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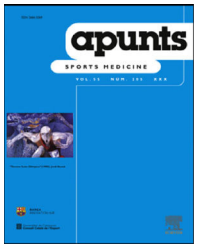

REVIEW

Mapping the field: A bibliometric analysis of women's football research trends and future directions

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Abstract Women's football is a fast-growing sport with a significant global presence. There has been no bibliometric analysis in the field of women's football, which could help figure out the importance of this study area and identify knowledge gaps. Therefore, this study reviews the scholarly literature on women's football using bibliometric data from Scopus from 1984 to February 2024. Using multiple performance and science mapping techniques, we map the research landscape, highlighting key contributors and trends in women's football literature. The foremost contributors are the United States, Leeds Beckett University, the European Regional Development Fund (European Commission), and the Journal of Strength and Conditioning Research. Based on the analysis, we predict that the keywords may be relevant to women's football research in the future. In the concluding section, we delineate the study's limitations and propose avenues for future research expansion.
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Introduction

The historical origins of women's football, which can be traced back to the latter part of the 19th century, hold great importance in the realms of sports and the advancement of women's rights.[1] Nowadays, Women's football has experienced significant growth and professionalization, providing more opportunities for women to play and work in the sport.[2] The third edition of 'Setting the Pace,' FIFA's comprehensive benchmarking report on women's football, highlights substantial growth and progress in the sport across all six confederations.[3] The surge in professionalization greatly enhanced the allure of women's football, resonating both on and off the pitch. Additionally, academia delved into this global sport, conducting clinical and theoretical experiments to further understand its dynamics. Numerous scientific approaches have been taken care of to answer research questions in the women's football domain. The researcher's primary search of articles relating to women's football yielded a significant number of outputs and revealed a rapid

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increase since 2019 in this domain. This observation has prompted an inquiry into the scholarly investigation of women's football, focusing on the spread of the research landscape, key contributors, and prevalent research themes within this domain. Consequently, the present study aims to conduct a bibliometric investigation on women's football research utilizing the Scopus database.

The bibliometric analysis aims to provide insights into the growth and development of a research domain, identify influential authors and institutions, uncover emerging research trends, and assess the impact of publications and researchers.[4,5] The current literature includes multiple bibliometric studies discussing different aspects of football such as safety in football stadiums,[6] Football tourism,[7] European Super League,[8] governance and sustainability,[9] and injury.[10,11] There is only one bibliometric study that exists on women's football by Kirkendall & Krustrup.[12] Their study investigates the evolution of literature concerning soccer, female soccer, and professional female soccer across different periods. We depart from their work in four fundamental ways. First, we utilize the Scopus citation database, a widely utilized resource in bibliometric studies. Second, our data spans from 1984 to February 2024, capturing the significant growth in research articles on women's football since 2019, a period overlooked in their study. Third, our search terms consist of single-word combinations of keywords 'women', 'female', 'girl', 'football', and 'soccer'. Finally, we integrate various science mapping techniques from the bibliometric toolbox and employ the biblioshiny web interface to generate more insights.

For the present investigation, bibliometric data has been retrieved from the Scopus citation database and the final dataset for the analysis after the exclusion criteria consists of 1057 research articles from 305 journals between 1984 to February 2024 published in the English language. We capitalize on all the possible bibliometric analysis techniques on the women's football literature data to draw meaningful insights. The reminder of this article is organized as follows: the second section comprises the data and methodology, followed by the results presented in the third section. Finally, the conclusion is provided in the fifth section.

Data and methods

Bibliometric analysis was introduced by Pritchard in 1969,[13] and the methodology relies solely on quantitative techniques for bibliometric data[14] to quantify and examine academic works.[15] It involves recognizing authors' published works, significant journals, employed methodologies, and derived conclusions.[16] Scholars utilize bibliometric analysis for many objectives, such as examining the intellectual structure of a given field and finding trends in article and source performance, relationship networks, and investigation themes.[4] Bibliometric analysis follows Study design, Data collection, Data analysis, Data visualization, and Interpretation.[5] The primary stages of selecting search keywords and databases for the data collection are crucial in bibliometric analysis.

Scopus stands out as one of the literature databases widely employed for bibliometric studies, revered for its extensive coverage and comprehensive citation database.[4,17,18] The present study uses the Scopus database and we begin our analysis process by searching the combinations of two sets of keywords. First is Women*, female*, and girl*; second is football* and soccer*. A basic search on Article Title, Abstract, or Keywords produces 10,816 documents. Upon search query, we observed that some studies not related to women's football are included in the search results. Consequently, we prioritize the 'article title' for the search query which is the most important part of a scientific paper.[19–21] We also limit the search query to article document type; Journal source type; and English language. Fig. 1 shows the inclusion criteria and refers table A1 the research query. The final dataset for the analysis consists of 1057 research articles published in 305 journals in the English language spanning between 1984 to February 2024.

Bibliometric analysis techniques are majorly grouped into two main categories: performance analysis and science mapping. Performance analysis entails a descriptive examination of the contributions made by research constituents. Whereas Science mapping identifies the associations among research elements.[22–24] We apply these techniques suggested by Aria & Cuccurullo[5]; Cobo et al.[23]; Donthu et al.[5] to women's football. We use the annual literature publication map, the total research articles published by affiliations, countries, funding institutions, and country collaboration links, to comprehend the demographical distributions of scientific publications in women's football. Furthermore, we

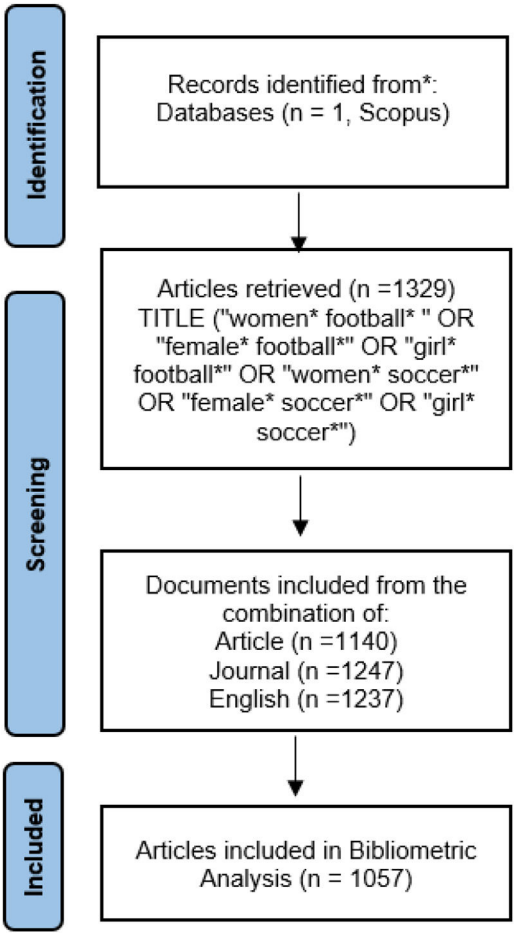

Fig. 1 Inclusion and exclusion criteria.

identify the top important journal sources, most relevant research work, and contributing authors in the women's football research, using different parameters such as the total number of published works, number of global citations received, and the number of articles fractionalized, respectively.

The primary objective of this study is to trace the thematic development of women's football research and outline possible future research paths associated with women's football. To understand women's football research's thematic foundations and development, we use three bibliometric science mapping techniques, such as co-occurrence map, thematic map, and co-citation analysis. We use a thematic evolution map, trend topics chart, and co-occurrence (overlay) visualization map based on authors' keywords to suggest latest and potential forthcoming study areas. We use a thematic map, thematic evolution map, Word TreeMap, Co-occurrence map, and collaboration network plots using biblioshiny; A customizable web interface utility backed by the R programming language.[5] In addition, we use VOSviewer, to produce co-word overlay visualization of keywords, bibliometric coupling, and co-citation analysis. VOSviewer is a free Java application, developed by van Eck & Waltman[25] for constructing and visualizing bibliometric networks, particularly co-authorship, citation, and co-citation networks.

Results and discussion

The results section has been categorized into two primary subsections; Performance Analysis and Science Mapping Analysis. First, the performance analysis consists of Annual Scientific Production across the Country, Institutions, and Research Funding Agencies, top Journals, most contributing Authors, and important Documents in women's football research. This performance analysis also takes into account international collaboration between institutions and countries. Second, we identify theme clusters and suggest potential future research fields of women's football using different science mapping bibliometric analysis techniques, including a keyword Co-occurrence Map (Fig. 6), thematic map (Fig. 7), Co-citation network (Fig. 8), thematic evolution map (Fig. 9), Trends Topic (Fig. 10) and Co-occurrence (Overlay) map (Fig. 11).

Performance analysis

Fig. 2 shows the research publication growth in women's football from 1984 to 2024 February. Though it is slow in the initial stages, the scientific research article publication has seen substantial growth since 2010. A total of 1057 documents were published across 24 Scopus research areas with an Annual Growth Rate of 10.49 %. Out of this, 690 are from medicine and 561 are from Health Professions subject areas. The highest number, 152 research articles were produced in 2022, followed by 143 in 2023, 120 in 2021, and 94 in 2020. The total scientific productions of the last four years (2020-2024 January) represent 53 percent of total research articles published in the women's football research domain. It points to the increasing attention of scholars in women's football research. Among the countries, the United States leads the table with a total publication of 239 articles, followed by the United Kingdom (207), and Spain (143). Fig. 3 shows the collaboration between countries. based on number of frequency of publications, the United Kingdom with Spain (18), Spain with Chile (16), and Norway with Denmark (15) are top of the table.

Among the institutes, Leeds Beckett University tops with 31 research articles, followed by Liverpool John Moores University (29) and Linköpings Universitet and Universidad de Extremadura with 26 each. Fig. 4 shows the collaboration clusters and links between various institutions. European Regional Development Fund (European Commission) has sponsored 17 research works and ranks top in funding agencies for women's football research. Followed by, Fundação para a Ciência e a Tecnologia (Foundation for Science and Technology- Lisbon, Portugal) with 16, and Conselho Nacional de Desenvolvimento Científico e Tecnológico (National Council for Scientific and Technological Development, Brazil) with 15 publications.

Based on the total number of articles published (TP), Table 1 lists the top 10 most important journals.

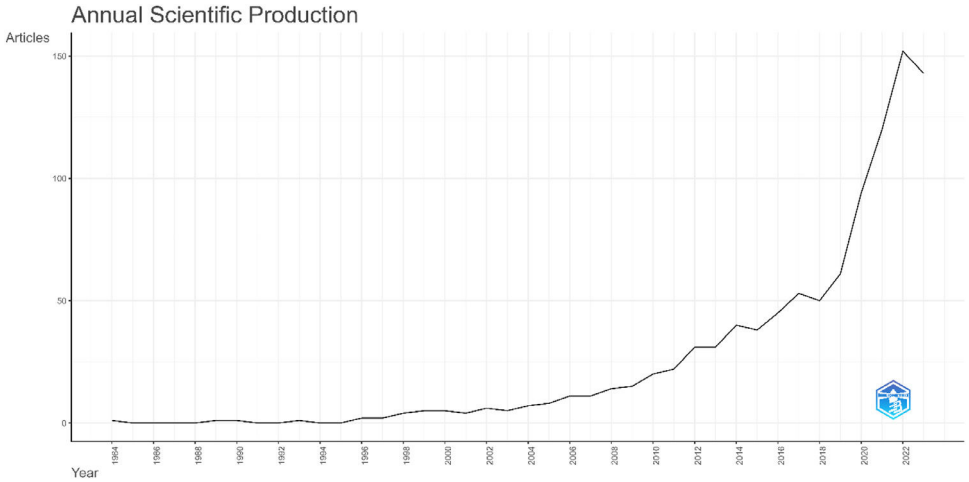

Fig. 2 Publication growth.

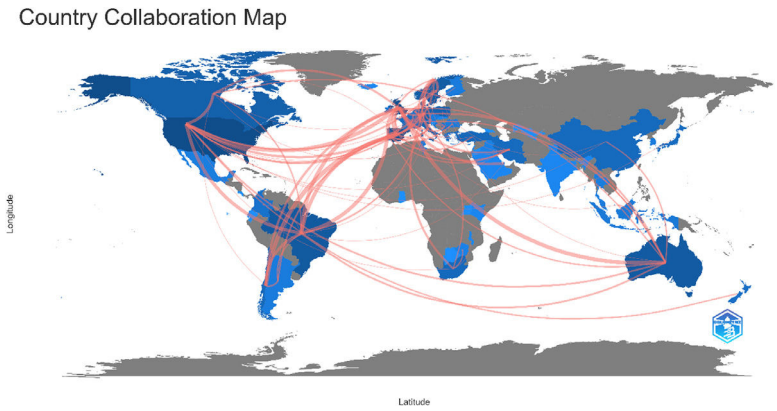

Fig. 3 Country publication and collaboration.

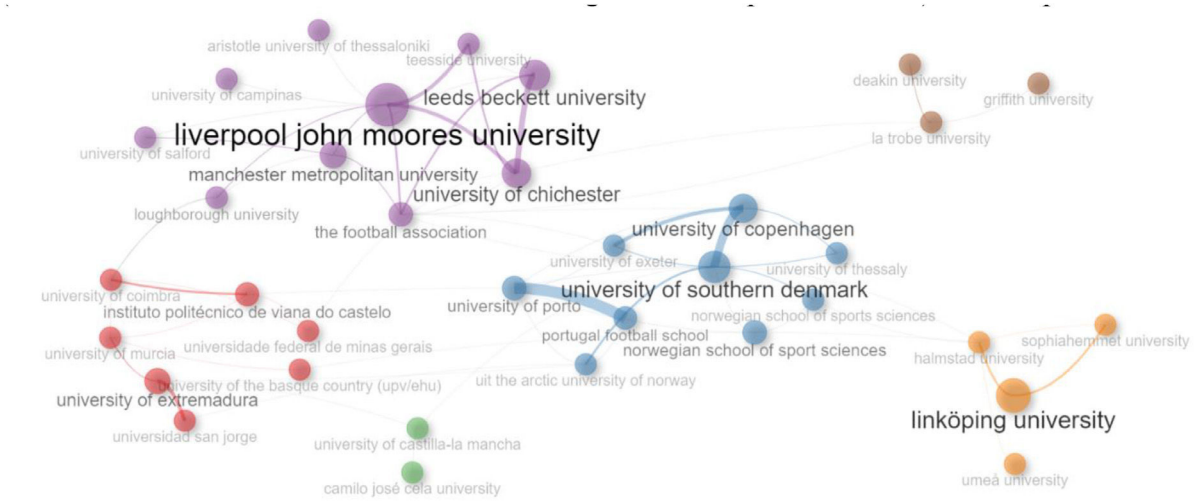

Fig. 4 Institute collaboration.

Table 1 Most relevant journals.

Journal Title	TP	Publisher	SCY	CS 2022	SNIP 2022
Journal of Strength and Conditioning Research	67	NSCA National Strength and Conditioning Association	Since1987	6.8	1.915
Soccer and Society	47	Taylor & Francis	Since 2009	2.3	1.083
Science and Medicine in Football	39	Taylor & Francis	Since 2017	4.9	1.433
International Journal of Environmental Research and Public Health	38	Multidisciplinary Digital Publishing Institute (MDPI)	Since 2004	5.4	1.28
Scandinavian Journal of Medicine and Science in Sports	32	Wiley-Blackwell	Since 1991	7.8	1.602
Journal of Sports Sciences	26	Taylor & Francis	Since 1983	6.5	1.653
International Journal of Sports Physiology and Performance	24	Human Kinetics Publishers Inc.	Since 2006	6.1	1.507
American Journal of Sports Medicine	21	SAGE	Since 1973	9.9	2.336
Journal of Sports Medicine and Physical Fitness	19	Edizioni Minerva Medica	Since 1962	3.3	0.8
Sports	18	Multidisciplinary Digital Publishing Institute (MDPI)	Since 2013	5.2	1.36

Table 2 Top ten articles.

Rank	Title	TC
1	High prevalence of knee osteoarthritis, pain, and functional limitations in female soccer players twelve years after anterior cruciate ligament injury	1121
2	Comprehensive warm-up programme to prevent injuries in young female footballers: cluster randomised controlled trial.	576
3	Physical demands during an elite female soccer game: Importance of training status.	505
4	Knee joint laxity and neuromuscular characteristics of male and female soccer and basketball players.[29]	370
5	Balance board training: Prevention of traumatic injuries of the lower extremities in female soccer players? A prospective randomized intervention study.[30]	310
6	Prevention of acute knee injuries in adolescent female football players: Cluster randomised controlled trial.[31]	300
7	Risk factors for leg injuries in female soccer players: A prospective investigation during one out-door season.[32]	287
8	High adherence to a neuromuscular injury prevention programme (FIFA 11+) improves functional balance and reduces injury risk in Canadian youth female football players: A cluster randomised trial.[33]	280
9	Time-motion analysis of small-sided training games and competition in elite women soccer players.[34]	274
10	Match activities of elite women soccer players at different performance levels.[35]	271

Furthermore, the table includes information on each journal's: Publisher, Scopus Coverage Years (SCY), CS 2022 (Cite Score 2022), and SNIP 2022 (Source Normalized Impact per Paper, 2022). Our results indicate that the Journal of Strength and Conditioning Research tops the list with 67 documents, followed by Soccer and Society (47), Science and Medicine in Football (39), International Journal of Environmental Research and Public Health (38), and Scandinavian Journal of Medicine and Science in Sports (32). From the list, based on the Cite Score 2022, the American Journal of Sports Medicine secured the highest score of 9.9, followed by the Scandinavian Journal of Medicine and Science in Sports (7.8) and the Journal of Strength and Conditioning Research (6.8). Notably, Taylor & Francis stands out as the major publisher, with three out of the top ten journals being affiliated with it. This underscores Taylor & Francis's significant presence and influence in the academic publishing landscape within the field of women's football.

We consider the total citations (TC) received by a research article to be a valuable method for identifying the most relevant articles in women's football research. Based on this, Table 2 lists the top 10 most important articles published related to women's football research. The study by Lohmander et al.,[26] aiming to ascertain how common radiographic knee osteoarthritis (OA) is among female soccer players twelve years following an anterior cruciate ligament (ACL) injury, alongside assessing knee-related symptoms and functional limitations has cited most (1121). Followed by, Soligard et al.[27] for investigating the impact of a thorough warm-up program specifically created to mitigate the risk of injuries among female youth football players with 576 citations. The third significant study revolves around examining the activity profile and physical loading experienced by elite female soccer players during matches, as well as exploring how their training level correlates with their physical performance in matches by Krustrup et al.[28]

We present the most contributing authors in women's football research (Table 3), based on the number of articles published and articles fractionalized. We adhere to fractionalized counting as a tool to identify the top authors since it provides a more robust measure than the total number of articles.[36] Our results display that Hägglund, M. is the most publishing scholar with a article fractionalized figure of 5.76 followed by Vescovi, J.D. (5.42), Nikolaidis, T. (3.77), Junge, A. (3.57) and Fältström, A. (3.33).

Science mapping

The main purposes of this research include finding the intellectual landscape of women's research, the present status of the domain, and upcoming research areas of interest. To identify the current status and focused areas of women's

Table 3 Top authors.

Author	NP	Author	Articles Fractionalized
Hägglund, M.	24	Hägglund, M.	5.76
Krustrup, P.	19	Vescovi, J.D.	5.42
Datson, N.	16	Nikolaidis, T.	3.77
Nakamura, F.Y.	16	Junge, A.	3.57
Nobari, H.	15	Fältström, A.	3.39
Clemente, F.M.	14	Kvist, J.	3.2
Emmonds, S.	14	Harris, J.	3
Fältström, A.	14	Ratna, A.	3
Junge, A.	14	Datson, N.	2.97
Brito, J.	12	Krustrup, P.	2.94
Kvist, J.	12	Nakamura, F.Y.	2.82

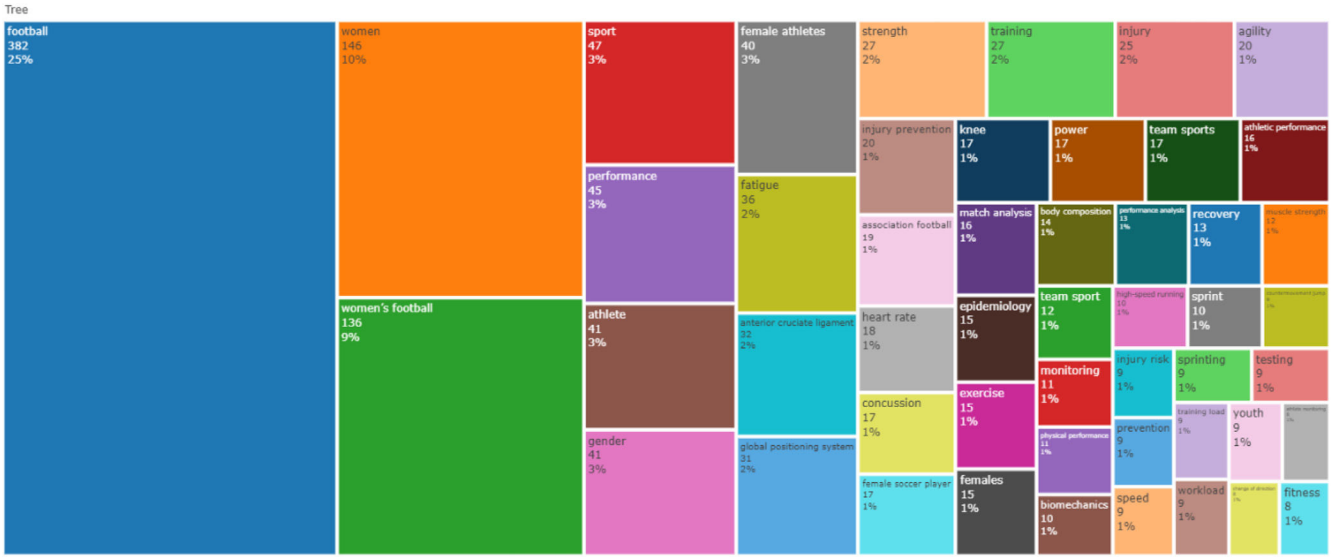

Fig. 5 Tree word.

football research, we use multiple science mapping techniques; co-occurrence analysis (Fig. 6), the thematic map (Fig. 7), and co-citation network (Fig. 8). Additionally, to suggest the potential future areas of investigation, we use two keyword analyses; Trend Topics (Fig. 10) and Co-occurrence (Overlay) visualization (Fig. 11) with the thematic evolution map (Fig. 9). For all the analyses based on keywords, we opt for keywords quoted by authors (DE) as a unit of analysis.

Fig. 5 displays the word tree map generated from Authors' Keywords (DE) using Biblioshiny to examine the most repeated keywords. The occurrence of keywords is shown by the proportions and color of the sub-rectangular, where a bigger box signifies a higher occurrence of keywords. The top five recurring authors' keywords quoted in articles are football (382 times, 25 %), women (146, 10 %), women's football (136, 8 %), sport (47, 3 %), and performance (45, 3 %). Other keywords include athlete, gender, female athletes, fatigue, anterior cruciate ligament, global positioning system, strength, training, injury, agility, and injury prevention.

We start the science mapping techniques using a co-occurrence map to identify the themes studied together in women's football research. Fig. 6, forms three major clusters green, blue, and red. The major cluster colored in green

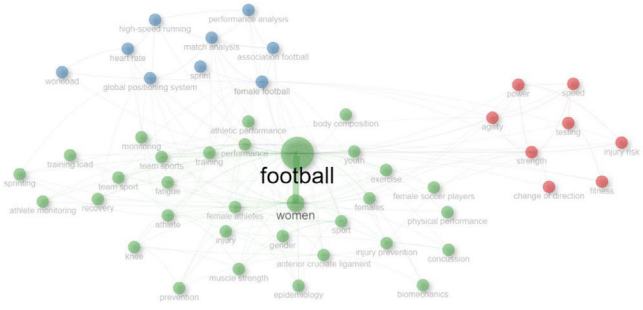

Fig. 6 Co-occurrence map. Clustering algorithm: walktrap, repulsion force: 0.1, normalization: association.

consists of Football, women, body composition, gender, injury, muscle strength, prevention, knee, biomechanics, concussion, injury prevention, physical performance, sprinting, training load, monitoring, team sports, training, athletic performance, recovery, athletic monitoring, exercise, fatigue, epidemiology, anterior cruciate ligament. The blue cluster identifies keywords such as Female football, association football, sprint, global positioning system, heart rate, workload, high-speed running, performance analysis, and match analysis studied together. The third major cluster colored in red has the common keywords of agility, power, speed, testing, strength, change of direction, fitness, and injury risk.

Further, we use a thematic map (Fig. 7) to find and report the research field's themes, patterns, and emerging areas. The basic themes in women's football research are related to the keywords such as football, women, performance, athlete, female athlete, fatigue, training, team sports, athletic performance, exercise, global positioning system, association football, heart rate, female soccer player, match analysis, performance analysis, recovery, high-speed running, sprinting, workload, women's football, strength, agility, power, body composition, sprint, countermovement jump, speed testing, youth, sport, gender, youth sport, coaching, motivation, social media, sports psychology, injury risk, screening, velocity, anterior cruciate ligament, injury, injury prevention, concussion, knee, epidemiology, biomechanics, prevention, rehabilitation, and sports medicine. We list the range of motion, warm-ups, physical performance, player tracking, sports performance, anthropometry, coping, COVID-19, elite athletes, carbohydrates, energy availability, diet, and deceleration as emerging themes. We identify, hamstrings, quadriceps, anxiety, cortisol, mental health, fans, femininity, strength training, and anterior cruciate ligament injuries as niche themes in women's football research.

Finally, we capitalize on a co-citation network analysis to categorize the thematic focus of studies in women's football research (Fig. 8). The minimum number of citations of a document is 15 and 328 documents out of 1057 met the

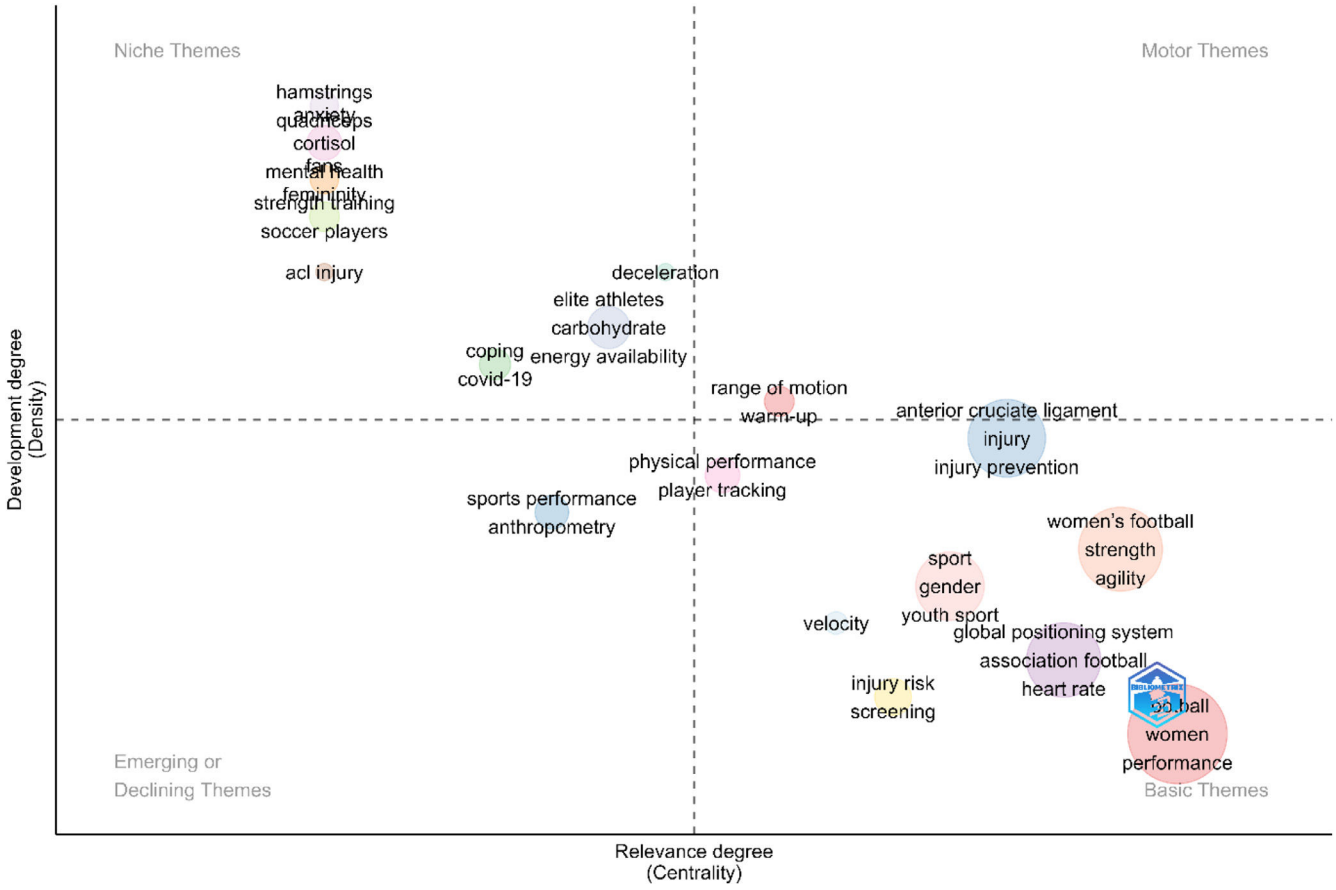

Fig. 7 Thematic map.

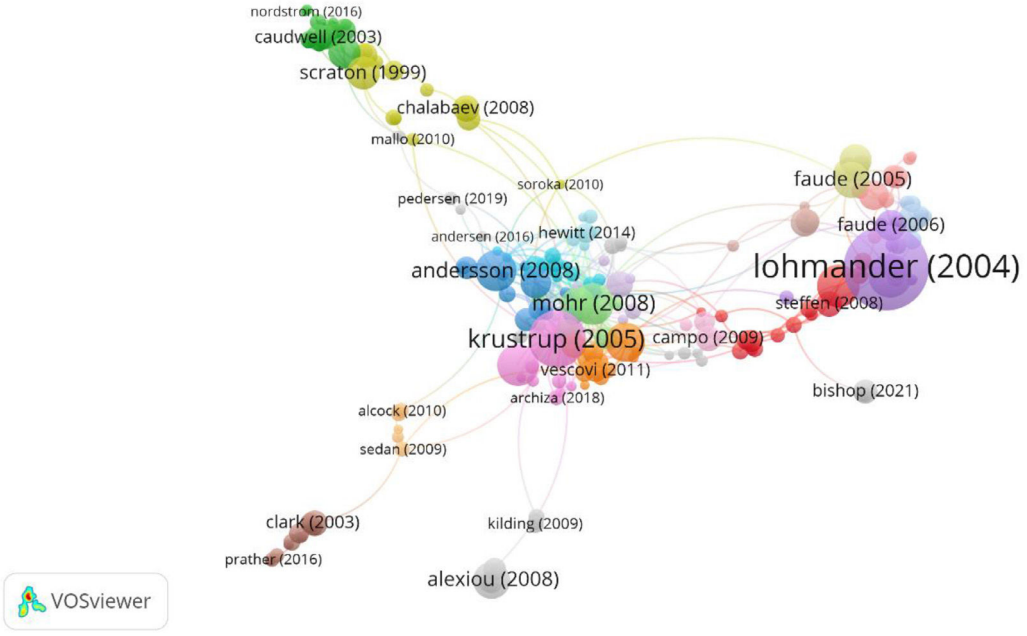

Fig. 8 Co-citation network. Minimum number of citations of a document: 15.

threshold. The left-top, green, and yellow-colored clusters share the common theme of research on gender, sex, and ethnicity among women's football players[37–40] and referees.[41] Gender comparison studies[42,43] are also carried out and clustered across these two clusters. The bottom left corner brown-colored cluster shares the studies on nutrition[44,45] and energy availability[46,47] among female soccer players. The second cluster colored light-orange shares

the research theme on different styles of kicks for scoring goals and winning games.[48–51] Gray-colored cluster related to heart rate-based research in women's football.[52–55]

Though the blue-colored cluster does not follow a common pattern, the high-sized bubbles are based on studies relating to fatigue and recovery.[56,57] Cyan-colored cluster gives more weight to experimental match studies discussing different aspects affecting women footballers and their game. Such as menstrual cycle[58], movement profiles[59], variation of match-running,[60] and explosive movement.[61] The pink-colored cluster in the middle shares the common theme of different training programs and the impact and importance of training on women footballers (Archiza et al.[62]; Gabbett & Mulvey[34]; Jackman et al.[63]; Krustrup et al.[28]). Whereas the green-colored cluster is particularly on studies dealing with sprint or intensive running on women's football players.[64–66]

The orange-colored middle cluster in the co-citation map forms the groups of studies based on the physical characteristics in women's football.[67–70] Particular studies on speed characteristics[71,72] and comparison studies of physical fitness among different groups[73,74] are also included in this cluster. The right-side clusters of the map colored in violet, and light yellow, red, blue, and brown majorly share the theme of injury in women's football. The major works form individual clusters based on the size of the bubble including;[75–80]. Whereas the red-colored links are studies based on the prevention of these injuries in women footballers.[27,81,82,33]

To draw the thematical evolution and potential areas for future studies in 'women's football', we opt for three visualization maps; trends topic and thematic evolution map using Biblioshiny and Co-occurrence overlay visualization map using VOSviewer. Fig. 9, visualizes a thematic evolution map produced using the Author's Keywords after setting two cut points (2017 and 2021) to identify the recent keywords. Further, Fig. 10 visualizes the trending keywords in women's football research based on the authors' repeated keywords. Whereas, Fig. 11 displays the co-occurrence (Overlay Visualization) created on the author's keywords with a threshold of 5 Minimum frequency of which 108 meet the threshold out of 2105 keywords.

The evolution map (Fig. 9) identifies keywords such as sleep, player tracking, sprint, aerobic capacity, muscle

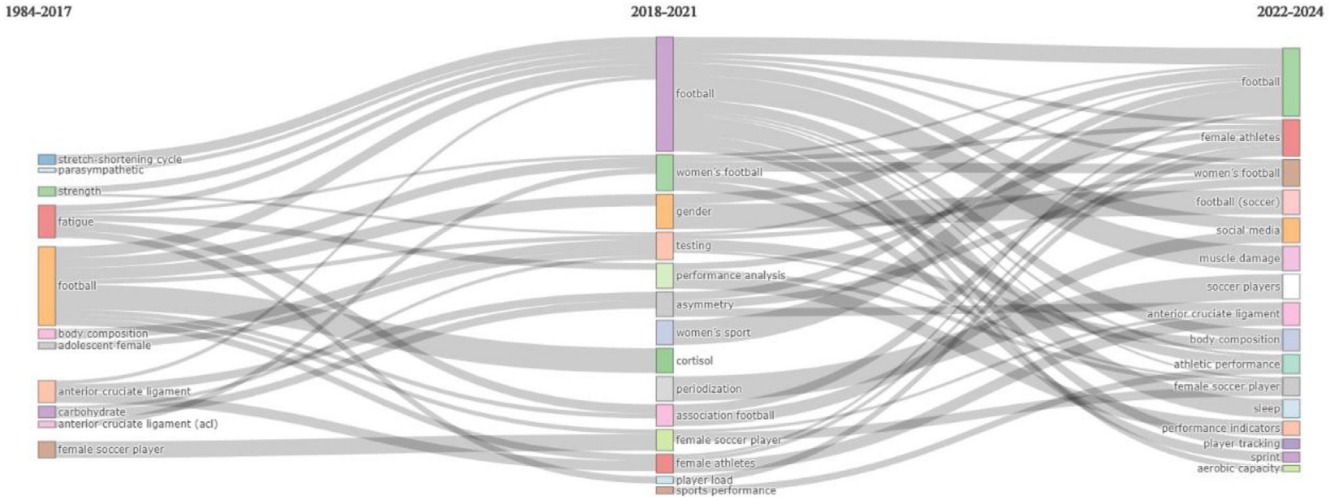

Fig. 9 Thematic evolution map. Number of cutting points: 2 (2017 and 2021), clustering algorithm: walktrap, min weight index: 0.1, min cluster frequency (per thousand docs): 5, weight index: inclusion index weighted by word-occurrences.

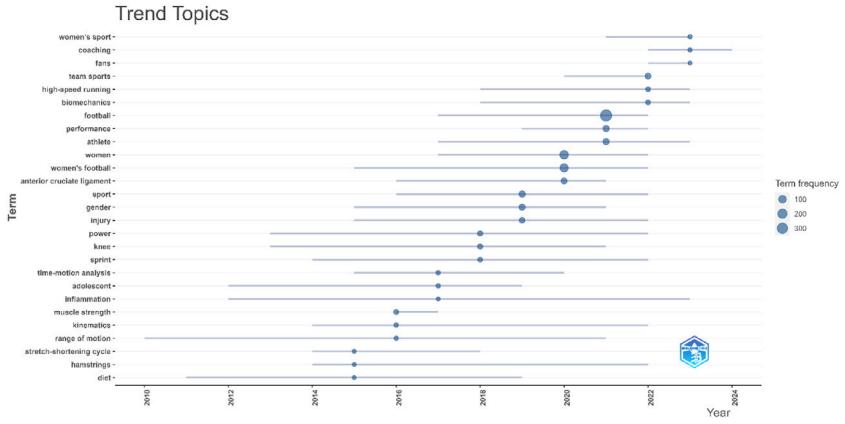

Fig. 10 Trend topics map. Parameters: Word minimum frequency: 5, number of words per year: 10.

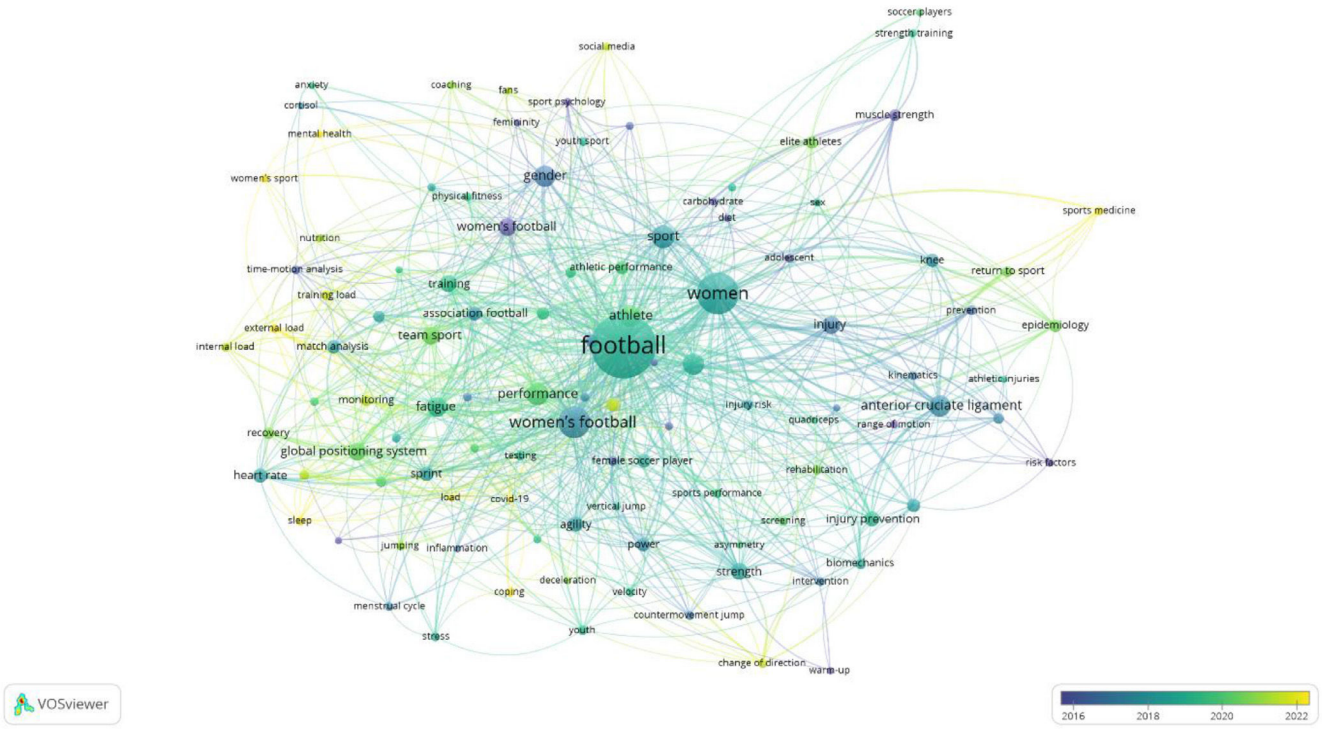

Fig. 11 Co-occurrence (overlay) map.

damage, anterior cruciate ligament, and body compositions are recent keywords in trend. The trends topic (Fig. 10) shows that keywords such as Inflammation, hamstrings, range of motion, kinematics, time-motion analysis, injury, power, biomechanics, high-speed running, team sport, fans, coaching, anterior cruciate ligament, and diet are the most trending authors' keywords quoted in research articles during 2020–2024. Whereas in the overlay visualization (Fig. 11), mental health, internal load, external load, sleep, coping, COVID-19, sports medicine, and load as the latest keywords colored in yellow are the future areas of research. Additionally, keywords such as training load, workload, Recovery, jumping, Monitoring, nutrition, team sport, change of direction, screening, rehabilitation, return to sport, epidemiology, social media, fans, coaching, anxiety, and high-speed running as recent focused keywords in women's football research.

Conclusion

This present study aims to fill a gap in the existing literature by conducting a bibliometric analysis of women's football, using 1057 research articles published between 1984 and 2024 from 305 journals, revealing a significant increase in academic output since 2010. This study reveals that the United States, Leeds Beckett University, the European Regional Development Fund (European Commission), and the Journal of Strength and Conditioning Research emerge as the foremost contributors in terms of the number of published documents within the women's football research. Also, this study lists the most relevant documents published and the authors who contributed to this specific area of research. In addition, our study visualizes the status of women's football research and predicts potential possible research areas by utilizing science mapping techniques from the bibliometric analysis toolbox. We identify the niche, emerging, motor, and basic themes that have gained attention in women's football. We anticipate that researchers need to give consideration based on the thematic map, evolution map, trends topic, and overlay visualization. Includes, range of motion, warm-ups, physical performance, player tracking, sports performance, anthropometry, coping, elite athletes, carbohydrates, energy availability, diet, deceleration, sleep, sprint, aerobic capacity, muscle damage, anterior cruciate ligament, body compositions, Inflammation, hamstrings, kinematics, time-motion analysis, injury, power, biomechanics, high-speed running, team sport, fans, coaching, mental health, internal load, external load, sports medicine, and load.

To conclude, this study holds several notable advantages over previous bibliometric analyses of women's football. Importantly, our dataset includes bibliometric data for the period from 2019 to 2024, during which 53 percent of total research articles related to women's football were published. Further, academicians, trainers, coaches, and players can benefit from our research in several ways. First, it helps researchers and decision-makers understand where women's football research stands at the moment. Second, our findings from the performance and science mapping techniques identify important contributors and collaborators from academia, funding agencies, and government institutions in women's football. This can help foster collaboration and can lead to more effective policy outcomes, ensuring that research findings are translated into actionable policies that address real-world challenges in women's football. Though this study concentrated mainly on women's football studies using the Scopus dataset, it's worth mentioning that

important studies from other sources might have been left out. Moreover, bibliometric studies rely on authors' keywords. It is every so often for authors to include inappropriate keywords in their articles, potentially affecting our results, particularly when identifying clusters and emerging themes. Finally, bibliometric studies are limited in their ability to foresee the research area in the short run. Bibliometric research on other various combinations of search fields and databases are potential expansions for this present study.

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Conflicts of interest

The authors declare that they have no conflicts of interest to report.

Data availability

Data will be made available on request.

Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.apunsm.2024.100448.

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