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A Bibliometric Analysis of Development Trends of Digitalization in Tai Chi

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ABSTRACT

As an important part of traditional Chinese martial arts, digital technology has profoundly influenced Tai Chi in recent years. However, there is still a lack of systematic analysis of the application of digitalization in the field of Tai Chi. This study aims to analyse the relevant literature retrieved from 2015 to 2024 in the Web of Science (WOS), SCOPUS, and China National Knowledge Infrastructure (CNKI) databases through bibliometric methods and then use VOSviewer software to visualize the publication volume, author cooperation network, and keyword co-occurrence. A total of 112 valid documents were retrieved (5 WOS, 97 Scopus, and 15 CNKI), of which 5 WOS articles were included in the Scopus database. Since 2015, the number of relevant English and Chinese literature has shown a steady upward trend, and the author cooperation network shows the characteristics of team-based English literature and decentralized Chinese literature. Keyword analysis shows that the English literature focuses on technological innovation and empirical research, while the Chinese literature pays more attention to cultural inheritance and teaching practice. This study systematically analyzes digital Tai Chi research trends using bibliometric methods, highlighting differences in focus between Chinese and English literature, and providing an important reference for future development in this field.

1. INTRODUCTION

Tai Chi is a traditional Chinese martial art that is widely popular around the world [1], and its health benefits are widely recognized [2]. Studies have shown that Tai Chi could improve physical and mental health of patients with various chronic diseases, including improving blood sugar control in patients with diabetes [3, 4], improving memory and attention in patients with cognitive impairment [5] and relieving stress and anxiety [6]. In recent years, with the rapid development of digital technology, emerging technologies such as virtual reality (VR), augmented reality (AR), and motion capture are changing the way Tai Chi is inherited, taught, and promoted [7, 8]. Researchers have studied the digitization of Tai Chi in various contexts. For example, the intelligent evaluation system based on motion capture technology could provide Tai Chi practitioners with instant feedback to help them correct their movements [9]; VR technology provides an immersive learning environment for remote teaching, breaking through the time and space limitations of traditional teaching [7, 10]. Especially during the COVID-19 pandemic, digital technology has played an important role in the teaching and promotion of Tai Chi. According to [11], the rapid transition of Tai Chi courses from face-to-face teaching to virtual classrooms significantly improved the accessibility and learning effect of Tai Chi. Furthermore, the application of artificial intelligence technology has also provided new possibilities for standardized evaluation of Tai Chi movements [12]. The study by [13] proposed learning-based action recognition system that could automatically evaluate the standardization of practitioners' movements, providing a powerful supplement to traditional subjective evaluation methods. At the same time, as the field of rapid development of digital health has brought new opportunities to the health field, the combination of virtual reality (VR), wearable devices, and telemedicine [14], it has opened new scenarios for the application of Tai Chi in the health intervention. However, despite the growth of applications, there is currently a lack of systematic analysis of the development of this research field. The focus of the reviews of the existing literature focuses mainly on the research of Tai Chi research for specific populations, such as patients with hypertension [15, 16], patients with diabetes [3,

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4], people with cognitive impairment [5], etc. This stems from Tai Chi as a traditional form of exercise, has well-established health benefits in specific conditions [17]. Most importantly, such reviews focus on the target population and explore in more depth the specific role of Tai Chi in improving physical and mental health. However, this research framework is relatively narrow, focusing mainly on the direct effects of health interventions, while ignoring the potential impact of Tai Chi on the integration of technology and digital promotion.

Therefore, there is a lack of systematic review of the development trend of Tai Chi digitalization, an emerging research field. Compared to traditional narrative reviews, bibliometric analysis can objectively quantify research trends and identify key themes and collaboration networks [18]. In addition, there may be differences in research focus and development trends in this field between Chinese and English academic circles, and this difference is also worth further discussion.

To address the shortcomings of this topic, this study uses bibliometric methods to analyze the literature on Tai Chi in the field of digitalization and is based on previous bibliometric research work. Therefore, this study aims to: (1) describe the development and characteristics of digital Tai Chi research; (2) identify the collaborative network between authors, institutions and countries; (3) analyze key research hotspots and evolution trends; and (4) identify the differences in research topics and methods between the Chinese and English literature.

2. METHODS

2.1 Study design, search strategy, and selection criteria

Following the method of bibliometric analysis [18], we retrieve bibliometric information on digital Tai Chi studies in English from the Web of Science (WoS) and Scopus databases and retrieved bibliometric information on digital Tai Chi studies in Chinese from the China National Knowledge Infrastructure (CNKI). WoS and Scopus were selected as sources of English literature because they are the most widely used international English databases, which contain many high-quality scientific publications [19, 20]. In addition, these two databases are particularly suitable for citation analysis and are well compatible with various bibliometric software [21, 22]. Similarly, CNKI, the largest and most widely used Chinese academic database in China, comprehensively covers Chinese research disciplines [23].

Therefore, this study covers all the component databases of WOS, Scopus, and CNKI. The search strategy used the following keyword combinations: WOS and Scopus with TS = (("Tai Chi" OR "Taiji" OR "Tai Chi Chuan" OR "Taijiquan" OR "Shadowboxing") AND ("Digital" OR "Virtual Reality" OR "Motion Capture" OR "Artificial Intelligence" OR "Smart" OR "Information Technology" OR "Mobile App" OR "Wearable" OR "Internet" OR "Digitalization" OR "Digitization" OR "Digitization")). CNKI with TS = ((Tai Ji Quan) AND ("Shu Zi Hua" OR "Ren Gong Zhi Neng" OR "Xu Ni Xian Shi")) and the time was set from 2015 to 2024. During the literature screening process, we filtered the data according to clear inclusion and exclusion criteria. The inclusion criteria included academic literature related to Tai Chi digitization, and the exclusion criteria included literature types that were not related to the research topic, such as books, newspaper articles, conference papers, and other non-academic indexed literature to ensures that the selected data have high academic quality and relevance, thereby supporting the reliability and systematicity of the analysis [24]. The search was completed on September 21, 2024, and the results were sorted by relevance. After selection and sorting, 97 valid articles were obtained from the Scopus database, and 5 and 15 valid articles were selected from the WOS and CNKI databases, respectively. It is worth noting that the five articles selected from the WOS database were also included in the Scopus database, which shows that the Scopus database has a more comprehensive collection of digital English research literature on Tai Chi. In addition, the Scopus database is known for its extensive interdisciplinary coverage, including research literature in natural sciences, medicine, social sciences and other fields, which is highly consistent with the interdisciplinary nature of Tai Chi digital research [25]. As an authoritative academic database in China, CNKI comprehensively covers domestic research literature on Tai Chi and is an important source for obtaining Chinese literature [23].

Therefore, based on the research purpose of this study, we decided to use Scopus and CNKI as data references in English and Chinese and finally obtained 112 valid articles as research samples. Among them, 97 articles were in English (accounting for 86.6%) and 15 articles were in Chinese (accounting for 13.4%).

2.2 Data analysis

Bibliometrics is a method of quantitative analysis of books, articles, or other publications using mathematics and statistics [26]. VOSviewer is a software used for bibliometric mapping. Data from the sample literature are imported into it to draw a knowledge map which can present the general external characteristics of the subject field, especially, it has unique advantages in cluster analysis [24]. This study used VOSviewer (version 1.6.20) to draw scientific maps of the Chinese and English literature, construct author cooperation networks and keyword co-occurrence networks, and explore its research hotspots and development trends. The flow diagram of the search strategy is shown in Figure 1.

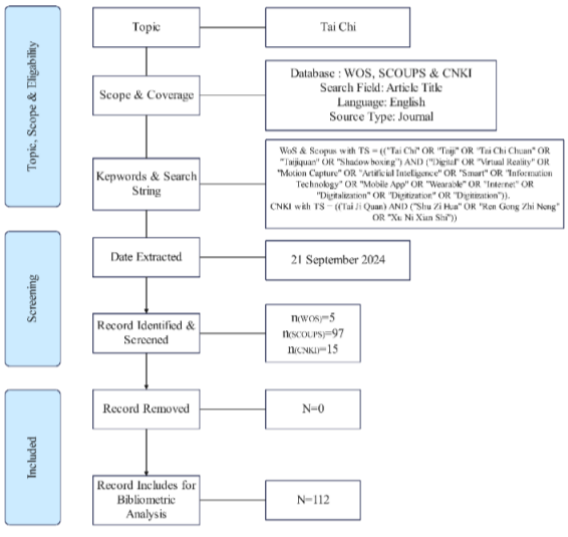

Fig. 1. Flow diagram of the search strategy

3. RESULT

3.1 Characteristics of the age distribution of the document

The research literature was exported using time series statistics, and Excel was used to process the data and plot the publication trends. As shown in Figure 2, the volume of Tai Chi digitization research in Scopus and CNKI has generally shown an upward trend. Among them, the relevant literature in the CNKI database reached a record high of 4 articles in 2021, which may be related to the surge in demand for online Tai Chi teaching during the COVID-19 pandemic. Similarly, the English literature in the Scopus database reached a peak of 20 articles in 2022. Although the number of published documents in 2023 has declined, from the overall trend, research enthusiasm has continued to rise in recent years; especially, the attention of English papers to the field of Tai Chi digitization has increased significantly, which intuitively reflects the importance of research in this field.

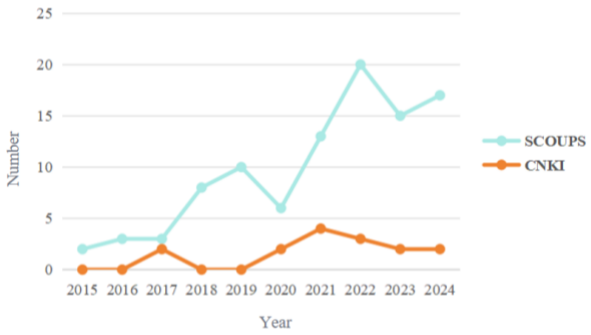

Fig. 2. Distribution of the literature by year

3.2 The journal with the most papers on Tai Chi Digitalization in English and Chinese

Table 1 lists the top 10 journals in terms of the number of English papers in the field of Tai Chi digitization. International Journal of Environmental Research and Public Health (4 papers; 4.12%) and PeerJ, Frontiers in Aging Neuroscience, BMJ Open (3 papers each; 3.09%) ranked in the top four. Other major publishing journals include Sensors Switzerland, Sensors, Journal of Integrative and Complementary Medicine, IEEE Sensors Journal, European Journal of Integrative Medicine, and Computational Intelligence and Neuroscience (2 papers each; 2.06%). The top two journals in terms of the number of Chinese papers are Wushu Research (3 papers; 20%) and Journal of Jiaozuo University (2 papers; 13.33%). The top ten English journals have 2 to 4 papers, and the top ten Chinese journals have 1 to 3 papers.

Table 1. Top 10 sources of publications by language category

SCOPUS (English)	Number	Percentage (%)	CNKI (Chinese)	Number	Percentage (%)
International Journal of Environmental Research and Public Health	4	4.12%	Wushu Studies (ISSN: 2096-1839)	3	20%
Peerj	3	3.09%	Journal of Jiaozuo University (ISSN：1008-7257)	2	13.33%
Frontiers In Aging Neuroscience	3	3.09%	Design (ISSN：1003-0069)	1	6.67%
BMj Open	3	3.09%	Art Science and Technology (ISSN：1004-9436)	1	6.67%
Sensors Switzerland	2		New Countryside (ISSN：1008-2182)	1	6.67%
Sensors	2	2.06%	Journal of Hangzhou Normal University (Natural Science Edition) (ISSN：1674-232X)	1	6.67%
Journal of Integrative and Complementary Medicine	2	2.06%	Ren Wen Tian Xia (ISSN：2095-3690)	1	6.67%
lEEE Sensors Journal	2	2.06%	Information Technology and Informatization (ISSN：1672-9528)	1	6.67%
European Journal of Integrative Medicine	2	2.06%	Science & Technology of Stationery & Sporting Goods (ISSN：1006-8902)	1	6.67%
Computational Intelligence and Neuroscience	2	2.06%	Hubei Sports Science (ISSN：1003-983X)	1	6.67%

3.3 Comparison of the most active institutions

Table 2 lists the top 10 institutions in terms of the number of papers on Tai Chi digitalization research. Shanghai University of Sport (5 papers; 5.15%) and Beijing Normal University (4 papers; 4.12%) ranked first and second in terms of English papers, and Anhui University of Chinese Medicine and Shandong Institute of Physical Education (3 papers each; 3.09%) ranked third. In terms of Chinese papers, Henan Polytechnic University (3 papers; 20%) and Jiaozuo

University (2 papers; 13.33%) were the institutions with the most papers.

Table 2. Active institutions in English and Chinese literature

Institution	Number	Percentage (%)	Institution	Number	Percentage (%)
Shanghai University of Sport	5	5.15%	Henan Polytechnic University	3	20%
Beijing Normal University	4	4.12%	Jiaozuo University	2	13.33%
Anhui University of Chinese Medicine	3	3.09%	Wuhan University of Technology	1	6.67%
Shandong Sport University	3	3.09%	Shanghai University of Engineering Science	1	6.67%
Ganzhou Teachers College	3	3.09%	Wuhan Polytechnic	1	6.67%
Rising Moon Tai Chi School	2	2.06%	East China Normal University	1	6.67%
Chengdu University of Traditional Chinese Medicine	2	2.06%	Guangdong Polytechnic of Science and Technology	1	6.67%
University of Haifa	2	2.06%	Renmin University of China	1	6.67%
Northwestern Polytechnical University	2	2.06%	Donghua University	1	6.67%
The University of Arizona	2	2.06%	Hangzhou Dianzi University	1	6.67%

3.4 Comparison of authors and co-authors

Figure 3 shows the analysis of the author's collaboration network. The author groups in the Scopus database have formed several clear research teams. The most active team is composed of Li Haojie (5 papers, 4.07%) and Lyu Shaojun (3 papers, 2.44%) from Beijing Normal University, followed by Bennell Kim L. (2 papers, 1.63%) from the University of Melbourne, Carr, Siobhán B. (2 papers, 1.63%) from the Royal Brompton and Harefield NHS Foundation Trust, Harrison Jenny (2 papers, 1.63%) from the Rising Moon Tai Chi School, and Zhu Shiyi Julia (2 papers, 1.63%) from the University of Melbourne.

In contrast, the author's collaboration network in the CNKI database is more scattered, showing multiple independent small research groups. For example, Han Yuhui's team and Yang Huidan's individual from Henan University of Technology have published only one article each and have not yet formed a large-scale collaborative research network.

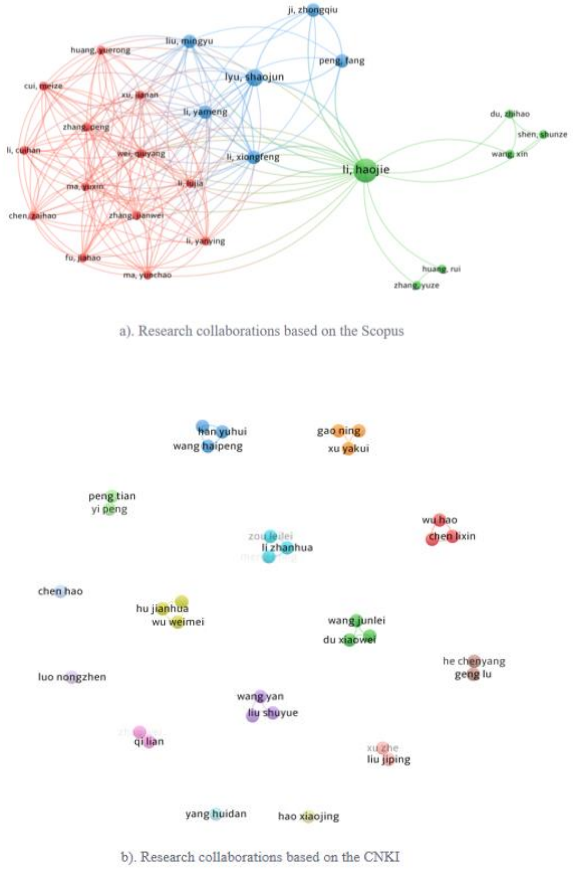

Fig. 3. By author: SCOPUS (3a) and CNKI (3b)

3.5 Comparison of keyword co-occurrence mapping

Figure 4 shows keyword co-occurrence networks, highlighting technology-focused trends in English literature and cultural themes in Chinese literature. Among them, 4a shows that 75 keywords and 1,372 links appearing in English publishers were included in four clusters of English papers. The first category (red) focuses on the development of technology and motion analysis, mainly exploring the digital collection and evaluation of Tai Chi movements. Keywords include biomechanics, kinematics, motion capture, machine learning, and wearable sensors. This type of research shows the in-depth application of Tai Chi in the field of science and technology, such as using motion capture technology to quantify movement parameters or improving motion recognition through machine learning [27]. The second category (green) focuses on cognitive function and health effects, focusing on the application of digital Tai Chi health intervention. Including keywords such as cognitive defect, dementia, mental health, and treatment outcome. For example, some studies have shown that VR-assisted Tai Chi training could help elderly patients with dementia improve their cognitive abilities, especially in terms of attention, memory, and executive function [28]. The third category (blue) explores the application of alternative medicine and comprehensive

therapy, combining Tai Chi with traditional therapies such as acupuncture, massage, and mindfulness. The fourth category (yellow) focuses on the balance function research of special populations, including body equilibrium and postural balance. These studies used advanced measurement equipment, such as force plate systems and 3D motion capture technology, to quantitatively evaluate the effect of Tai Chi on improving static and dynamic balance in the elderly [29].

Figure 4b shows the 26 keywords that appeared in the Chinese literature and the 58 included in the three clusters of Chinese papers. The first category (red) focuses on technology application and sports development, reflecting the technological innovation of Tai Chi in digital transformation. For example, digitization, mixed reality technology, dynamic balance, and technology development. The second category (green) focuses on cultural communication and international exchanges. Keywords revolve around cultural confidence, international communication, science, and technology, and particularly emphasize the promotion strategy in the context of the digital age, reflecting the modernization transformation of Tai Chi cultural communication. This cluster highlights the modern transformation of Tai Chi in its international dissemination, such as the use of social media platforms to promote Tai Chi [30, 31]. The third category (blue) focuses on cultural heritage protection, including keywords such as intangible cultural heritage, digital design, sports, and leisure. These studies have highlighted the role of digital technology in preserving intangible cultural heritage, such as establishing a virtual Tai Chi cultural exhibition through digital design [32, 33], thereby improving the dissemination effect and accessibility of Tai Chi.

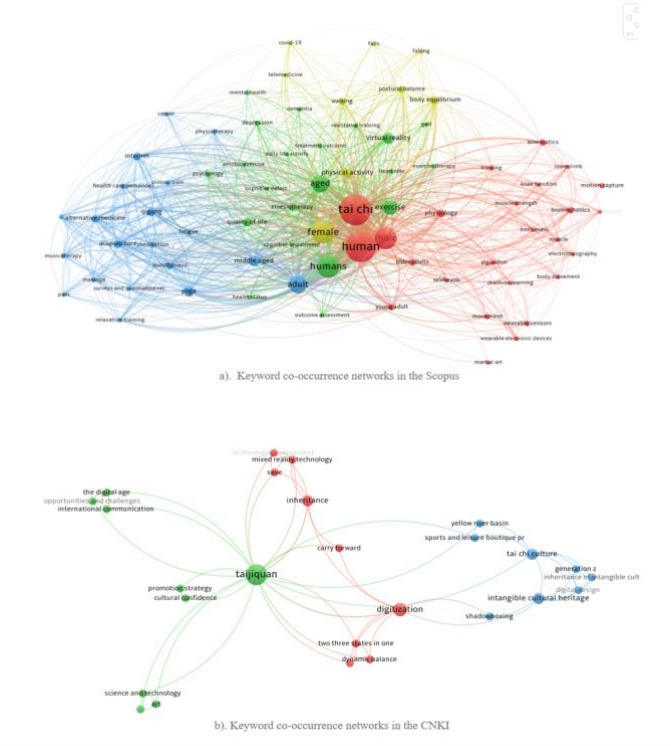

Fig. 4. Keyword co-occurrence networks by database: SCOPUS (4a) and CNKI (4b)

4. DISCUSSION

The results of this study are discussed as follows:

1) Describe the development and characteristics of digital Tai Chi research

To our knowledge, this is the first systematic bibliometric analysis to review the research progress of digital technology in the field of Tai Chi. Overall, the number of papers on Tai Chi has shown a steady upward trend, especially after 2020. The growth in research enthusiasm may benefit from multiple factors: first, the rapid development of digital technology has provided new possibilities for the innovative application of traditional Tai Chi; second, the COVID-19 pandemic has promoted the demand for distance learning and accelerated the research on digital applications; third, the national policy support for the digital protection of traditional culture, such as the implementation of the "Internet+" strategy and the "digital transformation" construction project. Surprisingly, the number of English papers is significantly higher than that of Chinese papers. This may be because English, as an international academic language, researchers are more inclined to publish their results to the international academic community to expand the influence of their research results [34].

So far, English literature has been published mainly in the International Journal of Environmental Research and Public Health. The International Journal of Environmental Research and Public Health focuses on the evaluation of the effects of health interventions [35-38]. PeerJ, Frontiers in Aging Neuroscience, and BMJ Open published innovative application research on digital Tai Chi from the perspectives of medicine, neuroscience, and interdisciplinary studies respectively.

The most cited English article, the study [39] constructed the MADS dataset, which provided standardized 3D posture data for complex movements such as Tai Chi for the first time, solving the basic data problem of motion analysis; the study [40] confirmed the effect of virtual reality Tai Chi on improving cognitive function in the elderly through a randomized controlled trial; the study [41] mainly studied the effect of virtual reality on behavioral change, but its innovative design of using Tai Chi as an experimental environment provided a starting point for subsequent research.

2) Identify the collaborative network between authors, institutions, and countries

Not surprisingly, Henan Polytechnic University and Jiaozuo University are at the forefront with the largest number of Chinese documents, which is closely related to the geographical advantages of Jiaozuo, Henan, the birthplace of Tai Chi. As the birthplace of Tai Chi [42, 43], Jiaozuo is the main inheritance place of Chen-style Tai Chi, with a profound cultural heritage and rich traditional resources. Local universities make full use of this regional feature and actively carry out Tai Chi digital protection and innovative application research. For example, Henan Polytechnic University combines mobile Internet and virtual simulation technology to carry out the digital teaching practice of Tai Chi [44]. Jiaozuo University explores the application of new-era digital technologies such as motion capture technology and virtual reality technology in the inheritance and promotion of Tai Chi culture, and explores the paths and countermeasures for

promoting the inheritance and promotion of Tai Chi culture under the background of digitalization, to better inherit and promote Tai Chi culture, and also provide strong support and development guarantee for the protection and revitalization of intangible cultural heritage [45]. This research model, which is based on regional advantages and focuses on the integration of traditional culture and modern technology, is conducive to the inheritance and promotion of traditional culture.

It is worth noting that the analysis of the author's cooperation network shows obvious differentiation characteristics. The author's cooperation in the English literature shows the characteristics of teamwork, with closer cooperation and more concentrated research power; while the author's cooperation in the Chinese literature shows the characteristics of independence, with each research group conducting research work relatively independently. To promote the development of Tai Chi digitization, cross-team cooperation needs to be strengthened.

3) Analyze key research hotspots and evolution trends

The English and Chinese literature have both similarities through keyword co-occurrence analysis in the research topics of Tai Chi digitization. For example, the commonalities are mainly reflected in the application of basic technologies, such as motion capture, VR, and other key technologies, especially innovations in motion recognition and virtual teaching, which reflect the general trend of health technology toward personalization and intelligence [14], echoing the development direction of global digital humanities focusing on user experience and health technology focusing on precise intervention [46, 47].

4) Identify the differences in research topics and methods between the Chinese and English literature

The two types of literature also show obvious differences in research focus. English papers pay more attention to technological innovation and empirical research, and key keywords include biomechanics, machine learning, and motion evaluation. This is consistent with the global trend of digital health emphasizing technology-driven, and reflects the emphasis of the digital health strategy on the application of innovative technologies [48]. In contrast, Chinese papers focus more on cultural heritage and teaching practice, with keywords mainly concentrated on traditional cultural heritage and innovation in teaching methods. This is consistent with the policy orientation of China's "14th Five-Year Plan for Digital Economy Development" [49], which clearly states that digital technology should be used to promote cultural heritage and dissemination to provides policy support for the study of Tai Chi digitalization.

5. CONCLUSION

Based on the bibliometric analysis of VOSviewer software, this article retrieved 5, 97, and 15 academic journal papers from the three core databases of WOS, SCOPUS, and CNKI, respectively, and systematically compared the number of papers, authors, research institutions, keyword clustering, etc. The overall trend of the number of articles published in Tai Chi digitization research, especially the increase in the English literature from 2 in 2017 to a peak of 20 in 2022, shows that the international academic community is increasingly interested in the research of Tai Chi digitization.

The journals of distribution analysis show that English papers are mainly published in journals such as the International Journal of Environmental Research and Public Health (4 papers; 4.12%) and PeerJ, Frontiers in Aging Neuroscience (3 papers; 3.09%), reflecting the interdisciplinary characteristics of this research field. Chinese papers are mainly published in professional journals such as "Wushu Studies" (3 papers; 20%).

The author's cooperation network analysis shows that in terms of English literature, multiple stable research teams have been formed. However, in terms of Chinese literature, local research institutions represented by Henan Polytechnic University (3 papers) and Jiaozuo University (2 papers) showed regional advantages, but there were relatively few cooperative relationships between teams.

Keyword co-occurrence analysis revealed the differences in the research focus of the English and Chinese literature: The English literature pays more attention to technological innovation and empirical research, and key keywords include biomechanics and machine learning; Chinese literature pays more attention to cultural inheritance and teaching practice. This difference reflects that Tai Chi digitization not only uses modern technology to improve dissemination efficiency, but also maintains the authenticity of traditional culture.

Finally, there are several limitations to this study. First, the scope of the search is limited to literature published in WOS and SCOPUS in English and CNKI in Chinese, which may exclude related studies included in other English databases (such as PubMed, Engineering Village) and Chinese databases (such as Wanfang, VIP). Second, although the topic of Tai Chi digitization is involved, some literature that only mentions these keywords in the abstract but is not focused on Tai Chi digitization may be included. At the same time, the subject word search may miss some information. Finally, due to the rapid development of digital technology, some of the latest research results and application trends may not have been fully reflected in the academic literature. Some underrepresented topics and interdisciplinary collaborations still need further exploration to expand research perspectives.

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