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Relationships between urban configuration and the vitality of public squares in Juiz de Fora (MG)

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Relações entre configuração urbana e vitalidade das praças de Juiz de Fora (MG)

RESUMO

Objetivo – investigar a relação entre a configuração da malha urbana e a vitalidade de 84 praças do município de Juiz de Fora (MG), considerando, além dos aspectos configuracionais, as características físicas desses espaços que podem contribuir ou dificultar sua apropriação e uso.

Metodologia – o estudo adota abordagem quantitativa, baseada na análise de medidas sintáticas da malha urbana (INT.R3, NAIN, NACH e INCH) e na mensuração da densidade de usuários por praça, buscando identificar correlações estatísticas entre configuração espacial e padrões de uso dos espaços públicos.

Originalidade/relevância – o estudo contribui para preencher lacunas da literatura ao investigar empiricamente a relação entre configuração espacial e vitalidade urbana no contexto brasileiro, ainda pouco explorado nos estudos fundamentados na Teoria da Sintaxe Espacial. Diferencia-se por analisar a totalidade das praças de uma cidade, superando abordagens baseadas em amostras reduzidas, e por empregar instrumentos estatísticos que permitem uma avaliação integrada entre morfologia urbana e padrões de uso dos espaços livres públicos.

Resultados - os resultados indicam que as praças de Juiz de Fora apresentam distribuição e padrões de vitalidade heterogêneos entre as Regiões de Planejamento, com maior concentração de praças e de vitalidade na região central da cidade. As análises estatísticas revelaram correlações positivas e significativas entre a densidade de usuários e as medidas sintáticas INT.R3, NACH e INCH, ainda que de magnitude fraca a moderada, indicando que a configuração urbana influencia a vitalidade, mas não atua como fator determinante. Destacam-se casos contrastantes, como a Praça Armando Toschi, que apresenta alta vitalidade em contexto de baixa integração, e a Praça Mundo Novo, que, apesar de alta integração espacial, registra baixos níveis de uso, evidenciando limites da configuração espacial como fator isolado.

Contribuições teóricas/metodológicas – o estudo reforça a contribuição da Teoria da Sintaxe Espacial para a compreensão da vitalidade urbana ao evidenciar seus alcances e limitações quando aplicada de forma empírica e estatisticamente testada. Metodologicamente, destaca-se a análise da totalidade das praças de uma cidade e a articulação entre medidas sintáticas e dados observacionais de uso, contribuindo para abordagens integradas na investigação dos espaços livres públicos.

Contribuições sociais e ambientais – os achados oferecem subsídios para o planejamento urbano ao indicar que a qualificação e o uso das praças dependem da articulação entre configuração espacial, atributos físicos e usos do entorno. Nesse sentido, o estudo pode orientar políticas públicas voltadas à melhoria, redistribuição e criação de praças, promovendo maior inclusão social, acesso aos equipamentos de lazer e valorização dos espaços públicos urbanos.

PALAVRAS-CHAVE: Espaços Livres Públicos. Teoria da Sintaxe Espacial. Planejamento territorial.

Relationships between urban configuration and the vitality of squares in Juiz de Fora (MG)

ABSTRACT

Objective – to investigate the relationship between urban street network configuration and the vitality of 84 public squares in the municipality of Juiz de Fora (MG), considering not only configurational aspects but also the physical characteristics of these spaces that may contribute to or hinder their appropriation and use.

Methodology – the study adopts a quantitative approach based on the analysis of syntactic measures of the urban network (INT.R3, NAIN, NACH, and INCH) and the measurement of user density in each square, seeking to identify statistical correlations between spatial configuration and patterns of use of public spaces.

Originality/Relevance – by empirically investigating the relationship between spatial configuration and the urban vitality of public squares in the Brazilian context, this study expands the body of evidence linking Space Syntax to public spaces. It stands out for analyzing the entirety of a city's public squares, overcoming approaches based on reduced samples, and for employing statistical instruments that enable an integrated assessment of urban morphology and patterns of use of public open spaces.

Results – the results indicate that public squares in Juiz de Fora present heterogeneous distributions and vitality patterns across Planning Regions, with a greater concentration of both squares and vitality levels in the city's central

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area. Statistical analyses revealed positive and significant correlations between user density and the syntactic measures, although with weak to moderate magnitude, indicating that urban configuration influences vitality but does not act as a determining factor. Contrasting cases stand out, such as Praça Armando Toschi, which shows high vitality in a context of low integration, and Praça Mundo Novo, which, despite high spatial integration, records low levels of use, highlighting the limits of spatial configuration as an isolated factor.

Theoretical/Methodological Contributions – the study reinforces the contribution of Space Syntax Theory to the understanding of urban vitality by evidencing its scope and limitations when applied empirically and tested statistically. Methodologically, it highlights the analysis of the entire set of public squares in a city and the articulation between syntactic measures and observational data on use, contributing to integrated approaches in the investigation of public open spaces.

Social and Environmental Contributions – the findings provide support for urban planning by indicating that the qualification and use of public squares depend on the articulation between spatial configuration, physical attributes, and surrounding land uses. In this sense, the study may guide public policies aimed at improving, redistributing, and creating public squares, promoting greater social inclusion, access to leisure facilities, and the valorization of urban public spaces.

KEYWORDS: Public Open Spaces. Space Syntax Theory. Territorial Planning.

Relaciones entre la configuración urbana y la vitalidade de las plazas em Juiz de For a (MG)

RESUMEN

Objetivo – investigar la relación entre la configuración de la red urbana y la vitalidad de 84 plazas del municipio de Juiz de Fora (MG), considerando no solo los aspectos configuracionales, sino también las características físicas de estos espacios que pueden contribuir o dificultar su apropiación y uso.

Metodología – el estudio adopta un enfoque cuantitativo, basado en el análisis de medidas sintácticas de la red urbana (INT.R3, NAIN, NACH e INCH) y en la medición de la densidad de usuarios por plaza, con el objetivo de identificar correlaciones estadísticas entre la configuración espacial y los patrones de uso de los espacios públicos.

Originalidad/Relevancia – al investigar empíricamente la relación entre la configuración espacial y la vitalidad urbana de las plazas en el contexto brasileño, este estudio amplía la evidencia que vincula la Sintaxis Espacial con los espacios públicos. Se diferencia por analizar la totalidad de las plazas de una ciudad, superando enfoques basados en muestras reducidas, y por emplear instrumentos estadísticos que permiten una evaluación integrada entre la morfología urbana y los patrones de uso de los espacios libres públicos.

Resultados – los resultados indican que las plazas de Juiz de Fora presentan distribuciones y patrones de vitalidad heterogéneos entre las Regiones de Planificación, con mayor concentración de plazas y mayores niveles de vitalidad en la región central de la ciudad. Los análisis estadísticos revelaron correlaciones positivas y significativas entre la densidad de usuarios y las medidas sintácticas INT.R3, NACH e INCH, aunque de magnitud débil a moderada, lo que indica que la configuración urbana influye en la vitalidad, pero no actúa como un factor determinante. Se destacan casos contrastantes, como la Praça Armando Toschi, que presenta alta vitalidad en un contexto de baja integración, y la Praça Mundo Novo, que, a pesar de una alta integración espacial, registra bajos niveles de uso, evidenciando los límites de la configuración espacial como factor aislado.

Contribuciones Teóricas/Metodológicas – el estudio refuerza la contribución de la Teoría de la Sintaxis Espacial para la comprensión de la vitalidad urbana al evidenciar sus alcances y limitaciones cuando se aplica de forma empírica y se somete a pruebas estadísticas. Metodológicamente, se destaca el análisis del conjunto total de las plazas de una ciudad y la articulación entre medidas sintácticas y datos observacionales de uso, contribuyendo a enfoques integrados en la investigación de los espacios libres públicos.

Contribuciones Sociales y Ambientales – los hallazgos ofrecen aportes para la planificación urbana al indicar que la cualificación y el uso de las plazas dependen de la articulación entre la configuración espacial, los atributos físicos y los usos del entorno. En este sentido, el estudio puede orientar políticas públicas dirigidas a la mejora, redistribución y creación de plazas, promoviendo una mayor inclusión social, el acceso a equipamientos de ocio y la valorización de los espacios públicos urbanos.

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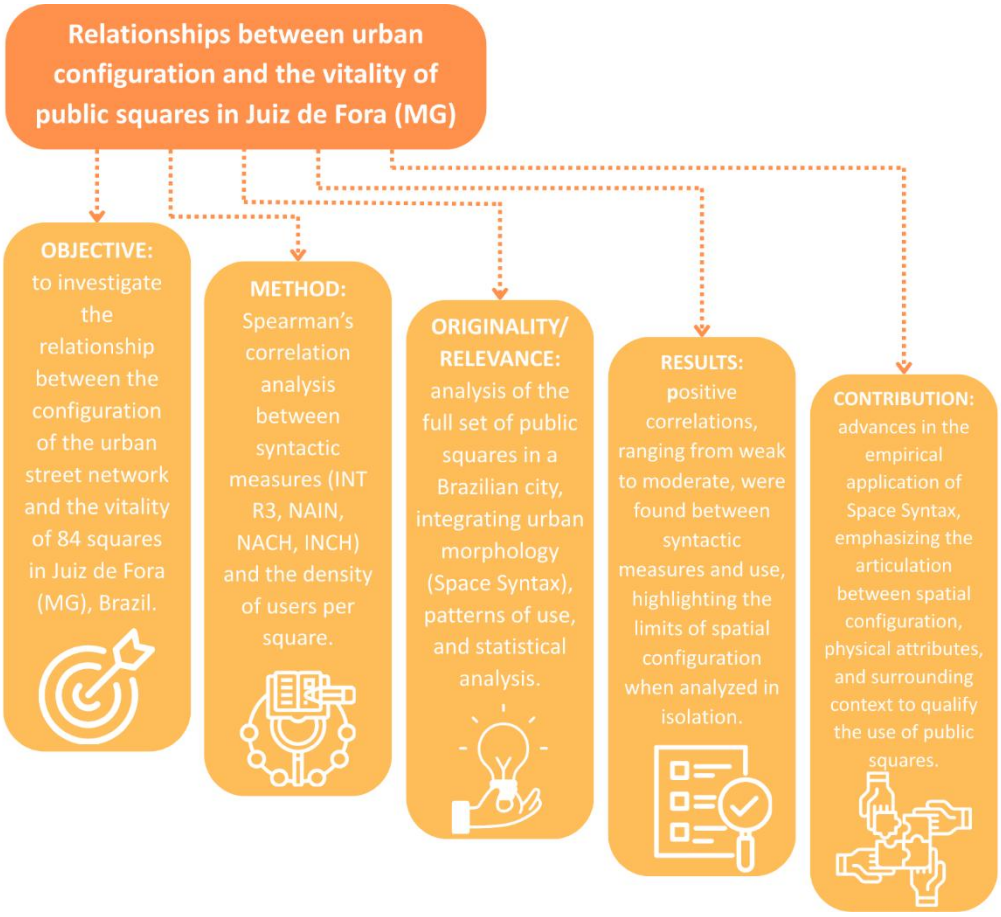
PALABRAS CLAVE: Espacios Libres Públicos. Teoría de la Sintaxis Espacial. Planificación Territorial.

GRAPHICAL ABSTRACT



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1 INTRODUCTION

Cities are the result of social organization and the forms and relations of production manifested in urban space; in other words, they are constructed through the relationship between space and the social agents who occupy it (Medeiros, 2006). In this process, the city structures places of sociability for the expression of a collective way of life inherent to human beings. Within this context, public open spaces stand out as essential components for fostering coexistence and sociability.

These spaces form [...] a network of open environments, free of buildings and accessible to users, which permeates the built area, assuming functions such as ensuring mobility and enabling encounters (Santana, 2015, p. 33). The combination of public open spaces and the "paths" that can be traversed within the urban fabric is fundamental to understanding movement and the presence of people throughout the urban network (Mahfoud; Bada; Cutini, 2022). Hillier and Hanson (1984) address the configurational dimension of the urban network through what they call "natural movement," emphasizing that spatial configuration directly influences movement patterns, revealing links between urban form and social patterns.

Space Syntax Theory (SS), founded by these authors, argues that human spatial organization establishes patterns composed essentially of barriers and permeabilities, which shape individual movement in space (Hillier; Hanson, 2005). Pereira et al. (2011, p. 7) reinforce this assertion by proposing [...] that urban configuration affects the spatial pattern of people's movements throughout the city, making it possible to predict which streets will be more or less busy based on their configurational characteristics.

Urban configuration, therefore, can be understood as systems of "boundaries and permeabilities," as described by the theory's authors. In simplified terms, the city can be reduced to two main elements: solids, composed of built objects inserted within their macro- and micro-plots, and voids, constituted by open spaces (Torres; Medeiros, 2019). These systems refer to the obstacles present in the urban environment that restrict individual movement and to the open spaces where circulation is possible, forming a network of interconnected spaces that consolidate the urban fabric.

These circulation possibilities contribute to urban dynamics and can also support investigations into the effects of urban form and its impact on the vitality of public spaces. In this sense, this study aims to investigate the relationship between the configuration of the urban grid and the vitality of 84 public squares in the municipality of Juiz de Fora, Brazil. Additionally, the study identifies the physical characteristics of these squares that may contribute to or hinder their vitality.

1.1 Theoretical Framework

Recent studies have used SS as one of the investigative methods to understand the relationships between the configurational aspects of the urban grid and the vitality of public spaces. These studies seek to assess how the morphological properties of the urban fabric influence social behavior and pedestrian flows in public spaces, demonstrating the potential of SS as a method for interpreting spatial use through configurational metrics.

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Gümüs and Yilmaz (2022), for example, analyzed a square in Turkey by applying the following syntactic measures: connectivity, global integration, local integration (R3), and visibility, in addition to behavioral mapping that recorded users' locations and activities. The authors observed that more visible areas, such as stairs and fountains, showed a higher concentration of people, indicating a positive correlation between visibility and use. Although they did not identify direct relationships for all attributes, they acknowledged that urban form significantly influences user presence.

Similarly, Askarizad and Safari (2020), in a square in Iran, employed measures of connectivity, global and local integration (R3), intelligibility, synergy, choice, and mean depth. They concluded that the most integrated areas of the square had a greater presence of people, further identifying that social interactions and behavioral patterns are directly related to the configurational quality of the environment.

Three other studies (Safari; Moridani, 2017; Fernandes; Boubezari, 2022; Messa et al., 2022) also examined specific squares, using metrics such as global and local integration (R3), connectivity, intelligibility, synergy, and visibility graph analysis. They indicated that social, symbolic, affective, and geometric factors, combined with spatial configuration, influence the presence and use of squares, highlighting the role of connectivity and integration measures as determinants of vitality.

This relationship is confirmed in comparative studies conducted in different countries—Tedjari and Abbaoui (2023) in Algeria; Mahfoud, Bada, and Cutini (2022) in Italy; Gümüs and Erdönmez (2021) in Turkey; and Choi and Kim (2022) in South Korea and the United Kingdom. Using measures of global and local integration (R3), choice, connectivity, intelligibility, synergy, visibility, normalized angular integration (NAIN), normalized angular choice (NACH), and the correlation between them (INCH), these studies found that pedestrian flow follows levels of integration and that squares located along main axes and with greater visual permeability tend to be more intensively used. However, they emphasize that other elements—such as vegetation, street furniture, geometry, and activity areas—must also be considered, as Space Syntax theory itself suggests that vitality elements act as multipliers of the effects naturally produced by spatial configuration (Hillier; Hanson, 2005).

Some studies have expanded the scale of analysis by examining multiple squares simultaneously. Johnsson and Camporeale (2022), analyzing seven squares in Sweden through visibility graph analysis, found greater presence of people in more integrated areas, demonstrating that Space Syntax can explain micromobility in relatively small public spaces such as squares. Sun, Pont, and Legeby (2017), also in Sweden, studied 12 squares and identified a strong correlation between integration and the number of people at radii R4, R6, and R10, as well as between choice and the number of visitors within 1 km and 2 km radii. Vitality was also associated with built and population density and proximity to services, while square size and shape showed no significant correlation.

In Brazil, Torres and Medeiros (2019) analyzed 29 squares in Goiânia, relating area, furniture and amenities, access points, land use, visual permeability, public transport stops, pedestrian and vehicle counts, and metrics of connectivity, global and local integration (R3), NAIN, and NACH. They found that larger squares exhibited more intense flows; the quality and diversity of furniture had limited influence on vitality; access points, land use, and permeability

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correlated with vitality, whereas public transport stops did not. Global and local integration measures, however, showed significant correlation with the presence and movement of people, demonstrating "a real correlation between the potential indicated by Space Syntax and urban vitality" (Torres; Medeiros, p. 13, 2019).

Yonder et al. (2023), in a study of 32 squares in Turkey, combined spatial variables (area, landscape, semi-open spaces, monuments, landmarks, transport, and aesthetic quality) and configurational variables (integration, connectivity, and visibility), proposing a computational model to indicate relationships between spatial and configurational characteristics. They concluded that urban networks make it possible to predict the spatial properties of squares, corroborating Space Syntax theory, albeit with some limitations.

Finally, Cavalcante, Medeiros, and Ribeiro (2024) examined all open spaces in Aracaju, Brazil, relating them to spatial accessibility. They confirmed the effectiveness of Space Syntax in identifying the distribution and location of open spaces and their respective accessibility characteristics, highlighting what the authors describe as a "coherent perspective of collaboration" between urban morphology and planning.

In light of the studies presented, the potential of Space Syntax to explain morphological relationships between urban surroundings and public space vitality becomes evident. However, most research has been concentrated in Asia and Europe, with only two studies conducted in Brazil. Moreover, the majority of studies analyze small samples, and only one explored the entire set of public open spaces in a city. Lastly, few studies have employed statistical instruments to complement the evaluation of these relationships.

In this context, the present study gains relevance by addressing the national geographic context and employing statistical tools to deepen the analysis of the relationships among the investigated variables. Unlike sample-based studies, this research encompasses all squares in a single city, enabling an integrated assessment of the relationship between urban vitality and spatial configuration, both at the level of the urban network and in the local specificities that compose it.

2 METHOD

With the aim of achieving the proposed objective, three methodological procedures were defined:

2.1 Organization of the municipal configurational system information

For the modeling of the urban grid, the open-source software QGIS was used to develop the axial map of the city of Juiz de Fora, following the Space Syntax (SS) methodology, for the subsequent evaluation of the syntactic measures of local integration (R3), NAIN, NACH, and INCH. In this study, the value of each syntactic measure was determined based on the segment surrounding the square that presented the highest value.

The integration measure, whether at a global or local scale, expresses the degree of accessibility of each line in the system relative to the others, indicating its structural importance and the likelihood of individuals being present in that space. In this study, local analysis was

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chosen, considering that the squares are distributed throughout the urban grid and that the relevance of their surrounding areas better reflects actual usage. For this purpose, a radius of three topological steps was adopted, defined by Zechin (2014) as the most appropriate for representing the distribution of movement flows and widely used in Space Syntax studies.

Normalized measures of integration (NAIN) and choice (NACH) were also evaluated, as they serve as indicators of centrality. While NAIN expresses the accessibility of a street relative to others in the urban system ("to-movement"), NACH indicates the likelihood of a segment being used based on its selection as a preferred route between all possible pairs of spaces ("through-movement"). These metrics thus allow for understanding both the potential for access and the probability of route selection within the street network (Yamu; Van Nes; Garau, 2021).

Additionally, the combined measure of Integration and Choice (INCH – INtegration + CHoice) was considered, as it assesses the combined potential of a segment to be simultaneously chosen as a destination and as a route (Hillier, 2007). In other words, this measure quantifies the extent to which the most accessible spaces are also the most frequently used as pathways between other points, making it a measure capable of explaining natural movement.

2.2 Vitality analysis

This analysis relates to information on the presence of people in the squares. This stage was carried out using an adaptation of the SOPARC protocol (McKenzie et al., 2006). User density was measured by counting the number of people on-site and dividing it by the area of the square. The number of people was determined based on the highest observed presence during a typical weekday and on a weekend day without rain (Beraldo et al., 2019). The area of each square was obtained from the floor plans provided by the municipal government or, when unavailable, measured directly on-site.

2.3 Statistical data analysis

Initially, the distribution and characterization of the sample squares were described, followed by an analysis of the correlation between the evaluated attributes (syntactic measures and vitality). Considering the complexity and heterogeneity of the variables - which in urban studies often do not follow a normal distribution or exhibit a linear relationship - the Spearman correlation was chosen. This is a non-parametric measure that assesses the strength and direction of the association between two ordinal variables (Sousa, 2019). The coefficient is calculated based on the ranks of the observations and ranges from -1 to 1. For interpretation, Cohen's scale was adopted (1988; 1992): $r = |0.00–0.099|$ corresponds to no correlation; $r = |0.10–0.299|$, weak correlation; $r = |0.30–0.499|$, moderate correlation; and $r = |\geq 0.50|$, strong correlation.

3 RESULTS

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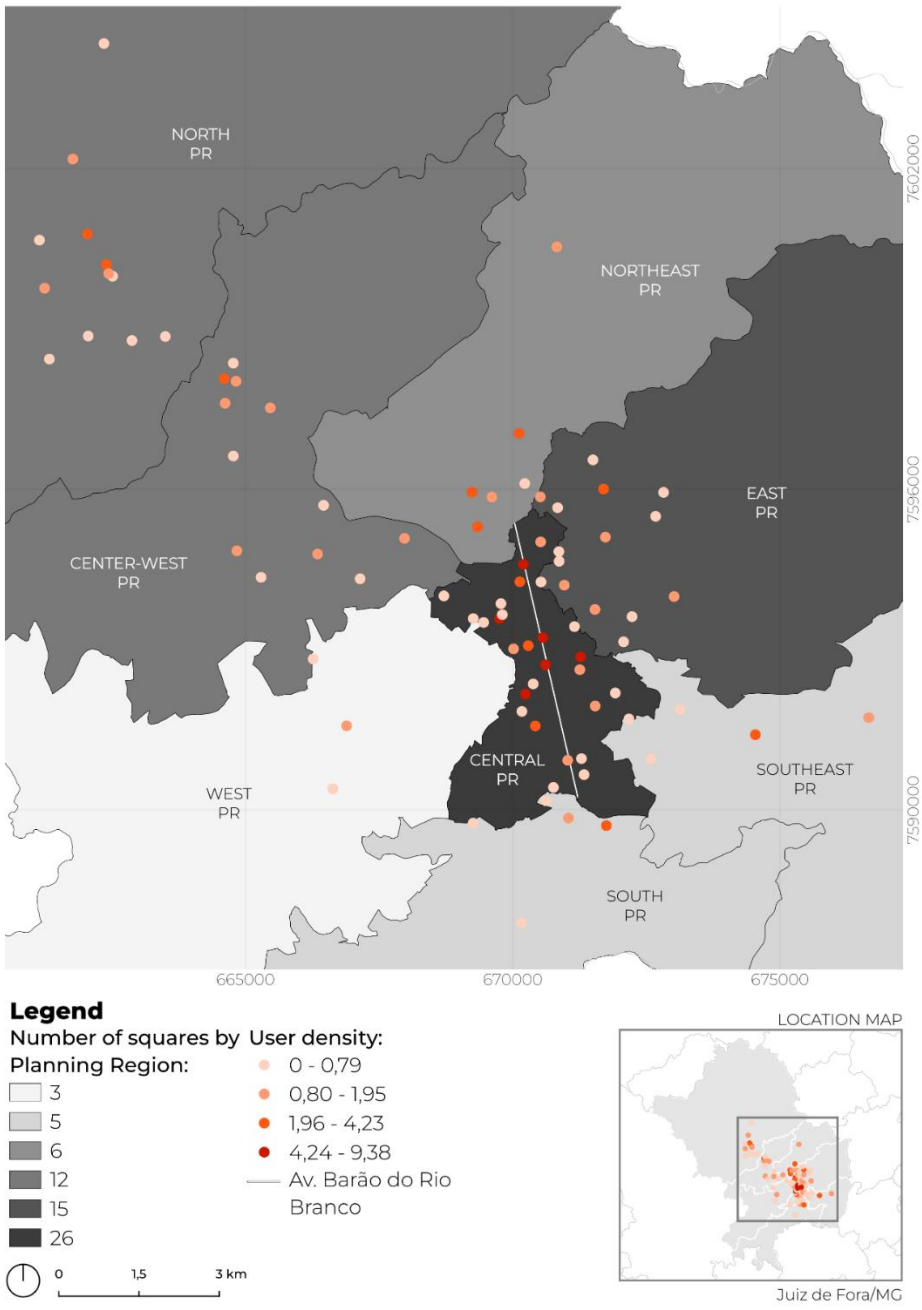
3.1 Distribution and characterization of the squares

Figure 1 shows the distribution of the squares in Juiz de Fora by Planning Region (RP) and their representative vitality values, highlighting substantial differences between areas of the city. The representation was based on the areas where the squares are located, in order to facilitate visualization. However, it is important to refer to the general map of the municipality to understand the full extent of areas that exceed the defined boundaries - particularly in the North RP - and thereby gain a better understanding of the overall distribution of squares across the city.

Figure 1 – Squares by Planning Region (RP)



Source: prepared by the authors (2025).

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Substantial differences between areas of the city are evident. It can be observed that the Central RP (RP Centro) concentrates the largest number of squares (26), followed by the East RP (RP Leste) with 15, and the Central-West (Centroeste) and North (Norte) RPs, each with 12 squares. In contrast, the Northeast RP (RP Nordeste) has 6 squares, while the South (Sul) and Southeast (Sudeste) RPs each have 5, indicating a lower provision of these spaces. Finally, the West RP (RP Oeste) is the region with the fewest squares among all RPs.

The analysis shows that central areas concentrate a greater number of recreational facilities, while peripheral regions have a reduced supply, reflecting different patterns of urban occupation. The predominance of squares in the city center can be explained by the historical formation of the urban fabric, where public open spaces were implemented in structuring areas, as occurs in RP Centro in Juiz de Fora. In central areas, higher building density and diversity of land uses favour the implementation of squares as points of gathering and sociability.

In contrast, peripheral areas, characterized by lower density, have a limited presence of squares, highlighting inequalities in access to public recreational and social spaces. This disparity in square distribution can directly affect residents' access to public open spaces and, consequently, influence patterns of urban vitality.

Cavalcante, Medeiros, and Ribeiro (2024), in their study of Aracaju/SE, observed that squares are distributed throughout the urban fabric, mostly within residential subdivisions and housing complexes. Although the study considered the entire system of public open spaces in the city (parks, institutional spaces, waterfronts, squares, medians, transmission lines, drainage canals, mangroves, and railways) in central areas, squares stand out as the most prominent element. The authors also identified a clear disparity in square quality, with better-quality squares located in more affluent areas and lower-quality ones in underprivileged areas.

It is further observed that the highest concentration of squares with elevated user density is located in the Central RP and adjacent areas, coinciding with the historically consolidated city center. This area features higher residential density, a greater presence of diverse land uses (health, commerce, education, among others), and higher connectivity of the street network, including the city's longest avenue (Avenida Barão do Rio Branco), which runs throughout the Central RP.

Similar results can be identified in the study by Cavalcante, Medeiros, and Ribeiro (2024). The most central areas, where squares predominate, are consolidated, exhibit higher global integration, and are generally well-served in terms of surrounding commerce and services. These areas experience high pedestrian flows during the day and lower activity at night. These central areas are mostly defined by squares originating from the oldest urban subdivisions of the municipality.

3.2 Analysis of the correlations between vitality and space syntax metrics

However, it is also noticeable that there are squares with high vitality in peripheral areas and squares with low vitality in the central area. In this context, configurational analysis through Space Syntax offers a valuable investigative approach, as it allows for the assessment of the extent to which the urban grid facilitates or restricts access to squares, regardless of other

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factors considered relevant in the literature, such as surrounding land-use diversity, residential density, presence of furniture and vegetation, or the quality of physical and architectural attributes.

Table 1 presents the vitality data alongside the values of the syntactic integration measures evaluated in this study. The data shown in the table allow for visualizing the correspondence between the vitality of the squares and their syntactic measures.

Table 1 – Sample data

Square	Vitality	INT. R3	NAIN	NACH	INCH
Praça de Esportes Planalto	0,56	0,704	0,429	0,819	4297,66
Praça José Petrato	1,20	0,873	0,419	0,900	4304,59
Praça Jornalista Décio Lopes	0,59	1,119	0,225	0,779	2258,19
Praça Dorvina Maria Barbosa	1,61	1,177	0,413	0,000	281,77
Praça de Desportos Izolino Gonçalves Coelho	2,74	1,206	0,457	1,254	6970,62
Praça Romeu Bellini	0,65	1,299	0,425	0,957	4858,32
Praça Vila Sr. Neném	1,95	1,299	0,379	0,832	3894,46
Praça dos Trovadores	0,40	1,375	0,525	0,806	4971,66
Praça Tenente Aviador Mauro Miranda	0,00	1,385	0,488	0,904	5338,7
Praça Terezinha de Jesus Oliveira	1,39	1,387	0,402	0,726	3476
Praça Vale do Ipê	0,00	1,426	0,502	0,943	5717,63
Praça Santa Paula	0,10	1,467	0,441	1,010	5431,15
Praça Gruta Nossa Senhora Aparecida	0,76	1,471	0,427	0,963	5031,77
Praça Judith Tedesco Bellini	0,20	1,515	0,415	0,925	4702,24
Praça Boa Vista e Cidade Jardim	0,07	1,536	0,527	0,618	3915,64
Praça Terezinha Fleury Cruz	1,60	1,569	0,337	1,079	4506,65
Praça Francisco Fortes Bustamante	0,28	1,601	0,528	0,935	5936,56
Praça João Raphael Zacharias	0,37	1,604	0,499	1,026	6186,5
Praça Olegário Filgueiras Filho	0,00	1,667	0,362	0,738	3310,3
Praça Doutor Pedro Batista Martins	1,28	1,722	0,477	0,888	5129,33
Praça João Álvares de Assis	0,86	1,731	0,239	0,920	2803,95
Praça Sylvia Faria de Barros	1,86	1,750	0,447	1,100	5543,09
Praça Ana Esméria	0,60	1,785	0,342	0,973	4138,99
Praça de Esportes Dejair Dias Ferreira	0,09	1,796	0,387	0,923	4404,61
Praça Alcides Antônio de Almeida	2,13	1,814	0,474	1,213	6980,15
Praça Vovó Elvira Gabriela do Carmo	0,50	1,835	0,404	1,322	6.670,07
Praça Armando Toschi	**9,38**	**1,837**	0,554	1,142	7554,42
Praça Sebastião Perfeito Filho	1,13	1,837	0,466	1,042	5904,95
Praça Francisco de Assis Lopes	0,37	1,839	0,422	0,938	4842,16
Praça Cardoso Sobrinho	0,32	1,886	0,503	0,884	5365,83
Praça José Alves Carvalho	0,00	1,891	0,515	0,947	5883,95
Praça Adalberto Landau	0,25	1,896	0,520	0,920	5761,02
Praça América Campos Machado	0,95	1,898	0,398	0,986	4833,5
Praça Maria Euzébia Delfino	0,38	1,898	0,382	0,884	4166,71
Praça Áureo Gomes Carneiro	1,32	1,942	0,277	1,117	3920,53
Praça Rômulo Quinhões	2,54	2,027	0,406	1,046	5156,92
Praça Carlos Rutier	0,83	2,033	0,538	1,000	6184,93
Praça Antonio Loures Campos	4,23	2,048	0,482	1,136	5911,14
Praça Padre Geraldo Pelzers	1,56	2,060	0,594	1,223	8650,3
Praça Vila Esperança I	0,71	2,102	0,451	1,112	5345,77
Praça Theotonio Petronilho Amorim	0,79	2,104	0,572	1,242	8487,15
Praça Pantaleone Arcuri	0,09	2,119	0,588	1,182	8300,01
Praça São Judas Tadeu	0,30	2,125	0,399	0,957	4700,54
Praça de Esporte e Lazer Arnaldo Roldão	1,70	2,140	0,500	0,877	5297,54
Praça Francisco Bellei	0,37	2,140	0,489	1,112	6574,01
Praça Presidente Kennedy	0,69	2,250	0,602	0,978	7207,91

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Praça Ideor Nunes de Souza	1,06	2,253	0,407	0,996	4842,21
Praça Miguel Gustavo	0,00	2,255	0,582	1,102	7653,56
Praça Nilo Sotto Maior	2,90	2,259	0,401	1,145	5388,15
Praça Paulo de Souza Lamarca	1,28	2,266	0,425	1,103	5541,69
Praça Déa Caputo Monachesi	0,58	2,295	0,288	0,907	2906,84
Praça Manoel Nunes	0,32	2,313	0,423	1,042	5397,6
Praça Major Esteves	3,77	2,333	0,497	0,929	5575,97
Praça Maria Luzia Gasparette	0,46	2,333	0,580	1,286	8494,02
Praça do Cruzeiro	0,32	2,382	0,584	0,860	5778,97
Praça Arthur Bernardes	2,50	2,387	0,588	1,100	7710,35
Praça Prefeito Olavo Costa	1,17	2,397	0,576	1,084	7462,98
Praça Doutor Dirceu de Andrade	0,00	2,431	0,527	1,135	6952,64
Praça José de Castro Barbosa e Canteiros	0,55	2,523	0,487	1,260	7222,71
Praça de Esporte e Lazer Carmen Villar	1,38	2,581	0,584	1,276	8892,66
Praça Maria Illydia Rezende de Andrade	1,09	2,640	0,483	1,139	6667,21
Praça João Bernardino Pires	0,27	2,697	0,465	1,075	5362,35
Praça Gabriel Visoná Marques	1,66	2,739	0,423	1,093	5575,53
Praça Guimarães Rosa	0,46	2,749	0,594	0,993	6719,9
Praça Almirante Tamandaré	0,88	2,753	0,518	1,377	8590,19
Praça Duque de Caxias	0,39	2,753	0,518	1,381	8615,33
Praça Herval da Cruz Braz	0,77	2,803	0,388	1,065	5091,75
Praça Rafael da Silva Cruz	0,65	2,914	0,485	0,973	5711,36
Praça Doutor João Felício	0,41	2,927	0,632	1,244	9037,61
Praça Coronel Jeremias Garcia	2,68	2,966	0,505	1,366	8329,25
Praça Santa Terezinha	2,86	3,128	0,626	1,212	8468,94
Praça Maria Lage	2,86	3,178	0,628	0,942	7014,71
Praça Poeta Daltemar Lima	0,23	3,257	0,638	1,249	9430,2
Praça Menelick de Carvalho	3,04	3,318	0,636	0,949	7148,77
Praça Dep. Jarbas de Lery Santos	2,43	3,331	0,635	1,109	8211,9
Praça Coronel Aprígio Ribeiro	5,96	3,409	0,624	1,301	9669,82
Praça Presidente Antônio Carlos	1,58	3,574	0,654	1,229	9140,11
Praça Pedro Marques	0,87	3,715	0,657	1,280	9404,85
Praça Doutor João Penido	7,76	3,875	0,657	1,374	10627,73
Parque Halfeld	7,20	4,544	0,694	1,495	12198,19
Praça Alfredo Lage	6,23	4,544	0,678	1,445	11542,65
Praça do Riachuelo	6,22	4,544	0,695	1,491	12174,06
Praça Mozart Geraldo Teixeira	0,86	4,544	0,694	1,467	11971,71
Praça Mundo Novo	**0,00**	**4,544**	0,558	1,073	7171

Source: Prepared by the authors (2025).

To evaluate these data, a statistical correlation analysis was conducted between the vitality of the squares—measured by user density (number of people per area)—and the configurational variables derived from Space Syntax—local integration (R3), NAIN, NACH, and INCH—as presented in Table 2.

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Table 2 - Spearman Correlation

Variable		Vitality	INT.R3	NAIN	NACH	INCH
Vitality	Spearman's rho	-				
	p-value					
INT.R3	Spearman's rho	0.273*	-			
	p-value	.012				
NAIN	Spearman's rho	0.159	0.635***	-		
	p-value	.148	<.001			
NACH	Spearman's rho	0.352**	0.638***	0.493***	-	
	p-value	.001	<.001	<.001		
INCH	Spearman's rho	0.261*	0.721***	0.873***	0.816***	-
	p-value	.016	<.001	<.001	<.001	

* p < .05, ** p < .01, *** p < .001
Source: Prepared by the authors (2025).

It is observed that vitality shows positive and statistically significant correlations with three of the four measures considered: INT.R3 (r = 0.273; p = 0.012), NACH (r = 0.352; p = 0.001), and INCH (r = 0.261; p = 0.016). The normalized integration measure (NAIN), however, showed a positive but not significant correlation (r = 0.159; p = 0.148).

The positive, significant, and high-magnitude correlations among the syntactic measures (INT.R3, NACH, NAIN, INCH) are expected, as all derive from the same urban system and share a common source: the configuration of the grid through the same axial system. Being intrinsically related, these measures naturally exhibit associations among themselves and, according to Space Syntax theory, reflect similar structural properties of the urban network that manifest in different aspects of connectivity and accessibility.

These results indicate that squares located in areas with higher local integration tend to attract greater user flow and longer stays, in line with Space Syntax theory, which asserts that urban network accessibility and connectivity play a key role in the appropriation of spaces. The strongest association was observed with the NACH syntactic measure, suggesting that the potential for through-movement (circulation potential) of a given segment is a relevant factor for the vitality of squares connected to that high-potential segment. The correlation with the INCH measure, although of lower magnitude, reinforces the idea that the combination of integration and choice also contributes to explaining usage dynamics in these spaces.

However, despite the significant correlations, it is important to note that their magnitudes are often weak to moderate. This is expected in urban studies, as urban phenomena are influenced by multiple interdependent factors, which limits the strength of observed statistical associations. Recent studies support this notion, indicating that the complexity and diversity of urban determinants result in correlations of low to moderate magnitude (Schuster-Olbrich et al., 2024; Jiang et al., 2024).

In this study, which addresses vitality, factors such as the quality of the physical space, availability of furniture and infrastructure, presence of vegetation, diversity of surrounding land uses, among other elements highlighted in the theoretical framework, also interact with the configurational structure, creating a heterogeneous dynamic in explaining public space appropriation.

Thus, the statistical analysis confirms the relevance of using Space Syntax as a tool to understand urban vitality, demonstrating that the distribution of squares within the street

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network influences how they are appropriated. At the same time, the results underscore the need to consider complementary variables to enable a more comprehensive and realistic analysis of the factors that determine vitality in public open spaces.

3.3 Integration and Vitality in Opposite Trends: A Comparison Between Two Squares

Thus, it is worth descriptively investigating cases where Space Syntax Theory yielded results contrary to expectations. For this purpose, two extreme cases were examined: Armando Toschi square (Figure 2), which exhibits high vitality despite being located in a low-integration area, and Mundo Novo square (Figure 3), which, conversely, shows low vitality even though it is situated in a high-integration area. Understanding such cases is relevant because they may indicate that, in addition to configurational variables, other factors can play a decisive role in the appropriation of public spaces.

Figure 2 –Armando Toschi square

Source: A) Google Street View; B) Alberto et al. (2020).

For example, Armando Toschi square presents several elements that may contribute to its high vitality, even though its configurational context is not particularly favourable. The first factor is the square's significant symbolic and cultural role, not only for the neighbourhood where it is located (Jardim Glória) but for the entire city of Juiz de Fora.

The square hosts cultural events, especially related to samba, due to the legacy of "Ministrinho," a prominent local samba musician (G1, 2014). This symbolic value gives the space a distinct identity and transforms it into a destination chosen not only as a passage point but also for longer stays. Furthermore, cultural activities like these generally attract diverse

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audiences, who may travel longer distances to attend specific events, fostering an emotional connection with the environment.

Another aspect that enhances the vitality of Armando Toschi square is the well-established nightlife in its surroundings. Bars around the square extend their activities beyond the premises and into the square itself. Tables occupy part of the public space, creating an environment conducive to social gatherings and group interactions. This appropriation encourages the use of the square at different times of day, increasing its vitality and visibility, particularly from late afternoon to night.

The diversity of surrounding land uses, including residential, commercial, and service lots, also encourages daily use of the square. In addition, the square's own features influence its appropriation: green areas, shading, benches, amenities (such as Wi-Fi), spaces for religious activities, and a dog park ("parcão"). All these elements are important not only for attracting visitors but also for extending their duration of stay.

It is also important to note that the square is well-rated in terms of passive surveillance (presence of permeable facades, active frontages, and visibility of the surroundings from the square's canter) and external accessibility (assessed across eleven criteria: surrounding sidewalk width [free zone >1.20 m; service zone >0.70 m]; minimum head clearance of 2.10 m; pedestrian crossings with tactile flooring and curb ramps [NBR9050]; absence of obstacles; maximum transverse slope of 3%; longitudinal slope following adjacent streets; tactile signage per NBR9050; even, firm, stable, non-vibrating, and slip-resistant flooring [NBR9050]; parking for persons with disabilities and for elderly users) (Alberto et al., 2020).

Lastly, the square has undergone relatively recent interventions, such as the installation of the dog park in 2022, improvements in paving, and maintenance of interlocking tiles (Prefeitura de Juiz de Fora, 2025). These upgrades reinforce the importance of urban environment quality in increasing user comfort and offering opportunities for diverse uses by different user profiles.

In this way, the square demonstrates that factors related to cultural identity, infrastructure, and space maintenance can compensate for configurational limitations, resulting in a level of vitality higher than what the syntactic analysis alone would predict.

In contrast, the Mundo Novo square (Figure 3) shows low vitality despite being in an area of high local integration (R3). Among the explanatory hypotheses for this phenomenon is the scarcity of other elements that might encourage the appropriation and active use of the space.

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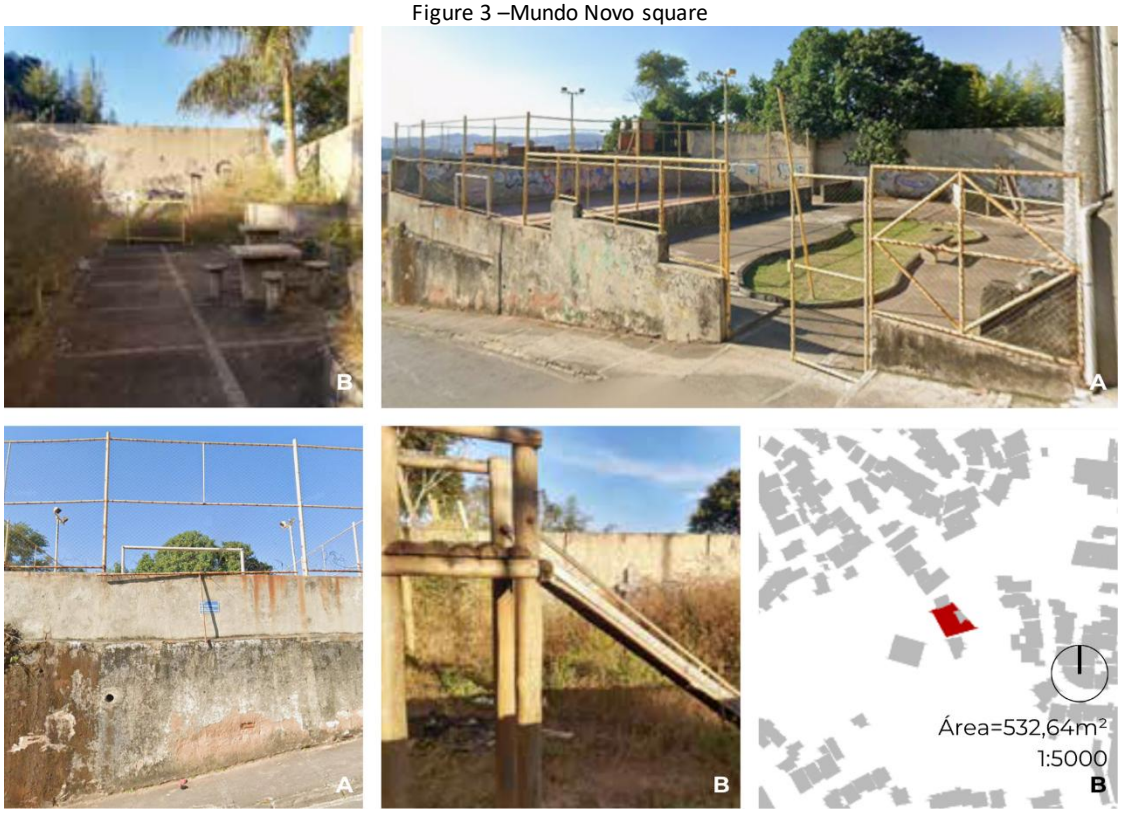
Figure 3 –Mundo Novo square



Source: A) Google Street View; B) Alberto et al. (2020).

The first element to highlight concerns the absence of a surrounding area with significant complementary uses, such as shops, services, or other institutional facilities, which could transform mere passing traffic into longer stays. In fact, the immediate surroundings of the square have few buildings, reducing opportunities for social interaction that normally arise from the relationship between public space and surrounding structures, and limiting the potential for natural surveillance (the “eyes on the street”).

It is important to emphasize that the square has a poor rating in terms of passive surveillance and external accessibility, especially when compared to Armando Toschi square, which has a high rating (Alberto et al., 2020). The perception of insecurity can reinforce a cycle of abandonment, meaning that the low presence of people discourages further presence. This occurs even in densely populated areas, such as the neighbourhood where the square is located, causing its vitality to remain low despite its high syntactic potential.

Additionally, factors related to the quality of the environment also influence how the square is used. Although there are some activity areas and furnishings (children’s playground, open sports court, game tables, and benches), the maintenance of these elements is insufficient, making them less inviting for use. Furthermore, the lack of vegetation and shading makes the environment less comfortable.

This situation suggests that, while spatial configuration is fundamental for accessibility potential, it is not sufficient on its own to ensure the appropriation of public space. In other words, even though the square is in an area with high potential flow due to the accessibility of the urban grid, this flow does not necessarily translate into longer stays, indicating that other

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factors play a decisive role in the use of recreational facilities. This finding aligns with the results of the studies presented in the theoretical framework and is further illustrated by the previous example of Armando Toschi square, where the quality of the space offered compensates for deficits in the accessibility of the urban grid.

4 CONCLUSION

This article aimed to understand the relationships between the vitality of 84 squares in Juiz de Fora—measured by user density—and the configuration of the city's urban grid, assessed through Space Syntax syntactic measures. It was observed that the squares in Juiz de Fora are not distributed homogeneously across the Planning Regions, and their vitality also exhibits different patterns of user density. Furthermore, most squares are concentrated in the Central RP, and those with the highest vitality are also predominantly located in the city center, reflecting different urban and social patterns in the availability and use of recreational facilities.

The statistical test applied to evaluate these two variables showed a positive and significant correlation with user density (INT.R3, NACH, and INCH), although the magnitude of the correlations was weak to moderate. These results indicate that urban configuration influences the vitality of squares, but it should not be understood as a sole determining factor. Other elements, such as the presence of diverse surrounding land uses, the density of buildings in the vicinity, and the physical condition of the space itself, also play important roles.

In this sense, the comparison between Armando Toschi square, which has high vitality, and Mundo Novo square, which exhibits lower vitality, reinforces the idea that the configurational design of the city must be integrated with other attributes of the space and its immediate surroundings to enhance its use.

Space Syntax, combined with empirical usage data and assessments of the physical condition of spaces, proves to be a valuable tool for revealing patterns of public space appropriation. It can also guide urban policies aimed at improving existing squares and creating new ones, promoting greater inclusion and access to these facilities. Future quantitative studies, incorporating statistical correlations and regressions across additional urban aspects that may influence square vitality, could further deepen the understanding of each factor's contribution.

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DECLARATIONS

AUTHOR CONTRIBUTIONS

- **Conception and Design**: Klaus, Lídia, and Sabrina
- **Data Curation**: Klaus and Lídia
- **Formal Analysis**: Klaus, Lídia, and Sabrina
- **Funding Acquisition**: Klaus
- **Investigation**: Klaus, Lídia, and Sabrina
- **Methodology**: Klaus, Lídia, and Sabrina
- **Writing – Original Draft**: Klaus, Lídia, and Sabrina
- **Writing – Review & Editing**: Klaus and Lídia
- **Final Review and Editing**: Klaus, Lídia, and Sabrina
- **Supervision**: Klaus

DECLARATION OF CONFLICT OF INTEREST

We, Klaus Chaves Alberto, Lídia Maia Moreira, and Sabrina Andrade Barbosa, declare that the manuscript entitled "**Relationships between urban configuration and the vitality of public squares in Juiz de Fora (MG)**":

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2. **Professional Relationships:** There are no professional relationships that could influence the analysis, interpretation, or presentation of the results.
3. **Personal Conflicts:** There are no personal conflicts of interest related to the content of the manuscript.