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REVİEW ARTICLE

Analyzing Global Trends and Publication Patterns in Sports Education Information Technology: A Bibliometric Review

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Abstract
A bibliometric analysis was performed to examine global publication trends and patterns connected to the use of information technology in sports education. All articles from the Scopus database from 1996–2023, totaling 396 articles related to this theme, were taken and then analysed using the help of mapping engineering analysis software, namely VOSviewer. The research findings show that there have been fluctuations in the number of publications, but 2011 marked the beginning of the trend for publications to increase by double digits. Of the 186 documents, the document types "conference paper" and “article" were the largest among the other types, with 173, respectively. The well-known journal " Journal of Physics Conference Series," is the scientific source that has published the most articles with 32 documents. Other findings revealed that the "Computer Science" area, with 193 documents, was the one most studied by scholars to carry out their research. China is the country with the highest number of publications, namely 266 documents, and one of its universities, namely Guangdong University of Foreign Studies, is the top affiliate with ten published documents. The use of the keywords "information technology" (82 occurrences), and “physical education” with (81 occurrences), is the most popular compared to other phrases for this topic. Our research provides more comprehensive information about the rapid progress of technological literacy in facilitating the development of sports education as a basic ingredient in building a country's sporting success.

Keywords
Sports, Education, İnformation Technology, Bibliometric, Scopus

INTRODUCTION

The demand for technological literacy in the modern era requires teachers, coaches, and sports practitioners to understand and apply technology in physical and sports education activities. The new competition system, new technology system, new consumption structure, and new business trend all show the structural transformation of the sports sector (Deng & Tang, 2020). The application of technology in sports learning for inclusive education is one of several research subjects covered by the use of technology in sports, including sports education (Shytikova et al., 2022), the use of virtual reality in athletes from various disciplines (Akbaş et al., 2019), the use system for sport management (Adi & Fathoni, 2022), the quality of sports training in universities (Qingtao, 2020), the modernization of computer technology in physical education and sports (Cojocaru et al., 2022), the effectiveness of movement analysis applications in physical education (Zulkifli & Danis, 2022), and quality of life (Homon et al., 2022).

Sports education information technology has become a key area of study and development due

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to the growing demand to improve athletic performance, training regimens, and instructional methods. One of them is the application of virtual reality technology, which has the potential to alter coaching methods in the field of sports (Purnomo et al., 2021). Athletes can carry out sports activities without being limited by time and distance (Marheni et al., 2022; Xie & Sun, 2022) Through the use of virtual reality, sports training can be made more effective, athlete motivation and interest increased, and a safe environment created for the development of technical and tactical skills (Gao & Sun, 2023). In addition, technology affects the diagnosis and planning of sports training (Vera-Rivera et al., 2019). Sports education technology will definitely play an increasingly important role in determining the future of sports as the industry develops, helping athletes, coaches, and sports fans alike.

In addition, the development of Sports ITech, which is a systematic taxonomy of sports technology and includes knowledge from sports literature from various disciplines such as motor learning, game design, pedagogy, and interaction design (Postma et al., 2022). Augmented reality technology is used in various learning fields, including sports education, to create smart campuses and improve the quality of education (Godoy Jr., 2020). The Compliant Sports Augmentation Framework (CSAF) aims to promote a sociocultural approach to sports technology design for grassroots sports (Ryan & Duckworth, 2020).

There are several examples of successful sports education programmes that incorporate technology to promote inclusivity. These include: 1) the use of computer virtual reality technology in college sports training, which can increase student participation and increase their interest in learning (Zhou, 2020); 2) development of e-sport which is based on modelling sports matches using computer programmes and can maintain the spirit of sports competition (Gabibov et al., 2020); 3) implementation of inclusive training in sports and technical sports, including modelship sports, through the use of technology to adapt the education and training process to the needs and abilities of each student (Shytikova et al., 2022); 4) the use of new technologies in the development of recreational sports, which can increase opportunities for participation, diversity and inclusion of a wide range of beneficiaries, and lead to the creation of wealth and economic prosperity (Fesanghari et al., 2021), 5) the application of artificial intelligence in competitive sports , which provides athletes with personalised sports quantitative analysis, training guidance, injury prevention and monitoring, and provides viewers with a more comfortable and realistic viewing experience (Wang, 2020).

Several studies have been conducted on the topic of sports education technology explaining the impact of online learning on sports participation during the COVID-19 pandemic (Sayyd et al., 2021). Another study presented ways to introduce and integrate modern information technology into interactive community sports education and training (Mei, 2014) or and efforts to increase sportsmanship among students (Hafiar et al., 2023). A study was also conducted in the Philippines on the use of Google Sites (Culajara, 2022) and mobile application (Culajara, 2023) in delivering PE instruction. Development of crawling-style swimming learning modules that are integrated with augmented reality technology (Nohantiya & Putra, 2020). A study that focuses on the design of basic basketball technology based on computer-based online teaching systems. This research puts forward a strategy to build an online teaching system based on basic basketball technology (Zhou, 2021). In addition, several bibliometric studies have been carried out regarding the use or utilisation of technology in sports, including to promote health (Belfiore et al., 2020), knowledge information in sports (Sofyan et al., 2022), and educational technology in physical education learning (Daharis et al., 2023; Perdima et al., 2022). However, our search results did not find bibliometric research in the field of sports education technology.

By analysing publications in this area in a methodical manner, bibliometric analysis offers a way to acquire a thorough overview of the research landscape in sports education technology. Scientific articles can be quantitatively evaluated using bibliometrics, which also identifies key research themes, author partnerships, and citation trends. Through bibliometric research, this study aims to map the intellectual environment around sports education technology, identify significant institutions and contributors, and identify emerging trends. Research evaluation, academic tenure and promotion procedures, grant application evaluation, journal rankings, university rankings,

and even country rankings use bibliometric analysis as a tool for measuring research results and impact (Henneken & Kurtz, 2019; José de Oliveira et al., 2019; Wang, 2020). It has certain advantages for assessing relevant information regarding a specific study field and can also be used to objectively analyse written papers (Mobin et al., 2023). This bibliometric study on technology in sports education was conducted as a result.

In order to provide a thorough overview of the most recent advancements and trends in this area, which can be used as a foundation for creating new research ideas and refining existing research. The formulation of the problems of this study is: 1) what are the trends and patterns in technology research in sports education from 1999 to 2023? 2) what are the most dominant subject areas in technology research in sports education? 3) what scientific sources are most productive? 4) which countries and affiliates are most active in publishing technology-related papers in sports education? 5) the article that gets the most quotes from other people? 6) what keywords are mostly used by the author?

MATERIALS AND METHODS

Data collection

Data collection is a crucial stage in bibliometric analysis since it establishes the quantity and quality of the data that will be used in the analysis. Scopus was chosen as the database for this bibliometric analysis because of its wide coverage of scientific literature in various disciplines, including technology in sports education (Aria & Cuccurullo, 2017). Scopus as one of the most thorough and reliable databases for bibliometric investigations, gives users access to a large number of international publications (Bornmann & Leydesdorff, 2013).

The search was done on October 20, 2023, and records from the years 1996 to 2023 were included to ensure complete literature coverage. The keywords selected for the search were "information technology" AND "physical education" OR "sport* education". An asterisk (*) was used as a wildcard. The search was limited to documents in the "final" and "article in press" publication stages. The search included the material categories "article", "conference paper", "book chapter", and "conference review". Included sources were books, book series, journal articles, and conference papers. In addition, only documents published in English, Russian, Portuguese, Spanish, Turkish, Arabic, Chinese, and Lithuanian were included in the search.

Using VOSviewer bibliometric software, the data was then gathered, and the acquired documents were analyzed to offer insights into research trends and patterns in the field of technology in sports education. a considerable number of scientific papers were analyzed using VOSviewer, a text mining and visualization application (van Eck & Waltman, 2017). These sources discuss a variety of bibliometric-related subjects, such as the use of subject categories to map science, the application of bibliometric analyses to research evaluation (Glänzel & Thijs, 2017), and the shifting nature of scientometrics research (Bornmann & Leydesdorff, 2014). Some review articles offer in-depth analyzes of scientific mapping work (Chen, 2017), while others propose integrated approaches to bibliometric network mapping and clustering (Waltman et al., 2010).

Data Analysis

The bibliometric analysis will be built from the search's findings. Using the bibliometric analysis program VOSviewer, the data was examined with a view to identifying global trends and publication patterns in sports education technology. Prolific authors, contributing institutions, the countries with the highest levels of activity in this field, and networks of research collaboration may all be found and studied. In this investigation, bibliometric tools, including coauthorship networks, citation networks, and analysis of keyword co-occurrence, are combined. The co-authorship network makes it possible to identify prolific writers and analyse their patterns of collaboration. The most influential articles and connections between diverse papers are understood through the citation network. Last but not least, the study of keyword co-occurrence enables the identification of the terms that are employed in the literature the most frequently and significantly. In a variety of domains, bibliometric analysis is a helpful method for identifying and calculating trends, patterns, and the impact of research (Abramo et al., 2009). An extensive overview of the technological research landscape in sports

education was given through the use of bibliometric approaches, which also allowed for the identification of key authors, publications, and study fields.

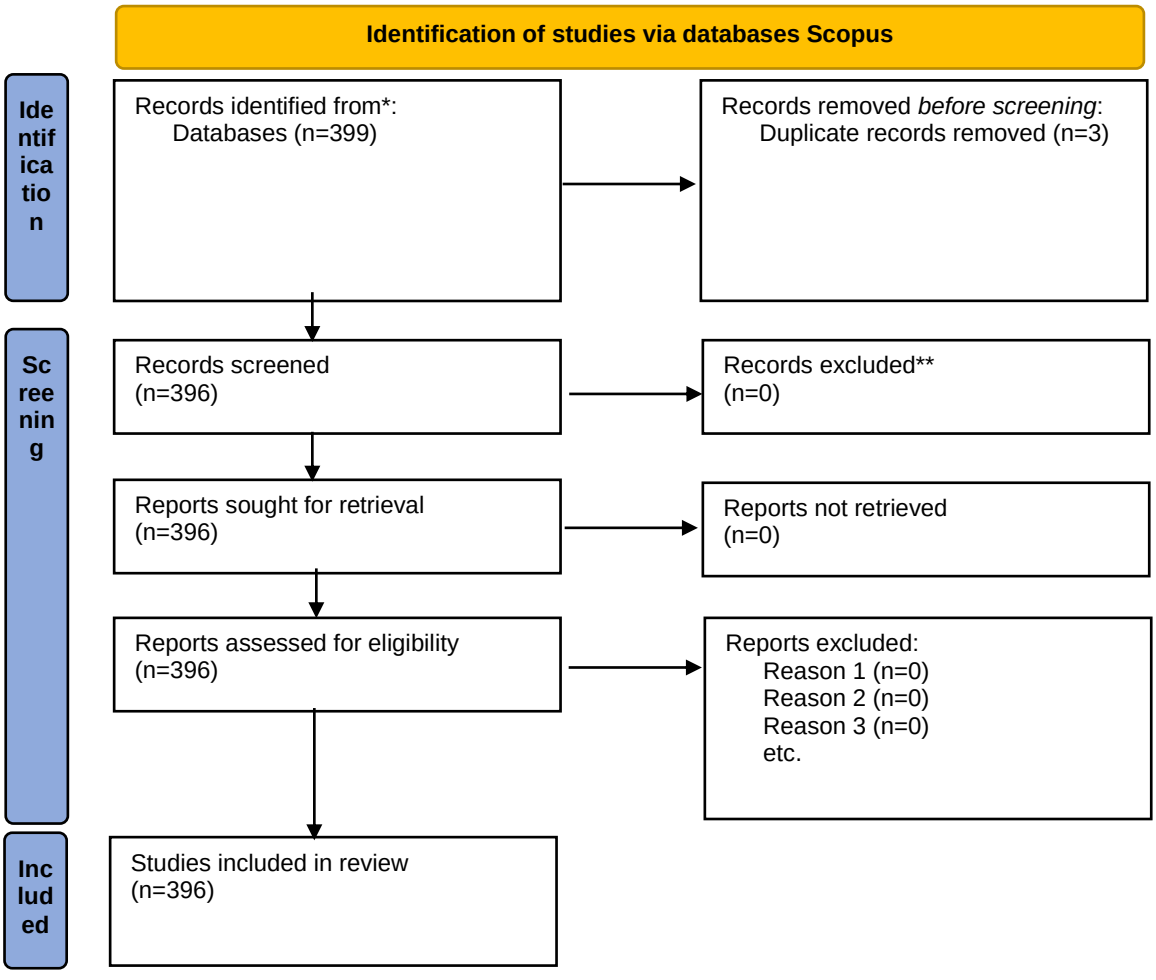

Figure 1. Metadata search and retrieval flowchart

RESULTS

Technology Research in Sport Education Trends and Patterns

A bibliometric analysis of the 396 publications in the Scopus database showed that information technology research in sports education has risen since 1996. The number of publications relating to information technology research in sports education has consistently increased over time, according to analysis of the data obtained. The year with the most publications was 2021 (110), then 2022 (51), and 2020 (37). While the number of publications climbed dramatically from 2020 to 2021. It should be noted that the number of publications since 1996 has been quite low, indicating an early interest in this field. Trends in publication are shown in Figure 2 by year.

A further finding of the investigation was that 390 (98.49%) of the documents were published, and 6 (1.51%) had the status of an article in press. The documents were published in English (358 documents/90.4%), Russian (27 documents/6.8%), Portuguese (4 documents/1.01%), Spanish (3 documents/0.75), Turkish (2 documents/0.5%), and Arabic, Chinese, and Lithuanian (1 documents/0.26%). The most common document type was the 186-document conference paper, followed by the 173-document article. In addition, a small number of documents are review with 16 documents, book chapter with seven documents, review with four documents, book with one document, and retracted with nine documents. Figure 2 shows the types of documents recorded in the Scopus database.

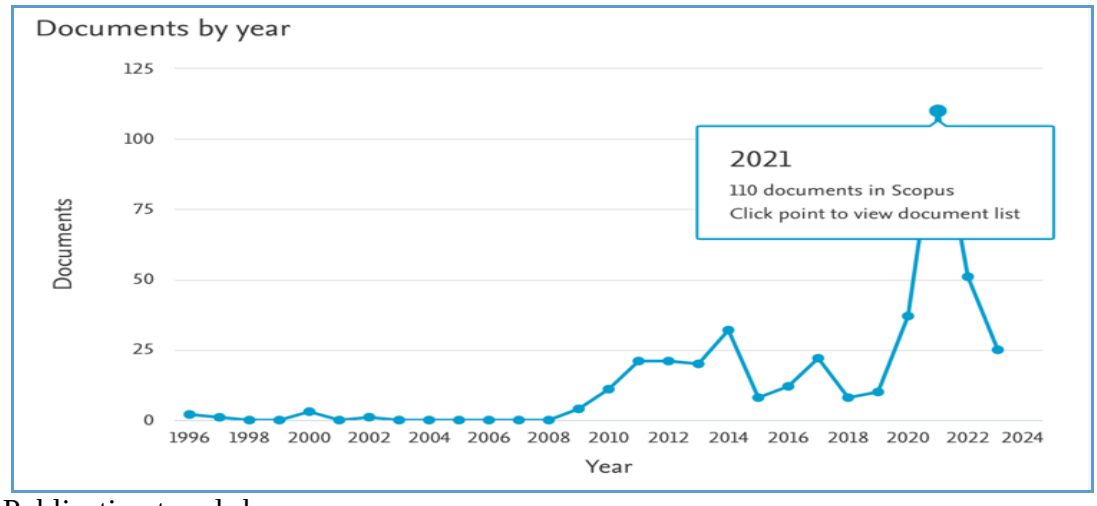

Figure 2. Publication trends by year

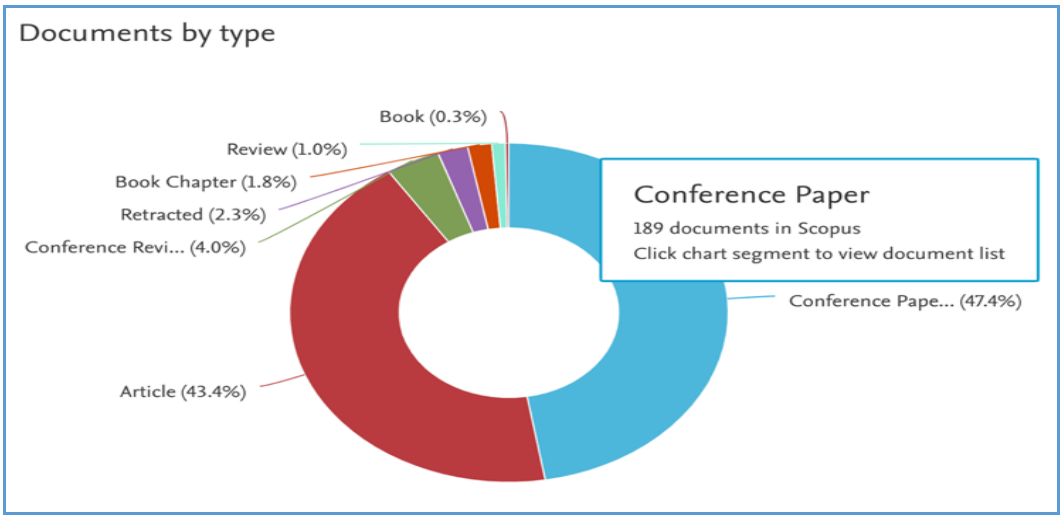

Figure 3. Publication trends by document type

Top Sources

This source title was found to have the highest number of documents related to information technology research in sports education. Due to the interdisciplinary nature of information technology research in sports education, which spans fields including physics, engineering, computer science, and education, the variety of top source titles is a reflection of this. Further examination of these resources' titles can shed light on the present condition, prospective future directions, and potential effects of technology research in sport education on the sports sector. Table 1 provides a list of the top 10 sources in the field of information technology in sports education.

Table 1. Top 10 Sources Title

No.	Source Title	Document Count
1	Journal Of Physics Conference Series	32
2	Proceedings 2021 International Conference On Information Technology And Contemporary Sports Tcs 2021	24
3	Teoriya I Praktika Fizicheskoy Kultury	22
4	Advances In Intelligent Systems And Computing	16
5	Lecture Notes In Electrical Engineering	12
6	Advanced Materials Research	11
7	Applied Mechanics And Materials	11
8	Boletin Tecnico Technical Bulletin	11
9	ACM International Conference Proceeding Series	9
10	Wireless Communications And Mobile Computing	9

Subject Areas

Computer science is the subject with the highest number of publications among the 193 documents used in the bibliometric analysis of information technology in sports education. Engineering came next with 141 papers, while social sciences were right behind with 126 publications. This demonstrates that much of the study in this area is concentrated on the creation and use of information technology in sports education. There are numerous documents in the social sciences field that show a growing interest in the social and cultural effects of technology in sports education. The role of information technology in sports education, health care, and injury prevention is also emphasised by the health and medical professions. These findings show that research on information technology in sports education is a diverse area that draws from many different academic disciplines. The subject areas in the information technology in sports education sector are depicted in Figure 4.

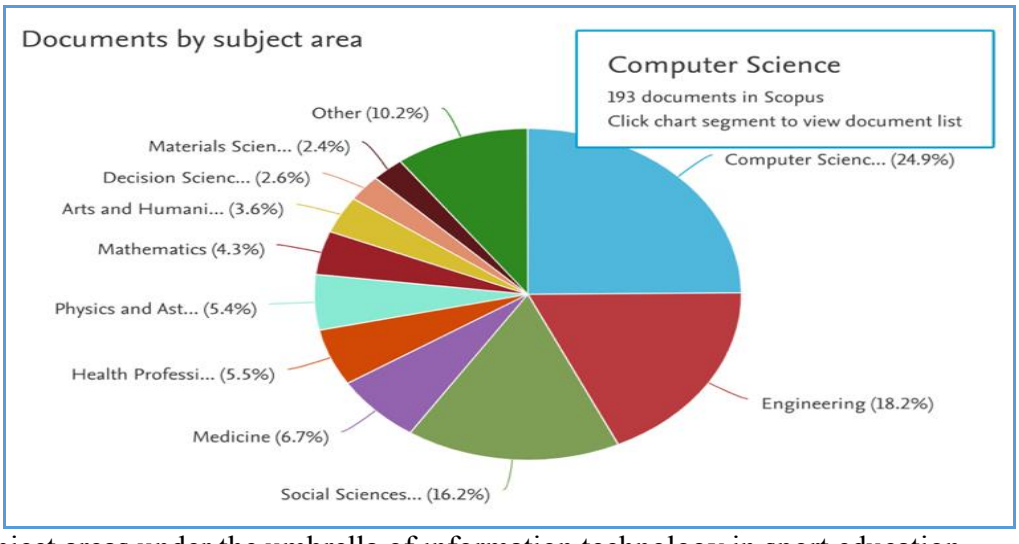

Figure 4. Subject areas under the umbrella of ınformation technology in sport education

Top Country and Affiliation

According to the data gathered, China, with 266 documents, is the top nation for information technology development in sports education. The second and third countries with the most publications are the Russian Federation with 31 documents, and the Ukraine, with 9 documents, and Spain and United States with each 8 documents. These results indicate that China is currently the leading country in terms of research results in information technology in sports education. In addition, the distribution of publications in these countries demonstrates that information technology research in sports education is a global endeavour and that there is active interest in this area worldwide.

The top affiliates in the data drawn for research on technology in sports education are mostly universities, research institutes, and other educational organisations from different parts of the world. The top affiliation for research on technology in sports education based on data collected is Guangdong University of Foreign Studies with 10 documents, followed by Jiangxi Science and Technology Normal University with 5 documents. Top affiliates demonstrate their active involvement in information technology research in sports education. These findings provide insight into institutions that are leading research in this area, which can be useful to researchers, policymakers, and industry players interested in collaborating with or funding research at these institutions.

Top 10 Articles with Top Cites and Most Relevant

This section shows the number of citations and authors for the top 10 articles with top cites and most relevant on information technology in sports education. The articles with the most citations were written by D.G. Liebermann, L. Katz, M.D. Hughes, R.M. Bartlett, J. McClements, I.M. Franks, with a total of 195 citations. The second most cited article, with 67 citations, is by M. Papastergiou. The third most cited article, with 59 citations, is by M. Papastergiou, V. Gerodimos, P. Antoniou. Table 2 describes the documents that get the most cites.

Table 2. Top 10 articles with top cites and most relevant

Cites	Authors	Title	Year
195	D.G. Liebermann, L. Katz, M.D. Hughes, R.M. Bartlett, J. McClements, I.M. Franks	Advances in the application of information technology to sport performance	2002
67	M. Papastergiou	Enhancing Physical Education and Sport Science students' self-efficacy and attitudes regarding Information and Communication Technologies through a computer literacy course	2010
59	M. Papastergiou, V. Gerodimos, P. Antoniou	Multimedia blogging in physical education: Effects on student knowledge and ICT self-efficacy	1996
43	R. Kretschmann	Physical education teacher subjective theories about integrating information and communication technology (ICT) into physical education	2015
39	B. Zhou	Smart classroom and multimedia network teaching platform application in college physical education teaching	2020
35	P.A. Hastie, A. Casey, A.-M. Tarter	A case study of wikis and student-designed games in physical education	2019
35	T. Weir, S. Connor	The use of digital video in physical education	2021
22	L. Pan	A big data-based data mining tool for physical education and technical and tactical analysis	2019
20	D. Li, C. Yi, Y. Gu	Research on College Physical Education and Sports Training Based on Virtual Reality Technology	2021
19	X. Huang, X. Huang, X. Wang	Strategy for improving the footballÂ teaching quality by AI and metaverse-empowered in mobile internet environment	2021

Top Keywords

From a total of 864 keywords, 28 were obtained that appeared frequently with the criteria of at least five occurrences. Based on figure 5 of the available visualisation overlays, the top author keywords are related to sports education technology information, namely "information technology" with 82 occurences and 75 total link strength. Followed by "physical education" with 81 occurences and 71 total link strength, and "college physical education" with 19 occurences and 18 total link strength. Other important keywords include "multimedia technology," "computer technology," "application," "big data," "sports," "sports teaching," and "students". Figure 5 also shows that "big data", is the most recent keywords used by the authors since 2021. These keywords show that the authors explore the use of technology and data in the fields of physical education and sports education to improve training techniques, performance analysis, and overall learning outcomes.

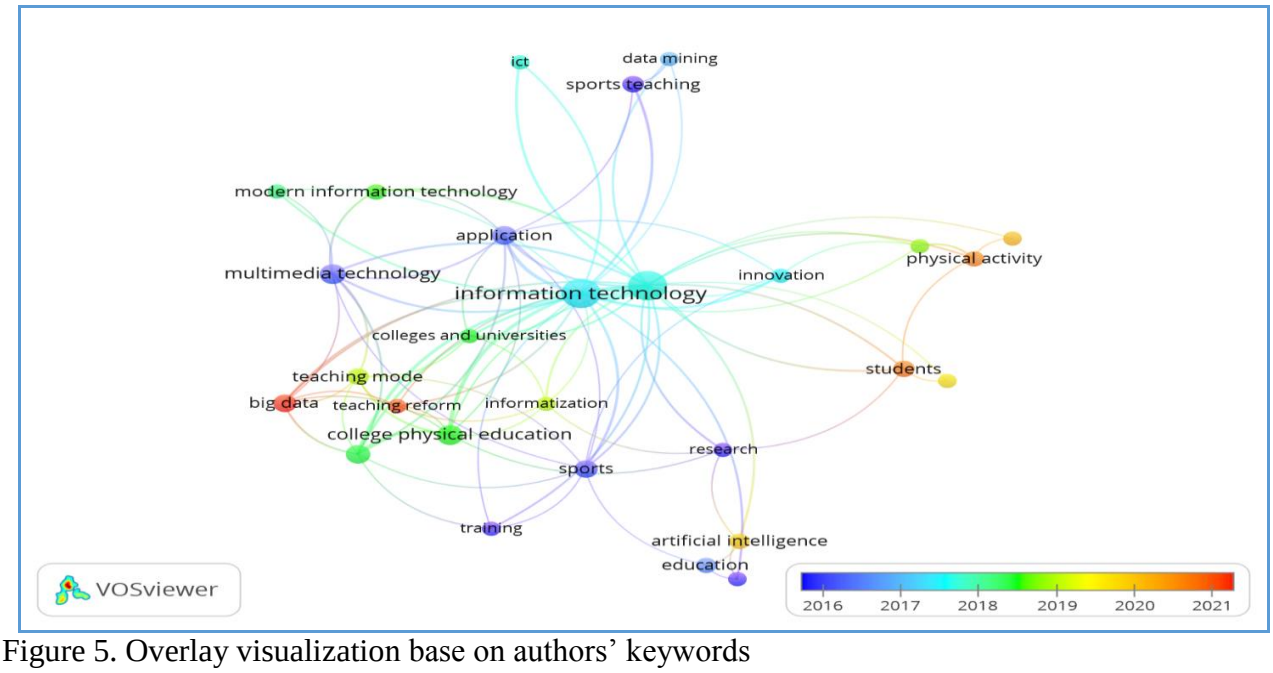

Figure 5. Overlay visualization base on authors' keywords

DISCUSSION

The increasing number of technology-related publications in sports education indicates a growing interest in this area, which can be attributed to the significant advances in technology that have allowed researchers to explore new ways to improve athletic performance (Pan, 2021), monitor health and fitness (Tjønndal & Røsten, 2022), and enhance the fan experience (Zhang et al., 2022). These developments demonstrate how technological research in sport education will continue to be essential in determining the direction of sport. Based on the trend of publication stability it's conceivable that researchers are starting to build a more substantial knowledge base in the subject (Kim & Kim, 2020). As information technology in sports education advances, there are countless prospects for greater study and development.

A bibliometric examination of 242 publications pulled from the Scopus database revealed an increase in technology research in sports education since 1996. More publications have been made over time, with 2021 recording the most publications. According to the study's findings, the bulk of the documents were produced in English and published as articles or conference papers. This highlights the relevance of technology research in sports education as a current academic hot topic and in the context of modern sports. Technology use in sports can significantly improve player performance, health tracking, and training (Holzinger et al., 2014). However, there are also challenges associated with the use of information technology in sports, such as concerns about data security and privacy. More research is therefore needed to resolve these challenges and fully utilize information technology in sports education.

The results of a bibliometric evaluation of 242 publications pulled from the Scopus database show how varied technological research in sports education is. Computer science is the subject area that has the most documents. Research in this field emphasizes the significance of information technology development and application in sports, notably in terms of training, health monitoring, and improving student performance in learning sports. The use of information technology in sports education also presents some difficulties, including concerns about data security and privacy. To address these issues and fully utilise information technology in sports education, more study is therefore required. The research focus of these sources also helps to explain their significance. For instance, whereas the Journal of Physics Conference Series promotes the use of information technology in sports education, Theoretical and Practical Fizicheskoy Kultury concentrates on health and fitness in sports. The range of subjects covered in technology research in sports education is demonstrated by these sources. The findings demonstrate that the range of the top resource titles for technology research in sports education reflects the interdisciplinary nature of the research. Because technology research in sports education crosses disciplinary boundaries and covers fields like physics, engineering, computer science, and education, the variety of top source titles is indicative of this. The future directions of technology research in sports education and the prospective effects of these results on the sports industry can be better understood by further examination of the source titles.

According to the study's findings, China has the most publications and is the top nation for technological research in sports education. This demonstrates that technology research in sports education is an international undertaking that has drawn the attention of researchers from all across the world. Universities, research centres, and other educational organizations from all over the world, particularly from China and Russian Fedration, were the study's top affiliations. Researchers, decision-makers, and members of the industry who are interested in working with or supporting research at these universities can gain knowledge from these findings. Guangdong University of Foreign Studies, for instance, finished as the study's top affiliate with three documents. For scholars, decision-makers, or business stakeholders looking to collaborate in the area of information technology in sports education, this institution may be an appealing option.

The top 10 papers about information technology in sports education, as determined by citations, are displayed. With a total of 195 citations, the paper by D.G. Liebermann, L. Katz, M.D. Hughes, R.M. Bartlett, J. McClements, I.M. Franks that explores advances in the application of information technology to sport performance has the most citations. The second-most cited article, by M. Papastergiou, discusses the use of enhancing physical education and sport science students' self-

efficacy and attitudes regarding information and communication technologies through a computer literacy course and has 67 citations.

The results of the study reveal that in their investigation of sports education technology, the authors' most commonly used terms were "physical education" and "sports education." This shows that technology's role in physical education and sports is the subject of the majority of studies. Research also highlights the use of "multimedia technology," "artificial intelligence," and "big data" in the context of physical education and sports. This demonstrates that the authors are investigating various technologies to improve performance analysis, training approaches, and student learning outcomes. The use of technology in sports education can increase student interest and participation while helping them understand the material better (Soltani & Morice, 2020). In addition, the study shows that some of the most recent terms in research on sport education technology are "big data," "data mining," and "accelerometer." This demonstrates that a growing topic of academic interest is data utilisation in physical education and sports.

These findings demonstrate the variety of academic fields that are represented in research on technology in sports education. This exemplifies the growing understanding of the value of technology in sport and its potential to enhance sports education performance in learning process, enhance health outcomes, and spur innovation in the sports sector. The findings of this analysis may help to direct future research in this field and suggest new areas for study.

Conclusions

Several inferences can be made based on the outcomes of a bibliometric examination of publications in sports education that deal with technology. First, there have been more publications, which shows a growing interest in the area. This is connected to technological developments that allow academics to investigate fresh approaches to boost athletic performance, track health and fitness, and improve the spectator experience. Second, this study reveals a pattern of stability in publications between 2010 and 2020, suggesting that scholars are starting to create a more substantial body of knowledge in this field. Third, the study of information technology in sports education is interdisciplinary, encompassing fields like computer science, physics, engineering, and education. Fourthly, China is the top-ranking nation in this study, followed by the Russian Federation and Ukraine. Fifth, a number of technological applications in sports instruction are highlighted in the most-cited articles, including the employment of a computer literacy course, multimedia blogging, ICT self-efficacy, smart classroom and multimedia network teaching platform applications, digital video, a big data-based data mining tool, virtual reality technology, and artificial intelligence. The most popular terms, which include multimedia technology, computer technology, application, big data are a reflection of the research's emphasis on the application of information technology in physical education and sports.

The limitation of this research is that it only uses one database, namely Scopus; there may be many relevant articles from other databases, such as Google Scholar, which has a larger number of documents. Another limitation is determining keywords. The keywords we determine may not summarise all the expected data. So, our recommendation for future research is to combine a larger collection of databases so that it will be possible to obtain more and more new information for analysis. Apart from that, selecting keywords is also important to get more accurate metadata.

The use of information technology in sports education has shown a lot of potential for enhancing student performance in the learning process, keeping track of fitness levels, and spurring new developments in the sports education sector. To fully realize the potential of technology in sports, issues like privacy and data security must be resolved. The analysis' findings shed light on current research trends and their prospective effects, and they can operate as a roadmap for future study and development for academics, decision-makers, and business stakeholders.

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Conflicts of Interest

The authors state that there is no conflict of interest.

Ethics Statement

This article is the result of research using bibliometric analysis. So an ethics statement is not needed.

Author Contributions

Study Design, HH, AAP and ALK; Data Collection, HH, DS and EP; Statistical Analysis, HH and EP; Data Interpretation, HH and DS; Manuscript Preparation, HH, DS and EP; Literature Search, HH, DS and EP. All authors have read and agreed to the published version of the manuscript.

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