Mapping and researching trends in volleyball training methods and technological advancements from 2015 to 2025

Mapeo e investigación de tendencias en métodos de entrenamiento y avances tecnológicos en voleibol de 2015 a 2025

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Abstract

Introduction: The training method in the sport of volleyball has undergone significant transformation along with the development of technology and a deeper understanding of athlete performance. The utilization of advanced tools and software such as data-driven training, video analytics, and fitness monitoring applications has opened up new opportunities in designing more targeted and efficient training programs.
Objective: This study aims to analyze the mapping and trends of training methods and technological advancements in the sport of volleyball from 2015-2025, using Scopus data, identifying collaborations, research gaps, and future study directions.
Methodology: This study uses bibliometric analysis Mapping and trends of training methods and technological advances in volleyball using the Scopus database with the range of 2015-2025. Through the selection process, and analysis according to the criteria, 264 documents with various related themes were obtained.
Results: The results of the analysis and research show that 2024 will have the highest number of publications with 35 publications. The most prolific authors and institutions that contributed the most documents came from Brazil, with 37 publications.
Conclusions: The trend of publication and research focus on volleyball training methods has increased sharply in the last 10 years. Technologies such as machine learning, wearable tech, and video analysis are starting to be integrated, although not evenly. Database expansion and cross-border collaboration are strongly recommended to support the development of more sophisticated and evidence-based training methods.

Keywords

Bibliometrics; international collaboration; artificial intelligence in sports; video analysis.

Resumen

Introducción: El método de entrenamiento en el deporte del voleibol ha sufrido una transformación significativa junto con el desarrollo de la tecnología y una comprensión más profunda del rendimiento de los atletas. La utilización de herramientas y software avanzados, como el entrenamiento basado en datos, el análisis de video y las aplicaciones de monitoreo de estado físico, ha abierto nuevas oportunidades en el diseño de programas de entrenamiento más específicos y eficientes.
Objetivo : Este estudio tiene como objetivo analizar el mapeo y las tendencias de los métodos de entrenamiento y los avances tecnológicos en el deporte del voleibol de 2015 a 2025, utilizando datos de Scopus, identificando colaboraciones, brechas de investigación y direcciones de estudios futuros.
Metodología: Este estudio utiliza el análisis bibliométrico y las tendencias de los métodos de entrenamiento y los avances tecnológicos en voleibol utilizando la base de datos Scopus con el rango de 2015-2025. A través del proceso de selección, y análisis de acuerdo con los criterios, se obtuvieron 264 documentos con diversos temas relacionados.
Resultados: Los resultados del análisis y la investigación muestran que 2024 tendrá el mayor número de publicaciones con 35 publicaciones. Los autores e instituciones más prolíficos que contribuyeron con más documentos provinieron de Brasil, con 37 publicaciones.
Conclusiones: La tendencia de publicación e investigación centrada en los métodos de entrenamiento de voleibol ha aumentado considerablemente en los últimos 10 años. Tecnologías como el aprendizaje automático, la tecnología portátil y el análisis de video están comenzando a integrarse, aunque no de manera uniforme. Se recomienda encarecidamente la expansión de la base de datos y la colaboración transfronteriza para apoyar el desarrollo de métodos de capacitación más sofisticados y basados en evidencia.

Palabras clave

Bibliometría; colaboración internacional; inteligencia artificial en el deporte; análisis de video.

Introduction

The sport of volleyball was invented in 1895 by William G. Morgan in the United States (C. Li et al., 2022; Prasetyo et al., 2024). He developed the game as an alternative to basketball that pays more attention to the physical fitness aspect without too much physical contact between players (Rodríguez Cayetano et al., 2022). The game was originally called "Mintonette" before it was officially renamed "volleyball" in 1896 (Destriani et al., 2022).

The sport of volleyball, with its ever-growing popularity in different parts of the world, has attracted the attention of researchers and practitioners to explore the effectiveness of training methods and the impact of technological advances in improving athletes' performance (Zhongbing Yang, 2023). In recent decades, the sport of volleyball has undergone rapid development, not only in terms of game strategy, but also in the training approaches used to improve athletes' performance (Fauzi et al., 2024; Nešić et al., 2020). This performance improvement is greatly influenced by the application of structured and evidence-based training methods, which take into account various aspects such as muscle strength, endurance, reaction speed, and technical-tactical aspects of the game. Therefore, it is important for coaches, researchers, and sports practitioners to understand the latest dynamics in volleyball training research trends in order to design more effective and efficient training programs (Yin et al., 2022). With the evolution of this sport, the training methods and pedagogical approaches applied by coaches and practitioners have also undergone significant changes. In this context, the period between 2015 and 2025 has witnessed a striking transformation in the way of training, especially with the development of technology in support of practice and evaluation.

Along with technological advancements, the sports training field has begun to adopt various digital innovations such as machine learning, deep learning, wearable technology, and automated video analytics (Ait-Bennacer et al., 2022). These technologies not only allow for real-time monitoring of athletes' performance, but also provide a data foundation for making more accurate and adaptive training decisions (Wan Ahmad et al., 2022). The integration of technology in the context of volleyball has opened up new spaces in research, particularly in evaluating the effectiveness of technology-based training methods and the potential for collaboration between countries in the development of sports science (Shih et al., 2022). The use of this technology not only allows coaches and athletes to monitor and analyze performance in real-time, but also encourages the development of training programs that are more tailored to the individual needs of each athlete (Revathi et al., 2022). In addition, technology supports the collection and analysis of big data, which has the potential to revolutionize conventional training methods and provide deeper insights into the influence of certain variables on performance (Wang & Yu, 2022).

Nevertheless, although the literature on volleyball training is constantly evolving, there are important gaps in the systematic mapping of the direction and intensity of research in this area, particularly with regard to the influence of technological advances on training practices (Marzano-Felisatti et al., 2022). Several previous studies have shown that although technology has great potential to revolutionize training methods, its application is still limited and not evenly distributed across different regions or levels of competition (Zhong & Xu, 2022). This raises the question of whether academia and training have adopted a technology-based approach across the board or whether they still tend to maintain established traditional methods (Andreanova et al., 2020).

Through a study of training trends and technological advances in volleyball that focus on the most dookumens per year, the distribution of authors, the institutions involved, the countries with the most publications. The purpose of this study is to answer research questions. Here to provide a comprehensive overview of training trends and technological advancements in volleyball from 2015-2025:

1. Determine the countries with the most publication contributions in the topic under review.
2. Analyze the distribution of the lead authors and institutional affiliations involved in the study.
3. Identify the number and development of publications per year related to training and technology in volleyball.
4. Unveil the main themes that have been the focus of research over the past decade.
5. Provide a bibliometric basis to guide the research and development of technology-based volleyball training programs in the future.

Therefore, this study aims to conduct a bibliometric analysis of research published between 2015 to 2025 regarding training methods and technological advances in the sport of volleyball. By understanding the scientific map in this field, it is hoped that it can make a significant contribution to the development of a more modern and effective technology-based volleyball training program.

Method

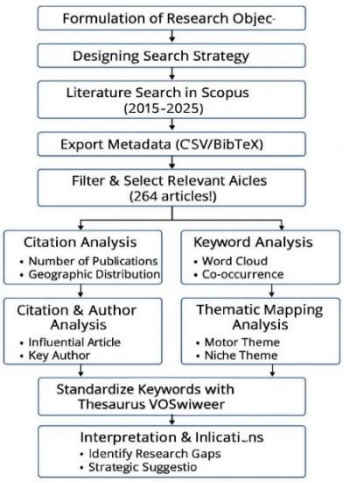
This study uses a bibliometric analysis approach to map research trends in the field of training methods and technological advances in the sport of volleyball during the period 2015 to 2025. Bibliometric analysis is a quantitative method used to evaluate, measure, and visualize the structure of scientific knowledge based on publication metadata. This method was chosen because of its ability to identify research dynamics, collaboration between researchers, as well as themes that develop over time (Mamani-Jilaja et al., 2023). Data was collected from a trusted academic database, Scopus (www.scopus.com), through a systematic search strategy using keywords such as "volleyball," "training methods," and "technology in the sport of volleyball,". The search was limited to publications published between 2015 and 2025, either in the form of journal articles, conference proceedings, or literature reviews. Search results are then filtered to ensure only documents that are relevant and contain complete bibliographic information are included. There are three components of bibliometrics, namely: (a) bibliometrics as the main domain of bibliometric research and traditionally used as a research methodology; (b) bibliometrics for the discipline (scientific information), given that the researcher works scientifically oriented, his interests affect his field of specialization and allow for the existence of a borderland along with quantitative research in the search for information; (c) bibliometrics for policy and management science, which is the domain of research evaluation on various research topics (Salinas-Ríos & García López, 2022).

Several data analysis techniques are used to uncover trends and patterns in Descriptive analysis is carried out first to map the trend of publication and its geographical distribution, providing insight into the countries and regions that are most active in publishing research related to volleyball training (Astuti et al., 2024; Ghani et al., 2020). Data visualization using tools like Biblioshiny provides a clear representation of key trends. Furthermore, keyword analysis was conducted using word cloud to identify the topics that came up most frequently, with key themes such as athletic performance, muscle strength, and volleyball dominating the análisis (Arnau-Mollá & Romero-Naranjo, 2022; Setiawan, 2023).

Additionally, citation analysis is used to highlight the most influential articles and authors in this field (Muppidi & Thammi Reddy, 2020). The Country Collaboration Map is used to illustrate patterns of international collaboration, showing the extent of collaboration between countries in this research área (Chen et al., 2023). Finally, thematic mapping analysis was conducted to classify research topics into four categories: Motor Themes, Basic Themes, Niche Themes, and Emerging or Declining Themes, which helped identify the most dominant and growing themes, as well as those that were declining or re-emerging (Velez-Estevez et al., 2022).

Next, in the results of the study, the researcher looks at the topic that represents the concept to be re-researched. For keywords that are not standardized or irrelevant to the study, the researcher uses the thesaurus available on the Vosviewer item tool to help standardize existing research concepts or terminology (Keskin et al., 2024; Sokolova, 2022). Next, bibliometric analysis looks at impact factors and citations, collaboration patterns, dissemination tactics, and reports on the production of scientific papers (Lazarides et al., 2023). Then the exposure of the data includes the source of the publication, the impact factor of the publication, the keywords used, the research network, and the productivity of the researcher to obtain the picture (Bai & Du, 2022). Furthermore, data collection uses the Scopus database to collect articles on publication development trends (Sofyan et al., 2022). Scopus is chosen as one of the best scientific document databases in the world, Scopus is considered to accommodate more research results and scientific works by academics, practitioners, and researchers who have a good reputation in the fields of education and society. The analysis of this research data was through keywords and filters, which were then processed and examined using the Rstudio program, which was intended to examine trends, scales and clusters of scientific publications about the research (Abbas et al., 2022; Sanabria Navarro et al., 2024). Furthermore, Rstudio as a tool to display and analyze trends in a systematic library review map (H. Li et al., 2020).

Figure 1. Data Selection Process

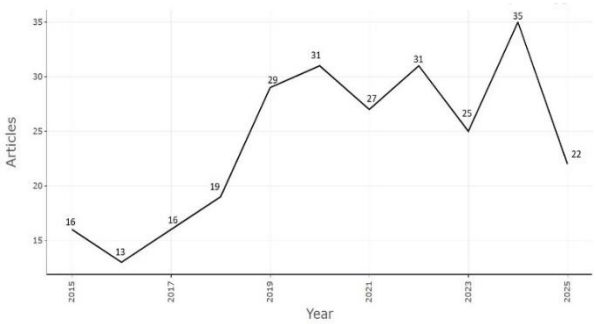


Results

This bibliometric analysis resulted in a total of 264 scientific publications related to training methods and technological advances in volleyball, which were indexed in the Scopus database during the period 2015 to 2025. These results are presented through descriptive indicators and bibliometric visualizations that include publication trends, author collaboration networks, keyword co-occurrence, and thematic mapping of the research. There has been an increase in the number of publications from year to year which shows an increase in academic attention and interest in the integration of technology in sports training. In addition, the analysis also identifies the most prolific authors, leading institutions, as well as the countries with the highest contributions in this field.

Based on the results of identification through the Scopus database in the last 10 years, namely from 2015 to 2025, the trend of research on publication data per year can be seen in Figure 2.

Figure 2. Year-by-Year Documents



The main observation of the data is an increase trend by year, there is a significant upward trend in the number of publications, especially in recent years. This shows the increasing interest and attention to the issue of physical education. The peak of publications, the year with the highest number of publications was 2023 with 35 documents.2022 also shows a high number with 31 documents, while 2024 shows a decrease to 22 documents. Fluctuating in the early years from 2015 to 2019, the number of publications is relatively low, with figures ranging from 2018 to 19 documents. In 2016, there was a decline, recording only 13 documents. A surge in 2022, a drastic increase was seen in 2022 with 31 documents, indicating the possibility of increased research funding, attention from academics, or growing awareness of the importance of inclusive education. The trend analysis, response to issues, increase in publications from 2020 to 2023 reflect the increasing interest of academic and government policies

related to research with the theme of training methods and technological advances in the sport of volleyball. The following is an analysis of the authors who contributed the most to the Scopus journal with the theme of training methods and technological advances in the sport of volleyball. The following visualization can be seen in Figure 3 below.

Figure 3. Documents based on the author of the document

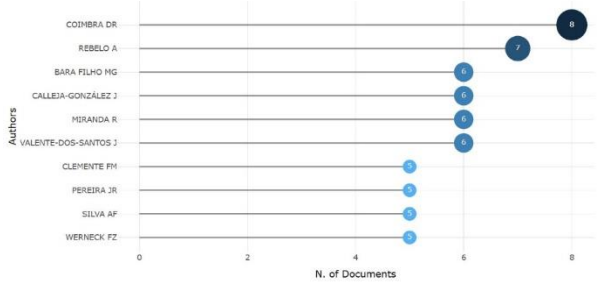


Figure 3 shows a list of the most relevant authors in research on training methods and technological advances in volleyball, based on the number of documents they have published. Here is an analysis of the data shown: Danilo Reis Coimbra is the most prolific author with a total of 8 documents, showing significant contributions in the field of volleyball training methods and the application of technology in training. André Rebelo followed with 7 documents, which also reflect his active involvement in research related to innovation in sports training. Other Authors' Contributions: Authors such as Calleja Filo MG, Julián Calleja-González, Renato Miranda, and João Valente-dos-Santos each have 6 documents. This suggests that there are several important academics who have contributed significantly in this field.

Several other authors, such as Clemente FM, Pereira JR, Silva AF, Wernck FZ with 5 documents each, also made significant contributions, although slightly lower than the top authors. The authors involved in this study likely examined the various training methods used in volleyball. They may delve into specific techniques, performance analysis, as well as optimal strategies to improve the skills of athletes. With the development of technology, especially in data analysis and athlete performance monitoring, the importance of integrating technology in training methods has become more visible. These authors may have researched the use of analytics software, sensors, and monitoring technologies to improve the effectiveness of training and athletes' results. This research could include an analysis of the impact of new technologies in the way coaches design training programs, as well as how technology can help athletes improve their technique and improve their physique.

Next, the researcher analyzed the articles related to the author's affiliation that contributed the most to Physical Education in inclusive schools, which can be seen in Figure 4 below.

Figure 4. Documents by Affiliate

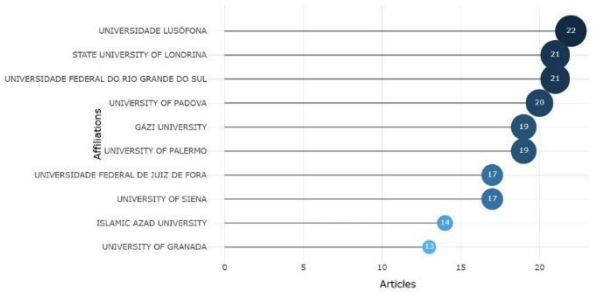


Figure 4 above shows a list of the most relevant affiliates in research regarding training methods and technological advances in the sport of volleyball, based on the number of published articles. Here is an analysis of the data shown, Universidade Lusófona occupies the top position with a total of 22 articles.

This contribution shows that the institution is very active in research related to training methods and new technologies in volleyball. The State University of Londrina and the Universidade Federal do Rio Grande do Sul each contributed 21 articles, reflecting a significant attention to innovative research in the development of training techniques and the use of technology. Other Contributions: The University of Padova and Gazi University compiled 20 and 19 articles, respectively. This shows that these two institutions also have a deep focus on the exploration of training methods and the utilization of technology in volleyball. The University of Palermo, the Universidade Federal de Juiz de Fora, and the University Of Siena with 19 and 17 articles, respectively, demonstrate their efforts in developing knowledge and practice in training techniques and the use of advanced technologies. The institutions with the Lowest Contribution, Islamic Azad University and the University of Granada, with 14 and 13 articles, also showed a commitment to research in this area, albeit with fewer contributions than other universities. Research conducted by these institutions may include the development and evaluation of innovative training methods, technical strategies to improve performance, as well as approaches to adaptive training that take individual athlete factors into consideration. This image highlights the important role of educational institutions in advancing the literature on training methods and technological advances in the sport of volleyball. With significant contributions from various universities, there is an academic community that is active in exploring and developing innovative solutions to improve the training and performance of volleyball athletes.

Furthermore, to map documents in different countries, you can see Figure 5 below.

Figure 5. Documents by Country or Region

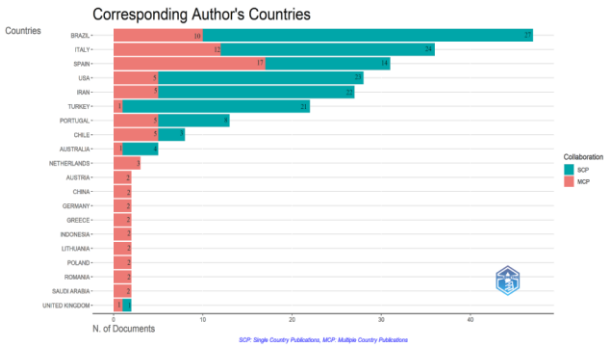


Figure 5 above illustrates the countries that contributed to the research on training methods and technological advances in the sport of volleyball, based on the number of documents published by the authors in question. The following is an analysis of the data presented with this theme, Dominating with 27 documents, showing that this country is a center of research activities related to training methods and the application of technology in volleyball. Brazil's commitment to the development of sport and physical education is very evident through this contribution. Following in second place with 24 documents, it shows strong involvement in research and exploration of various training methods. Italy is known for its strong tradition in sports, and this research may help in improving training techniques. With 17 documents, Spain also showed significant attention in research related to innovation and technology in volleyball training. This reflects the efforts to adapt the latest techniques and methodologies in the sport. The US and Iran, These two countries each contributed 5 documents, showing an interesting research collaboration in applying technology to improve volleyball training methods. Countries such as Turkey, Portugal, and Chile with 2 to 8 documents each also show investment in research relevant to the development of training techniques and technologies.

This graph shows two types of collaborations: Single Country Publications (SCP) and Multiple Country Publications (MCP). For example, Brazil has a high number of documents in both the SCP and the MCP, signifying that there is not only research being conducted locally, but also active international collaboration. This graph highlights the important role of Brazil and European countries in developing research related to training methods and the application of technology in volleyball. The existing collaboration

between these countries demonstrates a global commitment to innovation and improved practice in sport, and creates a foundation for further research in the future.

Figure 6. Thematic mapping documents

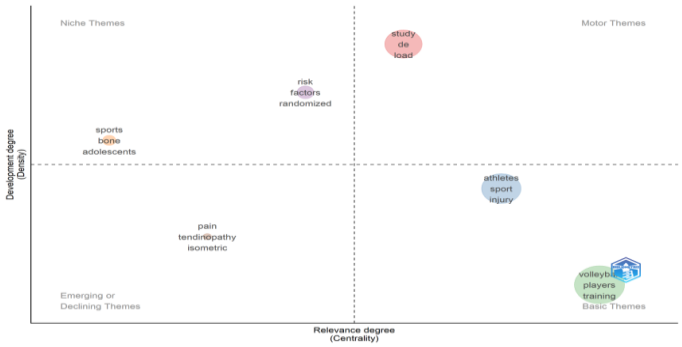


Figure 6 above is a thematic map that shows the relationship between two variables: the degree of relevance (centrality) and the degree of development (degree) of development (degree) of various themes related to research, especially in the context of sport and training. Here is an explanation of the elements shown: Quadrants and Themes: Upper Left Quadrant (Niche Themes): Displays themes that have high relevance but low development rate. Examples in this graph are: "risk factors" "randomized studies" The themes in this quadrant are usually understudied and can be opportunities for further exploration.

Upper Right Quadrant (Motor Themes): These themes show high relevance and high level of development. An example seen here is: "study de load" This theme has grown rapidly and is a major focus in current research, showing great attention from the research community.

Lower Left Quadrant (Emerging or Declining Themes): Displays themes with low relevance and low development rate. Visible examples are: "pain" "tendinopathy" "isometric" These themes may require further review or development to improve their relevance.

Lower Right Quadrant (Basic Themes): Contains themes with low relevance but high level of development. Examples here are: "injury" "athletes" "sports" This theme is well developed but may not have a great impact in the context of recent research. Volleyball-Related Special Theme: Volleyball Players Training: Clearly shown in the graph, this theme is in the lower right quadrant. This suggests that although there is already a lot of research and understanding developing on volleyball player training, it is possible that its relevance could be enhanced through further exploration or adoption of new methods.

This graph provides a clear picture of the status of various themes in the study, especially as it relates to sport and training. This mapping is useful for identifying areas that need more focus in research, as well as themes that are mature and can be used as a basis for further research. Thus, it helps researchers focus on topics that have high impact potential.

Figure 7. Word cloud

Figure 7 above is a word cloud that illustrates the main keywords of bibliometric analysis related to research topics, especially about volleyball and other related aspects. The following is an explanation of the elements in the word cloud:

Dominant Words: Volleyball: By the largest size, this word indicates that the main object of research is the sport of volleyball. This signifies significant attention in research on aspects related to volleyball.

Humans and Humans: It shows a focus on the research subject, which includes athletes and people in the context of volleyball-related studies and physical performance.

Demographics: Adult, Young Adult, Female, Male, Adolescent: These words indicate the focus of the research on a variety of demographic groups, covering age and gender. This is important to understand how those factors affect performance in sports.

Research Aspects: Controlled Study, Randomized Controlled Trial: Showing that many of the studies conducted are controlled studies, important for the validity of the research results.

Athletic Performance: Emphasizes a focus on athletes' achievements and performance in volleyball.

Methodology and Procedure: Exercise Training, Resistance Training, Biomechanics: This indicates that the research covers a wide range of training methods and biomechanical principles relevant to performance enhancement.

Conditions and Factors: Risk Factor, Body Composition, Muscle Strength: It shows that this study also touches on health and physical aspects that can affect athletes' performance.

Conclusion: This word cloud as a whole provides a clear visual picture of the themes and focuses in research related to volleyball. Larger words indicate the relevance and frequency of the word's appearance in the literature, so it can be helpful in understanding the issues being discussed in the research community.

Figure 8. Three courts

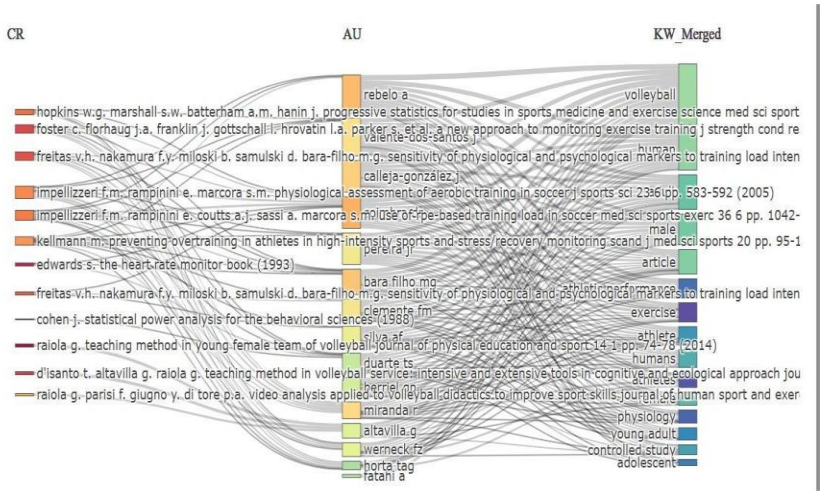


Figure 8 above is the Three-Field Plot, which shows the relationship between the reference source (CR), author (AU), and keyword or topic (KW_Merged) in a study that focuses on volleyball and related aspects. Here is an explanation of the elements in this plot:

Main Element: Reference Source (CR) Column: Displays a list of important documents that are referenced in the study. This includes articles covering teaching methods, research on athlete performance, and training strategies in volleyball.

Each colored bar indicates the importance or relevance of the document.

Author Column (AU): Indicates the name of the author who contributed to the research. These names relate to the documents in the CR column and indicate the author's collaboration and contribution in this field of study. The interconnectedness between the authors and the document reflects their influence on the development of sports theory and practice.

Keywords or Topics (KW_Merged): Summarized keywords indicate the focus of the research, such as "volleyball," "exercise," "human," "athletic performance," and "muscle strength." These keywords give an idea of what is the center of attention in the study, as well as the relevance of the topic in the research conducted.

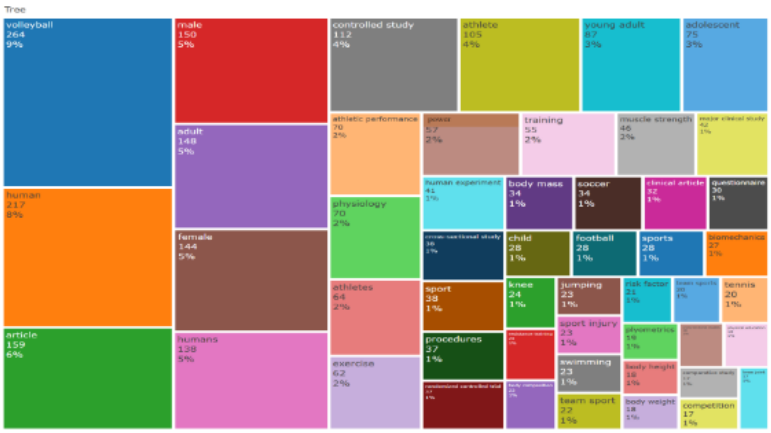
Inter-Column Interrelatedness: Intertwined: The lines that connect between the CR, AU, and KW_Merged columns show the relationship between a particular document, author, and keyword. This indicates that the documents are attributed to specific authors who researched those topics. Intertwined Visualization: Then, more links indicate stronger relationships, indicating that certain documents are often referenced along with specific authors as well as the same theme or topic.

Overall Analysis: Research Focus: This figure shows how research in the field of volleyball is structured, by identifying key documents, key authors, and central themes. It helps in understanding the knowledge networks within this field and identifying individual contributions as well as linkages between different researches.

Insight Brief: By visualizing the relationships between columns, the Three-Field Plot provides useful insights into who contributed to the research and what themes or issues were discussed the most.

Conclusion: The Three-Field Plot is an effective tool for analyzing and describing knowledge in the field of sports, especially volleyball, as well as showing how reference sources, authors, and topics are interrelated with each other. This can help researchers to identify future research directions and collaborations in this field.

Figure 9. Tree Map



The image above is a representation of a tree map that illustrates various keywords related to research in the field of volleyball and related aspects. This tree map presents information about keywords based on frequency, where the size of each box indicates the proportion or percentage of the total keywords captured in the analysis. Here is an explanation of the elements in the image:

Key Elements in the Tree Map: Dominant Keyword: Volleyball (264.9%): Being the largest keyword, indicating the main focus of research on the sport of volleyball. Human (217, 8%): Illustrates that the research subject relates to various aspects of human beings in the context of sport. Article (159.6%): Indicates published research in the form of an article is the most relevant source. Demographics and Age Groups: Male (150.5% and Female (144.5%): Reflects attention to gender in athletic research. Young Adult (87.3%) and Adolescent (75.3%): Highlights the focus of research on specific age groups, demonstrating relevance for development and training. Research Methodology: Controlled Study (112, 4%): Displays the importance of controlled research in the validity of the results obtained. Randomized Controlled Trial (37.1%): A commonly used research method to compare the effects of an intervention. Physical Performance and Training Aspects: Athletic Performance (70.2%): Indicates a focus on physical achievement in sports.

Training (55.2%) and Muscle Strength (46.2%): Illustrates the importance of training in improving muscle strength and athlete performance. Environmental and Psychological Factors: Biomechanics (27.1%) and Risk Factor (21.1%): Demonstrate attention to the technical aspects and risks associated with exercise and participation in sport. Other Activities and Sports: Strength (57.2%) and Soccer (34.1%): Reflect the association with other sports as a comparison in volleyball research. Swimming (23.1%) and Team Sports (22.1%): Indicate other sports that are also studied in the context of performance and physical activity.

Overall Analysis: Frequency Distribution: This tree map provides a clear picture of the research focus within the field of volleyball, with some keywords being more significant and used more frequently than others. Theme Linkage: Integrated keywords indicate that many aspects are related to each other, ranging from socio-cultural contexts, research methodologies, to environmental factors.

Conclusion: This tree map is an effective visual tool for understanding trends and focus in sports research, especially volleyball. By identifying the most frequently occurring keywords, researchers can evaluate who dominates this area of research and what aspects need to be explored further.

Discussion

In this study, the analysis of trends in training methods and technological advances in volleyball conducted between 2015 and 2025 shows a significant picture of the behavior and direction of research in this field (Salim et al., 2020). Through a bibliometric approach, the results obtained provide in-depth

insights and insights related to the evolution of training in volleyball, its influence on athlete performance, and its use in a global context. The main observations show a marked upward trend in publications related to volleyball training methods and technology, with the peak occurring in 2023. This indicates that academic interest in this topic is increasing, perhaps triggered by a recognition of the importance of evidence-based training and technological innovation in improving athlete performance. Also, the surge in publications that occurred post-COVID-19 pandemic signaled a greater concern from researchers and practitioners to leverage technology in training, especially in the context of distance learning that may have increased during the period (Andanaprawira, 2021).

An analysis of the authors and affiliates shows that some prominent academics, such as Danilo Reis Coimbra, made a major contribution to producing important works highlighting the use of technology in training (De Freitas et al., 2019; Duarte et al., 2019). Brazil's dominance in publications shows that the country has a high focus on developing science in the field of sports, especially volleyball. Universities such as the Universidade Lusófona and the State University of Londrina contribute significantly to the progress of research, proving that educational institutions play a key role in the development of science (Rebelo et al., 2024).

The thematic mapping carried out shows the diversity of topics studied, ranging from biomedical aspects to training methodologies (Bailey et al., 2022). The dominance of themes such as "athletic performance" and "training methods" emphasizes the need for a multidisciplinary approach in research. The resulting word cloud also reflects a focus on athlete demographics, training techniques, and risk factors, suggesting that it is important to consider different aspects in designing future research (Tang & Zhang, 2022). However, it is also seen that there are some under-researched themes, such as the use of certain technologies in training, that could be opportunities for further exploration. Despite the progress, the research also highlights gaps in the application of technology in training (Grin, 2022). This shows that although advanced technologies are available, access and application at different levels of competition are still limited. Especially in developing countries or at lower levels of education, training can still be dominated by traditional methods. This underscores the need to develop strategies to integrate technology more thoroughly in training practices, which may include training for trainers on the use of technology in training and competitions (Bilal et al., 2022).

The international collaborations identified in the analysis became an important element in the development of further research. Although Brazil and Italy showed large contributions, other countries, such as Spain, the U.S., and Iran, also showed active participation. This encourages the exchange of ideas and best practices, which can accelerate development and innovation in the field of volleyball training. The development of collaborative networks can increase synergy between researchers and institutions, which in turn will expand the scope of effective research and training practices (Harvey et al., 2023; Meuskens et al., 2020).

Based on the analysis conducted, there are several approaches that can be taken for future research: Exploration of Underresearched Themes: There is an opportunity to conduct more in-depth research on underresearched topics, such as the application of machine learning in the analysis of athlete performance data, or the impact of the use of wearable technology in improving technique and fitness. Comparative Studies: Conducting comparative research on training methods in different countries or cultures can provide new insights into more effective adaptation of specific training techniques. Researchers are also advised to pay attention to athletes' mental health, especially in the post-pandemic era, as part of a comprehensive sports training program. Overall, the research provides a foundation for further development in volleyball training common sense, where the integration of technology and educational innovation will play a crucial role in improving the overall performance of athletes.

Conclusions

This study successfully explains trends and developments in research regarding training methods and technological advances in the sport of volleyball from 2015 to 2025. Through bibliometric analysis involving data from the Scopus database, this study provides in-depth insights into the contributions of authors, institutions, and trends of emerging themes in the literature.

The results of the study show an increase in publications related to volleyball training, with the peak occurring in 2023. This reflects the growing academic interest and attention to studies focused on innovation in training and the application of technology. The dominant authors in this research, such as Danilo Reis Coimbra, contributed substantially, suggesting that there is a group of academics who are actively involved in the development of knowledge in this area.

The institutions with the most contributions, such as the Universidade Lusófona and the State University of Londrina, provide a foundation for research that improves understanding of training techniques and the use of technology in volleyball. Through location mapping, it can be seen that Brazil and Italy are countries with high research activity, showing significant global involvement in the exploration of this topic. The international collaborations identified in this study offer great potential in expanding the thematic and methodological scope of the research. The cross-border exchange of ideas and practices is an important means to enrich a more adaptive, multidisciplinary, and technology-based approach to volleyball training. However, although the adoption of technologies such as machine learning, wearable devices, and video analysis is beginning to appear in the literature, its application is still uneven globally. This shows that there is a gap between academic development and practice in the field, especially in areas or institutions with limited resources. In addition, the limitation of using only one database (Scopus) also indicates that the scope of the study can still be expanded.

Thus, this study not only maps bibliometric trends, but also provides a conceptual and practical foothold to drive a more systematic and innovation-based transformation of volleyball training. Advanced studies with a multidatabase approach, exploration of minor themes, and broader engagement of the global community are highly recommended to strengthen the development of future sports science and practice. Overall, the study provides an in-depth overview of the development direction of volleyball training and the role of technology in improving the effectiveness of training (Astuti et al., 2025).

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