or Taxi.

Results from this study also indicate a variety of activities performed in the Center, with predominance of leisure and shopping activities, but also with considerable values for housing and work. In addition to the open streets, there is the intense presence of people in the galleries, which are not only being used for crossing, but also for shopping and work. Such diversity is essential for walkability as it allows for a greater distribution of flows along the streets, thus for example, a longer stay of people on the streets at different times. This factor can be observed by the distribution of pedestrians throughout the day. Despite data suggesting a reduction of people in nighttime, almost half.
of the population interviewed attend the space every day and almost 90% go at least once a week to the place.

In addition, the influence of the reference elements on the readability of the region can be seen, based on the landmarks chosen by the users. The convergence of responses in Halfeld Park and Halfeld Street make them not only individual but local references, assuming focal point characteristics [2], which are positive for walkability by allowing visitors to have a greater understanding of the space they walk. Another factor that is associated with the readability of the region is the high rate of people who consider that they never get lost in the center of Juiz de Fora, with the value of 90%, which expresses a certain dominance of patrons over the region.

5.2.3. Quality of the walk.
The quality analysis of the aspects of walking encompasses the quality of day and night displacement and safety and the lighting according to the interviewees' point of view. The assessment was performed by the pedestrian with values from Great to Very Bad according to his own opinion and then the values were transformed to base 10, assuming the following values: Great = 10, Good = 7.5, Regular = 5, Bad = 2.5 and Very Bad = 0. From this translation, a final grade was made for each aspect and it is represented in the figure 6.

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Through the graph, it is possible to analyze the different evaluations between day and night, since both displacement and safety were worse evaluated in the night hours. In parallel with the frequency of people at night, presented in the topic of travel patterns, there is a coherence between the presented data, since a deserted area can generate some kind of discomfort, without the presence, for example, of "Eyes on the Street". In addition, the lighting does not, by comparison, assume as bad reviews and ratings as night safety, which allows further reflection on what are, in fact, the biggest influences on the downgrade of this note.

5.3. Results of Walkability Indicators.
The walkability study was developed from the ITDP indicators (2018) and their application in specific sections of the study region, in order to understand the characteristics of the region as a whole, avoiding concentration in one street. From this, 23 excerpts were chosen, which are represented by Figure 7, accompanied by subtitles.
Figure 7. Streets, avenues and galleries where the surveys were realized.
Source: Google MyMaps, adapted in 2019.

Hence, a table was developed (Table 3) integrating the chosen sections with the criteria evaluated according to the ITDP (2018). The table is accompanied by subtitles.
Table 3. Application of the ITDP criteria (2018) in the chosen sections

| Criteria | Sections | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 |
|----------|----------|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Paving   |          | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Number of sidewalks and differences per 100 m | 1.5 | 2.3 | 0.0 | 1.1 | 0.9 | 3.1 | 0.0 | 0.0 | 2.9 | 0.0 | 2.9 | 5.4 | 2.8 | 0.0 | 0.0 | 4.3 | 0.0 | 0.0 | 2.5 | 3.3 | 2.1 | 0.0 |
| Sidewalk width (m) | <2 | >2 | >2 | >2 | >2 | >2 | >2 | >2 | >2 | >2 | >2 | >2 | >2 | >2 | >2 | >2 | >2 | >2 | >2 | >2 | >2 | >2 | >2 |
| Number of people per minute (NNP) | 7 | 10 | 9 | 11 | 14 | 24 | 15 | 35 | 9 | 34 | 30 | 19 | 51 | 24 | 48 | 26 | 28 | 37 | 31 | 34 | 23 | 4.2 |
| Dimensions of the squares | 194 | 87 | 101 | 87 | 49 | 94 | 67 | 100 | 65 | 68 | >7 | 98 | 93 | 121 | 120 | 74 | 69 | 97 | 63 | 119 | 150 | 94 | 72 |
| Distance to transit | 2 | 2 | 2 | 3 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Documented resident (in %) | 60 | 50 | 30 | 50 | 80 | 80 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 |
| Physically accessible facilities | 7 | 5 | 0 | 0 | 2 | 1 | 0 | 0 | 0 | 1 | 0 | 2 | 3 | 2 | 2 | 0 | 3 | 3 | 2 | 1 | 3 | 2 |
| Visually accessible facilities | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N |
| Transit safety |          | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N |
| Street typology |          | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N |
| Pedestrian pathways exclusive, shared or segregated? | Se | Se | Se | Se | Se | Se | E | Se | E | Se | E | Se | E | Se | E | E | E | E | E | E | E | E | E | E |
| Is there a low motorized traffic? | N | N | N | N | N | N | Y | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N |
| Is there a properly inclined ramp or level of crossing at the sidewalk height? | Y | Y | Y | Y | Y | Y | Y | N | N | Y | N | Y | Y | N | N | Y | N | Y | Y | Y | Y | Y | Y | Y |
| Are there more than 10 seconds for the green light or at least islands every two lanes? | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Noise pollution |          | 74 | 68 | 68 | 65 | 67 | 66 | 58 | 68 | 70 | 67 | 65 | 80 | 76 | 77 | 67 | 74 | 72 | 67 | 74 | 74 | 67 | 57 | 65 |
| How many decibels in the street? | 4 | 5 | 6 | 6 | 7 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| Shadow and shelter |          | 8 | 3 | 2 | 9 | 9 | 10 | 8 | 10 | 10 | 10 | 9 | 9 | 8 | 10 | 9 | 10 | 9 | 10 | 9 | 10 | 9 | 10 |
| Percentage of sheltered sidewalk area (x%) | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N |
| Presence of 3 or more garbage bags on the sidewalk? | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N |
| Garbage collection |          | N | Y | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N |
| Is there more than 1 debris per meter of sidewalk length? | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N |
| Presence of critical waste or hazardous? | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N |
| Presence of irreversible assets? (sofa, etc.) | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N | N |

Legend

"Y" e "N" correspond to "yes" and "no";
"Se" e "E" correspond to "segregated street" and "exclusive street";
The colors blue, green, yellow and red correspond respectively to "great", "good", "sufficient" and "insufficient".
The source: authors, 2019
The data presented enable some considerations regarding the conditions for walkability. As long as the pedestrian flow, where they are not classified in optimum or good situation, there is insufficiency from saturated flow, which ends up hindering accessibility conditions. In relation to public establishments, it is remarkable the difference between day and night hours, since during the day the number of open establishments is great and at night this quantity and quality declines, generating a set of empty streets with less incentives for walking.

Furthermore, it is important to highlight the presence of private cars, since in half of the sections, the motorized flow is intense and medium to high speed, which influences the increase of noise pollution and the greater risks for pedestrians. In addition to these factors, noise pollution, represented by the value in decibels, occupies values only between "sufficient" and "good", which negatively influences the comfort conditions compared to an optimal situation.

Some sections, despite having more than two meters of sidewalk, have a very intense pedestrian flow which shows often crowded roads. This was mainly observed on the main avenues (Getúlio Vargas, B. do Rio Branco), taking into account walking on Av. Getúlio Vargas is more uncomfortable as bus stops occupy sidewalks.

6. Final Considerations
From a wide field research and computer simulations it was possible to verify that the Juiz de Fora commercial center is becoming to be suitable for pedestrians. The urban formation with the pedestrian galleries, the covered sidewalks, the alteration of common roads to pedestrian streets, the incentive to mixed use, among other factors, show the potential of walking of the urban center. Also, from the different analysis, it is noticed that, even from different methods, there are approaches between them, as the relation of the lack of security at night and the absence of open public spaces.

The constant presence of passersby throughout the day and the answers referring to the user's satisfaction corroborate the results of the Walkability Index assessment and the best connectivity observed in the computer simulations.

The presence of galleries contributes significantly to the local commerce, both increasing the possibilities of paths and the area for occupation with street stores and consequently rising the visual permeability of the streets. The mixed use of the region also supports the improvement of the sense of security and the growth in walking and bus travel.

It was observed that many stretches can still be improved by increasing sidewalks and defining separate bus stops and, mainly by encouraging other modes of travel such as cycling. It was also observed that the presence of vegetation is quite incipient, and the development of these elements could contribute to greater comfort in walking.

It is important to consider that this work finds limitations for presenting broader analysis on account of the designated space. However, comprehending different values from the spatial analysis, as integration and axiality, are essential for a more complete discussion of the subject. Also, it is important to consider, in further studies, more combinations of discussion topics between the three methods, as it is seen that they can be related.

It is suggested for the continuity of the research the verification of data and microclimatic simulations since it is sensible to the improvement of the thermal comfort inside the galleries and in streets with covered sidewalks.

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