

PEDESTRIAN MOVEMENT IN ARCHITECTURE AND PLANNING: 1962–2025 BIBLIOMETRIC REVIEW

Mimarlık ve Planlamada Yaya Hareketi: 1962–2025 Bibliyometrik İnceleme

Aslıhan ÇETİN COŞKUN ¹ 

Önder COŞKUN ² 

¹ Department of Interior Architecture and Environmental Design, Faculty of Architecture, İstanbul Kültür University | İç Mimarlık ve Çevre Tasarımı Bölümü, Mimarlık Fakültesi, İstanbul Kültür Üniversitesi

² Department of Bioengineering, Institute of Science, Süleyman Demirel University | Biyomühendislik Anabilim Dalı, Fen Bilimleri Enstitüsü, Süleyman Demirel Üniversitesi

Abstract

The aim of this study is to examine the evolution of academic research on pedestrian movements over time and to This study aims to examine the historical evolution, current status, and emerging trends in academic research on pedestrian movements through a comprehensive bibliometric analysis. Pedestrian movements, as a fundamental component of urban dynamics, have become a central focus in sustainable urban planning, particularly in response to critiques of car-oriented city design since the 1960s. The research analyzes 829 academic publications from 1962 to 2025, retrieved from Web of Science and Scopus databases, including journal articles, proceedings, book chapters, and reviews that mention "pedestrian movement" in their titles, abstracts, or keywords. Using VOS Viewer software, the data were analyzed in terms of publication trends, influential authors, collaborative networks, key concepts, and citation performance. The findings reveal a significant increase in pedestrian movement studies over time, with growing interdisciplinarity across fields such as architecture, urban planning, public health, and informatics. Major research themes identified include walkability, accessibility, safety, urban morphology, environmental perception, and digital modeling. Furthermore, the study highlights the rising importance of data-driven methods and international academic collaborations. Despite existing reviews focusing on specific topics like pedestrian safety or evacuation, this research fills a critical gap by offering the large-scale bibliometric overview of the pedestrian movement field. It also proposes future research directions based on observed trends and gaps in the literature. Overall, this study provides a valuable reference for scholars, urban policymakers, and planners, aiming to foster a more human-centered approach to urban design and to guide future investigations on pedestrian movements.

Keywords: bibliometric analysis, scientific mapping, performance analysis, VOS Viewer, pedestrian movement

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Correspondence | İletişim:
mmr.aslihan.cetin@hotmail.com

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Özet

Bu çalışma, yaya hareketleri üzerine yapılan akademik araştırmalardaki tarihsel evrimi, mevcut durumu ve ortaya çıkan eğilimleri kapsamlı bir bibliyometrik analiz yoluyla incelemeyi amaçlamaktadır. Kentsel dinamiklerin temel bir bileşeni olan yaya hareketleri, özellikle 1960'lardan bu yana araç odaklı şehir tasarımına yönelik eleştirilere yanıt olarak, sürdürülebilir şehir planlamasının merkezi bir odak noktası haline gelmiştir. Araştırma, 1962'den 2025'e kadar Web of Science ve Scopus veri tabanlarından alınan 829 akademik yayını analiz etmektedir. Bu yayınlar arasında başlıklarında, özetlerinde veya anahtar kelimelerinde "yaya hareketi"nden bahseden dergi makaleleri, bildiriler, kitap bölümleri ve incelemeler yer almaktadır. Veriler, VOS Viewer yazılımı kullanılarak yayın eğilimleri, etkili yazarlar, iş birliği ağları, temel kavramlar ve atıf performansı açısından analiz edilmiştir. Bulgular, mimarlık, şehir planlama, halk sağlığı ve bilişim gibi alanlarda disiplinlerarasılığın artmasıyla birlikte yaya hareketi çalışmalarında zaman içinde önemli bir artış olduğunu ortaya koymaktadır. Belirlenen ana araştırma temaları arasında yürünebilirlik, erişilebilirlik, güvenlik, kentsel morfoloji, çevresel algı ve dijital modelleme yer almaktadır. Çalışma ayrıca, veri odaklı yöntemlerin ve uluslararası akademik iş birliklerinin artan önemini vurgulamaktadır. Yaya güvenliği veya tahliye gibi belirli konulara odaklanan mevcut incelemelere rağmen, bu araştırma yaya hareketi alanına geniş ölçekli bir bibliyometrik genel bakış sunarak kritik bir boşluğu doldurmaktadır. Ayrıca, literatürdeki gözlemlenen eğilimlere ve boşluklara dayanarak gelecekteki araştırma yönleri de önermektedir. Genel olarak bu çalışma, kentsel tasarıma daha insan merkezli bir yaklaşım geliştirmeyi ve yaya dinamikleri üzerine gelecekteki araştırmalara rehberlik etmeyi amaçlayan akademisyenler, kentsel politika yapımcılar ve planlamacılar için değerli bir referans sunmaktadır.

Anahtar Kelimeler: bibliyometrik analiz, bilimsel haritalama, performans analizi, VOS Viewer, yaya hareketi

1. INTRODUCTION

The movements of pedestrians in public spaces and social life are a fundamental element in understanding urban dynamics and analyzing interactions with man-made environments. The modernization process that began in the 1960s began to criticize vehicle-centered urban design, modernist planning approaches and monotonous urbanization. Instead, attention was drawn to the need to prioritize pedestrian needs in cities and the importance of pedestrian-centered urban space life (Calthorpe, 1990; Jacobs, 1961). In this regard, studies have been carried out to understand pedestrian behaviors related to the socio-spatial order in urban areas (Gehl, 2011; Jacobs, 1961; Whyte, 1980).

In the modernization process, pedestrian movements play a critical role in terms of sustainable transportation, accessibility and use of public space (Gehl, 2011). Pedestrian movement studies contribute to making urban spaces more functional and human-centered by bridging the disciplines of urban planning, informatics, sociology, public health, transportation engineering and architecture (Jacobs, 1961). These studies have created an important area of research to understand how urban design is shaped at the human scale (Hillier & Hanson, 1984).

To date, many studies have been conducted on pedestrian movements in different areas: Urban mobility (Kapoor et al., 2023; Talpur et al., 2024), built environment (Hillier et al., 1993; Humberto et al., 2019; Loukaitou-Sideris, 2012), walkability (Cerioli et al., 2025; Lo, 2009; Mehta, 2008; Sadeghi & Serugendo, 2024), perception (Andresen et al., 2016; Hillier et al., 1993; Park & Garcia, 2020), accessibility (Cui et al., 2012; Guida et al., 2022; Niger, 2023; Rossetti et al., 2020), space syntax (Çetin et al., 2020; Sharmin & Kamruzzaman, 2018; Wu & Guo, 2014) environmental cognition (Fan et al., 2022; Hollmann, 2015; Khan, 2021), culture (Chraibi et al., 2025; Ishrath & Rajendran, 2024; Kaminka & Fridman, 2018), gender differences (Castelli et al., 2008; Choi et al., 2006; Subaih et al., 2020), covid 19 (Alam et al., 2022; Angel et al., 2023; Paul et al., 2023), land use (Lee & Seo, 2020; Lopez Baeza et al., 2021), morphology (Bhowmick et al., 2020; Çetin et al., 2020; Elzeni et al., 2022), pedestrian safety (Ma et al., 2022; Stoker et al., 2015; Yu, 2015), crime (Chainey & Desyllas, 2010; Loukaitou-Sideris, 2012).

Additionally, Recent bibliometric studies on pedestrian movements and related topics provide important points of comparison for the present study. For instance, Kumari and Mohanty (2025) analyzed the interdependency between pedestrian activity and the built environment, highlighting spatial configuration and urban form as critical determinants of pedestrian behavior. Similarly, Das et al. (2023) focused on pedestrian safety research, emphasizing trends in crowd modeling, simulation methods, and urban risk assessment. Büyüктаş and Demirkol (2024) examined the concept of walkability, showing that research increasingly integrates urban design, accessibility, and health-related aspects. Fang et al. (2024) investigated links between built environment and walking patterns, underscoring the growing importance of environmental and policy factors in promoting pedestrian activity. Abd Aziz et al. (2022) provided a bibliometric review of road user behavior, illustrating methodological trends and highlighting the role of traffic management and behavioral modeling. Ince (2025) mapped global trends in sustainable urban mobility, emphasizing the rise of data-driven analyses and smart mobility solutions.

This bibliometric review was conducted to reveal the evolution of pedestrian movement studies as an independent conceptual framework in the literature. Bibliometric analysis is a technique that uses statistical, mathematical and different measurement methods to examine both the current status and development trends and to predict the future directions of a research field (Xu & Yu, 2019). The bibliometric analysis method is an important evaluation tool that reveals the scope, development and impact of studies in a particular academic field (Van Eck & Waltman, 2017). This study aims to examine the historical evolution, basic trends and scientific collaborations of research on pedestrian movements in the field of architecture and planning. This study is the first to conduct a comprehensive bibliometric analysis of academic research on pedestrian movement in architecture and planning between 1962 and 2025. While systematic reviews on pedestrian movement have been published in the literature, these studies have generally focused on narrow topics such as pedestrian safety, walkability, or evacuation dynamics. In particular, how concepts such as space and pedestrian movement are addressed in the literature will be analyzed (Penn, 2003).

Bibliometric analysis methods are widely used to identify trends in different academic disciplines (Cuccurullo et al., 2016). Currently, only a systematic literature review has been conducted on pedestrian movements

in terms of pedestrian safety, walkability and evacuation dynamics (Fang et al., 2024; Ishrath & Rajendran, 2024; Ma et al., 2022; Mirhashemi et al., 2022). However, to date, no bibliometric review has been conducted that covers pedestrian movement studies on a large scale. This study aims to address this research gap by conducting bibliometric analysis using leading citation databases, Web of Science (WoS) and Scopus.

Hypothesis of the study:

This study investigates various aspects of the pedestrian movement and suggests new areas for future research. Pedestrian movement research has evolved into a rapidly growing and globally disseminated interdisciplinary field, where leading countries, institutions, and scholars shape its trajectory, and where the main focus has shifted from physical and spatial aspects to broader themes such as walkability, accessibility, safety, and human-centered urban design.

Therefore, the main research question (RQ) of this paper is: How has the development of pedestrian movement studies been reflected in the academic literature over the last fifty years?

According to the main RQ, the sub-RQs are given below:

RQ-1: What is the publication status of academic studies on pedestrian movements?

RQ-2: What are the roles of different fields (countries, institutions, academic journals and researchers) in the global dissemination of the concept of pedestrian movement?

RQ-3: What aspects of the pedestrian movement field have current research addressed?

RQ-4: What are the main topics that are most focused on in recent pedestrian movement studies?

In addition, this study aims to raise awareness in the field of pedestrian movements by providing the following insights:

1. To provide information on the published scientific literature in the field.
2. To conduct a comprehensive review and analysis of the publication process from past to pre-sent, identifying influential countries, institutions, journals, researchers and key documents in terms of impact, leading contributions and ongoing activities.
3. To highlight dominant research themes and emerging trends of interest.
4. To identify research gaps and outline potential directions for future study in the field.

The rest of the paper is organized as follows: Section 2 discusses the research methodology, data sources, database construction, and analysis in detail. Section 3 presents a summary of the research findings and discussion. Additionally, limitations of the study and suggestions for future studies are given. Section 5 presents the research conclusions.

2. METHODOLOGY

At this stage of the study; the analysis method VOS viewer was discussed; the database was created and research procedures covering the analysis processes were included.

2.1. Bibliometrics in the Analysis of Scientific Publications

Studying research performance, trends, interactions, and impacts in scientific literature can be done using bibliometrics, a quantitative method. It identifies research trends and objectively and reliably reviews science as a productive network of knowledge. It reveals the subtleties of the development of a particular field, allowing us to guide new directions in this field (Aziminezhad & Taherkhani, 2023).

There are two basic bibliometric analysis methods (Donthu et al., 2021). Performance analysis in bibliometric studies is a method used to measure the impact and productivity of publications in a research field (Cobo et al., 2011). This analysis provides information about the development of a field by examining the number of articles published in a particular field of research, their citations, authors, journals, and countries. Performance analysis helps assess the quality and engagement of academic research, as well as understand the impact of these studies on scientific communities. Scientific mapping helps analyze the relationships between key concepts, research themes, authors, journals, and countries in a field by creating a visual representation of academic literature (Baker et al., 2021; Cobo et al., 2011). Scientific mapping allows researchers to understand complex and large data sets and visually see how a particular field is evolving. This process provides visual representations of scientific literature, often in the form of network graphs, heat maps, and word clouds (Chen, 2017). Bibliometric analysis is performed according to the information obtained from databases. This method minimizes the personal evaluations of the researcher. This ensures that the authors do not interfere with any stage of the analysis process. Therefore, if another study conducts similar research in any geography based on the same search terms and databases, time periods and types of articles examined and methods, it will definitely reach the same results and outputs (Han et al., 2020). Commonly used tools in bibliometric analysis (Bales et al., 2020): VOS viewer (Van Eck & Waltman, 2017), Cite Space (Chen, 2017), Bibliometric (RStudio) (Aria & Cuccurullo, 2017), Bib Excel (Persson et al., 2009), Gephi (Bastian et al., 2009). VOS viewer has also been considered a very common and reliable tool and has been confirmed by many similar studies (Arruda et al., 2022; Bukar et al., 2023; Wong, 2018). This software can be used by users without any programming knowledge. It can import files from different databases through a user-friendly graphical interface. Therefore, it is much simpler to use compared to other tools (Hosseini et al., 2018). In this method, article connections are visualized as a network, forming links and nodes. Nodes represent each element of the research, while links indicate the relationships between these elements. This visualization helps to analyze the main themes and relationships in the research areas. Therefore, VOS viewer was used in this study.

2.2. Research Procedure

2.2.1. Data Sources

The analysis of this research is based on two databases: Web of Science and Scopus. Web of Science (WoS) is a citation database and an important resource for indexing academic publications world-wide and tracking research and scientific literature. Web of Science was developed in the late 1960s by the Institute for Scientific Information (ISI), founded by Eugene Garfield. At first, this database started as a system that only included

scientific citations. In the 1990s, it became an international platform called Web of Science. Later, in 2018, it was taken over by Clarivate Analytics and took its current form (Kumar & Mohindra, 2015). Scopus is a citation database developed by Elsevier that provides academic research data worldwide. It indexes a variety of academic resources, including scientific articles, journals, conference proceedings, books, and patents. Scopus was launched in 2004. It aims to provide a multidisciplinary research platform beyond tools such as "ScienceDirect", Elsevier's previously developed database used to track scientific literature (Burnham, 2006).

These databases were chosen for reasons: (1) They are widely recognized in the academic world for storing high-quality, peer-reviewed research publications. (2) They provide comprehensive coverage of publications in architecture, urban studies, transportation, and related disciplines. (3) They offer standardized bibliographic information (titles, abstracts, keywords, citations), which ensures consistency in bibliometric analysis. (4) Software tools used for text mining and bibliometric mapping (e.g., VOSviewer, Bibliometrix) are only capable of processing the bibliographic data exported from these databases. (5) Both databases are frequently used and recommended in bibliometric studies, which ensures comparability with previous research and enhances the reliability of findings. In addition, duplicate records from both databases were carefully checked and removed to ensure data consistency.

2.2.2. Creating Database

First, the aim was to create a database containing studies on pedestrian movements. Therefore, an extensive literature search was conducted consisting of keywords related to pedestrian movements. The search terms were chosen based on the author's knowledge of architecture and planning as well as the analysis of existing review articles on the subject. The literature on pedestrian movement studies was compiled using the term "pedestrian movement" (Figure 1).

The search results were limited by "subject heading" (title, keywords, and abstracts) to identify primarily pedestrian-related publications. Although this search did not cover all relevant publications, it did identify publications based on the researcher(s)'s pedestrian movement studies. However, it did reveal some publications related to information systems such as robotics and computer science, health, business, and materials science, as the terminology used is common across these research fields. Therefore, irrelevant publications unrelated to pedestrian movement were filtered from the database. The search was conducted on February 10, 2025, based on titles, abstracts, and keywords of research articles indexed from 1962 onwards. The reason for choosing 1962 is that it is a clear starting point in the relevant literature and that consistent data is available in the databases from this year onwards. 829 articles were obtained from Web of Science (WoS) and Scopus databases: Science Citation Index Expanded (SCIE), Social Sciences Citation Index (SSCI), Arts and Humanities Citation Index (AHCI), Emerging Sources Citation Index (ESCI), Conference Proceedings Citation Index – Social Science & Humanities (CPCI-SSH), Conference Proceedings Citation Index – Science (CPCI-S), Book Citation Index – Social Sciences & Humanities (BKCI-SSH). Differences in WOS subindices have minimal impact on the analysis results. Therefore, the purpose of the detailing is only to transparently display the data source.

Additionally, the Web of Science (WoS) database and Scopus database contain different numbers of indexes. To ensure comparability, the impact of the different WoS indexes on the analysis was carefully examined.

Consequently, the inclusion of multiple WoS indexes did not introduce significant bias or alter the overall patterns observed in the bibliometric results. Therefore, despite the difference in the number of indexes between WoS and Scopus, the comparative analyses remain valid and reliable.

Only studies written in English were included in the review.

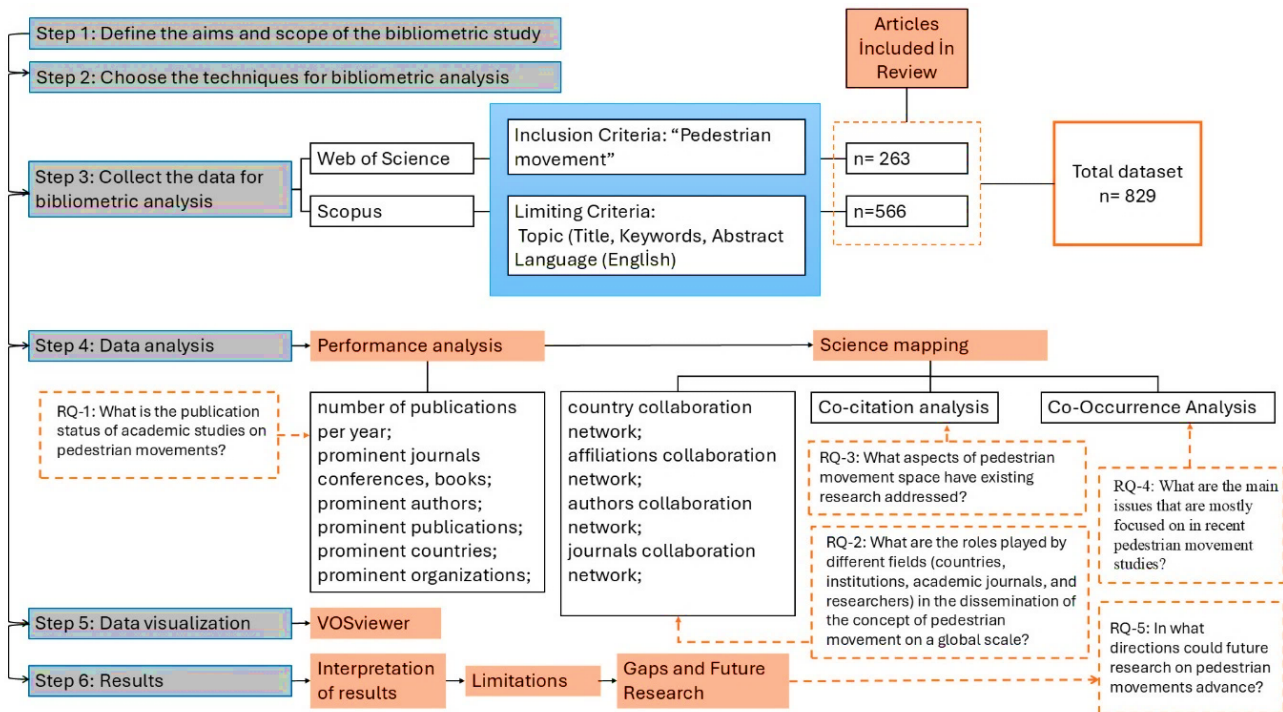


Figure 1. Workflow of bibliometric analysis of pedestrian movement studies (Source: Authors)

2.2.3. Analysis

In the study, co-occurrence analysis, bibliographic matching analysis of countries and organizations was conducted to identify the most prominent organizations and countries conducting re-search in this field. Co-citation analysis was also used to identify prominent journals and publications and to show the relationships between them. Each of these analyses emerges as a node and link diagram, with larger nodes and thicker links representing higher value of these elements. Node sizes reflect the frequency of the points to focus on, while the thickness of the links represents the strength of the relationship between the nodes.

3. FINDINGS AND DISCUSSION

This section provides an overview of the statistics of the dataset consisting of 829 documents from 1962 to 2025. It summarizes the 10 most important contributions to the field of pedestrian movement research, including elements such as authors, articles, sources, research institutions, and countries. Finally, it presents the bibliometric linkage and scientific map networks in pedestrian movement study, including components such as

word-based and citation networks. In order to see the database differences when presenting the analysis findings, WOS and Scopus results will be presented separately.

3.1. Summary Information About the Documents

Statistics on pedestrian movements from published documents are shown in Table 1. According to the findings, 829 journal articles, including books, proceedings, reviews, and journals, were published on the subject of pedestrian movement between 1962 and 2025. The total number of documents is 829, and the number of authors is 2268. The number of authors with only one document in the database is 2071, and those with two or more documents are 197. According to the type of documents, 557 articles, 7 early access articles, 227 conference papers, 32 books/book chapters, and 6 reviews were recorded.

Table 1. Data summary of publications on pedestrian movement between 1962 and 2025 (Source: Authors)

Details on the data	
Time range	1962-2025
Documents (articles, conf. proceedings, etc.)	829
Web of Science	263
Scopus	566
Authors	2268
Authors with one document	2071
Those with two or more documents	197
Article	557
Article; early access article	7
Proceedings paper	227
Book chapter	32
Review	6

Figure 2 shows the distribution of the number of scientific studies by year. The blue line shows the number of scientific articles published annually on the Web of Science; the orange line shows the number of scientific articles published annually in Scopus. Although pedestrian movement studies emerged between 1960 and 1970, they were studied in a very limited number. They received little attention between 1980 and 1990 but gained momentum after 2000. They made a big leap after 2010, with the most studies recorded during this period.

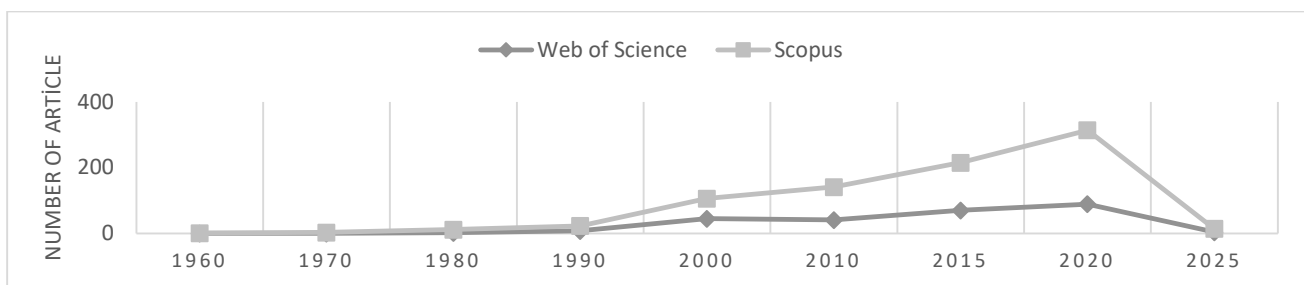


Figure 2. Distribution of publications on pedestrian movement in Web of Science and Scopus by year between 1962 and 2025 (Source: Authors)

Figure 3 shows the number of document types according to Web of Science and Scopus data-bases. This shows the diversity in publication types in the subject area.

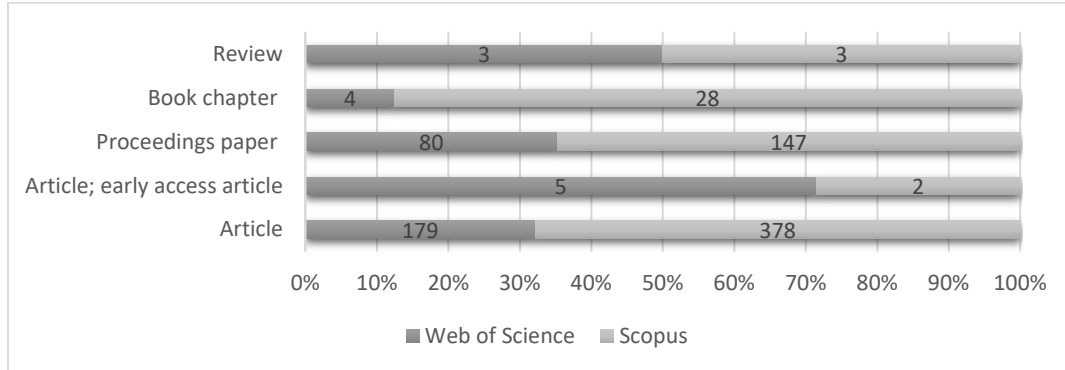


Figure 3. Distribution by Publication Types in Web of Science and Scopus Between 1962 and 2025 (Source: Authors)

3.2. Term Co-Occurrence Analysis

Term co-occurrence analyses were performed to determine the connections, nodes and thematic groups of the pedestrian movement topic (Burton et al., 2020; Donthu et al., 2021). The frequency of common use of terms determines the formation of clusters. This requires prior knowledge of the field, an understanding of changes in navigation processes over time, and the application of advanced technological methods. Common term analysis also assumes that terms that appear together frequently have a thematic relationship with each other.

The output of the VOS viewer Co-occurrence analysis is given in Figure 4. Node sizes are directly proportional to the number of terms. The co-occurrence frequency of the first 20 most repeated terms is shown in Table 2.

The most frequently used research terms in both databases between 1962-2025 were “pedestrian movement” (n=94), “space syntax” (n=75), “pedestrian” (n=52), “walkability” (n=45) (Table 2). These terms also have the highest values of total link strength. This finding indicates that authors give more importance to these key terms.

Table 2. Frequency and link strength of keywords related to pedestrian movement in Web of Science and Scopus databases (1962-2025) (top 10 most frequently occurring terms)

Web of Science			Scopus		
Keyword	Formation	Total connection strength	Keyword	Formation	Total connection strength
Pedestrian movement	37	146	Pedestrian movement	57	242
Space syntax	31	129	Space syntax	44	179
Walkability	15	73	Pedestrian	37	176
Pedestrian	17	72	Walkability	30	128
Urban design	6	32	Pedestrians	21	95
Urban morphology	7	30	Evacuation	16	66
Pedestrian simulation	6	29	Walking	12	63
Dwell time	3	26	Simulation	15	59
Walking	4	23	Social force model	13	58
Public transportation	2	22	Urban design	12	56

The terms “Urban design”, “Urban morphology”, “Pedestrian simulation”, “Evacuation” appeared to occur together with a high frequency. This shows that these terms have strong connections with different terms and clusters (Figure 4). The fact that the terms “Pedestrian flow”, “Simulation” and “GIS” are also included in the synonym table (Figure 4) and have a strong connection indicates that the focus is on the effect of urban form on pedestrian movements (Çetin et al., 2020; Elzeni et al., 2022).

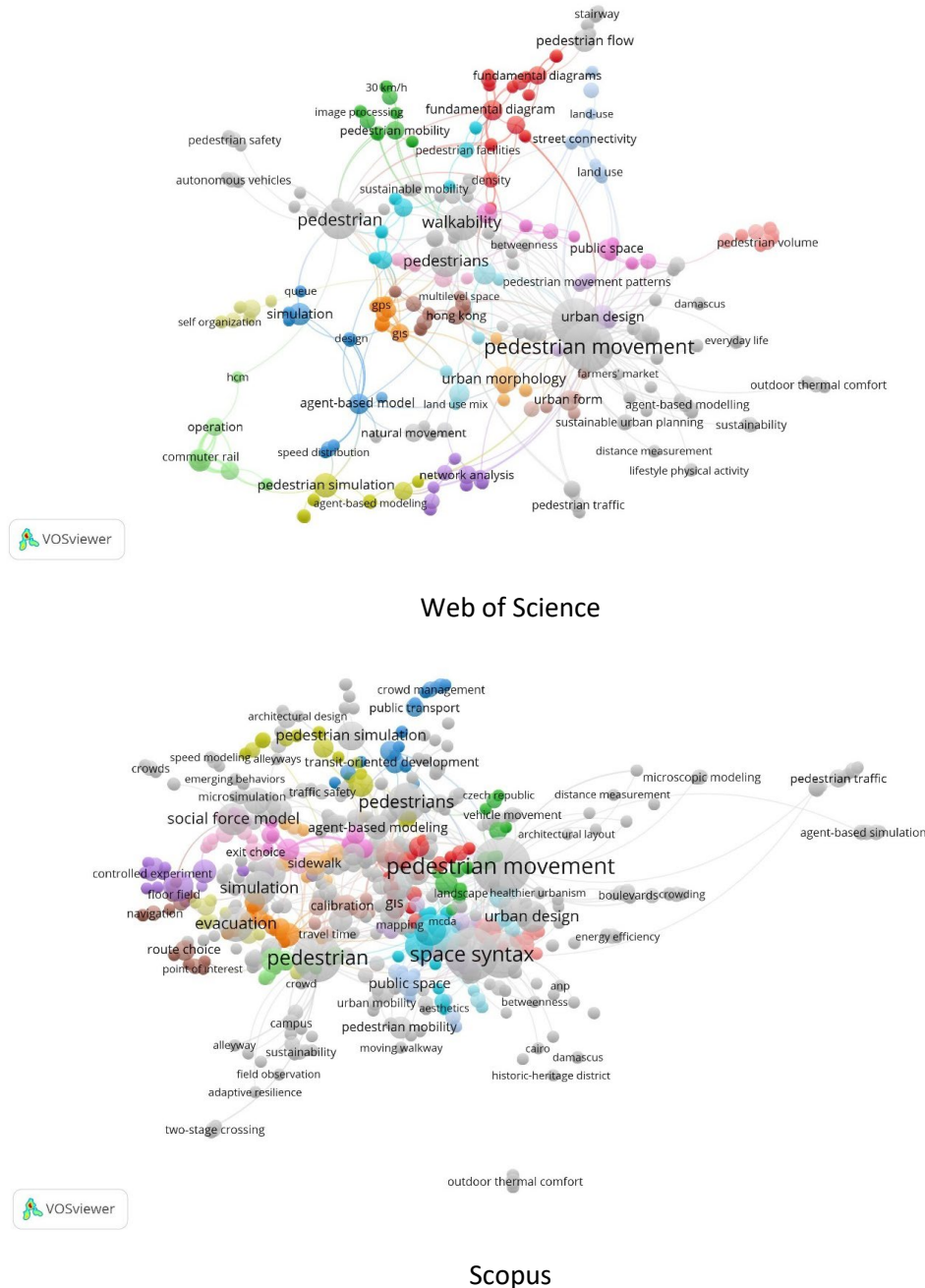


Figure 4. The term co-occurrence map

Figure 4 shows that 44 clusters are formed according to the color distributions according to the term co-occurrence WOS graph. This indicates that pedestrian movement studies are addressed within many subject areas. However, the first five cluster groups (cluster1-red, cluster2-green, cluster3-blue, cluster4-yellow and cluster5-purple) attract attention because they have the densest number of terms. Cluster1 includes terms related to the main subject of the study such as pedestrian behavior, pedestrian movements, spatial configuration, and pedestrian flow. Cluster2 emerged with terms such as urban mobility, pedestrian path, speed limit, local area traffic and pedestrian movement, speed and density at an urban scale. Cluster3 includes terms such as evacuation, fire safety, density of corridor where pedestrian safety is prominent. Cluster4 shows terms related to design, behavior and behavior modeling such as architectural design, pedestrian behavior, pedestrian simulation, pedestrian behavior modeling. Cluster5 includes terms such as cognitive distance, simulation, network analysis, pedestrian flow that include virtual reality and cognition (Table 3).

Table 3. Term clusters based on coterminous formation analysis

	Number Of Terms	Terms
Cluster1	30	pedestrian behavior, pedestrian dynamics, spatial configuration, pedestrian flow
Cluster2	22	urban mobility, pedestrian path, speed limit, local area traffic
Cluster3	22	evacuation, fire safety, density of corridor
Cluster4	21	architectural design, pedestrian behavior, pedestrian simulation, pedestrian behavior modeling, such as design, behavior, behavior modeling
Cluster5	20	cognitive distance, simulation, network analysis, pedestrian flow

3.3. Prominent Journals

Co-citation is a relationship between two items referenced by the same source (Van Eck & Waltman, 2017). This analysis was applied to identify the most influential journals in the field. Journals with at least one scientific article and more than 5 citations were selected for this analysis. Figure 5 presents the results of the co-citation analysis among the cited sources. The findings showed that Transportation Research Record and Environment and Planning B: Planning Design are the two leading journals in the field according to WOS and Scopus.

According to WOS, three main clusters can be defined; red, blue, green. The Transportation Research Record cluster is in blue and has an important place in the field of transportation research (M. L. Angel et al., 2014; Tang et al., 2021). Publications such as Environment and Planning B: Planning Design and Environment and Behavior (Haklay et al., 2001; Hillier et al., 1993; A. Turner et al., 2001) are included in the red cluster and cover studies on urban planning, environment and human behavior. Publications in the green cluster, such as Accident Analysis and Prevention (Li & Fernie, 2010), are related to physical modeling and safety analysis. There are dense connections between the red, blue, green, and yellow clusters. This shows that there is a strong academic interaction between different disciplines. In particular, the fields of transportation studies, environmental planning and engineering appear to be closely interconnected.

Table 4. Most active journals (top 10 journals with at least 1 article and more than

Web of Science			
	NP	TC	AC
Transportation Research Record	20	218	10.9
Environment and Planning B: Planning Design	8	260	32.5
Accident Analysis and Prevention	6	137	22.8
Environment and Behavior	3	123	41
Cities	4	102	25.5
Urban Design International	6	87	14.5
Landscape and Urban Planning	1	86	86
Journal Of Transport Geography	2	85	42.5
Journal Of Urban Design	6	82	13.7
Transportation Research Part B: Methodological	3	76	25.3
Scopus			
	NP	TC	AC
Environment And Planning B Planning And Design	7	201	28.8
Safety Science	20	150	7.5
Environment Behavior	3	138	46
Cities	4	133	33.3
Sustainability	9	121	13.4
Urban Design International	10	111	11.1
Transportation Research Record	25	111	4.4
Urban Design International	10	87	8.7
Journal Of Urban Design	6	79	13.2
Safety Science	20	68	3.4

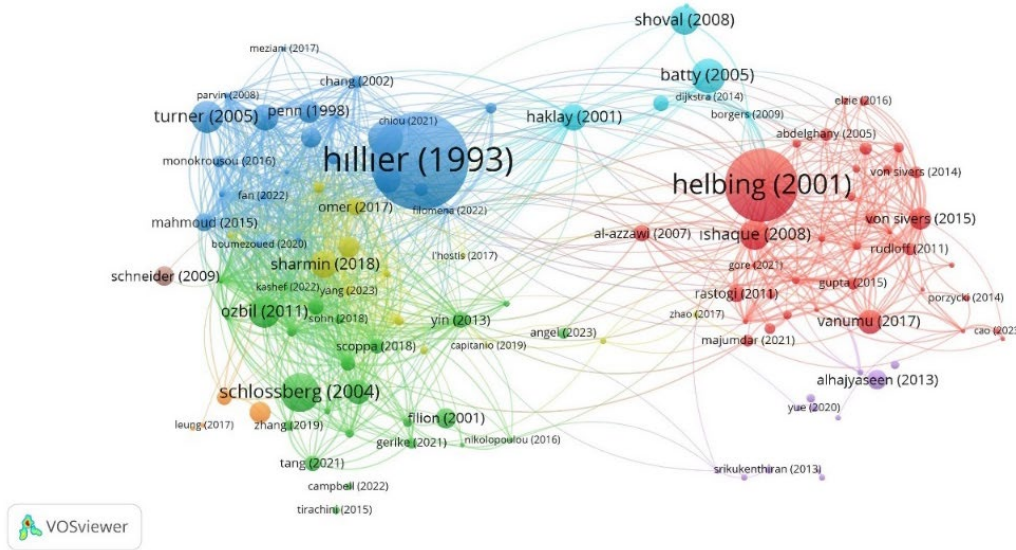
Note: NP = total number of publications; TC = total citations; AC = average number of citations (TC/NP).

3.4. Prominent Authors

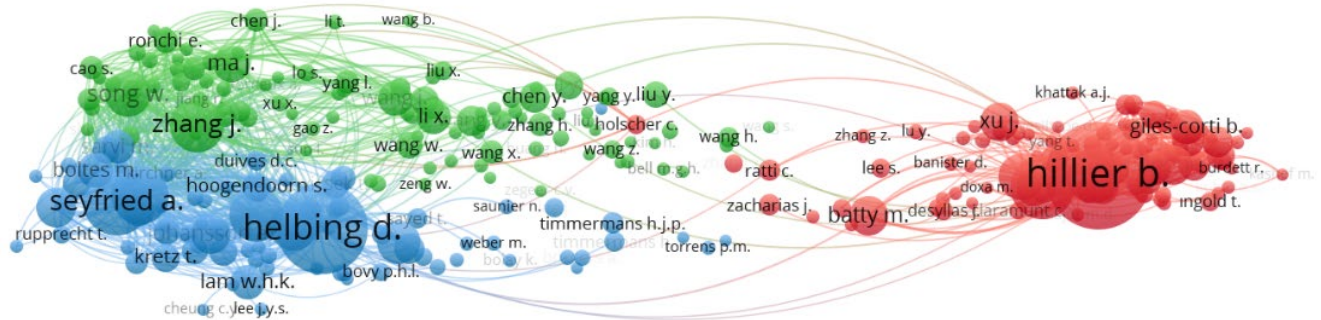
In order to identify the most influential authors on pedestrian movements, a co-citation analysis was conducted based on the citations. The most influential authors in WOS and Scopus are given in Figure 6, and the authors with at least 5 citations are given in Table 5. It is also seen that the results of this analysis largely overlap with the prominent publications analysis (Section 3.5).

According to WOS, three main clusters stand out: blue, green, and red. Hillier is located on the left side of the map as the largest node and is connected to a large number of researchers (Hillier et al., 1993). Hillier's study focuses on spatial analysis and use of space, and he is associated with important researchers such as Penn, Turner, Haklay, Batty (Haklay et al., 2001; B. Turner, 2006). Re-searchers in the green cluster, such as Schlossberg & Brown, Sharmin & Kamruzzaman and Ozbil et al., have developed new spatial analysis and transportation planning approaches based on Hillier's study (Ozbil et al., 2011; Sharmin & Kamruzzaman, 2018). Hillier's study has had a major academic impact on urban planning, spatial analysis and transport models. Helbing et al. is the second most important node on the right side of the network, with a major impact (Helbing & Molnár, 2001). Helbing's study is often related to pedestrian and traffic flow, simulation of human behavior, and crowd dynamics. Researchers such as von Sivers,

Vanumu, Ishaque, and Al-Azzawi have done new theoretical and applied analyses of Helbing's study. (Al-Azzawi & Raeside, 2007; Vanumu et al., 2017). Helbing's study has had a significant impact on the fields of crowd movement and transportation systems modeling.



Web of Science



Scopus

Figure 6. Co-citation analysis by authors

According to Scopus, three main clusters stand out: blue, green, red. Blue Cluster: Helbing et al. and Seyfried et al. stand out as the central figures of this cluster (Helbing & Molnár, 2001; Seyfried et al., 2005). Helbing is known for his influential work on pedestrian movement, crowd dynamics, and pedestrian simulations. Seyfried is particularly noted for his work on pedestrian flow and pedestrian density modeling. Other authors in this cluster include Hoogendoorn & Bovy and Boltes et al. (Hoogendoorn & Bovy, 2005). These could be researchers who do empirical and modeling studies on the pedestrian movement. Green Cluster: Authors like Zhang, Song et al. and Ma et al. are included in this cluster (Ma et al., 2022; Song et al., 2013). This group can act as a bridge between pedestrian

movements and indoor orientation. The green cluster can provide a link between the blue and red clusters, connecting both micro-changes or movements and larger orientation systems. Red Cluster: Hillier B has a major node as one of the pioneers of space syntax theory (Hillier, 2015). Authors such as Batty and Ratti are also influential in urban systems and spatial analysis (Batty, 2013a; Ratti, 2005). This cluster appears to focus on the study of pedestrian movements in the context of spatial layout and urban design. Helbing et al. and Hillier have the largest nodes, indicating that they are among the most cited researchers in the field of pedestrian movement and spatial analysis (Helbing & Molnár, 2001; Hillier, 2015). The blue cluster focuses on physical and mathematical modeling of pedestrian movements, while the red cluster focuses more on spatial organization and urban planning. The green cluster seems to be a transition point between these two approaches.

Table 5. Publication and citation distribution of leading authors according to Web of Science and Scopus data

Web of Science			
	NP	TC	AC
Hillier	2	818	409
Helbing	2	500	250
Middleton	3	146	48.7
Batty	1	138	138
Turner	2	121	60.5
Ozbil	2	117	58.5
Ishaque	3	115	38.3
Penn	4	68	17
Omer	7	48	6.9
Haklay	1	38	38
Scopus			
	NP	TC	AC
Hillier	4	1185	296.3
Helbing	1	620	620
Antoniou	1	454	454
Moussaid	1	405	405
Sisiopiku	1	286	286
Wong	1	216	216
Turner	2	175	87.5
Batty	1	165	165
Özbil	2	147	73.5
Lerman	2	133	66.5

Note: NP = total number of publications; TC = total citations; AC = average number of citations (TC/NP).

3.5. Prominent Publications

Co-citation analysis was also used to identify the most important publications in this field. In WOS and Scopus, analyses were conducted according to references that received at least 5 citations (Figure 7). Table 6 shows the 10 most cited publications and their authors.

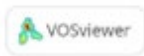
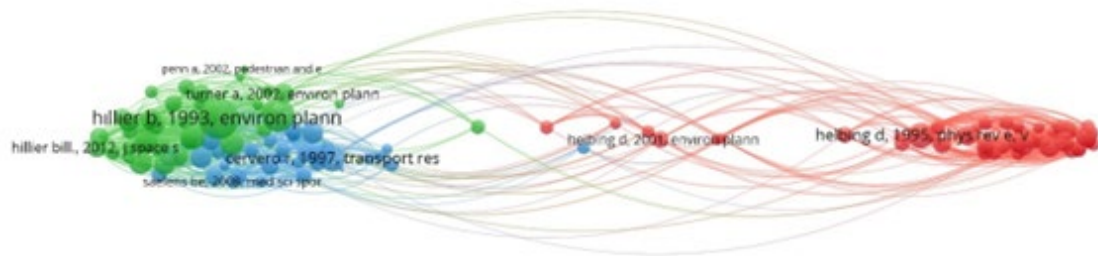
Table 6. Most cited fundamental publications in the field of pedestrian movement in Web of Science and Scopus

	Publications Title
Web of Science	
(Hillier et al., 1993)	Natural movement: or, configuration and attraction in urban pedestrian movement
(Hillier & Hanson, 1984)	The social logic of space
(Helbing & Molnár, 1995)	Social force model for pedestrian dynamics
(Lynch, 1964)	The image of the city
(Cervero & Kockelman, 1997)	Travel demand and the 3Ds: Density, diversity, and design
(Turner et al., 2005)	An algorithmic definition of the axial map
(Turner, 2003)	Analyzing the visual dynamics of spatial morphology
(Gehl, 2013)	Cities for people
(Pushkarev, 1975)	Urban space for pedestrians
(Haklay et al., 2001)	"So go downtown": simulating pedestrian movement in town centers
Scopus	
(Hillier & Hanson, 1984)	The social logic of space
(Lynch, 1964)	The image of the city
(Helbing & Molnár, 1995)	Social force model for pedestrian dynamics
(Whyte, 1980)	The social life of small urban spaces
(Hillier et al., 1993)	Natural movement: or, configuration and attraction in urban pedestrian movement
(Gehl, 2013)	Cities for people
(Hillier, 1996)	Space is the machine
(Batty, 2013)	The new science of cities
(Turner, 2005)	Could a road-center line be an axial line in disguise
(Peponis et al., 1997a)	The structure of urban space, movement and co-presence: The case of Atlanta

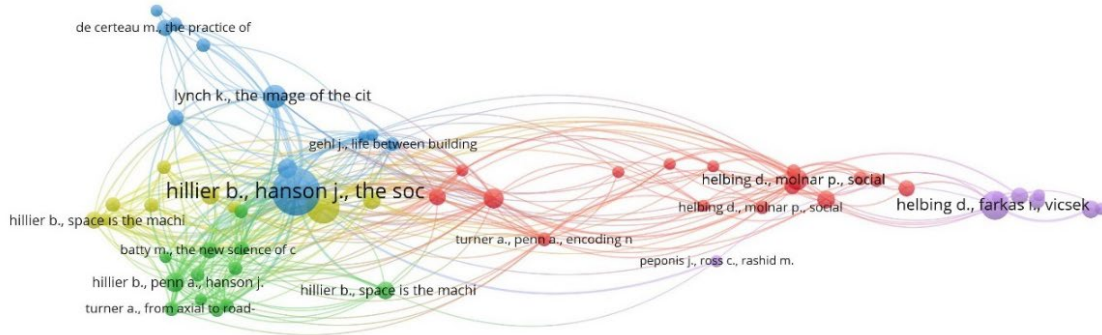
According to WOS, three main clusters stand out: red, green and blue. Red Cluster: Helbing & Molnár's Social force model for pedestrian movements is one of the most influential publications on crowd dynamics and physical modeling of pedestrian movements (Helbing & Molnár, 1995). Green Cluster: Hillier et al.'s Natural movement: or configuration and attraction in urban pedestrian movement focuses on the relationship between space syntax theory and pedestrian movements (Hillier et al., 1993). It is one of the most influential theoretical frameworks in urban planning and architecture. It is the center of the green cluster and a fundamental reference for spatial analysis studies. Turner's Analyzing the visual dynamics of spatial morphology study is a study that models pedestrian movements with spatial network analysis (Turner, 2003). It provides an important methodological contribution to the mapping of urban pedestrian movements. Blue Cluster: Cervero and Kockelman's Travel demand and the 3Ds: Density, diversity, and design study is an important study that evaluates the relationship between transportation and pedestrian movements (Cervero & Kockelman, 1997).

According to Scopus, four main clusters stand out: green, yellow, red and blue. Yellow-Green Cluster: includes studies examining the relationship between spatial organization of cities and pedestrian movements. Hillier and Hanson's The Social Logic of Space is at the center of the network and has a major impact (Hillier & Hanson, 1984). This publication has become a fundamental reference point for scholars interested in urban planning,

spatial analysis and structuration theory. The work of authors such as Hillier and Turner, Penn extends Hillier's theories. Classic urban studies such as Lynch's *The Image of the City* (Lynch, 1964) and Gehl's *Life Between Buildings* (Gehl, 2011) are related to this theory. These publications have had a broad academic impact in the fields of urban design, spatial analysis and urban sociology. Peponis et al., in *The Structure of Urban Space, Movement and Co-presence* (Peponis et al., 1997b), use space syntax analysis to show how people interact in cities and how spatial structures shape this. Turner, *could a Road-Centre Line Be an Axial Line in Disguise?* (A. Turner, 2005), is an algorithmic study that analyzes the impact of urban roads on pedestrian movements. Extends Hillier's axial analysis to examine how roads affect pedestrian movements. Red Set: includes studies that examine pedestrian movements with physical models.



Web of Science



Scopus

Figure 7. Co-citation analysis by cited references

Helbing and Molnár's Social force model for pedestrian movements (Helbing & Molnár, 1995), focuses on modeling crowd movements and traffic flow by creating a separate group within the citation network. Helbing's research on crowd simulations and pedestrian movements has had a major impact on transportation engineering and human movement modeling, particularly in the field of transportation engineering. Peponis and other researchers have developed these models for urban pedestrian movement and indoor guidance systems (Peponis et al., 1997a). Blue Cluster: Includes studies examining the social use of urban space and people's interaction with public spaces. Gehl analyzes how public spaces are used by people in his study *Life Between Buildings* (Gehl, 2011). De Certeau, in his work *The Practice of Everyday Life*, examines the space usage practices of people in daily life and how they reproduce them (De Certeau, 1988).

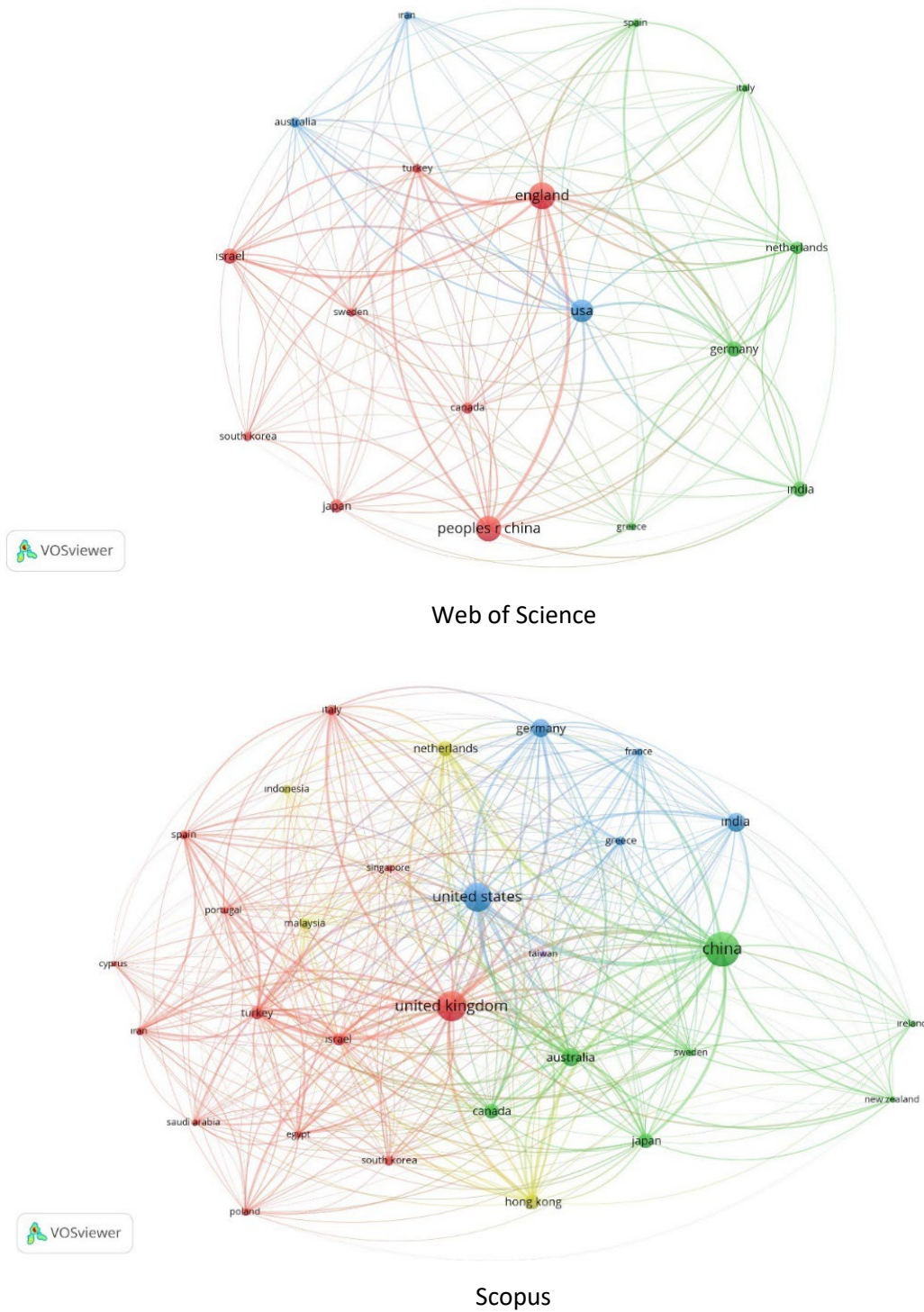
3.6. Prominent Countries

In this section, bibliographic link analysis was conducted to identify the most effective countries in pedestrian movement studies. "A bibliographic link is a link between two elements that cite the same document" (Van Eck & Waltman, 2017). The analysis results are presented in Figure 8, the total number of publications, total citations, average number of citations and their percentages are presented in Table 7, and the 5 most cited countries are presented on the map in Figure 9. Countries with at least five documents on pedestrian movements were included in this analysis.

Table 7. Publication and citation analysis of the most active countries in pedestrian movement in Web of Science and Scopus (with at least 5 documents)

Web of Science			
	NP	TC	AC
USA	32	1176	36.8
England	42	908	21.7
Germany	16	764	47.8
Israel	17	445	26.2
China	39	265	6.80
India	17	221	13
Australia	9	177	19.7
Turkey	7	175	25
Canada	10	125	12.5
Japan	13	121	9.3
Scopus			
	NP	TC	AC
United Kingdom	78	3401	43.6
USA	71	2327	32.8
China	99	1514	15.3
Germany	13	1059	81.5
Australia	33	739	22.4
Turkey	19	618	32.6
Japan	23	542	23.6
Israel	17	494	29.1
Netherlands	24	480	20
Canada	24	407	16.9

Note: NP = total number of publications; TC = total citations; AC = average number of citations (TC/NP).



Web of Science

Scopus

Figure 8. Co-citation analysis by countries

According to WOS, three clusters have been formed: red, blue, green. Red Cluster: It is note-worthy that England has the largest node. In addition, it is seen that countries such as China, Israel, Japan, Canada, South Korea, Sweden, and Turkey have made significant contributions. Blue Cluster: The USA, as one of the largest and most central countries, has a large number of international collaborations. USA-UK, USA-China, and USA-Germany connections are among the strongest international academic partnerships. Green Cluster: Germany and the Netherlands are the largest academic centers of this group. Academic ties between European countries are quite strong. India has gained an important place in this cluster by establishing close academic collaborations with Germany and the Netherlands.

According to Scopus, there are three main clusters: red, blue, green. Red Cluster: The United Kingdom stands out as the largest node. It has cooperation with countries such as Turkey, Italy, Spain, Iran, Israel, Poland, Egypt, Saudi Arabia. Blue Cluster: The United States has the largest node and has important connections with Germany, France, India, Greece, and the Netherlands. Green Cluster: China is the center of scientific production in the Asia-Pacific region. There is intensive academic cooperation with Japan, Australia, Canada, Hong Kong, Sweden, Ireland, and New Zealand.

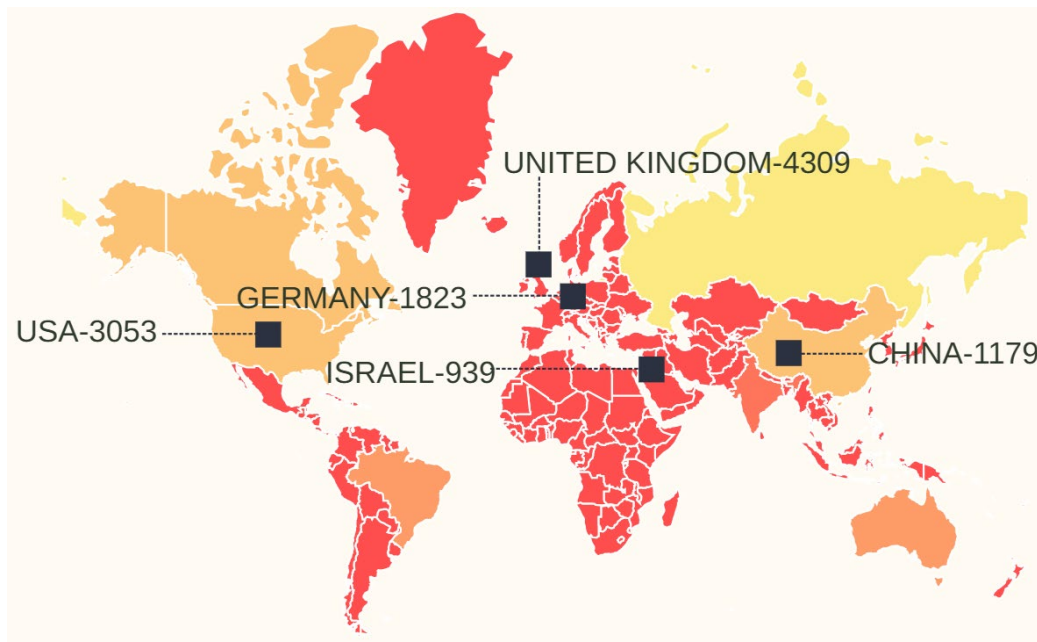


Figure 9. Top 5 countries with the total number of cited.

The findings reveal not only the quantitative magnitude of pedestrian movement research but also the evolution and research trends of the field. For example, the rapid increase in pedestrian movement studies since 2000 reflects the interest in pedestrian-focused approaches in urban design and transportation planning (Cervero & Kockelman, 1997; Gehl, 2011). Term-matching and cluster analyses indicate a concentration of research in key areas such as pedestrian behavior, urban design, simulation, and spatial analysis (Hillier et al., 1993; Helbing & Molnár, 1995; Turner, 2003). This suggests that researchers are turning to multidisciplinary methods to

understand the interactions between the physical and social environments and to improve pedestrian-friendly design of cities (Peponis et al., 1997a; Lynch, 1960). Prominent authors and publications have shaped theoretical frameworks and methodological approaches in the field, while international collaborations have strengthened the flow of scientific knowledge and international research standards (Hillier & Hanson, 1984; Helbing et al., 2001). Consequently, bibliometric analysis not only reveals the current state of knowledge regarding pedestrian spatial behavior but also provides guidance for future research and urban planning policies.

3.7. Answering Research Questions

RQ-1: What is the publication status of academic studies on pedestrian movements?

Academic studies on pedestrian movements have shown a steady quantitative growth, especially since the 1990s. Earlier works were limited in number and disciplinary scope, mostly focusing on architectural and urban planning perspectives. Over time, there has been a significant diversification in research themes, with increased use of computational tools and interdisciplinary methods. Bibliometric mapping also indicates that citation networks have expanded globally, showing that pedestrian movement has become a well-established research area with continuous scholarly attention.

RQ-2: What are the roles of different fields (countries, institutions, academic journals and researchers) in the global dissemination of the concept of pedestrian movement?

The dissemination of pedestrian movement research is shaped by a network of influential countries, institutions, journals, and scholars.

Countries: The UK and the USA have pioneered theoretical and methodological advances, while European and Asian countries have increasingly contributed empirical and technological perspectives.

Institutions: Leading universities and research centers in architecture, urban planning, and transport engineering have played a central role in shaping the field.

Journals: Core publications are concentrated in urban studies, planning, transportation, and interdisciplinary journals, which provide visibility to pedestrian-focused work.

Researchers: Seminal figures such as Hillier, Hanson, Helbing, Lynch, and Gehl have become highly cited reference points, anchoring the field's knowledge base.

RQ-3: What aspects of the pedestrian movement field have current research addressed?

Current research covers a wide spectrum of themes:

Physical-spatial aspects such as street networks, land use, and urban morphology.

Behavioral and perceptual aspects, including wayfinding, visual perception, and human-environment interaction.

Modeling approaches, focusing on simulation, algorithmic analysis, and data-driven techniques.

Social and cultural aspects, including public space use, pedestrian safety, and accessibility.

This shows that pedestrian movement research has moved beyond a purely physical focus and now embraces social, cognitive, and technological dimensions.

RQ-4: What are the main topics that are most focused on in recent pedestrian movement studies?

Recent studies cluster around three dominant themes:

Spatial structure and mobility: How urban form, street configuration, and spatial accessibility shape pedestrian flows.

Urban perception and human-space interaction: How pedestrians perceive, experience, and appropriate urban spaces.

Urban modeling and smart technologies: How computational models, simulations, and digital tools can predict and optimize pedestrian movements.

These clusters indicate a balance between theoretical, experiential, and technological orientations in current research.

3.8. Limitations

Although bibliometric analysis provides a systematic and powerful approach for evaluating large volumes of academic literature, the findings of this study should be interpreted with caution due to several limitations.

1. **Limitations of Data Sources:** Only publications indexed in Web of Science and Scopus were included. While these databases cover a substantial portion of global pedestrian movement research, relevant studies indexed in other sources—such as Google Scholar, IEEE Xplore, regional databases, or non-English journals—were not considered (Van Eck & Waltman, 2017).

2. **Scope and Selection of Keywords:** The literature search was based primarily on the term "pedestrian movement." However, the field employs a wide range of related terminologies such as "pedestrian dynamics," "walkability," "urban mobility," or "crowd modelling" (Helbing & Molnár, 2001). Restricting the analysis to a narrow set of keywords may have excluded relevant publications, particularly interdisciplinary studies that address pedestrian behavior indirectly.

3. **Methodological Constraints of Bibliometric Analysis:** While bibliometric methods effectively identify trends, patterns, and influential works quantitatively, they do not provide in-depth qualitative insights into the content, methodology, or theoretical contributions of the studies (Zupic & Čater, 2015). For instance, frequently cited works such as Hillier and Hanson's *The Social Logic of Space* or Gehl's *Cities for People* require detailed content analysis to fully understand their conceptual significance (Gehl, 2011; Hillier & Hanson, 1984).

4. **Context-Free Nature of Citation Analysis:** Citation counts reflect academic visibility rather than scientific quality or methodological rigor (Garfield, 2006). Highly cited publications may dominate the network due to historical prominence or foundational theories, while innovative recent studies might remain underrepresented. This limitation is particularly relevant when evaluating the influence of emerging models, digital tools, and novel approaches in pedestrian movement research.

5. **Lack of Regional and Cultural Considerations:** Pedestrian behavior is strongly influenced by local context, cultural norms, urban density, and infrastructure (Whyte, 1980). For example, European pedestrianization projects and high-density Asian cities exhibit markedly different movement patterns. This study, however,

focused on global bibliometric trends without differentiating geographical, socio-cultural, or infrastructural factors, which may limit the applicability of the results to specific regional contexts.

6. Temporal and Disciplinary Biases: The databases used tend to index more recent studies and those from certain disciplines such as urban planning, architecture, and civil engineering, potentially underrepresenting earlier studies or research from emerging fields like computational social science, behavioral economics, or public health. This may have skewed the interpretation of thematic evolution and cross-disciplinary integration over time.

Taken together, these limitations suggest that while the study provides a comprehensive overview of global academic trends in pedestrian movement research, its findings should be complemented with qualitative analyses, case studies, and context-specific investigations to capture the full complexity of pedestrian behavior across diverse urban environments.

Finally, to address these limitations in future research, several strategies can be implemented. Expanding the data sources to include additional academic databases (e.g., Google Scholar, IEEE Xplore) and regional journals would capture a broader spectrum of studies, including non-English and context-specific publications. Employing a more comprehensive set of keywords and using controlled vocabularies or thesauri can reduce the risk of omitting relevant studies and improve the inclusiveness of the literature search. Integrating bibliometric analysis with qualitative content analysis would provide deeper insights into the methodological rigor, theoretical contributions, and practical implications of influential works. To overcome the context-free nature of citation analysis, future studies could combine citation metrics with expert evaluations or case studies to better assess the scientific and practical value of publications. Moreover, incorporating regional, cultural, and infrastructural variables into bibliometric or mixed-method studies would enable researchers to account for local variations in pedestrian behavior. Finally, applying longitudinal analyses that track emerging disciplines, novel modelling approaches, and data-driven methodologies would allow future studies to capture the evolving, interdisciplinary nature of pedestrian movement research more accurately.

3.9. Future Research

Although this study provides a comprehensive bibliometric analysis of pedestrian movement research within architectural disciplines, there are several gaps that de-serve further investigation. A notable limitation is the reliance on publications indexed in Web of Science and Scopus, which may have excluded relevant research from regional journals or grey literature sources (Klarin, 2024). Future studies could expand the scope by including a wider range of databases to provide a more holistic understanding of the field.

Additionally, while the study identifies key thematic trends such as urban sustainability, smart cities, and digital modeling, a more in-depth examination of the theoretical underpinnings of these trends remains necessary. For example, previous studies (Gehl, 2013; Hillier & Hanson, 1984) have highlighted the role of spatial configuration in pedestrian movement, but more recent data-driven approaches incorporating machine learning and big data analytics (Batty, 2013b) require further synthesis with these underlying theories.

Another gap involves the geographic distribution of research collaborations. Findings show that dominant research clusters are concentrated in Europe, North America and East Asia, with limited contributions from developing regions. Encouraging academic partnerships between institutions from underrepresented regions and leading research centers could provide a more globally inclusive perspective on pedestrian movement studies (Cervero & Kockelman, 1997).

Furthermore, the study highlights the increasing importance of interdisciplinary collaborations, but the specific impact of interdisciplinary methodologies on pedestrian movement research remains understudied. Future research could focus on integrating perspectives from psychology, behavioral sciences, and environmental studies to develop more holistic models of pedestrian movements (Helbing & Molnár, 1995; Lynch, 1964).

Finally, advances in digital twin technology and real-time pedestrian simulations offer promising directions for future research. While previous studies have used agent-based modeling (Turner, 2003). Finally, advances in digital twin technology and real-time pedestrian simulations offer promising directions for future research. While previous studies have used agent-based modeling, integrating augmented reality and AI-enabled predictive analytics can significantly improve the accuracy of pedestrian movement prediction. Further research is needed to evaluate the practical applications of these technologies in urban planning and policy making.

By addressing these gaps, future studies can contribute to a more detailed and comprehensive understanding of pedestrian movement, ultimately informing better urban design practices and promoting more livable cities.

3.10. Urban Planning and Policy Development Recommendations

Pedestrian-First Design Principles:

The findings indicate that pedestrian movement is not only related to the physical environment but also to perception, accessibility, and social interaction. Therefore, pedestrian-first design principles should be adopted in urban planning, ensuring wide sidewalks, safe crossing points, green space connections, and continuity of public spaces.

Multi-Disciplinary Planning Approaches:

As the research demonstrates, pedestrian movement studies intersect disciplines such as architecture, urban planning, transportation engineering, sociology, and public health. Interdisciplinary collaboration should be encouraged in policy development, and urban planning processes should encompass not only spatial but also social and behavioral dimensions.

Walkability and Accessibility Standards:

The emphasis on walkability and accessibility highlighted in the results highlights the need to develop pedestrian-focused transportation standards in cities. Walkability indices should be integrated into local governments' spatial planning decisions, and inclusive standards should be introduced for the elderly, children, and people with disabilities.

Data-Based Urban Policies:

Bibliometric findings indicate that data-driven methods (e.g., spatial modeling, big data analytics) are on the rise. City governments should incorporate these methods into their planning processes to monitor pedestrian movement and make future projections.

Safety and Social Equity:

Based on the "pedestrian safety" and "social disparities" dimensions highlighted in the study, inclusive planning principles should be developed in cities that consider safe pedestrian crossings, lighting, gender equality, and cultural diversity.

4. CONCLUSION

This study offers a unique contribution by systematically mapping the historical development of academic research on pedestrian movements, primarily from the perspective of architecture and urban planning, through a comprehensive bibliometric analysis. Unlike previous reviews, this study integrates a longitudinal perspective, revealing not only the volume and growth of publications but also the evolving thematic focus and interdisciplinary connections within the field. The findings show that pedestrian movements are shaped by a complex interplay of physical environment, spatial configuration, human-space interaction, and urban modeling. Key seminal works, including Hillier and Hanson's *The Social Logic of Space* (1984) and Helbing and Molnár's *Social Force Model for Pedestrian Dynamics* (1995), demonstrate the foundational influence of spatial and mathematical modeling, while Lynch's *The Image of the City* (1960), Whyte's *The Social Life of Small Urban Spaces* (1980), and Gehl's *Cities for People* (2010) highlight the increasing recognition of human perception and user-centered design. Recent studies, such as Batty's *The New Science of Cities* (2013) and Hillier's *Space is the Machine* (2007), show the growing application of data-driven and algorithmic approaches for modeling pedestrian dynamics in complex urban systems.

By combining historical trends, theoretical frameworks, and methodological advances, this study reveals the field's transition into a highly interdisciplinary domain encompassing urban design, transportation, human behavior, and computational modeling. Its contribution lies in providing a detailed bibliometric roadmap that identifies the most influential publications, authors, and international collaborations, highlighting emerging trends and research gaps. This synthesis not only consolidates existing knowledge but also provides actionable guidance for future research and practical strategies to design sustainable, human-centered, and data-informed urban environments, setting this study apart from previous literature reviews.

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