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Bibliometric analysis of shooting skills research: mapping trends and emerging topics in sports science

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ABSTRACT

Shooting skills are an important aspect in various disciplines, including sports, and have attracted widespread attention from academic circles. This study aims to map emerging trends and topics in shooting skill studies over the past four decades using a bibliometric analysis approach. A total of 132 documents indexed in Scopus were analyzed using software such as VOSviewer and RStudio to evaluate publication trends, author contributions, institutional affiliations, country of origin, and frequently used keywords. The results show a significant increase in the number of publications after 2010, with a peak in 2023, reflecting the increasing academic interest in this topic. Authors such as Benton and Kingsley, as well as countries such as China, Indonesia, and the United States, stand out as major contributors. Thematic analysis identified key themes related to motor skills such as stability, accuracy, and agility, while recent trends focus on the use of advanced technologies such as virtual reality. The study also highlights the importance of international collaboration in advancing studies in this field. In conclusion, the integration of technology and interdisciplinary approaches offers great opportunities for developing shooting skill research in the future. These findings provide important contributions to understanding the development of literature in the field of sports science and open new directions for further research.

Keywords: shooting skills, bibliometrics, VOSviewer

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INTRODUCTION

Shooting skills play an important role in various fields, especially sports such as basketball, soccer, archery, and e-sports (Baron et al., 2024; Jiang, 2020; Mizher & Rashid, 2019). This ability not only determines individual success but also contributes significantly to team performance. In a competitive context, shooting is often the deciding factor, making it a highly studied aspect by athletes, coaches, and researchers (Ouyang et al., 2024). In addition, the development of this skill involves complex technical, physical, and psychological dimensions (Quevedo et al., 1999). Therefore, understanding research trends on shooting skills is important to support innovation in training and teaching.

Research on shooting skills has been going on for decades, starting from manual approaches to adopting modern technology (Grgic et al., 2022). In the early days, studies focused on biomechanical analysis to understand optimal movement. Over time, psychological aspects such as concentration and decision-making began to gain

attention (Mittal & Evangelista, 2023; Zhang & Tao, 2023). Technologies such as motion tracking and computer simulation have revolutionized the way shooting skills are analyzed and developed (Roberts et al., 2020; Sevil Serrano et al., 2017). This trend reflects a paradigm shift in sports research, from an intuitive approach to a data- and evidence-based one.

Bibliometric analysis is an approach used to explore and understand research dynamics based on scientific publication data (Eck & Waltman, 2010; Zupic & Čater, 2015). This method allows the identification of trends, dominant topics, and the contributions of researchers and institutions in a field (Herrera-Franco et al., 2020; Md Khudzari et al., 2018). In the context of shooting skills, bibliometrics can help map research developments globally (Donthu et al., 2021; Tibaná-Herrera et al., 2018). In addition, this technique provides insight into international collaboration patterns and the geographical distribution of studies. By utilizing bibliometric analysis, this study can provide a more structured picture of the development of topics in the long term (Van Eck et al., 2010; Van Eck & Waltman, 2014).

The topic of shooting skills was chosen because of its unique role in various sports and the increasing academic interest in this topic. (Habibie et al., 2019). This skill has wide applications, ranging from competitive performance to rehabilitation. In addition, shooting involves a complex combination of physical and psychological abilities that attracts the attention of many disciplines. In-depth research is needed to understand the various factors that influence shooting performance. Thus, this topic offers an opportunity to explore new insights through a more focused and comprehensive approach (Apifa et al., 2020).

A time span of four decades was chosen to provide a broad enough scope to assess the evolution of shooting skills research trends. During this time, methodological approaches, technologies used, and research focus are likely to have changed significantly. This period allows for the identification of changing trends and the influence of external factors such as technological innovation or sports policy. In addition, a four-decade analysis can provide insight into the global impact of this research, both in academic and practical settings. By looking back over 40 years, this article can offer a valuable historical perspective to support future research.

Despite the abundance of research on shooting skills, there are still gaps that have not been fully explored (Widodo, 2018). Some aspects, such as the socio-cultural influence on this skill or the contribution of cutting-edge technologies such as artificial intelligence, often receive less attention (Alkhusaini & Nurhidayat, 2021; Mulya, 2020). In addition, most studies focus on popular sports such as basketball, while other sports are less highlighted. With bibliometric analysis, this study can help identify areas that have not been explored to encourage future research. This approach provides an opportunity to fill the gaps and make new contributions to the existing literature. This study has significant relevance both theoretically and practically. Theoretically, this analysis makes an important contribution to understanding the dynamics of research on shooting skills, including global trends and cross-disciplinary collaborations. Practically, the insights gained can help coaches, athletes, and policy makers to develop more effective training strategies. The results of this study can be used to design new technologies or evidence-based training programs. Thus, this study is not only relevant to the academic community but also to practitioners in the field.

This study aims to provide a comprehensive overview of the research trends in shooting skills based on bibliometric analysis over four decades. This article is

structured systematically, starting from the introduction, analysis methods, findings, to discussion and implications. This study will also provide recommendations for future research based on the findings obtained. With this approach, this article is not only a reference for understanding past trends but also a guide for directing future research. Therefore, this study seeks to answer the following key questions related to shooting skills:
RQ1: What are the research trends related to shooting skills?
RQ2: Who are the most influential authors on the topic of shooting skills?
RQ3: What is the geographical distribution and cooperation between countries regarding shooting skills?
RQ4: How has the topic discussed related to shooting skills developed?
RQ5: What are the recommendations for future research directions related to shooting skills?

METHODS

This research method uses a bibliometric analysis approach referring to Moher's methodology, with the aim of mapping emerging trends and topics in shooting skills research over the past four decades. The analysis process begins with the identification of relevant documents, which is done by searching the Scopus database using keywords related to the research topic. The initial search results produced 178 documents covering various types of publications such as journal articles, conferences, and books. Next, a screening stage was carried out to filter documents based on document type and source type. At this stage, documents that did not meet the criteria for relevance or source quality were filtered, resulting in 154 documents that were more focused on the topic of shooting skills research. After the screening process, the next stage was the eligibility stage, where only documents published in English were considered for further analysis. This eligibility was carried out to ensure consistency and a better understanding of the existing literature. Based on these criteria, 132 documents successfully passed to enter the next stage. Documents that did not meet the eligibility criteria, such as those published in languages other than English, were removed to maintain the quality and completeness of the data. This process ensures that only relevant and understandable studies will be analyzed further. Documents that passed the eligibility stage, namely 132 documents, then entered the inclusion stage.

This analysis was conducted with the bibliometric package of R Studio Software and the web interfaces Biblioshiny and VOSviewer. It is intended to produce a concise and clear data visualization of the most influential authors, the countries that produce the most articles, the most influential and most cited articles, sub-topics of educational transformation, and future research issues that need to be addressed. The bibliometric method involves processing quantitative data, especially through bibliometric data in the form of written publications. There is a useful software, namely VOSviewer to perform graphical visualization of bibliometric data. In the first stage, the main information is displayed. Second, the visualization of the most relevant sources, the most influential authors, and the most cited documents and networks related to collaborations between authors, institutions, and sources is continued with the analysis of countries and keywords. Content analysis is carried out in the second stage as well as interpretation of the results, by examining the top 10 recommended articles. To answer (RQ1) related to the trend of this study, the authors utilize information on

annual scientific production (publication trends), and annual average citations (citation trends). In relation to (RQ2), the most influential authors are seen from the number of the most citations to a document. Insights into the author's country of origin and scientific production and international cooperation have also been discussed (RQ3). In answering (RQ4) the researcher looks at the keywords used by the authors in their documents which will be visualized with 3 approaches, namely: thematic map, thematic evolution, and research novelty. The author also provides recommendations for future research directions and limitations in relation to (RQ5), taking into account the answers to the two previous questions.

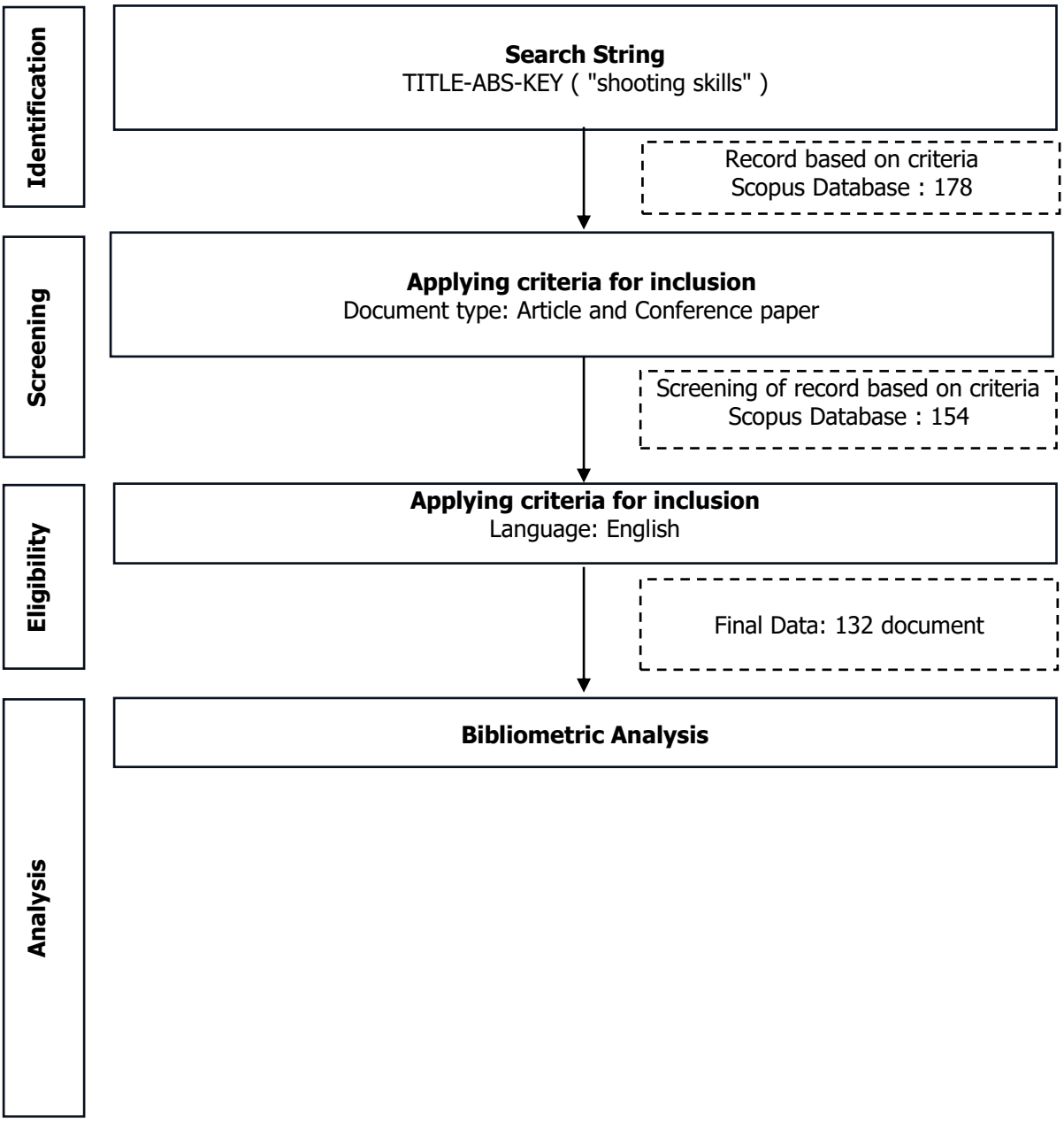


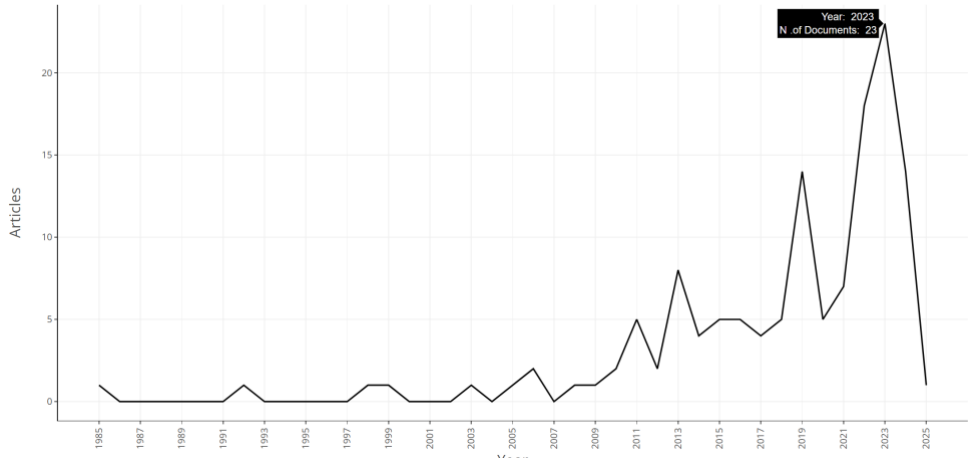
Figure 1. Data Collection Process

RESULTS AND DISCUSSION

Figure 2 provides an overview of the bibliometric analysis of research on shooting skills in sports science during the period 1985 to 2025, based on data processed from 132 documents in Scopus using the RStudio and biblioshiny applications. Of the total documents, 104 sources were recorded with contributions from 428 authors, of which only 19 authors produced documents individually (single-authored). This shows a high level of collaboration in this field, as supported by an average of 3.43 authors per document. In addition, international collaboration reached 20.45%, confirming that research on this topic has a global dimension. The average age of the documents is 5.95 years, indicating that the literature used is relatively new and relevant. With a total of 3,493 references used, each document refers to the literature intensively. The keywords used by the authors as many as 415 indicate the diversity of the topics analyzed. Meanwhile, the average citation per document is 10.89, indicating that this topic has received significant attention from the academic community. Although the annual growth rate shows 0%, this could be due to the data covering projections up to 2025 or research inactivity in certain years.

Figure 2. Main Information

Research Trends



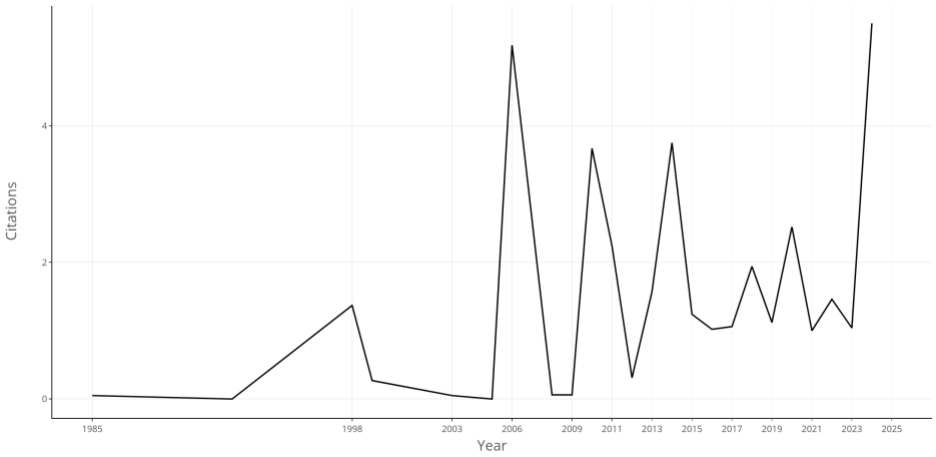


Figure 3. Publication trends (top) and citation trends (bottom)

The first figure shows the trend of research publications on shooting skills in sports science from 1985 to 2025. From this data, it can be seen that publications start to increase significantly after 2010, with a peak in 2023, where there are 23 published documents. This indicates an increase in research interest and activity in recent years, possibly influenced by the development of analytical technology, the implementation of new methods, or increased attention to the development of shooting skills in certain sports. However, the number of documents appears to decrease sharply after 2023, which may reflect the absence of complete data for 2025 or a possible shift in research focus to other topics. The second figure reflects the trend of the average citations per year of published documents. The peak of the average citations occurs in 2024 with a value of 5.5, indicating that documents published during this period have received significant recognition from the academic community. This suggests that research conducted more recently is more relevant and impactful, possibly due to the application of more sophisticated methods or a focus on important issues of global concern. This trend indicates the importance of maintaining the quality of research that is not only topically relevant but also able to attract broad attention from academics and practitioners.

Most Influential Author and Document

Table 1. Authors with the most publications

Authors	Articles	Fractionalized Articles
BENTON, DAVID	3	0.92
KINGSLEY, MICHAEL	3	0.92
RUSSELL, MARK	3	0.92
AZMI, SITI HARTINI	2	0.67
DOEWES, RUMI IQBAL	2	0.67
ELUMALAI, GUNATHEVAN	2	0.67
FAISAL, BAHAA DHYAB	2	0.67
FARROW, D.	2	0.37
HAGARA, LADISLAV	2	1.00
HIRAO, TAKAHIRO	2	1.00

The table above displays the most influential authors in research related to shooting skills based on their number of publications. The three authors with the largest number of articles are Benton, David, Kingsley, Michael, and Russell, Mark, each contributing three articles with a fractionalized value of 0.92. This value indicates their collective contribution in the collaboration of the author team. With the highest contribution, they play an important role in advancing research in this field. In addition, there are a number of other authors such as Azmi, Siti Hartini, Doewes, Rumi Iqbal, and Elumalai, Gunathevan who each have two articles with a fractionalized value of 0.67. Their contributions indicate significant cross-disciplinary collaboration. Interestingly, some authors such as Hagara, Ladislav and Hirao, Takahiro have a full fractionalized value (1.00), indicating that they are the sole author or have full contribution in the published articles. This data reflects the pattern of contribution in research, both through collaboration and individual work.

David, Michael and Mark have always been actively collaborating with a total of 3 joint documents, one of which is the study (Russell et al., 2010)on the development and validation of a skill test that includes shooting as one of the main components. This study shows that the shooting test used not only measures shooting accuracy, but also considers factors such as ball speed and accuracy in targeting moving targets, which reflects real-world situations in matches. By comparing the performance of professional and recreational players, this study revealed significant differences in shooting success, which supports the construct validity of the test. The results obtained provide valuable insights for coaches and players in understanding the technical and tactical aspects of shooting skills, as well as assisting in designing more effective training programs to improve goal-scoring ability. Thus, this article not only contributes to the academic literature, but also has important practical implications in the development of shooting skills on the field.

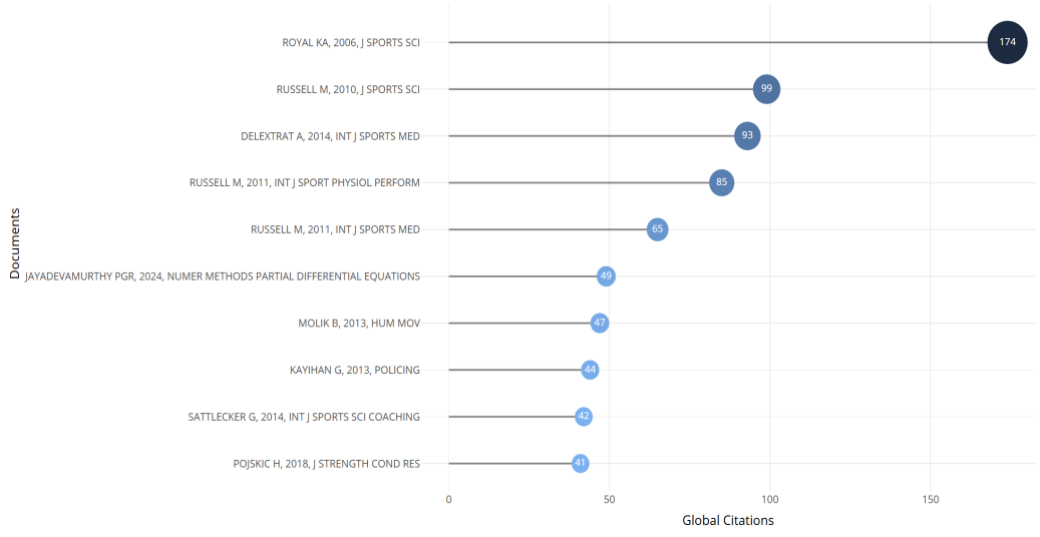


Figure 4. Most Influential Publications

The most influential publication in shooting skills, based on data from Figure 4, is a study written by (Royal et al., 2006)which has been the most cited compared to other articles. Its popularity is due to its deep insight into how fatigue affects athlete performance, especially in the context of water sports such as water polo. This study not only highlights the physical impact of fatigue on shooting skills, but also examines

cognitive aspects such as decision making under pressure. The finding that fatigue can cause a decline in technical skills, even though some elements of technique are maintained, provides a strong basis for further research in the fields of skill acquisition and sport psychology. Furthermore, this study is relevant to the study of shooting skills because it shows that factors such as body position and technique can be maintained despite increased fatigue, which is important for the development of training programs and recovery strategies for athletes. Thus, the contribution of this study to the understanding of the interaction between the physical and mental in sports performance makes it an important reference in the academic literature.

Geographical distribution of publications and cooperation between countries

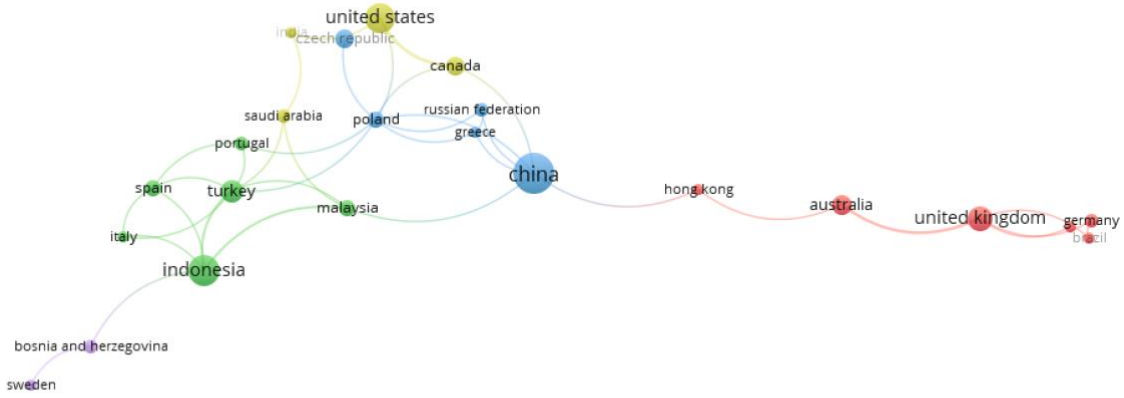


Figure 5. Collaboration between countries

Figure 5 shows the geographical distribution of the number of studies related to shooting skills in the context of sports science, as well as the collaborative relationships between the countries involved. The size of the circles represents the number of documents produced by each country, while the lines connecting the circles reflect the level of collaboration between the countries. China is the country with the largest contribution, producing 23 documents. Indonesia ranks second in this contribution with a total of 14 documents. The larger circles for China and Indonesia confirm the relatively high research intensity compared to other countries on this topic. In addition to the number of documents, the graph also illustrates significant collaboration networks between countries. For example, China has strong connections with several other countries, such as the United States and Poland, indicating international cooperation in research. Indonesia is also connected with countries such as Malaysia and Turkey, reflecting quite active regional collaboration. These collaboration patterns demonstrate the importance of global networks in advancing shooting skills research and provide insight into collaboration trends in the sports science community.

Table 2. 10 countries with the largest number of publications

Country	Documents	Citations	Total Link Strength
China	23	45	3

Indonesia	14	75	5
United States	13	132	4
United Kingdom	9	417	3
Iraq	9	7	0
Turkey	7	101	5
Australia	6	471	3
Canada	5	81	5
Czech Republic	5	17	1
Japan	5	10	0

Based on the data in Table 2, China dominates publications related to shooting skills with the highest number of documents (23) and total citations (45), reflecting its major contribution to global research in this field. The 23 documents focus on the keywords shooting training and shooting actions, while Indonesia and the United States follow with a smaller number of documents (14 and 13) focusing on shooting skills in the performance and decision making sections. The higher link strength in developed countries (such as the United States, England, and Australia with more than 100 total citations) indicates a broader connection in global collaboration compared to developing countries. Developed countries have a greater influence in building global research networks, both in terms of collaboration between researchers and the resulting academic impact. This shows the importance of strong research infrastructure, adequate funding, and access to modern technology and resources in supporting the development of science. On the other hand, although the number of documents from developing countries, such as Indonesia, is relatively smaller, the focus on specific aspects such as performances and decision making reflects the potential to make unique contributions in this field. Efforts to increase international collaboration, research funding, and strengthen academic networks can help developing countries expand their global impact and relevance in the study of shooting skills and sports science in general. This means that cross-country collaboration strategies are needed to support the distribution of knowledge and innovation, so that research in the field of shooting skills can develop more inclusively and multidimensionally.

One of the studies from the United Kingdom was written by (Smith & Bedwell, 2021) which discusses the analysis of goals scored during UEFA Euro 2020 with an ecological dynamics approach in the context of shooting skills training in football. This study aims to understand how players perceive proximity to defenders when receiving passes and when shooting. By analyzing 67 goals scored through one or two touches, the authors found that changes in proximity between the goal scorer and defender can affect the outcome of the shot. These findings suggest that shooting training using static defender positions or stationary equipment may be ineffective, as they do not reflect the dynamics that occur in real match situations. Therefore, this study provides guidance for coaches to design more realistic and dynamic training, where defenders move to create an environment that more closely resembles competition conditions, thereby improving players' shooting skills more effectively.

Research Topic Development

The thematic map in Figure 6, also called a strategic map, represents the position of the authors' keywords and groups them into several study groups (Schöggl et al.,

2020; Zhidebekkyzy et al., 2022). The X-axis shows the significance or centrality of the research topic. The Y-axis represents the density, which measures the development of the theme (Cobo et al., 2011). There are several core clusters, and each quadrant is occupied by one or two primary clusters. Figure 6 illustrates a thematic map with four primary quadrants as follows.

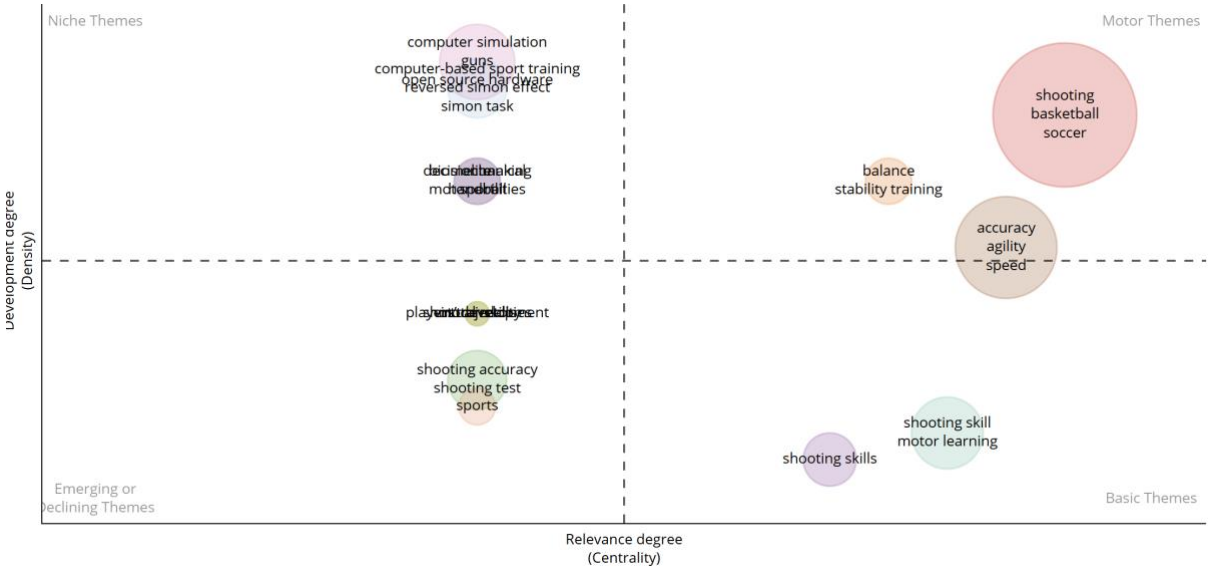


Figure 6. Thematic map

The first quadrant (top right) contains motor themes with a high level of relevance and development, indicating that the research topics in this quadrant are well developed and significant for the field of knowledge. The motor themes are shooting in basketball and soccer, balance, stability training and accuracy. The second quadrant is the top left quadrant, which is also known as a special theme with a high level of density but a low level of centrality or limited significance in the field. The special themes are computer simulation and decision making. The bottom left quadrant, also called the new theme quadrant, contains research topics with low centrality and density, indicating that the development of the topic is limited. Topics included in this cluster include issues regarding virtual reality in shooting accuracy and shooting tests. New themes in this study can continue to develop in the future, but they can also disappear over time. The fourth quadrant on the bottom right is the basic theme quadrant, which includes research topics with a high level of relevance but a low level of development, indicating that these themes are important for a field of study and cover general topics in various fields of research.

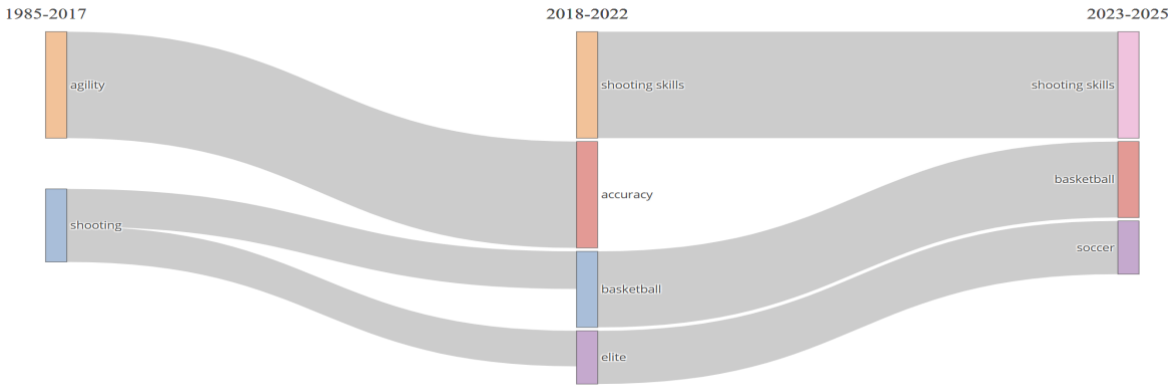


Figure 7. Thematic Evolution

Based on the visualization of research trends shown, in the early period (1985–2017), the research focus was dominated by the themes of "agility" and "shooting," which reflected the need to understand basic skills in sports related to speed of movement and shooting techniques. This theme reflects an era in which sports research still focused on developing basic physical skills that are the foundation for various sports. In the next period (2018–2022), there was a shift in research focus to the themes of "shooting skills," "accuracy," and "basketball," which shows the increasing specificity of research in shooting skills, especially on accuracy and its application in sports such as basketball. The emphasis on "elite" also reflects attention to high-achieving or high-level athletes, indicating that research is starting to be directed to support the needs of competitive performance. Entering the latest period (2023–2025), the theme of "shooting skills" remains the main focus, but with diversification of applications in other sports such as "basketball" and "soccer." This reflects how research trends are increasingly oriented towards the application of shooting skills in various sport contexts, while adapting to the development of more sophisticated data analysis technologies and the demands of the professional sport community. This shift shows an evolution from basic research to a more interdisciplinary and practical approach.

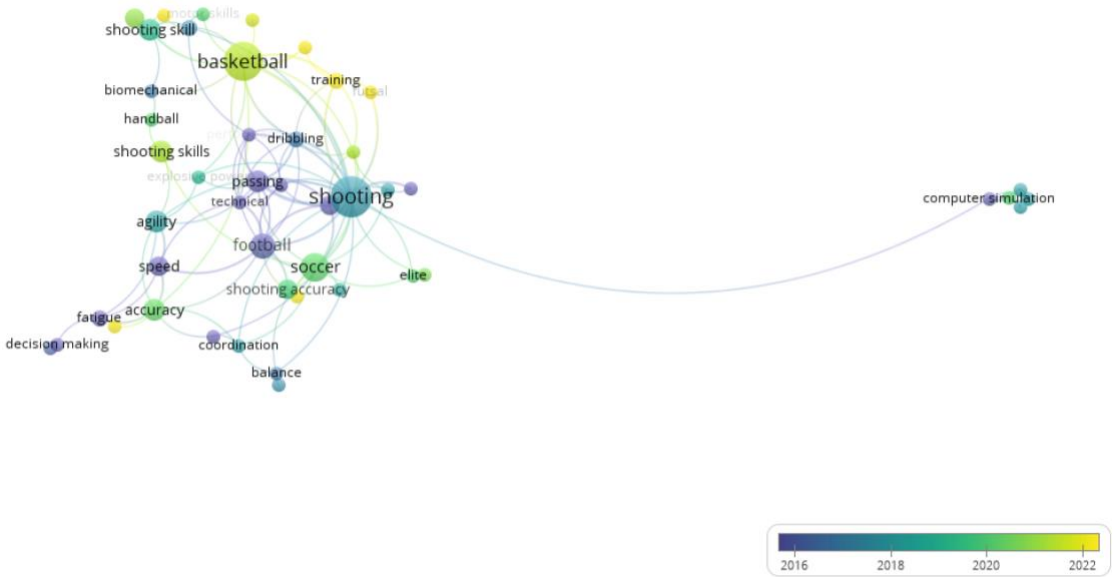


Figure 8. Overlay Visualization

Figure 8 is an overlay visualization from VOSviewer showing the development of keywords in research related to educational transformation. The colors in the visualization indicate the age of the theme emergence, where blue represents older themes (before 2016) and yellow represents newer themes (2022-2024). Keywords such as "shooting test, vu+irtual reality, training, heart rate and futsal" are in the yellow area, indicating that these themes are trending and relevant in current research. The relationship between heart rate and shooting skills reflects the research focus on the relationship between the physiological state of athletes and shooting skills performance (Khalmanskikh, 2016). Heart rate is often used as an indicator of stress levels, fatigue, or physical intensity during sports activities (Arai & Ishikawa, 2024; Souabni et al., 2023). In the context of shooting skills, recent research tends to explore how heart rate variability or increases affect shooting accuracy and consistency, especially in demanding situations such as competitive matches. For example, in sports such as futsal or basketball, high-pressure conditions that increase heart rate can affect concentration, decision-making, and body stability, all of which have a direct impact on shooting performance (Cai et al., 2022; Kayihan et al., 2013). In addition, this theme is also relevant to the use of technology such as virtual reality to simulate match conditions to test players' physical and psychological responses to such pressure (Fedasyuk & Vorobiov, 2023; Sha'lan, 2023; Wu, 2022). Thus, this relationship is an important topic in designing training programs that not only improve technical skills but also players' physiological and mental adaptation.

The results show significant developments in shooting skills research over the past four decades, with trends focusing on various technical, tactical, and physiological aspects. From the bibliometric analysis, an increase in publications began to be seen since 2010, with a peak in 2023, indicating a continued growing interest in this topic. China, Indonesia, and the United States are the countries with the largest contributions, supported by extensive international collaboration, such as the strong relationship between China and the United States. This reflects that shooting skills research has developed into a global effort that covers various sports contexts, such as basketball, soccer, and futsal, with significant influence from research involving modern technologies such as virtual reality.

Thematic analysis and trend visualization reveal the evolution of research focus from basic skills such as "agility" and "shooting" in the early period to more complex and specific themes such as "decision making" and "virtual reality" in the latter period. The study also highlights the importance of physiological and mental adaptations, such as the relationship between heart rate and shooting accuracy, which are now of primary interest. Overlay visualizations show new themes such as virtual reality and shooting tests that are increasingly relevant, supporting the use of technology in simulating real competition conditions. Thus, the study provides in-depth insights into the evolutionary trajectory of shooting skills research, as well as the importance of an interdisciplinary approach that integrates technical, physiological and strategic analysis to support skill development in different sports.

CONCLUSION

This study successfully maps the emerging trends and topics in shooting skill studies over the past four decades, using a bibliometric analysis approach to 132 documents

published in the Scopus database. The results show a significant increase in the number of publications after 2010, with a peak in 2023, reflecting the high academic attention to this topic. The study highlights the major contributions of authors such as Benton, Kingsley, and Russell, as well as the dominance of countries such as China, Indonesia, and the United States in producing related publications. Thematic analysis reveals that motor themes such as stability, accuracy, and agility are the main focus, while recent trends involve the application of advanced technologies such as virtual reality in studying shooting skills. International collaborations, especially between developed and developing countries, underline the importance of global networks in advancing research in this field. This study not only provides in-depth insights into the evolution of the topic and the contributions of key actors, but also highlights future research directions, such as the integration of physiological analysis, new technologies, and interdisciplinary approaches in the development of shooting skills in various sports.

CONFLICT OF INTEREST

All authors declare no conflict of interest in this manuscript.

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