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# Football Performance Analysis Technology: A Bibliometric Study

**Marisca Wahyu Anita*, Mochamad Ridwan**

Physical Education, Health and Recreation Study Prrogram, Universitas Negeri Surabaya

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## Abstract

Sophisticated technology, such as the Global Positioning System (GPS), has been widely used in football. GPS is used to analyze the performance of football athletes. Few journals have discussed football performance analysis utilizing technology, with less than a hundred articles published each year. This research aimed to explore, trace, and review the development of research and publications on scientific analysis related to technology in football using bibliometric analysis. The study used the Scopus database, using the keywords ("football" OR "soccer") AND (" performance" OR "playing") AND ("technology" OR “virtual reality"). A total of 249 articles matched the specified keywords starting from 2019 to March 2024. The study found that the highest publication occurred in 2022, with China being the top country in article publications. Meanwhile, the Institute of Electrical and Electronics Engineers Inc, NSCA National Strength and Conditioning Association, and Springer Science and Business Media Deutschland GmbH were active journals in publications.

✉ Correspondence Address : Lidah Wetan, Lakarsantri, Surabaya, 60213
E-mail : marisca.21002@mhs.unesa.ac.id

## INTRODUCTION

Football has become a global sport that attracts millions of fans and players by responding to challenges and opportunities, making this sport continue to innovate (Işın & Yi, 2024). Football sport also has the potential to be a recreational activity regardless of different variables, such as age, gender, and social background (Randers et al., 2024). Technological advances make professional football teams increasingly adopt quantitative analysis processes and prediction techniques (Shen et al., 2024). A previous study argued that adopting new technology depends on its perceived benefits and the user convenience (Aarons et al., 2023).

The challenge in the current era is the lack of technology that is able to predict the actual performance accurately (Mat-Rasid et al., 2023). In the dynamic development of play on the field, players need to show flexibility in their positions. This demands optimal levels of physical fitness and adaptability (Yang & Feng, 2024). The higher education division level often does not utilize technology optimally, especially in terms of the use of technology, for example, sensor technology as the main tool for collecting objective and sustainable data. In fact, this technology has a great potential to accurately measure training loads, evaluate health performance, and reduce the risk of injury (Seshadri et al., 2024). Performance analysis in team sports, such as technical, tactical, and conditional aspects, becomes obstacles in realizing the modelling process to understand the team behaviour comprehensively (Pino-Ortega et al., 2021). There is cumulative evidence that football often utilises technology in the contest league (Ghasem et al., 2021). Football focuses on technological innovation and new creativity as its support (Pradana et al., 2024). These technologies have been noted in the scientific literature and previous researchers have applied them to assess the effectiveness of training programs, leading to the development of individually tailored training plans (Rebelo et al., 2023). From the scientific aspect, performance analysis is also important for academic researchers, sports organizations, athletes, and coaches, enabling them to optimize training programs (Zhang et al., 2024). Technological advances create the potential for acceleration, deceleration, and precise and accurate data processing (Miguens et al., 2024).

Several technologies that support performance analysis in football, namely the Global Positioning System (GPS), measure a player position every second (Modric et al., 2019). Local Position Measurement (LPM) is a system capable of accurately measuring acceleration for the evaluation process as a characteristic of team sports (Fischer-Sonderegger et al., 2021). Microelectromechanical technology (MEMS) is an element for analysis in the form of GPS which increases reading accuracy (Almulla et al., s2020). An accelerometer (ACC) is a sensor device that measures physical activity by recording player movements (Guo et al., 2022). The Heart Rate Monitor is a marker of a player fitness progress (Pasadyn et al., 2019). Identification (RFID) applied to assess player performance, position identification, tactical patterns as well and team formation dynamics was carried out in 50 football matches in the 2014/2015 season in the German Bundesliga, which resulted in 11,160 work values (Schlenger et al., 2023).

This research aimed to explore, trace, and review the development of research and publications of scientific analysis related to technology in football using bibliometric analysis carried out on the Scopus database. Many previous studies have produced articles on technology and football topics, such as the application of AI and VR technology in football player tactics (Shao, 2024), the technology in tracking health performance (Almulla et al., 2020), analysis and evaluation of performance models using live global positioning technology (Ponsano et al., 2020), and influence of professional opponents by using sensor technology (Nobari et al., 2023). However, no research had used bibliometric analysis on this topic. Some articles had used bibliometric analysis, but the article was only limited to entrepreneurship in the football sport, namely the article published by (Pradana et al., 2024) (Escamilla-Fajardo et al., 2020) on football innovation. This proves that there is no bibliometric analysis for football performance. The author attempted to summarise football analysis technology articles using a bibliometric approach. A comprehensive article is vital to link the diverse bodies of knowledge about the current research situation. This makes these articles valuable as a resource to be utilised by academics, students, and practitioners in the field (Raman et al., 2024).

This research used the bibliometric method, which can help researchers evaluate research performance

(Magadán-Díaz & Rivas-García, 2022). In conducting metadata searches, researchers had not found any bibliometric studies discussing football performance analysis technology in the Scopus database or others. The author only used one database, namely Scopus, because the distribution of reputable scientific publications in this database is the largest of all existing databases. Through this research, we aimed to fill gaps and open new perspectives for future research. An objective and up-to-date overview of technology in football performance analysis based on bibliometric analysis and visualisation are provided in this article. In this way, we can fulfil the information and document needed by researchers, academics, and practitioners. This analysis can provide a comprehensive overview of the existing literature and provide guidance and directions for future research. Another advantage is that it is important in developing the proliferating sport sector (Wilkins, 2024). Researchers were motivated to find the the productivity of the Scopus database each year in technology and football publications, the authors, articles, countries, and journals influencing the topic of technology and football, and the keywords often used in technology and football topics.

## METHODS

Bibliometric analysis is a method used to measure the influence and impact of a research article for further research (Diane Cooper, 2015). Bibliometrics is a branch of library intelligence that utilises mathematical and statistical tools to map, assess, and predict the latest developments and trends in science and technology by considering several diverse characteristics (Long et al., 2024). This research used a pervasive database, namely Scopus. Scopus, under the Elsevier Co, is a well-known database and indexed in more than 1,400 journals for many fields, including social sciences and mathematics (Mohamed et al., 2020).

### Search Strategies

The first step was to log in to the Scopus account. After that, the author entered the keywords used, namely ("football" OR "soccer") AND ("performance" OR "playing") AND ("technology" OR "virtual reality"). To obtain the documents, the researchers conducted a phrase search in the Scopus database on 16 March 2024. The search results showed that there were 1,002 articles about technology in football performance analysis published in the Scopus database from 2019 to March 2024. Articles published in 2024 were limited only until 16 March 2024, with regular publication as the inclusion criteria. Next, the researchers filtered the 1,002 articles found into document types in English language, ranged from 2019 to 2024, with health, computer science, engineering, social sciences, arts, and humanities as the key areas, so the total number of documents found were 249. At least 200 documents are required for a suitable bibliometric analysis process (Gazali & Saad, 2023). The results of the mapping were exported to Research Information Systems (RIS) format to accommodate articles without a large space capacity. The third stage involved exporting CSV format for Vosviewer software and obtaining more detailed citation data. All texts were filtered, verified, and stored correctly.

### Data Collection Procedure

A total of 1,002 articles had been retrieved from the Scopus database from the 2019 to March 2024 period. These articles had been screened and verified to ensure that they met the specified inclusion criteria. After the screening process, a total of 249 articles were selected for inclusion in the result analysis.

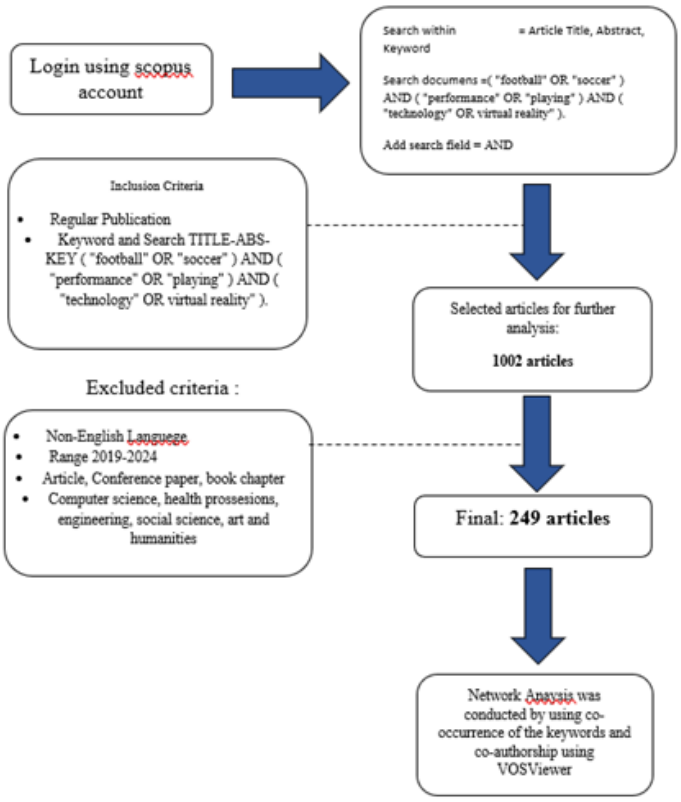


**Figure 1.** Flow Chart of The Selection Process

## RESULT

The analysis of published articles can show the progress in a particular research discipline (Jiang et al., 2024). In the Scopus database, from 2019 to 2024, there was still little research published. The peak of publication was found in 2022 (68 articles). There was a decline of publications in 2021, 2023, and 2024. Although the number of publication each year was below 100, research on this field is indicated to continue and develop.

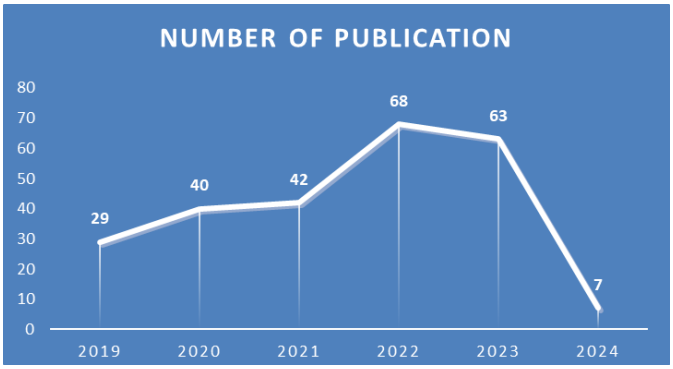


**Figure 2.** Number of Publications

Table 1 shows the top ten most cited articles in football performance analysis. One article was published by Aquino (Aquino et al., 2020) titled "Influence of Situational Variables, Team Formation, and Playing Position on Match Running Performance and Social Network Analysis in Brazilian Professional Soccer Players." The highest citation number was 73. The article published in the Journal of Strength and Conditioning Research showed no significant interaction between the team formation and playing position observed in the running and network variables.

The second article was from a journal published by Weakley (Weakley et al., 2020) titled "Show Me, Tell Me, Encourage Me: The Effect of Different Forms of Feedback on Resistance Training Performance", with 53 citations, in the Journal of Strength and Conditioning Research.

**Table 2.** Ten Countries with High Publications

| Countries | Document |
|---|---|
| China | 47 |
| United Kingdom | 38 |
| Spain | 33 |
| United States | 27 |
| Australia | 20 |
| Portugal | 17 |
| Brazil | 16 |
| Germany | 14 |
| Italy | 13 |
| India | 11 |

**Table 1.** Table 1. Ten Most Cited Articles

| Rank | Authors | Title | Citations |
|---|---|---|---|
| 1. | (Aquino et al., 2020) | Influence of situational variables, team formation, and playing position on match running performance and social network analysis in Brazilian professional soccer players | 73 |
| 2. | (Weakley et al., 2020) | Show me, tell me, encourage me: the effect of different forms of feedback on resistance training perfomance | 52 |
| 3. | (Beato et al., 2021) | Implementing high-speed running and sprinting training in professional soccer | 45 |
| 4. | (Goes et al., 2019) | Not every pass can be an assist: a data-driven model to measure pass affectiveness in professional soccer matches | 43 |
| 5. | (Reche-Soto et al., 2019) | Player load and metabolic power dynamics as load quantifiers in soccer | 43 |
| 6. | (Wood et al., 2021) | Testing the construct validity of a soccer-specific virtual reality simulator using novice, academy, and professional soccer players | 41 |
| 7. | (McFadden et al., 2020) | Comparison of internal and external training loads in male and female collegiate soccer players during practices and games | 36 |
| 8. | (Caccese et al., 2019) | Effects of repetitive head impact on a concussion assessment battery | 35 |
| 9. | (Li et al., 2020) | Does overexertion correlate with increased injury? The relationship between player workload and soft tissue injury in professional American football players using wearable technology | 29 |
| 10. | (Loturco et al., 2022) | Practices of strength and conditioning coaches in Brazilian elite soccer | 28 |

Table 2 shows the ten countries that contributed the most publications discussing football performance analysis technology, including China, the United Kingdom, Spain, the United States, Australia, Portugal, Brazil, Germany, Italy, and India. China led the way with the publication of 47 documents.

**Table 3.** Top Journals in Publication Productivity

| Journal | Publication |
|---|---|
| Institute of Electrical and Electronics Engineers Inc. | 33 |
| NSCA National Strength and Conditioning Association | 20 |
| Springer Science and Business Media Deutschland GmbH | 18 |
| Taylor and Francis Ltd. | 17 |
| MDPI | 12 |
| SAGE Publications Ltd | 11 |
| Hindawi Limited | 10 |
| Routledge | 10 |
| Human Kinetics Publishers Inc. | 9 |
| MDPI AG | 7 |

The ten journals active in football performance analysis technology were the Institute of Electrical and Electronics Engineers Inc., NSCA National Strength and Conditioning Association, Springer Science and Business Media Deutschland GmbH, Taylor and Francis Ltd, and MDPI. These journals were five of the ten most active journals in publication in this field.

article. From the titles and abstracts of the 249 articles analysed, we extracted 114 keywords that were cited ten times or more. Some frequently appearing keywords included football, soccer, GPS, performance, team sports, monitoring, and technology. The first group, consisting of the words "football" and "soccer," described the use of technology in the context of the sport of football. The second group, involving the word "GPS," dealt with monitoring athletes and distance. The third group highlighted the results of the game, while the fourth group discussed training in the context of team sports, especially in the context of training at football academies.

## DISCUSSION

The attention to physical and mental well-being is growing. As an integral part of improving physical condition, the role of sport is increasingly prominent in human lives. To gain an in-depth and scientifically

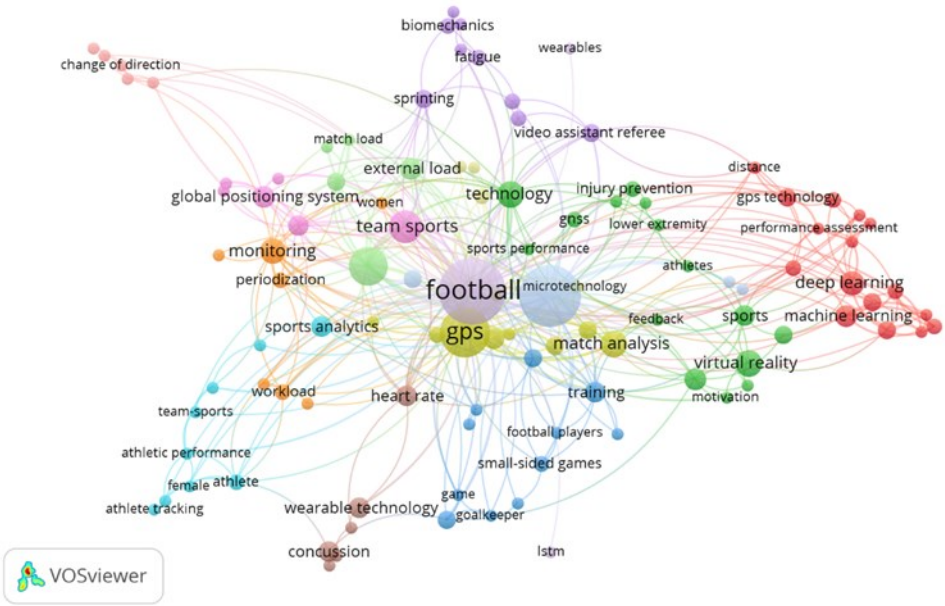


**Figure 3.** Keyword Grouping Analysis

Figure 3 shows the results of keyword clustering based on algorithms reported in the cited literature. The visualisation depicts clusters of keywords that frequently appear together in the same research context. By analysing keywords, we managed to get the frequency of occurrence of keywords related to the main topic of this

based understanding of the contribution of sport, further research into sport impact evaluation technology is needed (Wang, 2023). The main aim of this bibliometric analysis was to map and highlight technological advances in football performance analysis. The analysis in this article contained six categories, namely 1) year,

2) author and article title, 3) country, 4) journal, and 5) keywords. The distribution of articles related to the topic of football performance analysis reached the United Kingdom, Spain, the United States, and Australia. Still, China was the country that published most articles on the topic of football performance analysis. Bibliometric analysis related to football performance in 2019-2024, which was limited to March, showed an increase from 2020 – 2022. The peak occurred in 2022 with 68 published articles. In 2022, there was a drive for technology, such as Virtual Reality (VR), as an impact from the Covid-19 pandemic (Mota et al., 2024). During the COVID-19 pandemic, the increased use of technology had caused a shift from a negative to a positive perspective (Shui et al., 2024). It should be noted that the discussions of various related articles in 2022 took place during the Covid-19 pandemic.

This situation could change the dynamics of organising sport competitions in different parts of the world. For almost a season and a half, matches were held in empty stadiums, so the pressure on referees from the spectators was significantly reduced (Gasparetto & Loktionov, 2023). Without using the existing technology, it will greatly hinder the analysis process itself. Traditional analysis of football performance still relies heavily on manual observation and recording, which is time-consuming and tends to be busy. This process is susceptible to subjective influences, limiting the ability to holistically evaluate the athlete performance (Mou, 2024). With rapid advances in the Internet of Things (IoT) and artificial intelligence (AI), the role of football training systems continues to evolve to accommodate increasingly complex training demands (Hu & Zhang, 2023). Therefore, the quality of football, including players and coaches, will be helped by technology which is increasingly developing every year. This article can help examine the development of the benefits of technology that is already functioning well.

This research aimed to explore, trace, and review the development of research and publications of scientific analysis related to technology in football using bibliometric analysis carried out on the Scopus database. A lot of previous studies had produced articles on technology and football topics, such as the application of AI and VR technology in football player tactics (Shao, 2024). Technology in tracking performance health (Almulla et al., 2020), analysis and evaluation of performance models using live global positioning technology (Ponsano et al., 2020), and influence of professional opponents using sensor technology (Nobari et al., 2023). However, no one had used bibliometric analysis on this topic. Some articles had used bibliometric analysis but only limited to entrepreneurship in the football sport, namely the article published by (Pradana et al., 2024) (Escamilla-Fajardo et al., 2020) on football innovation. This proves that there was no bibliometric analysis for football performance. The author attempted to summarise football analysis technology articles using a bibliometric approach. These comprehensive articles are vital links between diverse bodies of knowledge about the current research situation. Therefore, this article is essential as a resource to be utilised by academics, students, and practitioners in the field (Raman et al., 2024).

## CONCLUSION

This study provides a comprehensive overview of the development of publications on football performance analysis technology and its impact on research productivity in this field. The results show an increase from 2019 to 2022 and a decrease in 2023. This research has several limitations, such as the limited database used and the lack of in-depth analysis of the content of publications. Therefore, it is recommended that further research conduct a deeper analysis into the contents of the publications and involve a more diverse data sources. This research implies the importance of better understanding and utilisation of technology regarding football performance analysis in national and international sports. By deepening our knowledge of analytical technology in sports, especially football, we can strengthen participations in our national sport achievements, address related social problems, and encourage the development of policies supporting innovation in sport technological infrastructure.

## CONFLICT OF INTEREST

The authors declared no conflict of interest.

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