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Artificial Intelligence and the Metaverse in Sport: Emerging Trends and Future Directions from a Bibliometric Analysis

Sporda Yapay Zekâ ve Metaverse: Bibliyometrik Bir Analizden Ortaya Çıkan Eğilimler ve Gelecekteki Yönelimler

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ABSTRACT

In recent years, artificial intelligence (AI) and metaverse technologies have found applications in areas such as athlete performance analysis, fan engagement and virtual event management, leading to a growing volume of research in these areas. The aim of this study is to reveal the bibliometric profile of scientific research on AI and metaverse in sports and to increase the knowledge at the intersection of these disciplines by analyzing scientific production and trends in this field. For this purpose, 255 publications on AI and metaverse in sports between 1992-2025 in the Web of Science (WoS) core collection in the period of October 2024 were examined by bibliometric analysis technique. As a result of the analysis, it was concluded that scientific studies on AI and metaverse in sports have increased over the years and attracted more and more attention. Especially the high scientific production in 2022 and the high citation rate in 2013 revealed the potential and importance of these fields. It is possible to say that this study is important in terms of identifying new research/application areas, emphasizing international collaborations, providing important information/data for academia/the sports industry, encouraging interdisciplinary approaches, guiding future studies and contributing to the relevant literature. In future studies, it is considered necessary to conduct more research on AI and metaverse in sports and to develop practical projects. In this context, it is recommended to conduct research to explain the effects of AI and metaverse technologies on sports and how these technologies can be used in sports organizations.

Keywords: *Sport management, Technology Management, Digital technology, AI, Metaverse*

ÖZ

Son yıllarda, yapay zekâ ve metaverse teknolojileri sporcu performans analizi, taraftar katılımı ve sanal etkinlik yönetimi gibi alanlarda uygulama alanı bulmuş ve bu alanlarda giderek artan bir araştırma hacmine yol açmıştır. Bu çalışmanın amacı, sporda yapay zekâ ve metaverse ile ilgili bilimsel araştırmaların bibliyometrik profilini ortaya koymak ve bu alandaki bilimsel üretim ve eğilimleri analiz ederek bu disiplinlerin kesişim noktasındaki bilgi birikimini artırmaktır. Bu amaç doğrultusunda Ekim 2024 döneminde Web of Science (WoS) çekirdek koleksiyonunda 1992-2025 yıl aralığındaki sporda yapay zekâ ve metaverse konulu 255 yayın bibliyometrik analiz tekniği ile incelenmiştir. Analiz sonucunda sporda yapay zekâ ve metaverse ile ilgili bilimsel çalışmaların yıllar içerisinde artış gösterdiği ve giderek daha fazla ilgi gördüğü sonucuna ulaşılmıştır. Özellikle 2022 yılındaki yüksek bilimsel üretim ve 2013 yılındaki yüksek atıf oranı, bu alanların potansiyelini ve önemini ortaya koymuştur. Bu çalışmanın yeni araştırma/uygulama alanlarının belirlenmesi, uluslararası iş birliklerinin vurgulanması, akademi veya spor endüstrisi için önemli bilgiler/veriler sunması, disiplinlerarası yaklaşımların teşvik edilmesi, gelecekteki çalışmalara yol gösterici olması ve ilgili literatüre katkı sağlaması açısından önemli olduğunu söylemek mümkündür. Bundan sonraki çalışmalarda sporda yapay zekâ ve metaverse konusuna yönelik daha fazla araştırma yapılması ve uygulamaya dönük projelerin geliştirilmesinin gerekli olduğu düşünülmektedir. Bu bağlamda yapay zekâ ve metaverse teknolojilerinin spor üzerindeki etkilerini ve bu teknolojilerin spor organizasyonlarında nasıl kullanılabileceğini açıklamaya yönelik araştırmaların yapılması önerilmektedir.

Keywords: *Spor yönetimi, Teknoloji Yönetimi, Dijital teknoloji, Yapay zekâ, Metaverse*

INTRODUCTION

Sport is a physical, spiritual and mental activity aimed at protecting and improving human health. Today, sport plays an important role in the development of countries (Ulusoy et al., 2019). At the same time, sports is an important sector that attracts millions of people, where a large amount of income can be earned and a large number of people are employed, and in this respect, it is constantly growing and developing by utilizing new technologies (Microsoft Edge AI, 2023). This has led to the use of digital technologies in the management and organization of many sports branches such as football, gymnastics, athletics, tennis, swimming and archery (Şentürk and Özer, 2022). For example, AI is used for match analysis in football, motion capture is used to optimize performance in gymnastics, and real-time biometric data tracking is used in swimming. The most important of these technologies are AI and metaverse. AI is a technology that enables a computer or machine to use the cognitive skills of human intelligence such as reasoning, problem solving, inference and generalization (Arslan, 2020). The metaverse is the virtual world reality that creates added value with digitalization, and this technology brings together virtual interactions, games, social experiences, and commercial opportunities, offering various opportunities for users to create, share, and economically profit from their digital assets (Dertli and Dertli, 2023a; Dertli and Dertli, 2024a). Nowadays, AI and metaverse are technologies that have the potential to lead to significant changes and developments in sports nutrition, physical activity and exercise habits, and to have a great impact on both technical and social dimensions in the sports world. AI and the metaverse offer advantages in sports injury prevention and rehabilitation, performance analysis and improvement, training and coaching, social connections and motivation. AI and metaverse provide a more effective and efficient training experience by providing personalized nutrition plans and exercise programs to improve athletes' performance. In addition, interactive training and data analysis in virtual environments support athletes to achieve their goals and contribute to the adoption of innovative approaches in the sports industry. However, AI and the metaverse offer advantages in sports injury prevention and rehabilitation, performance analysis and improvement, training and coaching, social connections and motivation (Dertli and Dertli, 2023b). AI analyzes athletes' performance data to identify their strengths and weaknesses. Thus, special training programs can be created for athletes to optimize their performance. AI-supported coaching systems help athletes improve their techniques by providing instant feedback. In addition, trainings in the metaverse enable athletes to apply their theoretical knowledge in practice (Gençoğlu and Asan, 2023). Based on these explanations, it can be said that AI and metaverse are technologies that facilitate sports management and organization activities. It can be seen that these technologies are utilized especially in the planning and decision-making processes of sports.

When the relevant literature is examined, it is seen that there are many studies that separately address the connection of sports with AI and metaverse (Alaeddinoğlu et al., 2023; Dindorf et al., 2023; Hu et al, 2022; Kalkan, 2021; Kim and Kim, 2024; Mehra et al., 2024; Sanabria Navarro et al., 2024). Despite this, few studies have addressed the connection of sport with AI and the metaverse. Dertli and Dertli (2024) examined the effects of AI and metaverse technologies in digital transformation processes in football. Yılmaz (2024) compared the effects of metaverse and AI technologies in the fields of recreation and sports and examined the research trends in both fields and the interactions between these fields. Based on this result, a study was planned to examine the research on AI and metaverse in sports from a bibliometric perspective. The reason why the concepts of AI and metaverse in sports are discussed together in the research is as follows: They are technologies that have attracted great interest in sports as in every field in the digitalized world in recent years and aim to offer more advanced and interactive digital experiences by complementing each other.

This study aims to analyse the bibliometric profile of scientific research at the intersection of AI and the metaverse in sport, with a focus on identifying trends, collaborations and emerging research areas. This study is considered to be important in terms of identifying new research areas on AI and metaverse in sports, emphasising international collaborations, providing important information for academia and the sports sector, encouraging interdisciplinary approaches, guiding future studies and contributing to the literature.

METHOD

In this study, it was deemed appropriate to use bibliometric analysis technique within the scope of quantitative research method in order to evaluate the course of scientific research on AI and metaverse in sport. According to De Bellis (2009), *"bibliometric analysis is a scientific as well as computer-aided analysis technique that can identify the underlying research or authors and their relationships to cover all publications related to a particular topic or field"* (Han et al., 2020). The most important reason why this analysis technique is preferred is that it can reveal trends and research gaps in certain areas by analyzing scientific publications quantitatively (Dertli and Dertli, 2024b).

In the study, the dataset of 255 publications on artificial intelligence and metaverse in sports between 1992-2025 in the WoS core collection during the period October 2024 was analysed. In the review process, AI and metaverse in sport were searched with the keywords (TI= (Artificial Intelligence* OR AI OR metaverse*)) AND TI=(sport*) in accordance with the research topic. Sankey Diagram, Bibliometrix-R and VOSviewer scientific programs, which are frequently preferred in the bibliometric analysis process, were used to visualize/map the data on 255 publications obtained as a result of the review. In this context, the following parameters were used to filter the analysis process:

- "Quote report"
- "Main information"
- "Annual scientific production"
- "Average annual citation"
- "Three-field plot (keyword-country-keyword plus)",
- "Three-field plot (title-country-summary)"
- "Document types"
- "WoS index"
- "Broadcast language"
- "Open access status"
- "Density map of co-authors' institutions"
- "Authors' productions over time"
- "Author productivity with Lotka's law"
- "Citation network map of documents"
- "Network map of co-authors' countries"
- "Scientific production of countries"
- "World map of countries' cooperation"
- "Thematic evolution"
- "Network map of common words"
- "Word cloud of keyword plus"
- "Word cloud of author keywords"

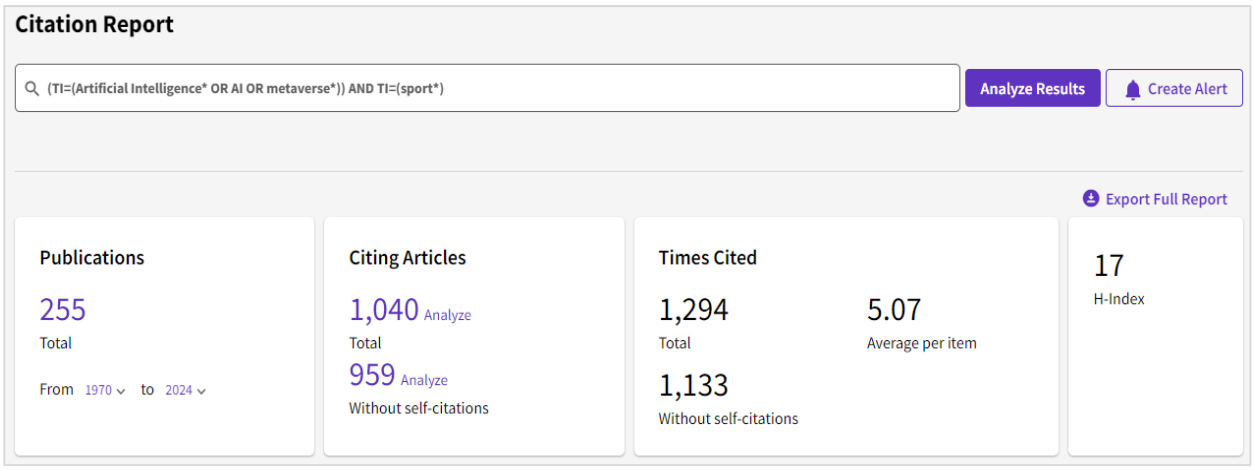
- "Word cloud of titles"
- "Word cloud of abstracts"

RESULTS

In this section, the bibliometric results obtained regarding the publications on AI and metaverse in sports are presented. Since there is no study directly related to the bibliometric analysis of AI and metaverse literature in sports in the relevant literature, no comparison could be made within the scope of this study as in Yenisoy and Hassan (2024)'s research. Figure 1 shows the citation information related to the analysis.

Figure 1

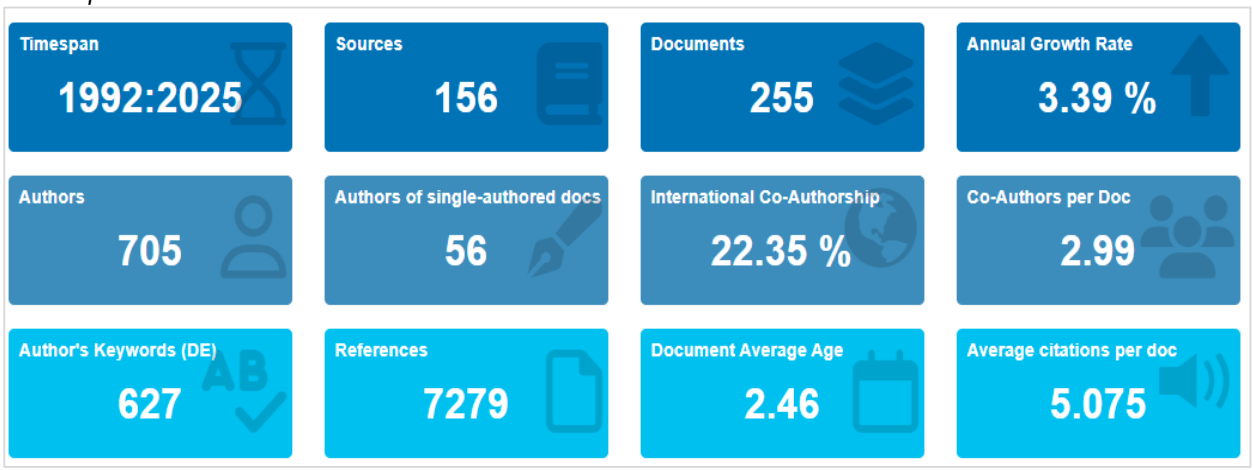
Citation Report



When Figure 1 is analyzed, it is seen that there are 255 publications within the scope of AI and metaverse in sports. Figure 2 shows the main information about the analysis.

Figure 2

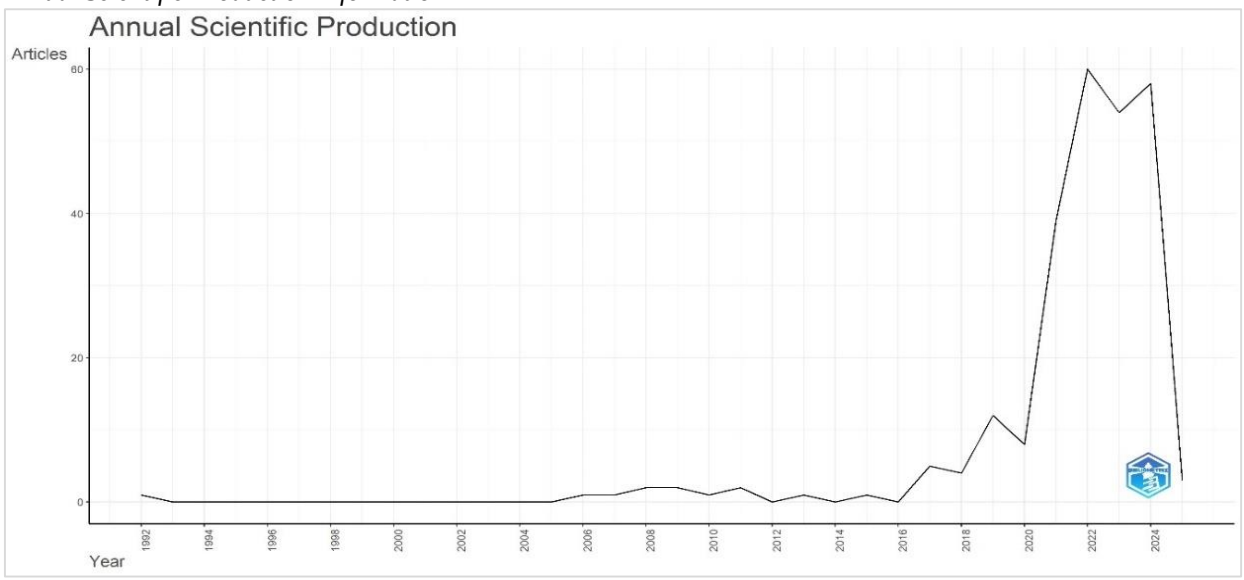
Main Information



When Figure 2 is examined, it is determined that 255 documents, 156 sources and 705 authors produced studies on the related subject between 1992-2025. In Figure 3, scientific production information on the research topic between 1992-2025 is given annually.

Figure 3

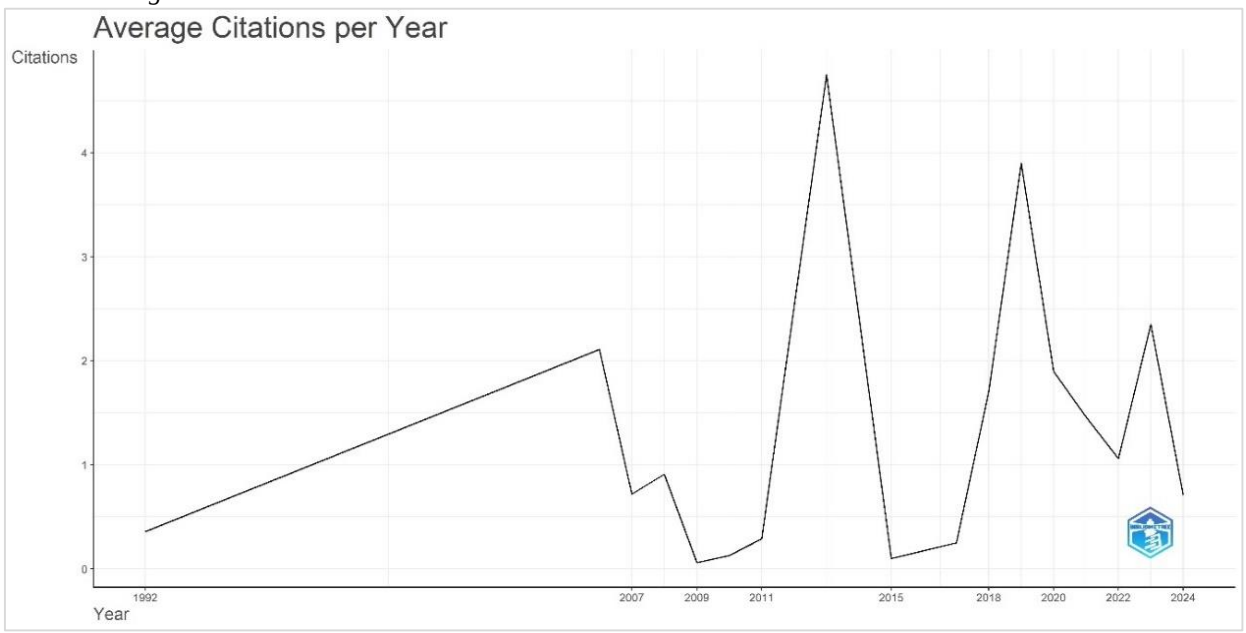
Annual Scientific Production Information



According to Figure 3, it is seen that the highest number of scientific productions related to AI and metadata in sports were made in 2022 (60 studies), 2024 (58 studies), 2023 (54 studies), 2021 (39 studies) and 2019 (12 studies), respectively. Figure 4 shows the annual average citation graph related to the research topic.

Figure 4

Annual Average Citation



As seen in Figure 4, it was found that the studies on AI and metaverse in sports were cited the most in 2013 (rate: 57%), 2006 (rate: 40%), 2019 (rate: 23.42%), 2008 (rate: 15.50%) and 2007 (rate: 13%), respectively. Figure 5 shows the keyword-country-keyword plus data related to the research topic.

Figure 5

Three-Field Plot (Keyword-Country-Keyword Plus)

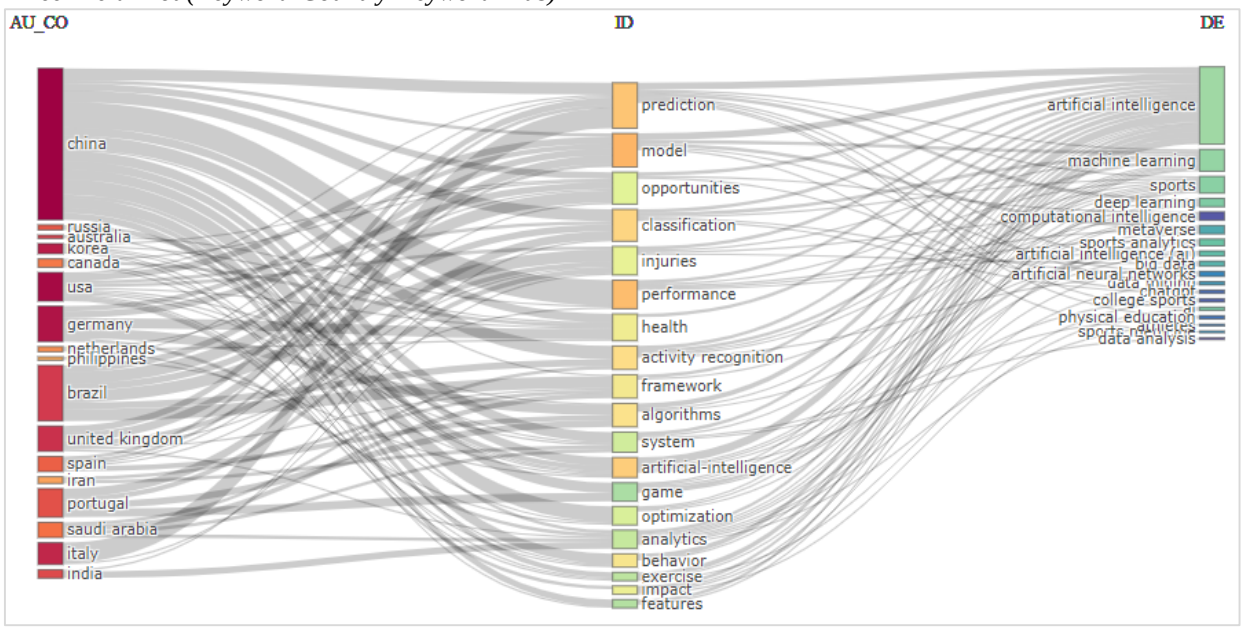


Figure 5 shows that in countries such as China, USA, Germany and Russia, keywords such as “sports”, “AI”, “health”, “injuries” are used more in the field of AI and metaverse in sports. Figure 6 shows the title-country-summary data within the scope of the research topic.

Figure 6

Three-Field Plot (Title-Country-Summary)

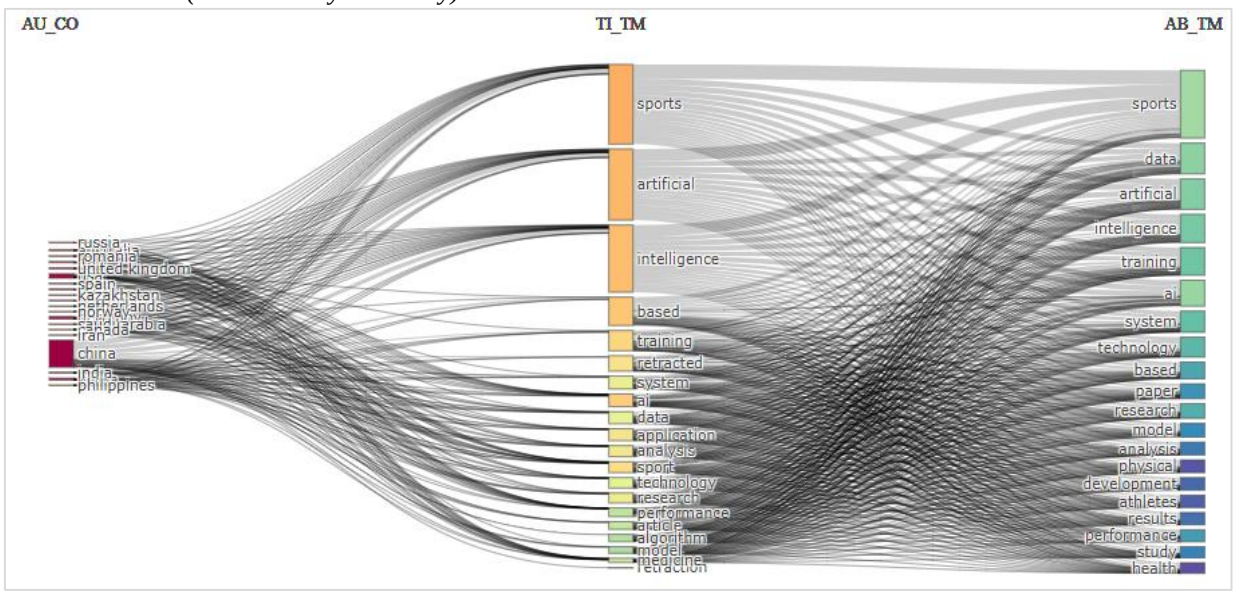


Figure 6 shows that in countries such as Russia, China and the United Kingdom, words such as “sport”, “technology”, “performance” and “health” are used more in titles and abstracts related to AI and metaverse in sports. Figure 7 shows the types of documents within the scope of the research topic.

Figure 7

Document Types

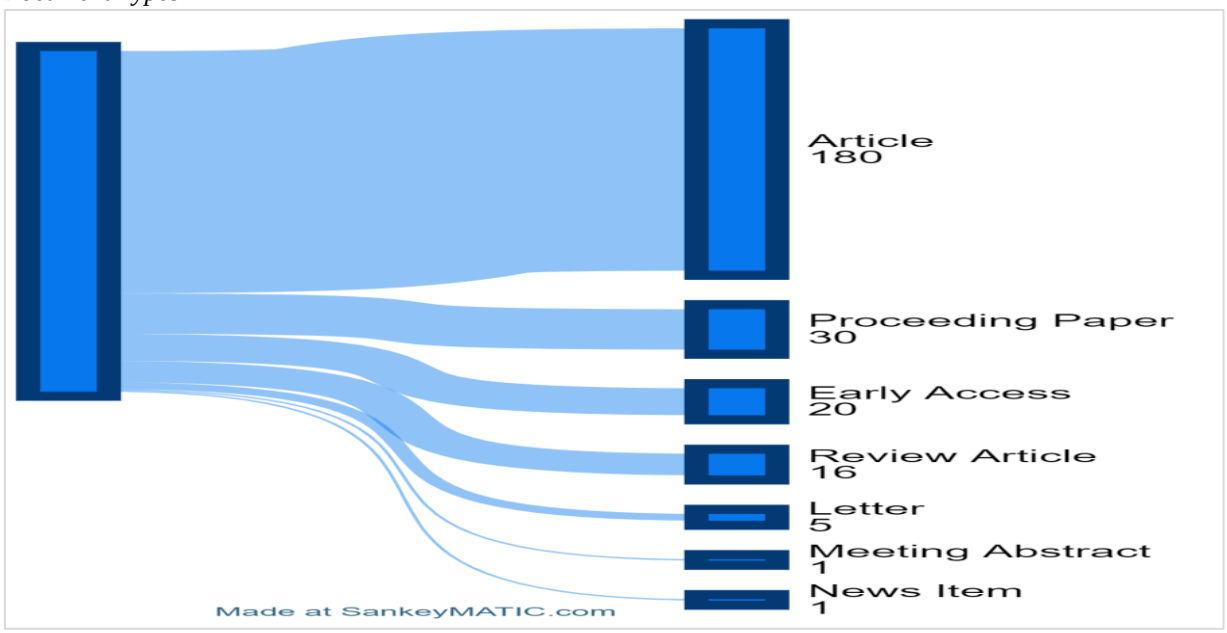


Figure 7 shows that the studies on AI and metaverse in sports are mostly published in the "article" type. Figure 8 shows the WoS index data within the scope of the subject.

Figure 8.

WoS Index

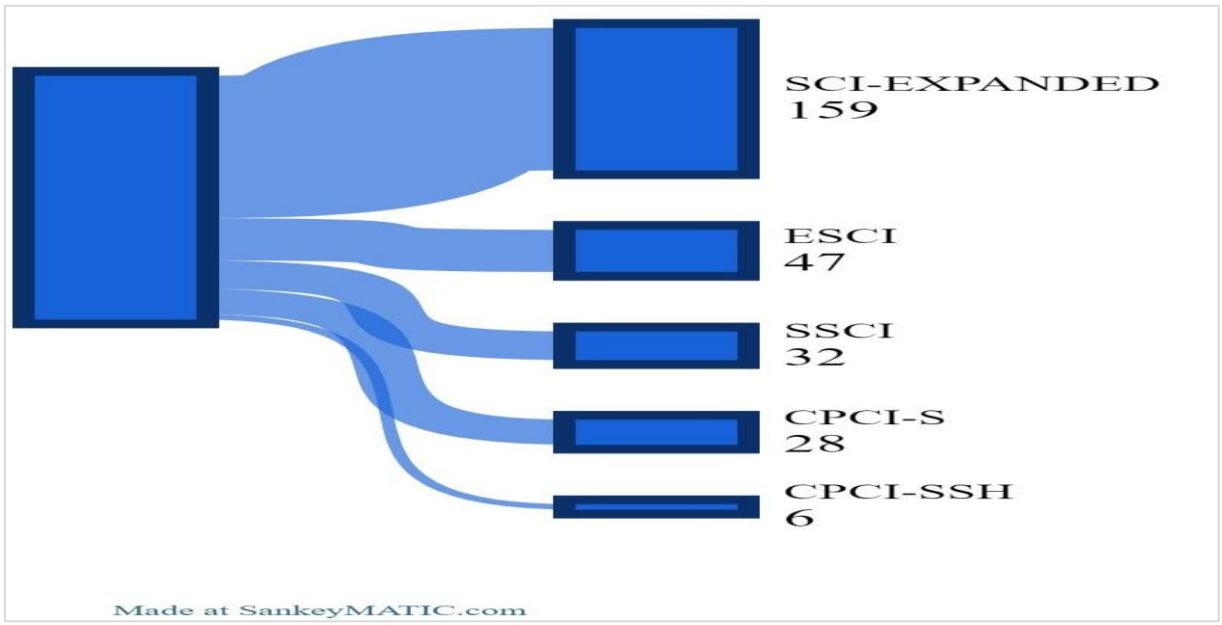


Figure 8 shows that the studies on AI and metaverse in sports are mostly published in SCI-EXPANDED (159 studies), ESCI (47 studies) and SSCI (32 studies) indices, respectively. Figure 9 shows the publication languages of the related studies.

Figure 9

Publication Language

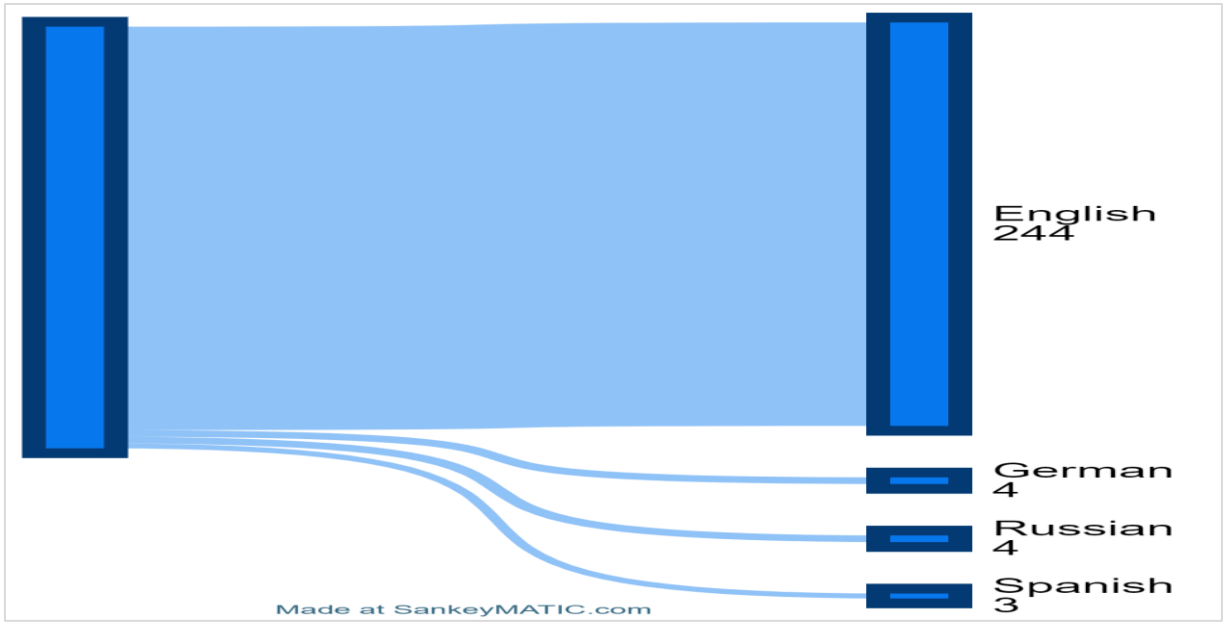


Figure 9 shows that studies on AI and metaverse in sports are mostly published in "English" language with 244 studies. Figure 10 shows the open access status of the studies on the subject.

Figure 10

Open Access Status

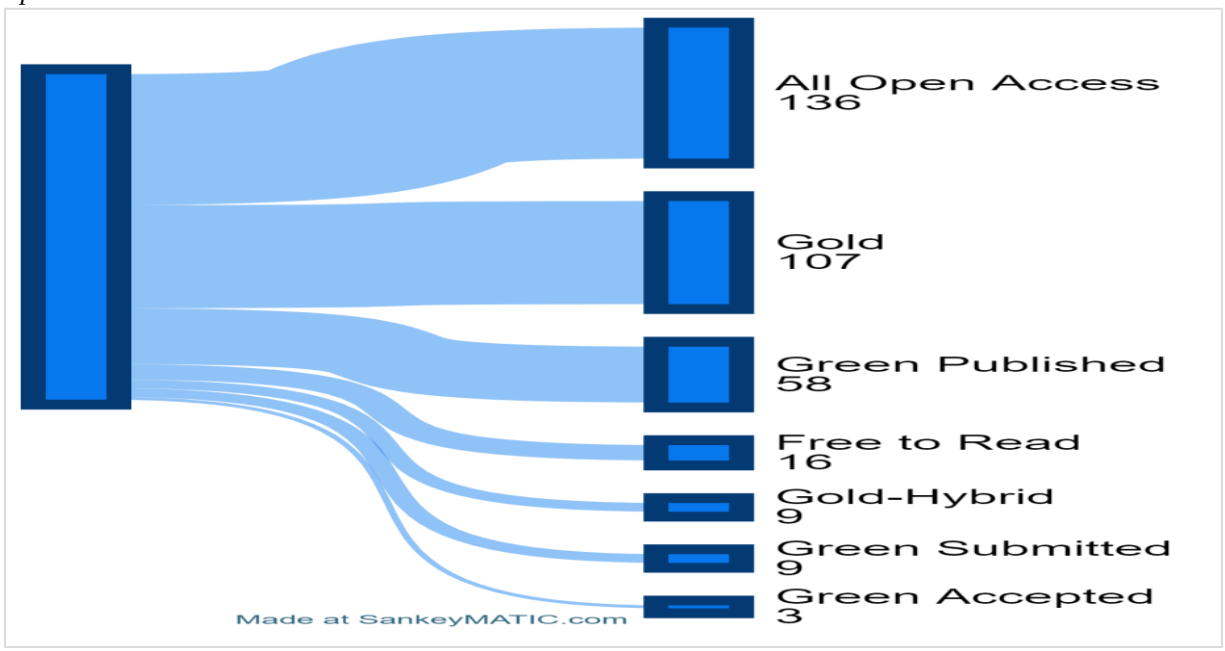


Figure 10 shows that a significant number of studies (136 studies) on AI and metaverse in sports have open access. This result can be said to be an important advantage for sports researchers. Figure 11 shows the density map of the institutions of the study authors.

Figure 11

Density Map of Authors' Institutions

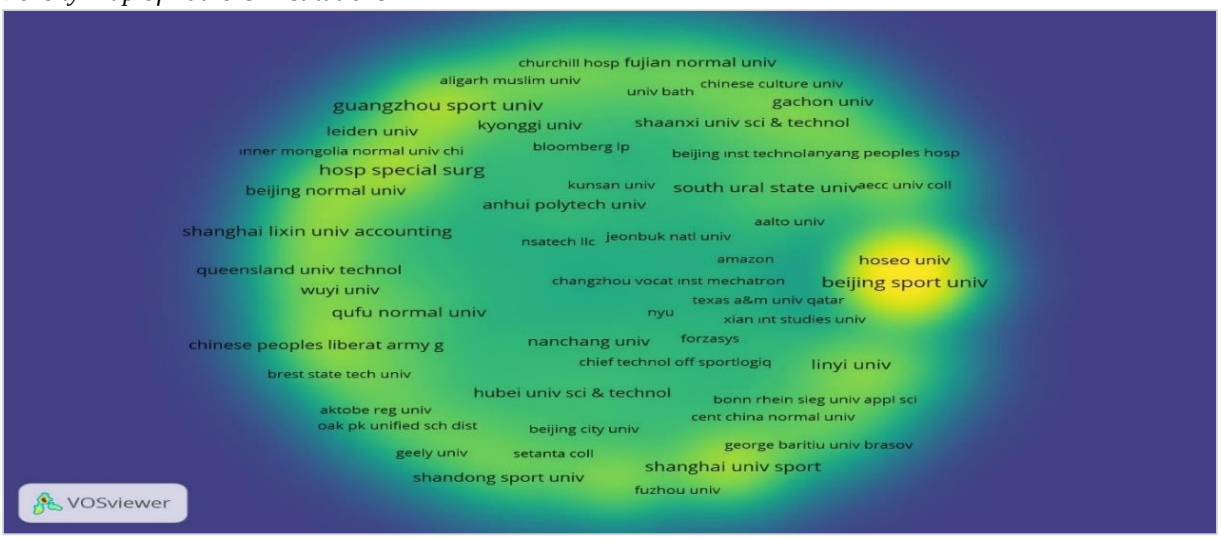


Figure 11 shows that the authors' institutions are listed as “Beijing Sport Univ” (publication: 4, citation: 48, total link strength: 15), “Guanzghou Sport Univ” (publication: 4, citation: 5, total link strength: 6), “Zhengzhou Univ” (publication: 3, citation: 45, total link strength: 15), “Univ South China” (publication: 3, citation: 21, total link strength: 13), “Shanghai Univ Sport” (publication: 3, citation: 144, total link strength: 7), ‘Linyi Univ’ (publication: 3, citation: 10, total link strength: 6), ‘Adamson Univ’ (publication: 3, citation: 2, total link strength: 5), ‘Qufu Normal Univ’ (publication: 3, citation: 4, total link strength: 2), ‘South Ural State Univ’ (publication: 3, citation: 3, total link strength: 3) and ‘Humboldt Univ’ (publication: 2, citation: 29, total link strength: 13). Figure 12 shows the authors' production over time.

Figure 12

Authors' Production over Time

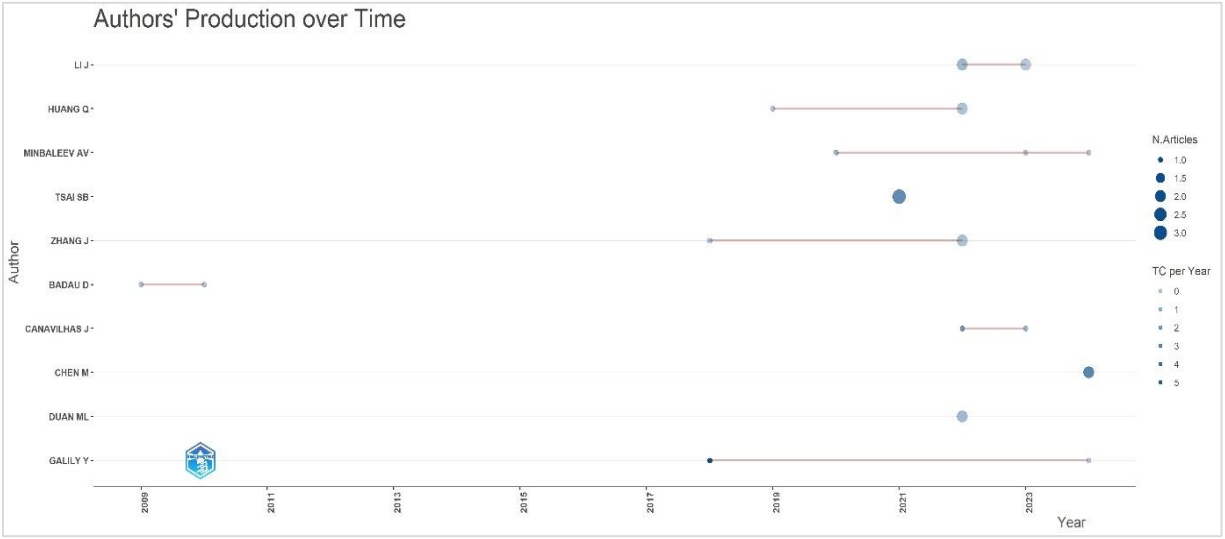


Figure 12 shows that the studies on AI and metaverse in sports are mostly prepared by “Tsai Sb”. Figure 13 shows Lotka's Law and author productivity.

Figure 13

Author Productivity with Lotka's Law

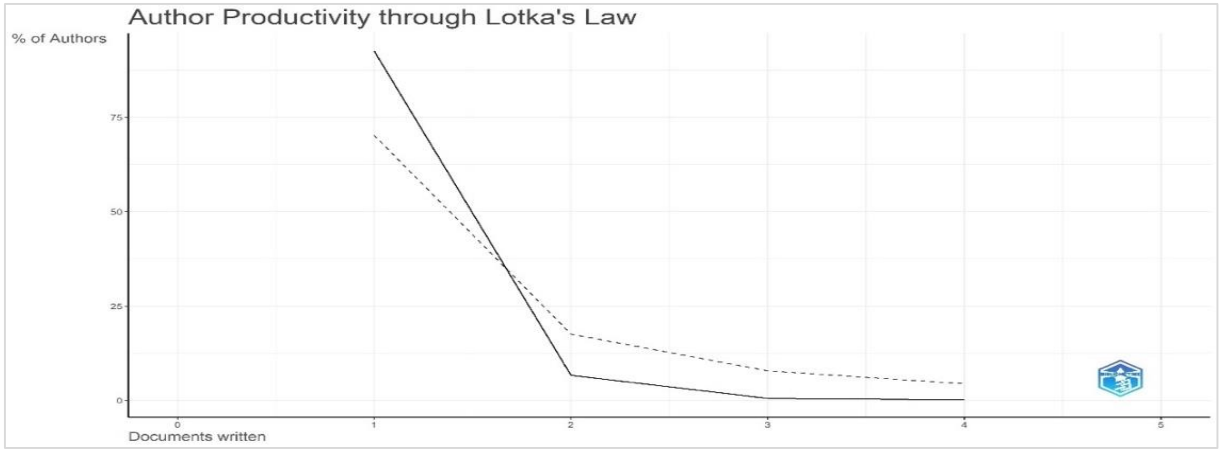


Figure 13 shows that the number of authors of the 1st written document is 653 with a ratio of 0.926, the number of authors of the 2nd written document is 47 with a ratio of 0.067, the number of authors of the 3rd written document is 4 with a ratio of 0.006 and the number of authors of the 4th written document is 1 with a ratio of 0.001. Figure 14 shows the citation network map of the documents within the scope of the research topic.

Figure 14

Citation Network Map of Documents

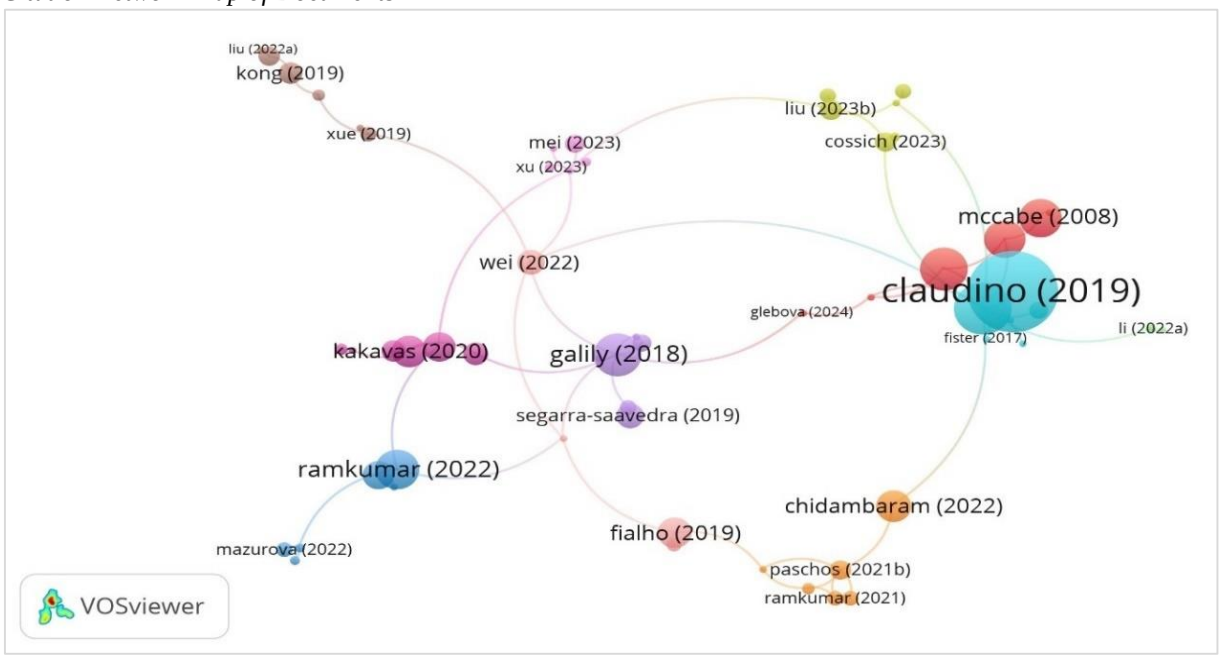


Figure 14 shows that the studies consist of 59 nodes, 11 clusters and 71 links. In this context, it is seen that document citations are 'Claudino (2019)' (citation: 140, link: 1), 'Novatchkov (2013)' (citation: 57, link: 13), 'Barlett (2006)' (citation: 40, link: 3), 'Galily (2018)' (citation: 39, link: 8), 'Ramkumar (2022)' (citation: 33, link: 15), 'Chu (2019)' (citation: 33, link: 2), 'Mccabe (2008)' (citation: 31, link: 2), 'Chamit (2021)' (citation: 29, link: 3), "Kakavas (2020)" (citation: 21, link: 4) and "Chidambaram (2022)" (citation: 21, link: 2). Figure 15 shows the network map of the countries of the study authors.

Figure 15

Network Map of Authors' Countries

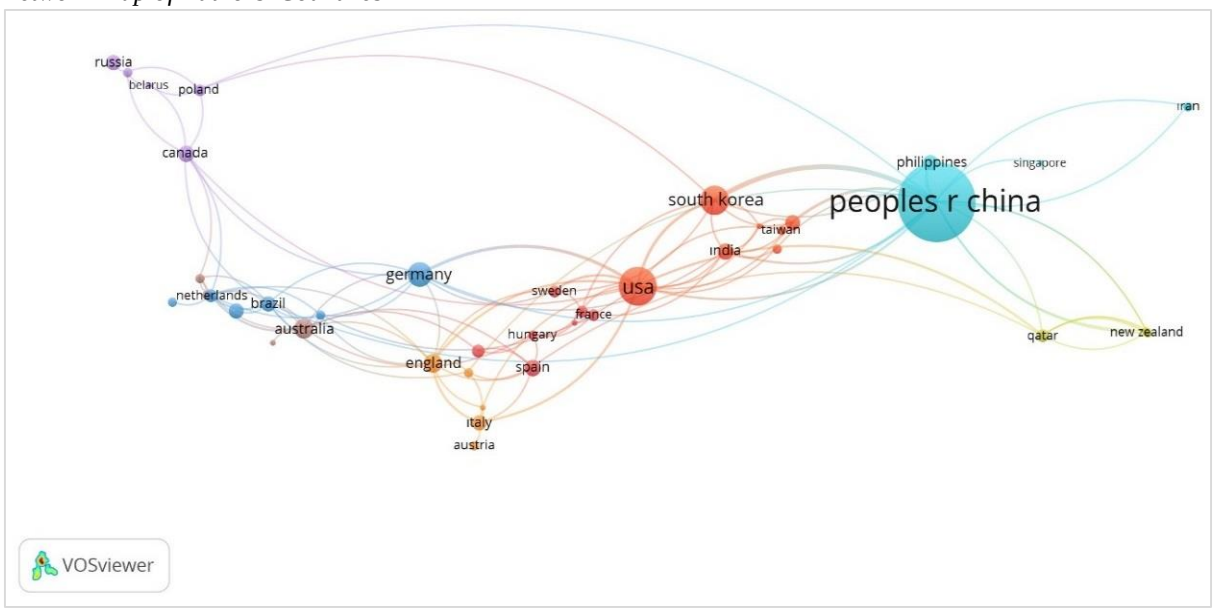


Figure 15 shows that the studies consist of 44 nodes, 8 clusters, 118 links and 144 total link strengths. In this context, the countries of the co-authors are “People's Republic of China” (publication: 135, citation: 557, total link strength: 32), “USA” (publication: 32, citation: 216, total link strength: 26), “South Korea” (publication: 19, citation: 79, total link strength: 19), “Germany” (publication: 13, citation: 147, total link strength: 13), “Australia” (publication: 9, citation: 150, total link strength: 12), “UK” (publication: 8, citation: 182, total link strength: 13), “India” (publication: 6, citation: 15, total link strength: 9), “Canada” (publication: 6, citation: 21, total link strength: 8), “Spain” (publication: 6, citation: 41, total link strength: 7), “Brazil” (publication: 5, citation: 235, total link strength: 11). Figure 16 shows the scientific production map of the countries within the scope of the subject.

Figure 16

Scientific Production Map of Countries

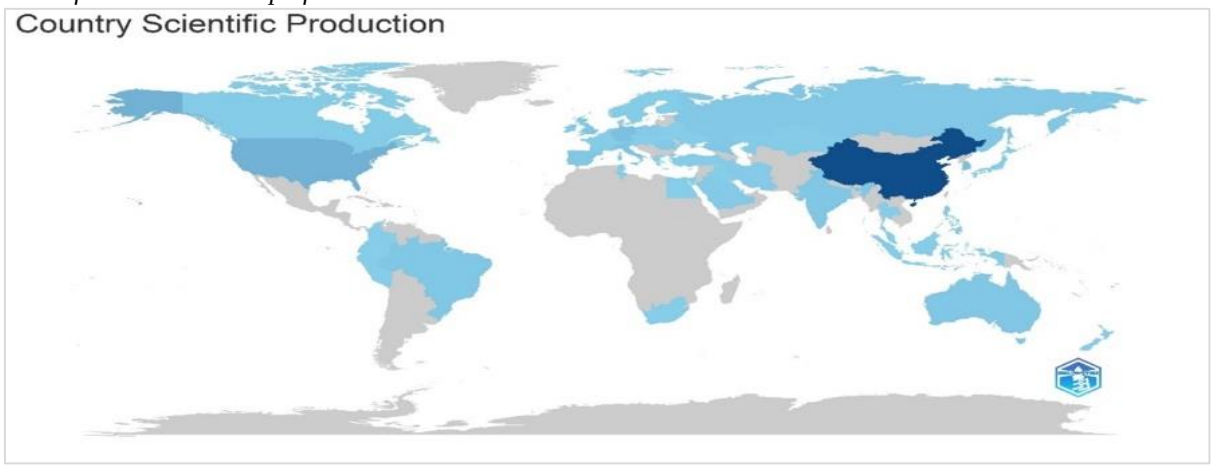


Figure 16 shows that 279 of the studies on AI and metaverse in sports were conducted in “China”, 59 in “USA”, 29 in “Germany”, 26 in “South Korea”. 19 of them were conducted in “Italy”, 18 in “England”, 16 in “Brazil”, 15 each in “Australia” and “India”, and 12 in “Portugal”.

Figure 17

Cooperation Map of Countries

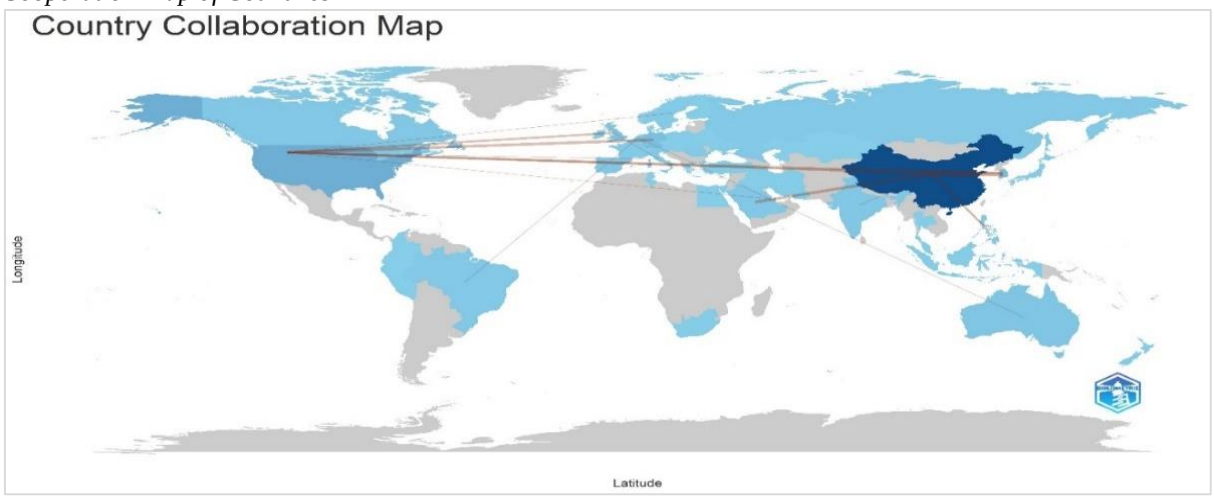


Figure 17 shows that 9 of the publications on AI and metaverse in sports were made in cooperation with "China-Korea", 4 with "China-Saudi Arabia" and "USA-Germany", 3 with "China-Philippines", "China-USA", "USA-Korea", "USA-UK", 2 with "Australia-Netherlands", "Brazil-Netherlands", "China-India". Figure 18 shows the thematic evolution of the studies within the scope of the subject.

Figure 18

Thematic Evolution

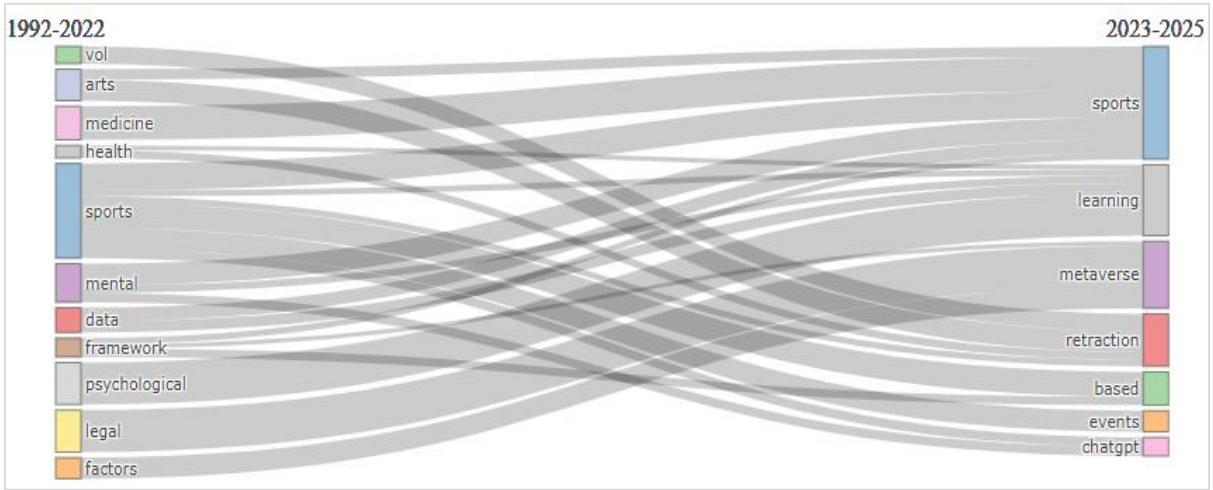


Figure 18 shows the integration of AI and metaverse with sports. In this context, it is seen that the integration of sports with AI and metaverse is progressing as time passes. Figure 19 shows the network map of common words in the related studies.

Figure 19

Network Map of Common Words

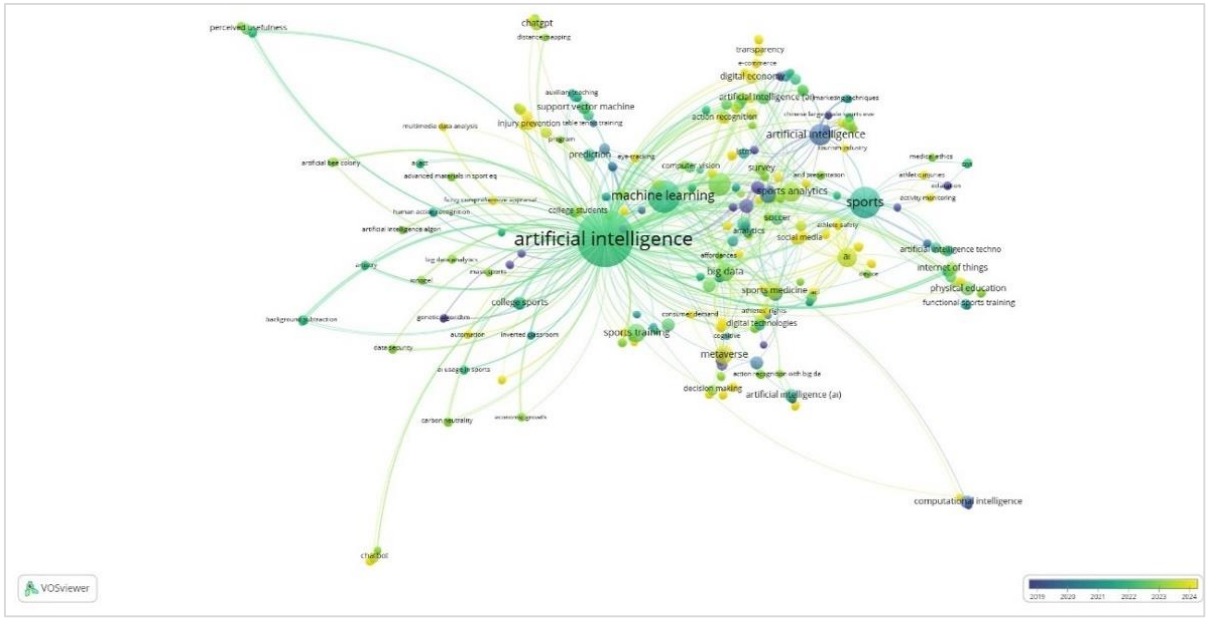


Figure 19 shows that the studies consist of 565 nodes, 67 clusters, 1965 links and 2077 total link strengths. In this context, common words are “artificial intelligence” (publication: 85, total link strength: 381), “machine learning” (publication: 25, total link strength: 125), “sports” (publication: 23, total link strength: 121), “deep learning” (publication: 11, total link strength: 56), “sports analytics” (publication: 8, total link strength: 48), ‘AI’ (publication: 8, total link strength: 41), “big data” (publication: 7, total connection strength: 46), “metaverse” (publication: 7, total connection strength: 37), “sports education” (publication: 7, total connection strength: 23), “sports medicine” (publication: 5, total connection strength: 26). Figure 20 shows the word cloud created based on the keywords of the related studies.

Figure 20

Word Cloud of Keyword Art

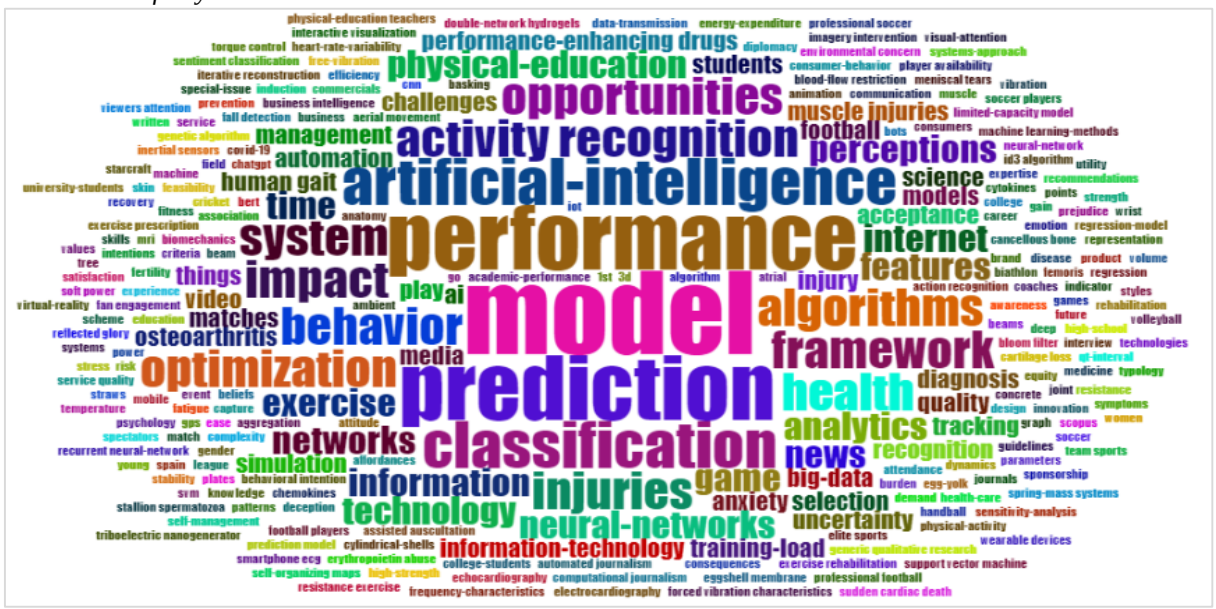


Figure 20 shows that the keywords used in the studies on AI and metaverse in sports are “model”, “performance”, “prediction”, “AI”, “classification”, “health”, “injuries”, “exercise”, “internet” and “game”. Figure 21 shows the word cloud created based on the author keywords of the related studies.

Figure 21

Word Cloud of Author Keywords

Figure 21 shows that words such as “artificial intelligence”, “sports”, “deep learning”, “sports analytics”, “big data”, “metaverse”, “sports medicine”, “athletes”, “physical education” and “football” are mostly used in the author keywords of studies on AI and metaverse in sports. Figure 22 shows the word cloud created based on the titles of the related studies.

Figure 22

Word Cloud of Titles

Figure 22 shows that words such as “sport”, “artificial”, “intelligence”, “education”, “technology”, “health”, “reality”, “students”, “digital” and “metaverse” are mostly used in the titles of studies on AI and metaverse in sports. Figure 23 shows the word cloud created based on the summaries of the studies on the subject.

Figure 23

Word Cloud of Abstracts

Figure 23 shows that words such as “sport”, “articial intelligence”, “data”, “artificial”, “intelligence”, “education”, “technology”, “athletes”, “metaverse” and “health” are mostly used in the abstracts of studies on AI and metaverse in sports. This result is similar to the word cloud of the titles. It can be said that all these findings contribute to the literature on technology management in sport and are in line with the purpose of the study.

CONCLUSION AND RECOMMENDATIONS

AI and metaverse are technologies that lead to significant changes and developments in sports in many areas such as nutrition, activity and exercise. For this reason, it is important to determine the direction of the literature on this subject by examining the studies on AI and metaverse in sport. Therefore, in this study, the bibliometric profile of scientific research on AI and metaverse in sports was tried to be revealed and the results obtained showed that keywords, documents, citations, themes, countries and collaborations related to the subject were prominent.

Within the scope of the study, it was determined that the publications on AI and metaverse in sports were published between 1992 and 2025. This result shows that there is an important research area on AI and metaverse in sports. Therefore, the data set between 1992-2025 is a reflection of the increasing interest and development in the combination of these disciplines. The increase in the number of studies reveals the academic community's efforts to understand the impact of these innovative technologies on sport. Therefore, a more in-depth examination of the potential of AI and metaverse technologies in the field of sport is thought to fill the gaps in this field and guide future research. At this point, it can be said that more studies are needed on the effects of AI and metaverse integration in sports.

The citation rates of scientific studies on AI and metaverse in sports over the years clearly reveal the academic interest and development of these topics. In particular, the fact that the annual scientific production reached the highest level in 2022 reveals the increasing interest in this field and the impact of technological developments in this field. Looking at the average annual citation rates, the 57% achieved in 2013 reveals that this year presented important results and innovations on the topic. The years 2006 and 2008 also have notable citation rates. This shows that the basic concepts and approaches were also identified in the studies conducted in those years. The lower citation rates of the studies conducted in recent years (2019, 2020, 2021) can be said to be due to the fact that the researches conducted in these periods reinforce the existing knowledge rather than innovation.

The cooperation map of countries highlights the dominance of China and its partnerships with countries such as South Korea and the USA and shows a strategic focus on technological advances in sport. Strengthening collaborations with emerging research countries can diversify and enrich the field.

The data for the three-field plot shows that certain keywords are used more in certain countries. In fact, keywords such as “sports”, “AI”, “health” and “injuries” are at the forefront in “China”, “USA”, “Germany” and “Russia”. This reveals that these countries focus on research in the field of sports and technology and conduct in-depth studies on these topics. However, the frequent use of terms such as “technology”, “performance” and “health” in titles and abstracts reveals the applied and practical aspects of the studies.

When the data on the countries of the co-authors, the scientific production of the countries and the cooperation of the countries are analysed, it is seen that ‘China’ ranks at the top with the number of publications and citation power in this field, and this shows that the country is in a leading position in AI and sports research. Collaborations between countries reveal that sharing knowledge and experience at the international level enables the development of innovative solutions by bringing together the expertise of different countries.

The data on word usage shows that keywords such as “AI”, “machine learning” and “sport” are commonly used. In particular, words such as “model”, “performance” and “prediction” appear prominently in most of the studies. This highlights the growing importance of analytical approaches to improve sport performance. It also reveals the role of concepts such as sports analytics and big data in the digitalization of sports.

When all these results are evaluated, it is concluded that scientific studies on AI and metaverse in sports have increased over the years and have attracted more and more attention in academic circles. This result contributes to the accumulation of knowledge on the related subject. Especially the high annual scientific production in 2022 and the high citation rate in 2013 reveal the potential and importance of this field. In the future, further in-depth research on these topics could change the dynamics of the sports industry and contribute to the emergence of innovative practices. Studies for 2025 indicate that research in this field will continue and further develop. In this context, it is extremely important that future studies focus on the digitalization of sports and the integration of AI applications. At the same time, a multidisciplinary approach to research offers great potential for innovative solutions in the fields of sports science, technology and health. In particular, it is thought that studies carried out to increase the performance of athletes and improve their health conditions will increase the importance of scientific production in this field. In this context, it is important to further research AI and metaverse in sports and to develop practical projects in the coming years. On the other hand, due to the nature of bibliometric analyses, only data such as published articles and citations are evaluated, which limits the in-depth examination of the research topic. Therefore, it can be said that it is important to conduct future research using methods such as qualitative analysis or case studies in order to obtain more comprehensive results. However, in order to determine the impacts of AI and metaverse technologies on sport, it is recommended to conduct applied research that combines perspectives from different disciplines and explains how these technologies can be used in sport organizations.

Author Contribution:

1. **Yusuf ESMER:** Idea/Concept, Design, Checking, Data Collection and Processing, Analysis-Interpretation, Writing, Critical Review.

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