Digital Transformation in Football: The Role of Artificial Intelligence and Metaverse

Futbolda Dijital Dönüşüm: Yapay Zekâ ve Metaverse'ün Rolü

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Abstract

Digital transformation in football presents many new opportunities and challenges. The effective use of technologies such as artificial intelligence and the Metaverse play a critical role in shaping the future of football. This research aims to examine the effects of artificial intelligence and metaverse technologies on digital transformation processes in football through bibliometric analysis. At the end of the study, it was concluded that the role of technologies such as artificial intelligence and metaverse in football will become more prominent in the coming years. Therefore, it is crucial for researchers to consider the impact and potential benefits of these technologies from a broader perspective in order to understand the digital transformation of football. In particular, adopting an interdisciplinary approach in this field can contribute to the emergence of innovative ideas. Recent research shows that soccer is evolving not only as a sport, but also as a business model and experience. Therefore, it is important that future studies on the digital transformation of football bring together perspectives from different disciplines to develop a more holistic understanding. To increase interest in research on the digital transformation of football, there needs to be a sustained emphasis on the importance and potential of this topic. In the future, deepening and expanding research in this area will increase the potential for further innovation and development in football's digitalization process. In conclusion, more research should be conducted on how the digital transformation process will transform the football industry and what the future implications might be.

Keywords: Football, digital transformation, artificial intelligence, metaverse, bibliometrics

Özet

Futbolda dijital dönüşüm, birçok yeni fırsat ve zorluk barındırmaktadır. Yapay zekâ ve metaverse gibi teknolojilerin etkin kullanımı, futbolun geleceğini şekillendirmede kritik bir rol oynamaktadır. Bu araştırma, futbolda dijital dönüşüm süreçlerinde yapay zekâ ve metaverse teknolojilerinin etkilerini bibliyometrik analiz yöntemiyle incelemeyi amaçlamaktadır. Çalışma sonunda yapay zekâ ve metaverse gibi teknolojilerin futboldaki rolünün gelecek yıllarda daha da belirginleşeceği sonucuna ulaşılmıştır. Dolayısıyla araştırmacıların bu teknolojilerin etkilerini ve potansiyel faydalarını daha geniş bir perspektiften ele alması, futbolun dijital dönüşümünü anlamak açısından son derece önem arz etmektedir. Özellikle, bu alanda disiplinlerarası bir yaklaşım benimsemek, yenilikçi fikirlerin ortaya çıkmasına katkı sağlayabilir. Son yıllarda yapılan araştırmalar, futbolun sadece bir spor değil, aynı zamanda bir iş modeli ve deneyim alanı olarak da evrildiğini göstermektedir. Bu nedenle, futbolun dijital dönüşümü üzerine yapılacak çalışmaların, farklı disiplinlerden gelen bakış açılarını bir araya getirerek daha bütünsel bir anlayış geliştirmesi önemlidir. Futbolun dijital dönüşümü araştırmalarına yönelik ilgiyi artırmak için, bu konunun önemi ve potansiyeli üzerine sürekli bir vurgunun yapılması gerekmektedir. Gelecekte, bu alan üzerindeki araştırmaların derinleşmesi ve yaygınlaşması, futbolun dijitalleşme sürecinde daha fazla yenilik ve gelişim sağlama potansiyelini artıracağı düşünülmektedir. Sonuç olarak, dijital dönüşüm sürecinin futbol endüstrisini nasıl dönüştüreceği ve gelecekteki etkilerinin neler olabileceği üzerine daha fazla araştırma yapılmalıdır.

Anahtar Kelimeler: Futbol, dijital dönüşüm, yapay zekâ, metaverse, bibliyometrik

Introduction

Although the concept of sport is recognized in the world with the support of English, it does not actually come from English origin. The concept emerged from the Latin words disportare or deportare, meaning to distribute or separate (Keten, 1993, as cited in Gökdağ et al., p. 202).

Considering the social effects of the concept of sport, it is one of the biggest impact factors in the world in terms of health, culture and bringing people together. With the spread of modern sports, it has become a situation that has become a point of interest for people all over the world. Especially with the development of technology, it has become one of the universal concepts of people in the world. (Tezcan, 1992, as cited in Alaeddinoğlu, 2024, p. 26). Among the sports branches, football is the most known and the first one that comes to mind. The fact that it includes so many people as athletes and more than that as spectators increases the importance of football (İnal, 2004, as cited in Evli et al., 2023, p. 2362).

Football has been a sport that has been followed with interest from past to present and has attracted the masses. The game of football, played within the framework of certain rules, has also become a large sector in terms of sports economy. It is stated that the highest level of performance and all physiological characteristics should be analyzed in the football branch, as it consists of various movement sequences and includes versatile skills. In the literature, performance is defined as the score obtained from physical, physiological and biomotor data (Kul & Aydemir, 2024, p. 63).

Football is moving beyond being just a sport throughout history and is entering a new phase with the impact of technology. In this transformation, innovative elements such as artificial intelligence and the metaverse are important in radically changing the dynamics of the game. Digital transformation in football presents many new opportunities and challenges. The effective use of technologies such as artificial intelligence and the Metaverse play a critical role in shaping the future of football. This research aims to examine the effects of artificial intelligence and metaverse technologies on digital transformation processes in football through bibliometric analysis.

Furthermore, the analysis of trends in the literature aims to contribute to understanding the future directions of the digitalization process of football. This study is considered to play an important role in terms of ınnovation, fan experience, performance and development of the football industry. In terms of innovation, digital transformation in football helps clubs and organizations to gain competitive advantage. Artificial intelligence can accelerate data analysis and strategy development, while the metaverse can deepen fan engagement. In terms of fan experience, the metaverse can change the way football fans watch and interact with the game by offering new experiences. This can increase fan loyalty. Performance AI can play an important role in analyzing and improving player performance. This can enable teams to make data-driven decisions. In terms of the development of the football industry, this study aims to guide industry professionals by revealing how the digitalization process of the football industry has evolved and its potential future directions. At this point, it is thought that determining the trends in the literature through bibliometric analysis will contribute to an in-depth understanding of the digital transformation process of football. Since there are gaps in the literature on the research topic, it is thought that this study will make a highly original and important contribution.

METHOD

The data obtained in this study were analyzed by bibliometric analysis method (Ateş & Ünsal, 2024, p.1088). The concept of bibliometrics is envisaged to be used in all studies that aim to quantify the processes of written communication and is rapidly gaining acceptance in the field of information science (Büyükbaykal & İli, 2020, p. 575). According to Ellegaard and Wallin (2015), bibliometric analysis method contributes to the most detailed examination of the topics in the research field.

An advanced search with the keywords football*, soccer*, artificial intelligence*, AI, metaverse*, digital*, digital transformation, technolog* in the Web of Science database and 854 publications in the categories of sport sciences or hospitalıty leısure sport tourism were subjected to bibliometric analysis.

Web of Science database with advanced search indicators for advanced data analysis the diversity in providing control mechanisms, the reliability of the research it was preferred in terms of including reliable and qualified studies in terms of publication ethics (Arpacı, 2024, p. 160). The following parameters were examined within the scope of the study:

- Web of Science Categories,
- Citation topics meso,
- Citation topics micro,
- Research areas,
- Times cited and publications over time,
- Web of Science ındex,
- Open Access,
- Languages,
- Author-co-author network map,
- Organization-co-author network map,
- Corresponding author's countries,
- Network map of common words,
- Keyword's plus thematic map,
- Author's keywords thematic map
- Countries' collaboration world map.

The data obtained in the study were analyzed using VOSviewer and Bibliometrix r programs.

FINDIGS

In this section, the effects of artificial intelligence and the metaverse on football are examined in detail, and the opportunities offered by digital transformation are presented, as well as the threats it brings.

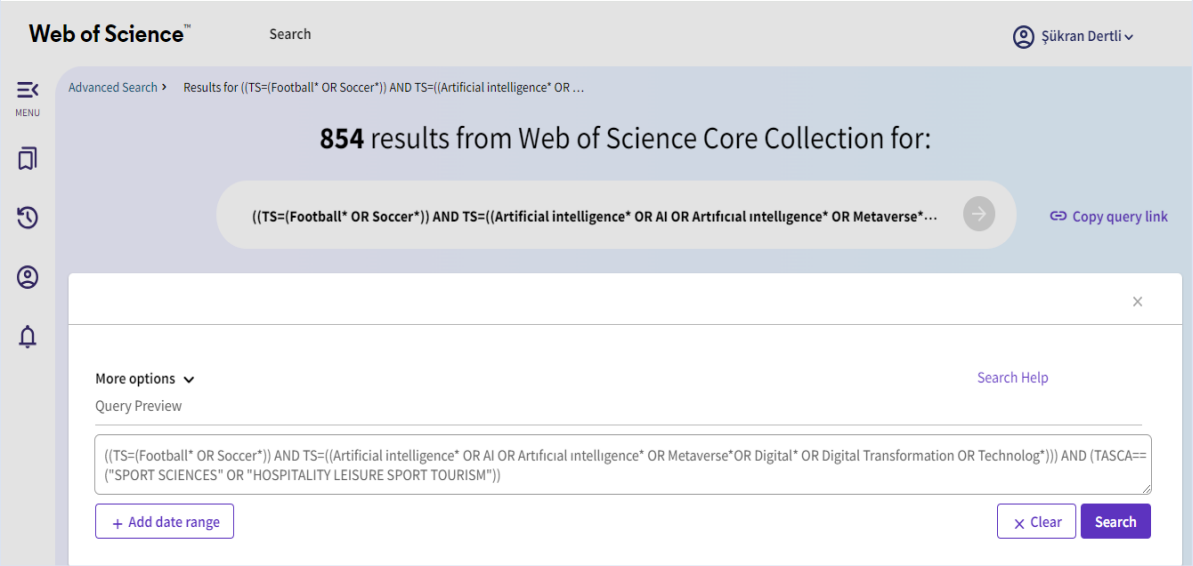

Figure 1. Citation report

In Figure 1, it is seen that a data set consisting of 854 publications on the role of artificial intelligence and metaverse in the digital transformation of football has been accessed and the current examinations have been carried out.

Table 1. Web of Science Categories

Web of Science Categories	Record Count	% of 854
1. Sport Sciences	649	75.995%
2. Hospitality Leisure Sport Tourism	242	28.337%
3. Physiology	52	6.089%
4. Psychology Applied	39	4.567%
5. Sociology	31	3.630%
6. Orthopedics	29	3.396%
7. Engineering Mechanical	28	3.279%
8. Rehabilitation	17	1.991%
9. Education Educational Research	16	1.874%
10. Psychology	15	1.756%

In Table 1, the top 10 distributions of the analyzes made according to Web of Science categories are as follows: 649 (75,995%), Hospitality Leisure Sports Tourism: 242 (28,337%), Physiology: 52

(6,089%), Applied Psychology: 39 (4,567%), Sociology: 31 (3,630%),

Orthopedics: 29 (3,396%), Engineering Mechanics: 28 (3,279%), Rehabilitation: 17 (1,991%), Education Educational Research: 16 (1,874%), Psychology: 15 (%1,756). These findings show which disciplines are more prominent in the digital transformation of football and the trends in research. In particular, the "Sport Sciences" category stands out as having the largest share in this regard. Other disciplines offer important contributions to understanding the multifaceted effects of football's digitalization process

Table 2. Citation topics meso

Citation Topics Meso	Record	% of
1. Sports Science	562	65.808%
2. Hospitality, Leisure,	62	7.260%
3. Trauma & Emergency	48	5.621%
4. Orthopedics	24	2.810%
5. Management	20	2.342%
6. Economic Theory	19	2.225%
7. Communication	6	0.703%
8. Back Pain	5	0.585%
9. Nutrition & Dietetics	5	0.585%
10. Gait & Posture	5	0.585%

In Table 2, the top 10 distributions of the analyses made according to citation topics meso is as follows:

Sports Science: 562 (65.808%), Hospitality, Leisure, Sport & Tourism: 62 (7.260%), Trauma & Emergency Surgery: 48 (5.621%), Orthopedics: 24 (2.810%), Management: 20 (2.342%). Economic Theory: 19 (2.225%), Communication: 6 (0.703%), Back Pain: 5 (0.585%), Nutrition & Dietetics: 5 (0.585%), Gait & Posture: 5 (0.585%). These findings show that the most cited topics in the digital transformation of soccer are largely related to sports science. Other topics represent research areas of different disciplines related to various aspects of sport.

Table 3. Citation topics micro

Citation Topics Micro	Record	% of
1. Soccer	501	58.665%
2. Sport	60	7.026%
3. Traumatic Brain	48	5.621%
4. Sport Psychology	41	4.801%
5. Competitive	17	1.991%
6. Anterior Cruciate	16	1.874%
7. Technology	7	0.820%
8. Core	6	0.703%
9. Customer	6	0.703%
10. Muscle Damage	5	0.585%

In Table 3, the top 10 distributions of the analyses made according to citation topics micro is as follows:

Soccer: 501 (58.665%), Sport: 60 (7.026%), Traumatic Brain Injury: 48 (5.621%), Sport Psychology: 41 (4.801%), Competitive Balance: 17 (1.991%), Anterior Cruciate Ligament: 16 (1.874%), Technology Acceptance Model: 7 (0.820%), Core Temperature: 6 (0.703%), Customer Satisfaction: 6 (0.703%), Muscle Damage: 5 (0.585%). These findings reflect the visibility and interaction of soccer, artificial intelligence and Metaverse in the literature. In particular, the title "Soccer" shows that soccer is the main focus and how intensive the studies in this field are.

Table 4. Research areas

Research Areas	Record	% of
1. Sport Sciences	649	75.995%
2. Social Sciences	243	28.454%
3. Physiology	52	6.089%
4. Psychology	48	5.621%
5. Engineering	44	5.152%
6. Sociology	31	3.630%
7. Orthopedics	29	3.396%
8. Rehabilitation	17	1.991%
9. Education	16	1.874%
10. Computer Science	14	1.639%

In Table 4, the top 10 distributions of the analyses made according to research areas is as follows:

Sport Sciences: 649 (75.995%), Social Sciences Other Topics: 243 (28.454%), Physiology: 52 (6.089%), Psychology: 48 (5.621%), Engineering: 44 (5.152%), Sociology: 31 (3.630%), Orthopedics: 29 (3.396%), Rehabilitation: 17 (1.991%), Education Educational Research: 16 (1.874%), Computer Science: 14 (1.639%). These findings reflect which academic disciplines are prominent in relation to the digital transformation of soccer and the interactions between these disciplines. While the field of Sport Sciences has the highest proportion of soccer research, other social sciences and engineering fields have also made significant contributions.

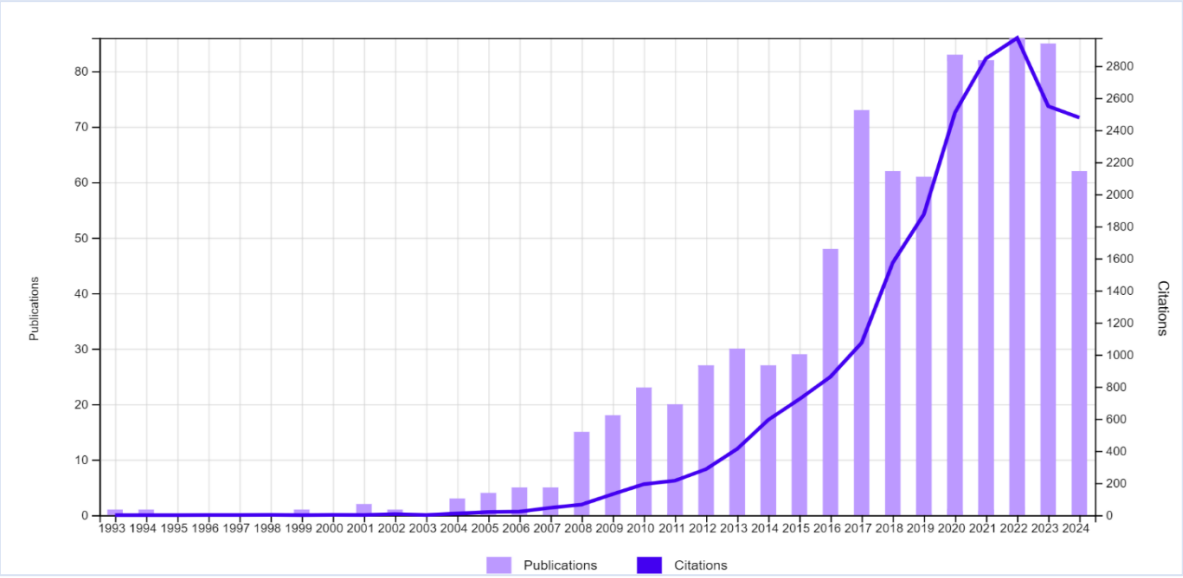

Figure 2. Times cited and publications over time

Figure 2 shows a remarkable increase in the number of publications on digital transformation in football. This increase has been evident since the early 2000s. Especially in 2024, there was an 854% increase in the number of registrations. While there were 61 records in 2019, this number increased to 83 in 2020, 82 in 2021, 86 in 2022 and 85 in 2023. In 2023, the number of publications remained at 7.260%, in 2022 at 9.953%, in 2021 at 10.070% and

in 2020 at 9.602%. It has shown a steady increase since 2019. The starting point of this trend is 2010. In that year, the number of publications was 23, followed by 20 in 2011, 27 in 2012 and 30 in 2013. In 2014, this number dropped to 27 and then started to increase again. The rise, which started with 29 records in 2015, reached 48 in 2016, 73 in 2017, 62 in 2018 and 61 in 2019. This rapid adoption of digital transformation in football is directly related to the growing academic interest in the impact of technologies such as artificial intelligence and the Metaverse. When the number of citations is analyzed; between 2004 and 2022, the digital transformation of football, artificial intelligence and academic studies on the Metaverse caused a significant increase in the number of citations. During this period, it was observed that as the number of studies increased, the citations to these studies also increased rapidly. In particular, 2022 was the year when the topic of digital transformation in the football industry reached the highest level of impact in the academic literature. However, it is noteworthy that there has been a decline in citation rates since 2023.

Table 5. Web of Science ındex

Web of Science Index	Record	% of
Science Citation Index Expanded (SCI-	499	58.431%
Emerging Sources Citation Index (ESCI)	214	25.059%
Social Sciences Citation Index (SSCI)	160	18.735%
Conference Proceedings Citation Index – Science	43	5.035%
Conference Proceedings Citation Index – Social	18	2.108%
Book Citation Index – Social Sciences & Humanities	4	0.468%
Arts & Humanities Citation Index (A&HCI)	3	0.351%
Book Citation Index – Science (BKCI-S)	3	0.351%

According to the Web of Science data in Table 5, the distribution of indexes in which research on soccer, artificial intelligence and Metaverse is published is as follows:

SCI-EXPANDED: 499 (58.431%), ESCI: 214 (25.059%), SSCI: 160 (18.735%), CPCI-S: 43 (5.035%), CPCI-SSH: 18 (2.108%), BKCI-SSH: 4 (0.468%), A&HCI: 3 (0.351%), BKCI-S: 3 (0.351%). These data show in which academic sources the research on the digital transformation of football and artificial intelligence and Metaverse applications in

this process is concentrated. The fact that the SCI-EXPANDED index has the highest rate indicates that research with high scientific quality is also prominent in the field of football, while the lower rates of other indexes suggest that the literature on this subject has not yet fully matured.

Table 6. Open access

Open Access	Record Count	% of 854
• **All**	343	40.164%
• **Gold**	133	15.574%
• **Gold-**	63	7.377%
• **Free to**	57	6.674%
• **Green**	148	17.330%
• **Green**	78	9.133%
• **Green**	60	7.026%

According to Web of Science data in Table 6, the open access distribution of research on football, artificial intelligence and Metaverse is as follows: All Open Access: 343 (40.164%), Gold: 133 (15.574%), Gold-Hybrid: 63 (7.377%), Free to Read: 57 (6.674%). Green Published: 148 (17.330%), Green Accepted: 78 (9.133%), Green Submitted: 60 (7.026%).

Table 7. Languages

Languages	Record	% of
• **English**	794	92.974%
• **Spanish**	29	3.396%
• **Portuguese**	14	1.639%
• **Russian**	6	0.703%
• **Chinese**	4	0.468%
• **German**	4	0.468%
• **Ukrainian**	2	0.234%
• **French**	1	0.117%

According to Web of Science data in Table 7, the publication language distribution of research on football, artificial intelligence and Metaverse is as follows: English: 794 (92.974%), Spanish: 29 (3.396%), Portuguese: 14 (1.639%). Russian: 6 (0.703%), Chinese: 4 (0.468%), German: 4 (0.468%), Ukrainian: 2 (0.234%), French: 1 (0.117%).

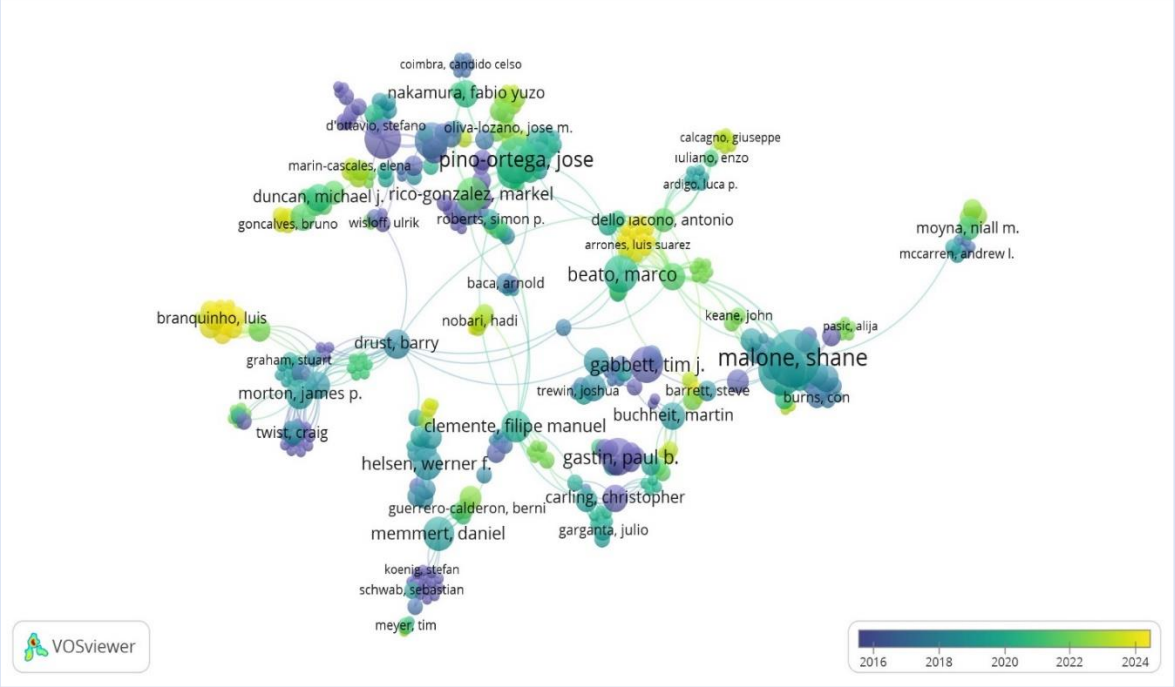

Figure 3. Author-co-author network map.

Author-co-author network map in Figure 2 has the values of items:374, clusters:25, links:1564, total link strength:1993. According to total link strength values Malone, Shane: 82 total link strength, 23 documents, 829 citations; Collins, Kieran: 74 total link strength, 18 documents, 689 citations; Morton, James P: 52 total link strength, 6 documents, 191 citations. Pino-Ortega, Jose: 48 total link strength, 15 documents, 353 citations; Close, Grame I: 45 total link strength, 5 documents, 190 citations; Morgans, Ryland: 38 total link strength, 4 documents, 120 citations; Coratella, Giuseppe: 36 total link strength, 5 documents, 75 citations. Castagna, Carlo: 34 total link strength, 11 documents, 1017 citations; Guskiewicz, Kevin M: 33 total link strength, 8 documents, 877 citations; Branquinho, Luis: 33 total link strength, 4 documents, 3689 citations.

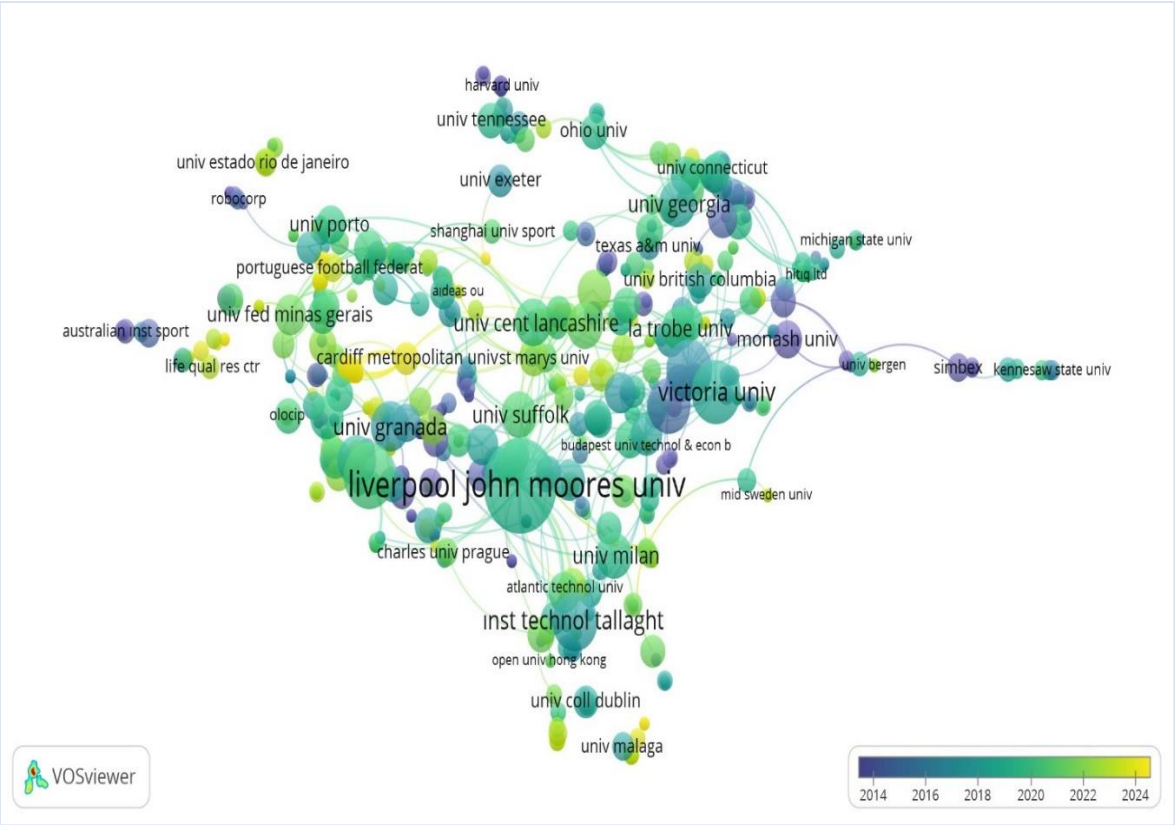

Figure 4. Organization-co-author network map.

Organization-co-author network map in Figure 3 has the values of items:746, clusters:41, links:2378, total link strength:2656. Liverpool John Moores University by total link strength: 96 total link strength, 42 documents, 2095 citations; Univ Extremadura: 68 total link strength, 20 documents, 459 citations; Univ Murcia: 61 total link strength, 21 documents, 741 citations. Univ Tras os Montes & Alto Douro: 48 total link strength, 10 documents, 348 citations; Victoria Univ: 48 total link strength, 19 documents, 1675 citations; Edith Cowan Univ: 45 total link strength, 11 documents, 207 citations; Univ Milan: 43 total link strength, 10 documents, 439 citations. Univ Castilla La Mancha: 41 total link strength, 17 documents, 263 citations; Univ Suffolk: 39 total link strength, 10 documents, 179 citations; Univ N Carolina: 36 total link strength, 11 documents, 1330 citations.

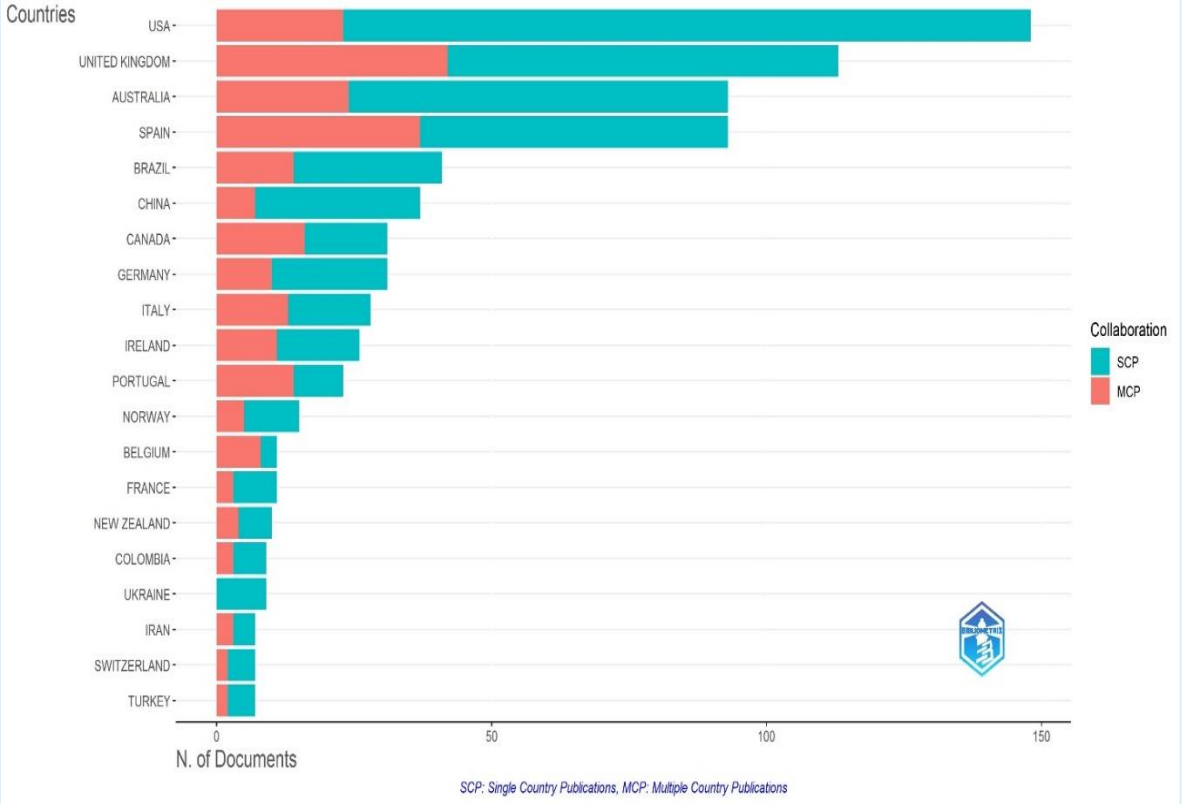

Figure 5. Corresponding author's countries

In Figure 4, according to the number of publications of the respective authors' countries, USA: 148 articles; 17.3% articles; 125 SCP; 23 MCP; 15.5% MCP, United Kingdom: 113 articles; 13.2% articles; 71 SCP; 42 MCP; 37.2% MCP, Australia: 93 articles; 10.9% articles; 69 SCP; 24 MCP; 25.8% MCP. Spain: 93 articles; 10.9% articles; 56 SCP; 37 MCP; 39.8% MCP, Brazil: 41 articles; 4.8% articles; 27 SCP; 14 MCP; 34.1% MCP, China: 37 articles; 4.3% articles; 30 SCP; 7 MCP; 18.9% MCP. Canada: 31 articles; 3.6% articles; 15 SCP; 16 MCP; 51.6% MCP, Germany: 31 articles; 3.6% articles; 21 SCP; 10 MCP; 32.3% MCP, Italy: 28 articles; 3.3% articles; 15 SCP; 13 MCP; 46.4% MCP, Ireland: 26 articles; 3.0% articles; 15; SCP; 11; MCP; 42.3 MCP.

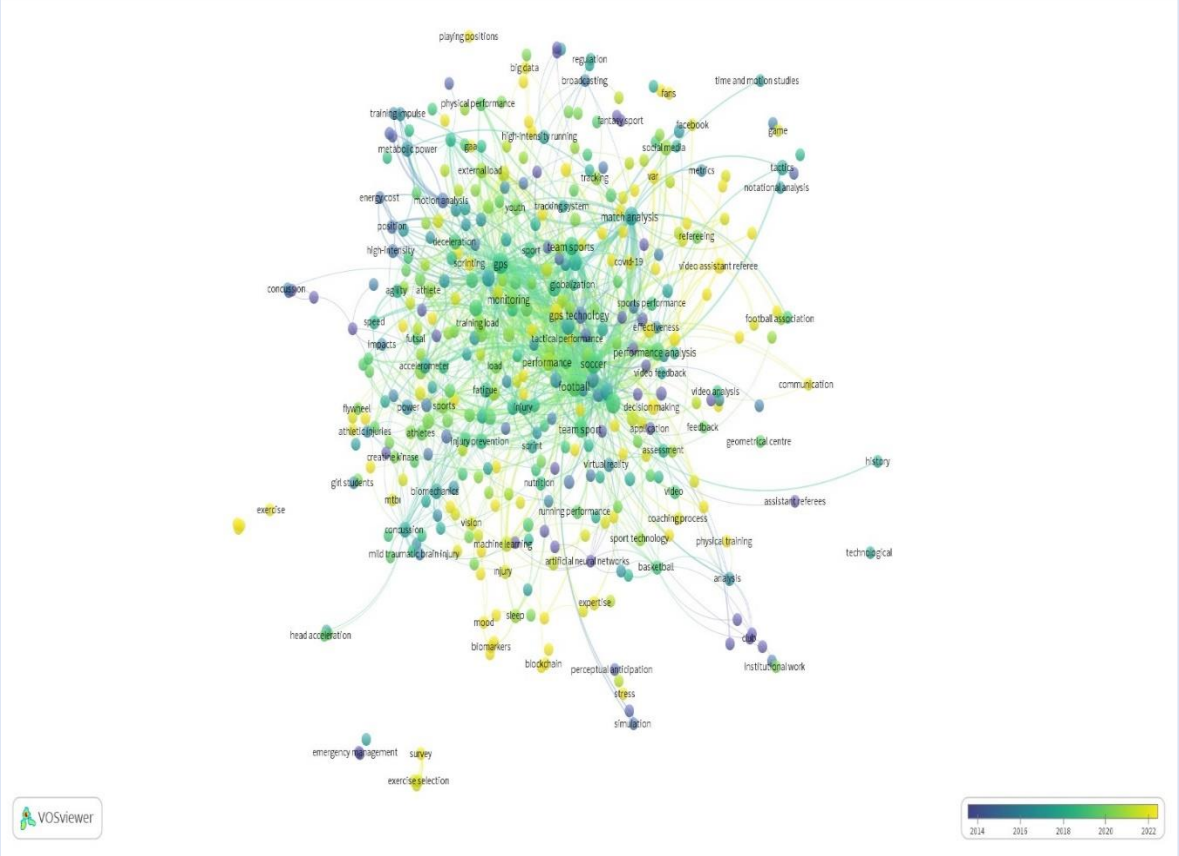

Figure 6. Network map of common words

Network map of common words in Figure 5 has values of items:426, clusters:28, links:2321, total link strength:3150. Soccer by total connection strength: 515 total connection strength, 134 incidents, soccer: 404 total connection strength, 108 incidents, gps: 332 total connection strength, 95 incidents. Technology: 230 total link strength, 64 occurrences, performance: 166 total link strength, 39 occurrences, team sports: 152 total connection strength, 40 occurrences, match analysis: 138 total connection strength, 39 occurrences. Team sports: 114 total link strength, 35 occurrences, performance analysis: 101 total link strength, 31 occurrences, training: 100 total link strength, 20 occurrences.

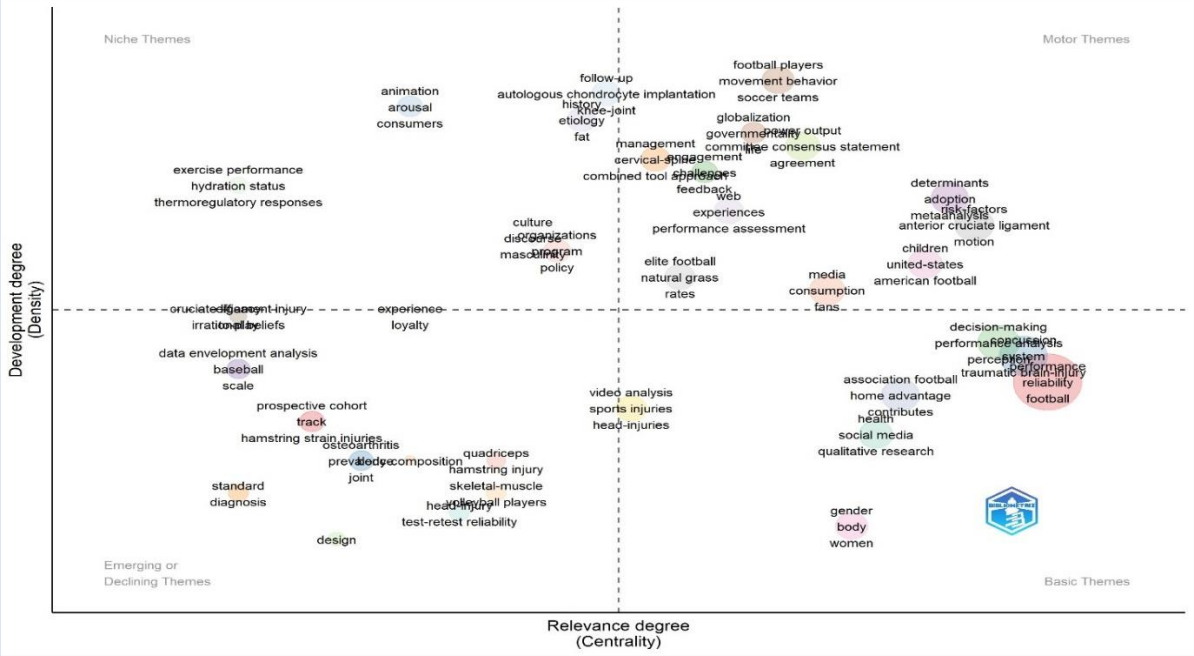

Figure 7. Keyword's plus thematic map

The thematic analysis of keyword's plus in Figure 6 shows that it is concentrated around key concepts identified to examine the role of digital transformation and artificial intelligence and the metaverse in the football domain. Among these concepts, terms such as “performance”, “concussion”, “decision-making”, “management” and “health” were found to be prominent. The findings of the analysis reveal the relationship and importance of these terms across studies. Performance: This concept has the highest centrality (26.536) and density (57.810). This suggests that the impact of digital transformation processes on football performance is an important focus for research. Concussion: With a centrality of 7.467, this concept is critical to the health and safety of soccer players. Research reveals a growing interest in the monitoring and management of concussion in athletes. Decision Making: With a centrality of 5.638, this term highlights that artificial intelligence or metaverse is an important topic to improve the strategic decision-making processes of football teams using data analysis. Management: Although the digitalization of football management and organizational structures is less prominent with 0.898 centrality, it can be said that developments in this area are important for the future of the sport. Gender and Children: These concepts offer different perspectives on the social dimensions of football and point to the need for research on gender equality and child development.

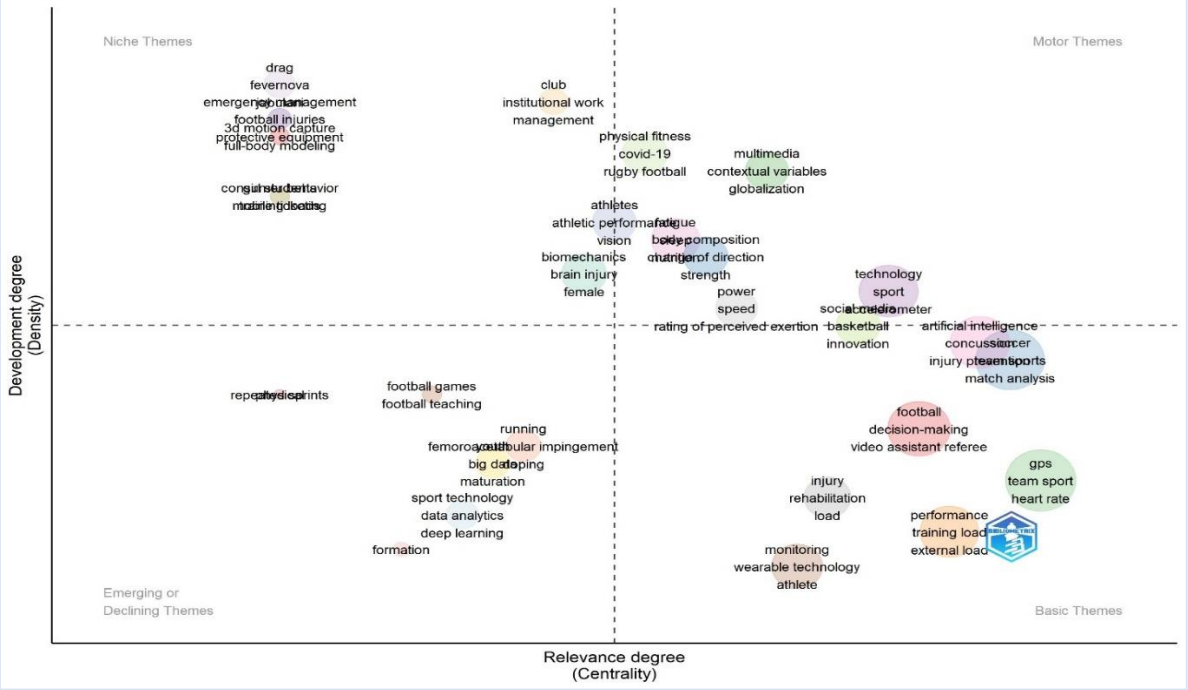

Figure 8. Author's keywords thematic map

The thematic map of author keywords in Figure 7, the keyword analysis on the digital transformation of football, artificial intelligence and the role of the metaverse reveals the interactions and importance of specific topics. In total, the data includes high frequency terms such as 236 soccer, 422 street, 491 GPS. These illustrate the critical roles of soccer technology and digital tools in soccer performance. The keywords Artificial Intelligence and Performance are frequently found in the literature and there are many studies on their applications in soccer. In particular, these studies have focused on the potential of artificial intelligence to improve player performance and reduce injury risks. The concepts of Social Media and Youth illustrate the impact of digital platforms on the younger generation and emphasize the increasing role of social interaction.

Young people's interactions with football are shaped through social media. Multimedia and Consumer Behavior stand out as important topics exploring the impact of the digitalization of football on consumer habits. The keywords Football and Technology show high frequency (236 and 422). This highlights the importance and popularity of football in the digital transformation. GPS (491) and Technology (173) have high Callon Density values in conjunction, indicating the role of technology in improving soccer performance.

The keywords Artificial Intelligence (175) and Performance (167) show how technology is being used to monitor and enhance soccer performance. Monitoring (80) and Injuries (54) have an important place in the health management of athletes, albeit with low frequency. The keywords Social Media (42) and Youth (16) indicate the impact on social interaction and youth in the digital transformation of football. Biomechanics (45) and Physical Performance (48) are important topics for assessing athletes' physical performance. These areas are related to the goals of reducing injury risks and improving performance. The words Multimedia (37) and Consumer Behavior (4) show how the sports industry is evolving on digital platforms and developing new ways to increase consumer interactions. In short, it shows that keywords with high Callon Centrality and Density values interact with each other by appearing intensively in the literature. The concepts of Social Media and Youth revealed the impact of digital platforms on the young generation. The links between technology, GPS, and Artificial Intelligence are directly related to the digitalization of football and the evolution of sport sciences.

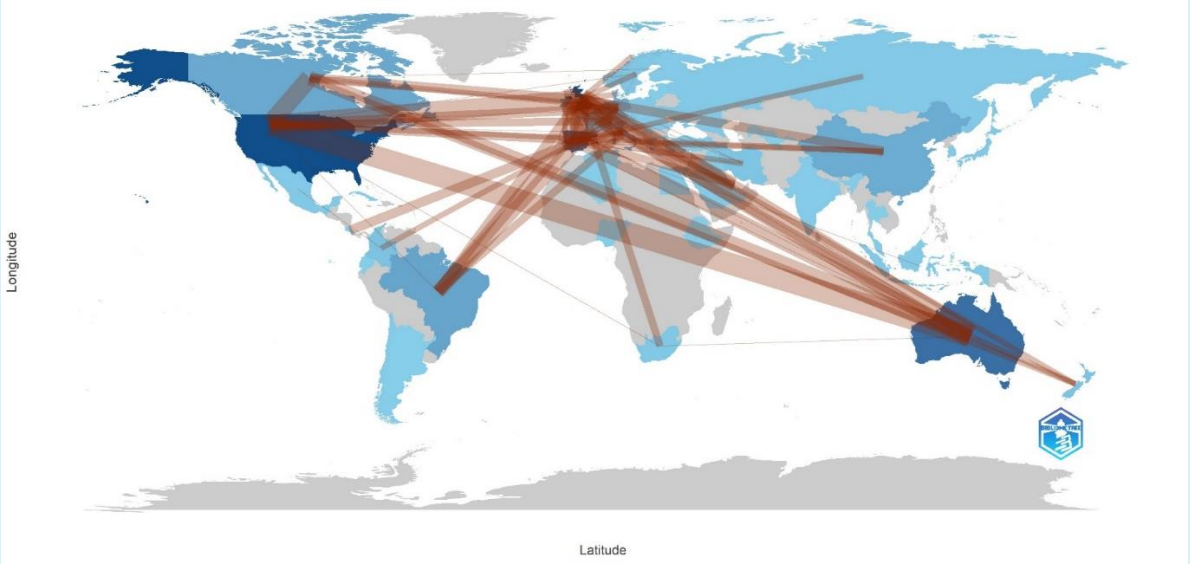

Figure 9. Countries' collaboration world map

The Cooperation of the Countries ranked in the top 10 in Figure 9 is as follows: United Kingdom and Ireland:25, United Kingdom and Australia:22, Usa and Australia:20, United Kingdom and Italy:17, Usa and United Kingdom:16. United Kingdom and Spain:15, Usa and Canada:15, Spain and Portugal:14, United Kingdom and Portugal:12, United Kingdom and France:11.

DISCUSSION AND CONCLUSION

In the analysis by Web of Science categories in a total of 854 records were found on football, artificial intelligence and Metaverse.

The findings of the study show that there has been an increase in the number of broadcasts. This increase reveals that digital transformation is a critical issue in the football industry. However, it is important to note that this increase is not only a quantitative development, but also needs a qualitative depth. The increase in research highlights the potential of the football industry in digital transformation and the importance of innovative approaches to it. The increase in the number of publications also reveals that digital transformation is becoming an increasingly critical area for the football industry. The increasing number of studies allows experts from different disciplines to come together to examine the digital transformation of football. On the other hand, the digital transformation of football encompasses not only technical aspects, but also social and cultural dimensions. In particular, the interaction of fans, the management styles of football clubs and commercial strategies are affected by this transformation. Therefore, future studies in this field need to adopt a more comprehensive and interdisciplinary approach. Therefore, in all these cases in the number of broadcasts, it shows that more innovation and development can be expected in the digitalization process of the football industry.

The increase in the number of citations shows that the digital transformation of football has become not only an area of academic interest but also an industrial necessity. The effects of artificial intelligence and the Metaverse on soccer have provided a rich field of study for many researchers. However, the decline in 2023 can be attributed to reasons such as “Saturation”, “Change of Focus”, “Short-Term Interest”. In this context, many studies may have been conducted on the subject by 2022. This may have created a sense of academic saturation and led to new studies receiving fewer citations. Researchers may have turned to new and different fields other than digital transformation. This may have led to the idea that existing studies do not make a sufficient contribution. The fact that digital transformation and related

technologies are seen as a temporary trend may have reduced the permanence of studies in this field.

When all these situations are evaluated, the increase in the number of citations shows how important the issue of digital transformation has become in the football industry. However, the decline after 2023 could mean that this topic is potentially not addressed in sufficient depth in the academic literature or that there is an increased focus on other topics. This is in line with the fact that the football industry is in constant development and change.

Within the scope of the study, it was concluded that artificial intelligence is used in many areas such as monitoring player performance and developing game strategies, while the metaverse offers important opportunities in terms of increasing fan interaction, organizing virtual events and taking the football experience to new dimensions, and artificial intelligence offers important opportunities in terms of monitoring player performance and developing game strategies.

This analysis, based on Web of Science (WoS) data, clearly reveals in which disciplines research on the digital transformation of football is concentrated. Sport Sciences, the most cited category, shows how the technical and physical aspects of football dominate the research field. This highlights the importance of sports science in studying soccer performance, player health and training techniques. Other categories reveal that the digital transformation of football needs to be addressed not only as a sport, but also in its broader social, economic and psychological dimensions. The Hospitality, Leisure, Sport & Tourism category shows how football interacts with the tourism and leisure sectors, while areas such as Physiology, Psychology Applied allow for the study of the effects of players' health and psychological state on performance. However, the relatively low number of citations for some categories suggests that the relationship between these fields and football has not been sufficiently explored or that they still need to be more widely covered in the academic literature. Especially the low citation numbers in the categories of Sociology, Orthopedics, Engineering Mechanical indicate that important topics such as social structures of football, injuries and mechanical innovations need to be further examined. This analysis shows that research on the digital transformation of football is mostly concentrated within the framework of sports sciences and there is a large literature in this field. However, it is clear that the relationships of soccer with social, psychological and engineering fields have not been sufficiently explored. This highlights the need to bring together different disciplines to better understand and develop the digital transformation of the football industry.

Research on digital transformation in football should not be limited to sports sciences. With the contributions of other disciplines, the social, economic and psychological dynamics of football can be better understood. This interdisciplinary approach will make it possible to address the effects and consequences of the digitalization process of football in a more comprehensive way, especially in an environment where today's football is increasingly based on data and technology. Consequently, diversifying such research on the digital transformation of football will be critical for the future directions of the football industry. Interdisciplinary collaboration and innovative research methods can help to gain a deeper understanding of football's digitalization process and seize emerging opportunities. The meso-distribution of citation topics reveals how the digital transformation of football intersects with various disciplines. The category “Sports Science” accounts for more than half of the total citations, highlighting the impact and importance of sports science on football. On the other hand, the presence of fields such as “Hospitality, Leisure, Sport & Tourism” shows that the social and economic dimensions of football are not ignored. However, the low number of citations for some topics may indicate that the

relationship between these fields and soccer has been less researched or that these topics have not yet been sufficiently covered in the literature. In particular, topics such as “Communication”, “Back Pain” and “Nutrition & Dietetics” attract less attention despite their importance in the overall dynamics of football. This analysis reveals that research on the digital transformation of football is mostly sports science-centered and there is a rich literature in this field. The low rates of other topics indicate that the relationship between football and these disciplines needs to be further examined. The effects of fields such as health and communication on football are critical to understanding the digitalization process. The high number of citations in the sports sciences category underlines the interest and necessity for studies in this field. However, more research on other topics would allow for a deeper understanding of the digital transformation of football. In conclusion, the digitalization process of football has a complex structure that brings together many disciplines. Within this structure, increasing interdisciplinary cooperation and including different perspectives is important for the future of football research. The distribution of citation topics at the micro level provides an important basis for examining the digital transformation of soccer and the impact of technological innovations on this process.

The fact that the Soccer category has the highest rate reveals the unique dynamics of soccer and the majority of research in this field. On the other hand, topics such as Sport Psychology and Traumatic Brain Injury provide important data on the psychological and physiological effects of the digitalization process of football on athletes. Artificial intelligence and the Metaverse have the potential to optimize athletes' performance by influencing data analysis and decision-making processes in the field of sport psychology. However, the low citation numbers of topics such as Technology Acceptance Model indicate that studies on technology adoption in the digitalization process of football have not yet been prominent enough. This suggests that researchers should conduct further studies on the adoption dynamics of AI and Metaverse applications in the football industry. The digital transformation process in soccer is not only a technical change, but also a social and psychological transformation. The highly cited topic "Soccer" provides a broad ground for examining the cultural and social aspects of soccer, as well as how it interacts with technological innovations such as AI and the Metaverse. AI has profound implications for data analysis and player performance, while the Metaverse is reshaping fan engagement and experiences. In this process of transformation, better understanding the relationship between the core elements of soccer and technology should be an important goal for future research. The analysis of citation topics at the micro level clearly shows the main trends and research areas in the digital transformation of football. The predominance of the "Soccer" topic indicates that the unique dynamics of soccer are important, while other topics received less attention, suggesting that there are still unexplored areas in the digitalization of soccer. These findings once again highlight the need for a more interdisciplinary approach to understanding the digital transformation of the soccer industry.

The analysis of the research areas shows that the digital transformation process of football is largely shaped around sport sciences. The more frequent use of the Sport Sciences category reveals how important the technical and performance aspects of football are for research. However, the high number of citations in Social Sciences Other Topics emphasizes the need to investigate the social, cultural and economic aspects of football. Furthermore, the low number of citations in Computer Science and Engineering indicate that the potential of artificial intelligence and Metaverse applications in soccer research has not yet been adequately utilized.

This indicates that there are still unexplored areas of the digitalization process of the football industry. When all the results obtained are evaluated, the predominance of the Sport Sciences category shows that the physical aspects of football come to the forefront. However, the high number of entries in Social Sciences Other Topics reveals that the social dynamics, fan behavior and economic effects of football are also important.

The concentration of soccer research in high impact factor indexes such as Science Citation Index Expanded (SCI-EXPANDED) shows that this field is taken seriously in science and its technical aspects are examined in detail. This situation reveals that soccer is not just a sport, but can be the subject of scientific and technological research. The significant share of other indexes such as Emerging Sources Citation Index (ESCI) and Social Sciences Citation Index (SSCI) shows that the social and cultural dimensions of football are also receiving more and more attention. However, it is clear that these areas are not yet mature enough and need further research. The low number of entries in the Conference Proceedings Citation Index (both SCI and SSH) suggests that the number of presentations and publications in congresses on football and digital transformation is still limited and that these topics need to be included more in academic debates. The digital transformation process of football is fed by the combination of various academic disciplines. This shows that football research is not only limited to sports sciences, but also social sciences, engineering and computer sciences play an important role in this process. In particular, the impact of modern technologies such as artificial intelligence and the Metaverse on football has aroused a deep interest in the academic world as well as the sports community. However, the available data shows that more research and publications are needed on the digitalization process of football. This will be critical to better understand the evolution and transformation of the football industry. Diversification of research is important to determine the future dynamics of football. This analysis shows the intensity and academic quality of research on football, artificial intelligence and Metaverse. While the dominance of the SCI-EXPANDED index reveals the seriousness of football in scientific research, the low number of records in other indexes shows that the literature on this subject is not yet fully developed. In conclusion, increasing research on the digital transformation of football, especially in the social and engineering fields, will make significant contributions to the development of the football industry.

Diversifying studies in this field and encouraging interdisciplinary collaboration is critical for understanding the future directions of football and seizing the opportunities that arise in this process.

This bibliometric study reveals the key components of digital transformation in football and their interactions. Elements such as artificial intelligence, technological developments and social media are important factors shaping the future of football. The relationships between these themes provide a valuable foundation to guide future research. Research focuses on key areas such as enhancing football performance, ensuring athletes' health safety and optimizing strategic decision-making processes. In particular, concepts such as "performance" and "concussion" stand out as issues that need more attention in the field of sports sciences. This study provides an important framework for understanding the role of artificial intelligence and the metaverse in the digital transformation of soccer. The interplay between the themes can help determine the direction of research and areas for future development of the football industry. In particular, it seems that more work needs to be done in the areas of health, performance and management. This is an important conclusion for both academic and practical applications. The results of the analysis show that the key themes in the digital transformation in football are technological developments and social interactions. Keywords with high Callon Centrality and Density values are heavily present in the literature and reveal that these topics interact with each other. In particular, the role of technologies such as GPS and artificial intelligence in improving soccer performance is evident in the research findings. This study reveals the complexity and multidimensional nature of soccer's digital transformation. The impact of technology, especially artificial intelligence and GPS systems, on the assessment and improvement of soccer performance constitutes an important area of research in the field of sports science. Furthermore, the impact of social media and digital platforms on the younger generation reflects the evolution of sports culture and fan interaction. The digitalization of football is not only affecting the performance of players, but also transforming consumer behavior. Changes in consumers' expectations of matches and players are important elements to consider in clubs' strategic

planning. In this context, multimedia content and social media interactions are becoming increasingly important. In conclusion, this bibliometric study reveals that artificial intelligence and the metaverse play important roles in the digital transformation of football.

By exploring the interactions in these areas in depth, future research can help us better understand how the digitalization process of football is taking shape and which elements are decisive in this process. Furthermore, these results can be used as an important resource for football organizations to develop their digital strategies.

Digital transformation reveals how football is changing for both players and administrations. In particular, artificial intelligence applications, data analysis and monitoring systems are improving the performance of athletes and helping to prevent injuries. However, exploring social issues such as "gender" and "children" is crucial for football to become more inclusive. Participation in soccer can contribute significantly to children's physical fitness, teamwork and social interactions. Research can examine how these experiences foster resilience, discipline and a sense of belonging among young players. Examining how gender affects children's experiences in soccer can provide insights into the different challenges faced by boys and girls. This may involve analyzing motivations, expectations and social dynamics within teams. Exploring the role of coaches and mentors in shaping children's attitudes towards gender can be critical. Programs that promote positive role models and equal treatment can help challenge stereotypes and create a supportive environment. The intersection of gender and child development in soccer highlights the need for comprehensive research that addresses these social dimensions.

In future studies, it is suggested that concepts such as "health", "risk factors" and "media" be examined in more detail. These areas are critical to understanding the social and psychological impacts of the digital transformation process. Case studies showing how AI and metaverse applications work in real-world scenarios should be conducted. This will help translate theoretical knowledge into practice. Multidisciplinary research that brings together sports science, psychology, sociology and technology should be encouraged. In this way, the digital transformation of football can be addressed more comprehensively. Because more research on the psychological factors that influence the performance of soccer players is important to understand the relationship between sports psychology and digital transformation. Training programs for the development of digital skills for athletes, technical teams and managers should be organized. This will increase the effective use of digital technologies. Increasing applied research can help put theoretical knowledge into practice.

More studies should be conducted on the factors affecting the performance of soccer players, especially in the field of health. The effects of artificial intelligence and the Metaverse on football should be studied in collaboration with different disciplines such as social sciences and engineering. This can help to understand the multifaceted effects of soccer's digital transformation. These recommendations provide an important roadmap for a better understanding and implementation of the impacts of digital transformation in the football world.

Publication Ethics: During the preparation and writing process of this study, adherence to the “Higher Education Institutions Scientific Research and Publication Ethics Directive” was ensured, encompassing scientific, ethical, and citation rules. The collected data were not manipulated in any way, and this study has not been submitted for evaluation to any other academic publication platform

Conflict of Interest Among Authors: Within the scope of this study, there are no personal or financial conflicts of interest among the authors.

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