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Clausen, Emma, Flood, Tess, Okholm Kryger, Katrine, Lewin, Gary, McCall, Alan, Stebbings, Georgina and Elliott-Sale, Kirsty (2025) Auditing the representation of elite female players in football performance and injury research. *Football Medicine and Science*, 10 (3). pp. 358-373.

<https://doi.org/10.1080/24733938.2025.2577442>

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To cite this article: Emma Clausen , Tessa R. Flood , Katrine Okholm Kryger , Gary Lewin , Alan McCall , Georgina K. Stebbings & Kirsty J. Elliott-Sale (2026) Auditing the representation of elite female players in football performance and injury research, Science and Medicine in Football, 10:3, 358-373, DOI: [10.1080/24733938.2025.2577442](https://doi.org/10.1080/24733938.2025.2577442)

To link to this article: <https://doi.org/10.1080/24733938.2025.2577442>



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# Auditing the representation of elite female players in football performance and injury research

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## ABSTRACT

This audit assessed the representation of elite female footballers in performance and injury research and evaluated the consideration of ovarian hormones within this research. A standardised audit of performance and injury research in elite football was conducted, systematically reviewing studies to quantify the inclusion of elite female players and the consideration of ovarian hormone profiles. A total of 722 studies were included. Female-only research has increased in recent years, with 47% ( $n = 44$ ) of all female-only studies published since 2022. However, male-only studies dominate, comprising 83% ( $n = 600$ ) of all studies. Female-only studies accounted for 13% of all research, with women representing 7% of all participants. Only one study investigated injury characteristics and recovery in exclusively female players. Of the 104 studies including female players, 96% did not provide sufficient information to define menstrual status. Only four studies offered enough detail to be evaluated using the tiering system by Smith et al. (2022b): 2.5 were ranked ungraded (menstrual status defined but with insufficient methodological control), 1.5 ranked bronze tier (some methodological control). No study was classified as gold tier, which indicates best practice. Our findings show elite female footballers remain significantly under-represented, particularly in studies examining injury characteristics and recovery, with minimal consideration of ovarian hormones. To advance the field and improve methodological quality, future research must use robust objective measures (e.g. ovulation testing or progesterone monitoring) to determine ovarian hormone profiles and ensure sex-balanced representation across all research themes to accelerate the development of the women's game.

## ARTICLE HISTORY

Accepted 4 September 2025

## KEYWORDS

Football; soccer; performance; injury; ovarian hormones; women

## Introduction

The popularity and professionalism of women's football has increased in recent years, enabling players to access full-time training, professional coaching, and comprehensive sports science and medical support (Emmonds et al. 2019). This shift has been marked by the formal professionalisation of several major leagues, such as the National Women's Soccer League (NWSL) in the United States in 2012, the Women's Super League (WSL) in the United Kingdom in the 2018–19 season, and Spain's Liga F in the 2021–22 season. Despite these advancements, research on female athletes remains limited in both general sports science (Cowley et al. 2021) and specifically in football research (Emmonds et al. 2019; Okholm Kryger et al. 2021). The lack of sex-specific research restricts our understanding of the unique demands and

health needs of female players, potentially limiting opportunities to optimise performance and mitigate injury risks by overlooking female-specific factors.

In response to these challenges, several reviews have mapped the current research landscape in women's football. For example, Okholm Kryger et al. (2021) provided a comprehensive overview of the quantity of research across all levels of competitive women's football, examining studies published in four languages. Their work provided an essential foundation for understanding the overall landscape of women's football research, highlighting areas where knowledge is developing and where gaps remain. Similarly, Randell et al. (2021) identified research gaps in physical demands, talent identification, body composition, injury risk, and health in the women's game. While these reviews

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 Supplemental data for this article can be accessed online at <https://doi.org/10.1080/24733938.2025.2577442>

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provided valuable insights into existing research coverage, they did not quantify the extent of underrepresentation between elite male and female players or assess how ovarian hormone profiles (i.e., a female-specific factor) were incorporated.

Adding to these challenges, many studies on women's football focus on sub-elite or recreational players, whose physiology and training differ from elite players. Findings from such studies may have limited relevance for top-flight players, who require tailored strategies and evidence to meet their distinct demands (Burden et al. 2021). Even within studies labelled as 'elite', the rapid evolution and increasing professionalism of the women's game means that relatively recent literature may already be outdated. As performance standards and player expectations increase, players themselves are increasingly calling for research that protects their health, supports their development, and aligns with the realities of the modern game (BBC sport 2019, 2023, 2024; Telegraph sport 2022; Fox 2023). While the research landscape for women's football remains underdeveloped compared to the men's game, the relatively early stage of professionalism in women's football presents a unique opportunity to prioritise rigorous, high-quality methodologies to accelerate knowledge and understanding in the women's game (McCall et al. 2022).

One emerging topic within women's football is the role of ovarian hormone profiles in performance and injury risk, due to the non-reproductive actions of oestrogen and progesterone. To date, low-quality studies and methodological inconsistencies have hindered understanding of if and how ovarian hormones impact athletic performance and injury risk or occurrence (Elliott-Sale et al. 2020; Herzberg et al. 2017; McNulty et al. 2020). It is crucial that future research addresses these factors by adhering to best practice methodological guidelines (Burden et al. 2024; Elliott-Sale et al. 2021; Elliott-Sale et al. 2024; Elliott-Sale et al. 2025; Jonge et al. 2019), but it remains unclear how well such recommendations are currently being implemented, particularly in elite football research.

To investigate these gaps, an established audit protocol (Smith et al. 2022a) was used, which provides a systematic and objective approach to evaluate research coverage while minimising bias. This method enables the identification of specific gaps by quantifying representation and examining methodological characteristics. While narrative and scoping reviews can also offer structured insights, the audit approach is especially appropriate for generating structured, data informed insights that highlight research gaps. It allows for a clearer assessment of how elite female footballers are represented in the existing evidence base and where future research efforts can be most effectively directed.

The primary aim of this study was to systematically assess the representation of elite female footballers in performance and injury research, with a focus on comparing the inclusion of elite female and elite male players. The secondary aim was to evaluate whether ovarian hormone profiles have been considered in this literature, and, if so, to examine the methodological quality of that research. By quantifying the scope and characteristics of existing studies, this audit can provide a clear understanding of how elite female footballers are represented in the current evidence base and highlight areas where their inclusion remains limited. It could also identify how and to what extent ovarian hormones have been integrated into performance and injury research in elite football. This structured approach could help to pinpoint specific knowledge gaps and guide future research efforts ensuring that time, funding, and resources are directed toward the most impactful areas for advancing scientific understanding and improving support for elite female footballers.

## Methods

This audit followed an adapted (see amendments to original audit framework) version of the protocol developed by Smith et al. (2022a). The protocol was published prior to the commencement of the searches.

## Eligibility criteria

Studies eligible for inclusion were original peer reviewed journal articles (reviews, conference abstracts, and other grey literature were excluded), written in English and full text accessible with no date restrictions. To be included, studies had to involve elite football (soccer) players, as defined below, and report original data on outcomes related to performance and/or injury. The population and study outcomes are detailed in Table 1 and were used as the predefined inclusion and exclusion criteria.

## Definition of elite

The Participant Classification Framework from McKay et al. (2022), commonly used in previous audits (Kuikman et al. 2022; Flood et al. 2024; Kelly et al. 2024), was not applied in this audit because the definitions for tiers 4 and 5 are more suited to individual athletes rather than team sports. As such, for the purpose of this audit, 'elite' was defined based on criteria used in prior research (Okholm Kryger et al. 2021). The inclusion criteria for 'elite' players were as follows:

**Table 1.** Inclusion and exclusion criteria for full text screening.

| Criteria             | Details                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|----------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Text availability    | Full text obtained                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| Type of article      | Original articles or case reports                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| Participants         | Only includes male and/or female senior elite football players                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| Participants details | <ul style="list-style-type: none"> <li>• Explicitly states the number of participants.</li> <li>• Explicitly states the sex or male: female ratio of participants – If sex of participants was not explicitly stated but could be determined from additional details included in the paper (e.g., league or competition participants competed in) papers were included (e.g., English Premier League = males; Women's Super League = females).</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| Study outcomes       | <p>The main aim of the study must have either a <i>performance</i> or <i>injury</i> outcome:</p> <p><b>Performance:</b></p> <ul style="list-style-type: none"> <li>• <b>Match demands:</b> Studies focusing on the physical and/or technical demands during match play, such as running performance, distance covered, sprinting efforts, pass accuracy, or shots on target.</li> <li>• <b>Training demands:</b> Studies assessing physical or technical demands in training sessions, including measures such as external training loads (e.g., running performance, distances covered).</li> <li>• <b>Performance testing:</b> Studies evaluating players' performance metrics, such as speed, power, strength, agility, or endurance (e.g., 30–15 IFT, squat 1RM, countermovement jump).</li> <li>• <b>Physical training:</b> Studies involving a physical training period or intervention with performance tests conducted pre- and post-intervention, or at regular intervals throughout.</li> <li>• <b>Combined performance:</b> Studies including one or more of the above performance outcomes</li> </ul> <p><b>Injury:</b></p> <ul style="list-style-type: none"> <li>• <b>Injury incidence:</b> Studies that examined injury rates, risk factors, or the epidemiology of injuries among football players. This includes identifying common injuries and tracking injury occurrence across seasons or competitions.</li> <li>• <b>Injury characteristics and recovery:</b> Studies exploring either injury characteristics (e.g., diagnosis and classification), injury management strategies, or rehabilitation and return to play processes.</li> <li>• <b>Combined injury:</b> Studies including both injury incidence and rehabilitation or return to play outcomes.</li> </ul> <p><b>Combined category (performance and injury):</b> Studies combining performance and injury outcomes</p> <p>Papers were included if the main outcome was not a performance, injury or combined outcome as stated above. Papers which covered the topics below as a primary outcome were excluded.</p> |
| Exclusion criteria   | <ul style="list-style-type: none"> <li>• <b>Internal Load Measures:</b> Studies focusing on internal load measures (e.g., RPE, heart rate).</li> <li>• <b>Muscle Activation:</b> Studies primarily examining muscle activation (e.g., using electromyography).</li> <li>• <b>Reliability/Validity Studies:</b> Studies primarily assessing the reliability, validity, or variability of testing protocols or equipment.</li> <li>• <b>Nutritional Interventions:</b> Studies examining the effects of supplements or nutritional interventions on performance or injury.</li> <li>• <b>Self-reported injury data:</b> Studies where injury data are collected through player surveys.</li> <li>• <b>Injury data from unverified online sources:</b> Studies using injury data from websites or league databases without verification through primary research methods (e.g., medical records).</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |

Note: IFT = intermittent fitness test; 1RM = one repetition maximum; RPE = rating of perceived exertion.

- **Male players:** Studies were limited to national teams or players in fully professional leagues at the time of the study.
- **Female players:** Studies were restricted to national teams or players in the first division of their respective country at the time of the study.

Any player described as 'professional' in the study was considered elite, in line with Okholm Kryger et al. (2021). In cases where a study included players from more than one league or national team, the paper was excluded if any of the leagues or teams did not meet the inclusion criteria for 'elite' status. Studies that did not provide sufficient information about the competitive level of the players were also excluded. This approach ensured that only studies exclusively involving elite players were included in the analysis.

## Search strategy

An electronic search of PubMed, Web of Science, and SPORT Discus was conducted in July 2024 using the standardised search terms of the audit protocol (Smith et al. 2022a): (athlete OR sport OR healthy)

AND (discipline-specific terms) AND (exercise OR performance OR endurance OR aerobic OR strength OR power OR anaerobic OR speed OR skill OR tactics) NOT animal NOT rodent. Discipline-specific terms were a) (soccer OR football) NOT American NOT AFL NOT Gaelic NOT AFLW b) (professional OR elite OR world class OR international) c) (injur\*). The \* symbol is a truncation operator used to capture variations such as 'injury', 'injuries' and 'injured'. Review articles were screened for additional relevant papers not detected in the primary search.

## Screening and selection

Searches from PubMed, Web of Science and SPORT Discus were imported into the Rayyan software (Rayyan QCRI, Qatar Computing Research Institute, Doha, Qatar) and duplicates removed. Two researchers (EC, TF) independently screened each paper title and abstract based on the pre-defined inclusion criteria and study outcome definitions (Table 1). Any conflicts in selection were discussed and resolved between the two researchers.

## Full text screening and data extraction

Following initial title and abstract screening, a full-text review of the included articles was performed. Data extraction was conducted by two researchers (EC, TF), both of whom have prior training and experience in screening and data extraction. All relevant data, including title, author names, publication year, and journal were extracted and recorded in an Excel spreadsheet.

Each researcher independently assigned a research theme, subtheme, menstrual status and tier classification according to the amended audit framework (Smith et al. 2022a). Any discrepancies were resolved through discussion until consensus was reached. The extracted outcomes are summarised in Table 2.

## Amendments to original audit framework

Amendments were made to outcome 2 and outcome 3 of the original audit protocol (Smith et al. 2022a). For

outcome 2, athlete calibre was not extracted as all players were considered elite (definition above). For outcome 3, the research themes were expanded to better align with the specific research objectives of this audit. These were first divided into broad themes of performance, injury, and combined research and then further broken down into sub-themes (Table 2) to aid the analysis of outcomes 3–5.

Outcome 5 was assessed using the menstrual status tier system (see Smith et al. 2022a for the full criteria). For clarity, unclassified was used to describe scenarios where:

- Insufficient information was available to classify participants' menstrual status;
- A study included a mixed female cohort in which individual menstrual status could not be determined;
- Studies that stated hormonal contraceptive (HC) use was not excluded but did not provide further details about the number of HC users or differentiate results based on menstrual status;

**Table 2.** A summary of extracted data from football performance and injury studies included in the current audit, based on the amended audit framework (Smith et al. 2022a).

| Outcome                                             | Subcategories                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|-----------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Outcome 1: Population type                          | Total number of studies that include: <ul style="list-style-type: none"> <li>• Males only</li> <li>• Females only</li> <li>• Mixed sex cohort</li> <li>• MvF sub analysis</li> <li>• MvF design features</li> </ul> <i>Split by performance, injury and combined broad themes</i>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| Outcome 2: Sample size                              | <ul style="list-style-type: none"> <li>• Total sample size</li> <li>• Total male participant number</li> <li>• Total female participant number</li> <li>• Median study sample size</li> </ul> <i>Split by performance, injury and combined broad themes</i>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| Outcome 3: Research theme                           | Number of studies and population split by: <p><b>Performance</b></p> <ul style="list-style-type: none"> <li>• Match demands</li> <li>• Training demands</li> <li>• Performance testing</li> <li>• Physical training</li> <li>• Combined performance</li> </ul> <p><b>Injury</b></p> <ul style="list-style-type: none"> <li>• Injury incidence</li> <li>• Injury characteristics and recovery</li> <li>• Combined injury</li> </ul> <p><b>Combined category</b> Combined performance and injury themes</p>                                                                                                                                                                                                                                                                         |
| Outcome 4: Study impact                             | <ul style="list-style-type: none"> <li>• Journal publication date</li> <li>• 4-year impact factor (retrieved 23rd October 2024)</li> <li>• Altmetric score (retrieved 28th October 2024)</li> </ul> <i>split by broad theme and population type</i>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| Outcome 5: Menstrual status and tier classification | <p><i>Menstrual status</i></p> <ul style="list-style-type: none"> <li>• MC (i.e., including eumenorrheic and naturally menstruating women)</li> <li>• HC users</li> <li>• Menstrual irregularities</li> <li>• Mixed menstrual status</li> <li>• Unclassified</li> </ul> <p><i>Tier classification (see Smith et al. 2022a for detailed classification)</i></p> <ul style="list-style-type: none"> <li>• Gold (best-practice methodologies as detailed by Elliott-Sale et al. 2021)</li> <li>• Silver (achieve some, but not all, methodological considerations)</li> <li>• Bronze (achieve some, but not all, methodological considerations)</li> <li>• Ungraded (menstrual status is defined, but methodological control is insufficient to award bronze/silver/gold)</li> </ul> |

Note: MvF = male v female; MC = menstrual cycle; HC = hormonal contraceptive.



- Studies where HC users were excluded, but it was not explicitly stated that the remaining participants were naturally menstruating.

For studies involving mixed menstrual status, each participant classification was assessed separately. For example, if a study included both naturally menstruating women and those using HC, these groups were evaluated individually, with 0.5 points assigned to each participant classification.

## Statistical analysis

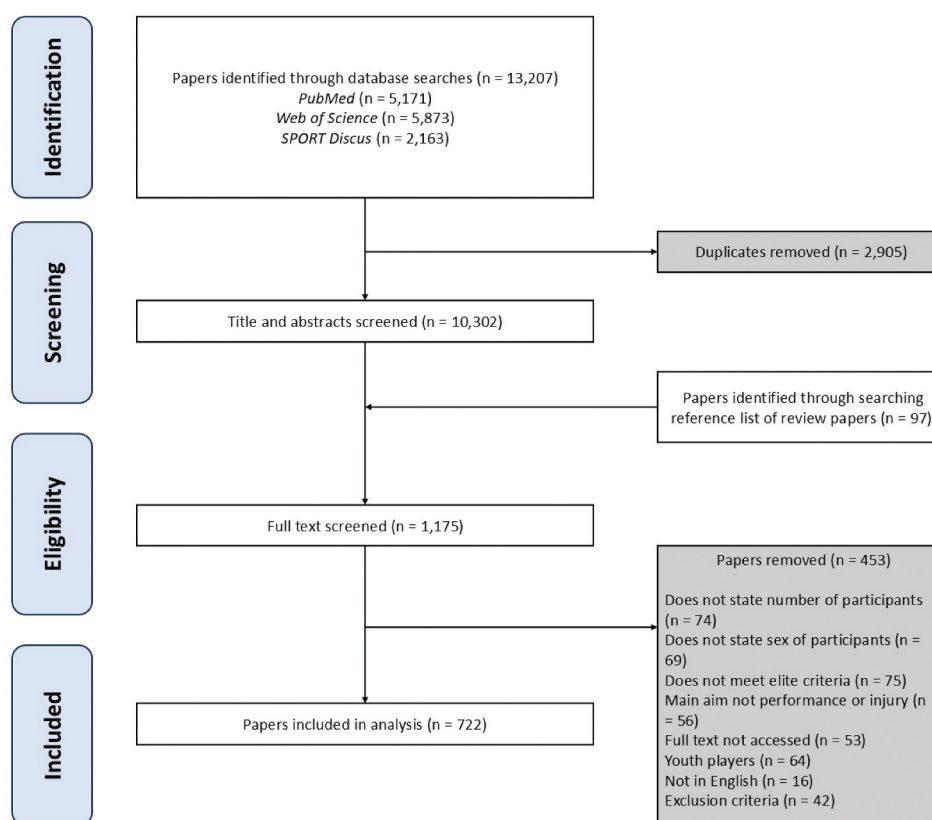
Frequency-based metrics were reported as counts and percentages of the total number of studies or participants. This included the number of studies by participant population type (outcome 1), the number and sex of participants across studies (outcome 2), the number of studies classified by broad research theme and sub-theme (outcome 3), and the number of studies categorised by menstrual status and tier classification (outcome 5). Inspection of histograms for male and female

sample sizes, journal impact factor (IF), and Altmetric scores revealed the data were not normally distributed. Therefore, results were reported as median  $\pm$  interquartile range (IQR). The proportion of studies achieving Altmetric scores  $>20$  was assessed in a binary manner (i.e., the number of studies in each population type with Altmetric scores above 20 were counted as either above or below the threshold) to distinguish studies receiving higher attention relative to other studies.

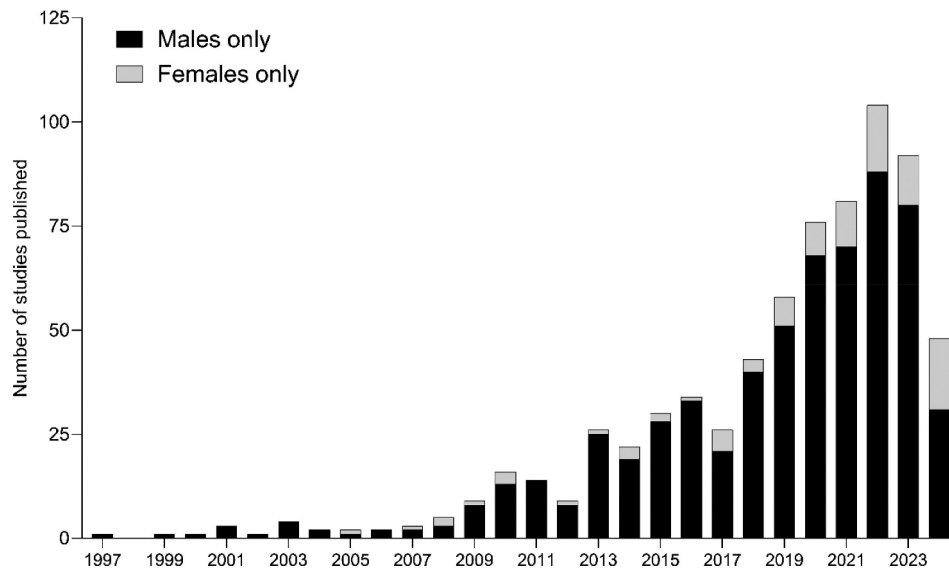
## Results

The results are presented by outcome in the following order: (1) population type, (2) sample size, (3) research theme, (4) study impact, and (5) menstrual status.

A total of 722 studies were included in this audit (Figure 1), encompassing 98,777 participants of which 7% were female. Of the 722 included studies, 87% included at least one male participant, while only 14% included at least one female participant. Between 1997 (i.e., date of first included paper) and 2024, an average of 22 male-only studies were



**Figure 1.** Flowchart demonstrating the screening process for the audit and the total number of studies included for extraction. Exclusion criteria ( $n = 42$ ) refers to studies focusing on: internal load measures ( $n = 5$ ), muscle activation ( $n = 1$ ), reliability/validity ( $n = 4$ ), nutritional interventions ( $n = 4$ ), self-reported injury data ( $n = 1$ ), injury data from unverified online sources ( $n = 17$ ), or not being specific to football ( $n = 8$ ). A full list of included studies and extracted data fields is available via the Open Science Framework (OSF).



**Figure 2.** Number of studies published per year in male or female-only elite football cohorts between January 1997 and July 2024. Note: Data for 2024 includes publications up to July only.

**Table 3.** Number of studies published overall and per [broad] research theme separated by population type.

| Population type     | Performance | Injury | Combined (Performance and Injury) | Total |
|---------------------|-------------|--------|-----------------------------------|-------|
| Males only          | 391         | 188    | 39                                | 618   |
| Females only        | 76          | 17     | 2                                 | 95    |
| Mixed sex cohort    | 0           | 2      | 0                                 | 2     |
| MvF sub analysis    | 1           | 1      | 0                                 | 2     |
| MvF design features | 3           | 2      | 0                                 | 5     |

published annually, compared to fewer than four female-only studies – a 6.5-fold difference. The annual publication rate of female-only studies increased from 1.25 (2010–2013) to 11.75 (2020–2023); however, male-only studies also saw substantial growth, rising from 13.5 to 76.5 per year over the same period (Figure 2).

### Outcome 1 – population type

Male-only studies were predominant across all research themes: performance (83%), injury (90%) and combined (95%) (Table 3). In contrast, female-only studies made up a smaller proportion representing on average ~10% across themes: performance (16%), injury (8%), combined (5%). Studies comparing males and females directly (MvF comparisons) were rare and limited to sub-analysis (performance  $n = 1$ ; injury  $n = 1$ ) or specific methodological design features (performance  $n = 3$ ; injury  $n = 2$ ).

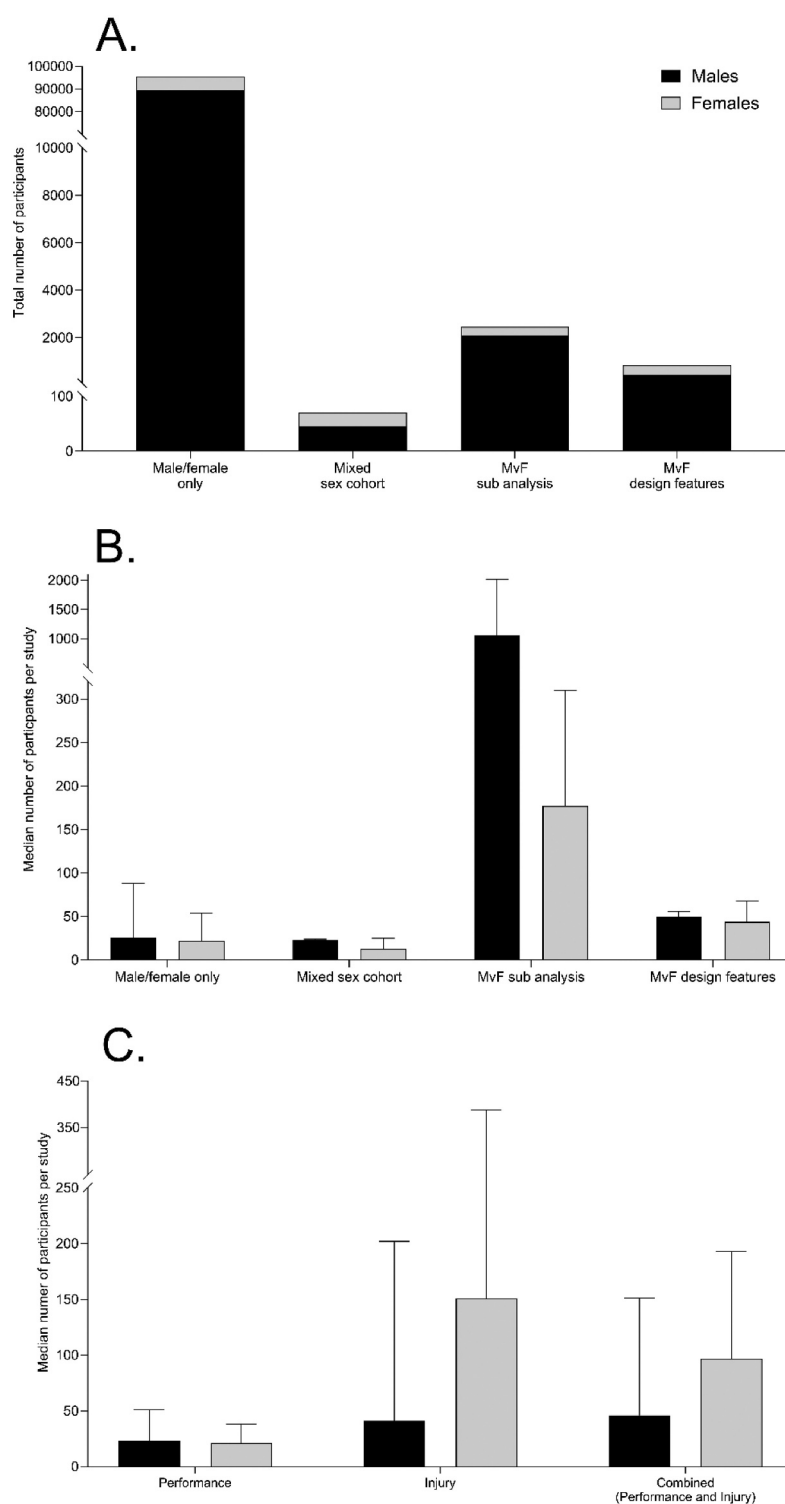
### Outcome 2 – sample size

Across all studies, 98,777 participants were included. Male-only studies comprised 89,631 males (91%), while female-only studies included 5,782 females (6%) (Figure 3(A)). Mixed-sex cohort studies had notably smaller participant numbers including a total of 45 males (<1%) and 25 females (<1%). Studies incorporating MvF sub-analyses included 2,107 males (2%) and 354 females (<1%) whereas studies with MvF design features had a more balanced representation of 438 (<1%) males and 395 females (<1%). Median sample sizes were comparable between male-only and female-only studies, with mixed-sex cohorts showing similar sample sizes for both sexes (Figure 3(B)). MvF studies also had comparable sample sizes for men and females.

MvF sub-analysis studies exhibited the greatest variation in sample sizes, with  $1,054 \pm 966$  for males and  $177 \pm 133$  for females. This variation was largely due to the limited number of studies ( $n = 2$ ) in this category and the inclusion of a substantial study by Waldén et al. (2011), which analysed ACL injury incidence in elite football across 57 clubs over multiple seasons (2001–2009), encompassing 2,329 participants (2,019 males and 310 females).

When split by broad research theme, male participants outnumbered female participants in all categories: performance (34,473 males vs. 2,776 females), injury (53,672 males vs. 3,586 females), and combined theme (4,076 males vs. 194 females). Median sample sizes in performance research were similar between males and females, while injury research showed a wider range for males compared to females. Combined theme studies





**Figure 3.** (A) Total number of participants per study population type separated by sex. (B) Median number of participants per study by population type and sex. (C) Median number of participants per study separated by broad research theme and sex. Male (m), female (f). Error bars represent the interquartile range. MvF = male vs. female.

revealed a different trend, with higher median sample sizes for females than males (Figure 3(C)).

### Outcome 3 – research theme

Performance studies accounted for 65% of all studies, followed by injury research (29%). Combined theme studies, which included both performance and injury aims, were the least represented (6%) (Table 3).

#### Performance

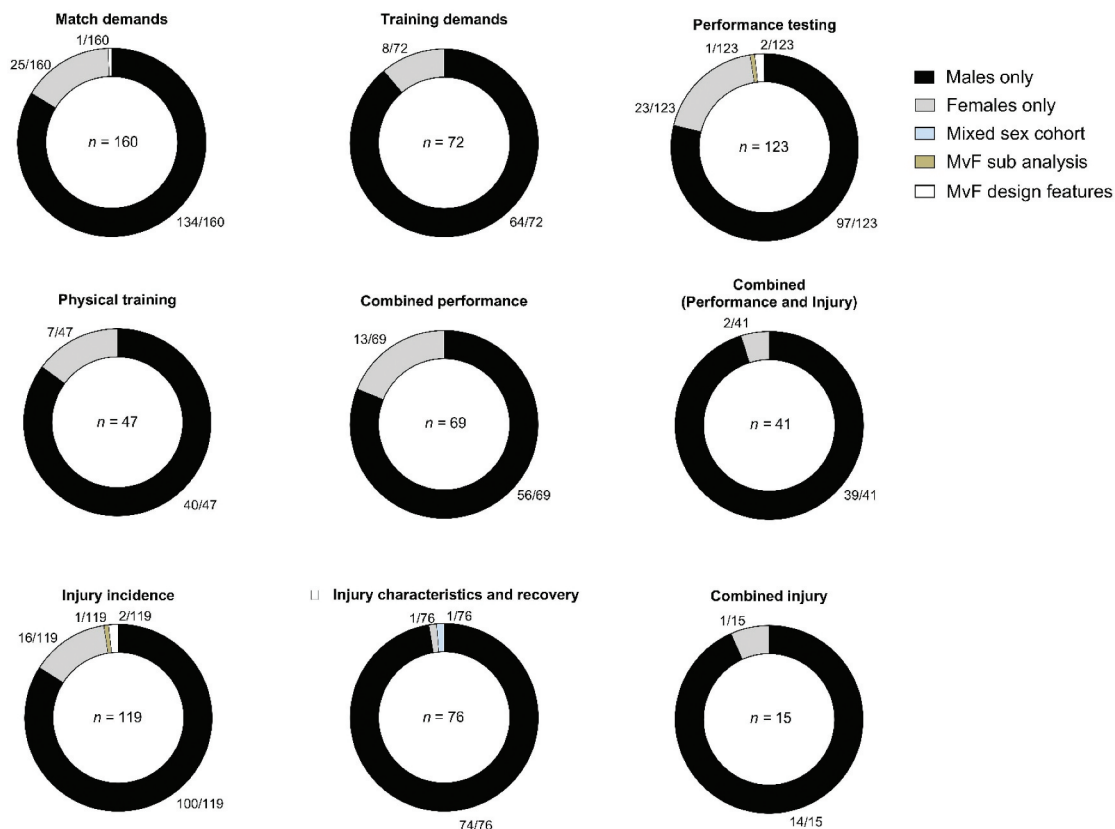
Performance research was overwhelmingly male dominated, with 92% of participants ( $n = 34,473$ ) compared to 8% ( $n = 2,776$ ) female participants (Figure 5(A)). The most studied sub-theme was match demands (34%), followed by performance testing (26%), training demands (15%), combined performance (15%), and physical training (10%) (Figure 4).

Female-focused research was concentrated in match demands and performance testing, comprising 50% of all female-only studies. However, female representation remained low across all sub-themes, particularly in match demand research (5% female,  $n = 1,113$ ). Median

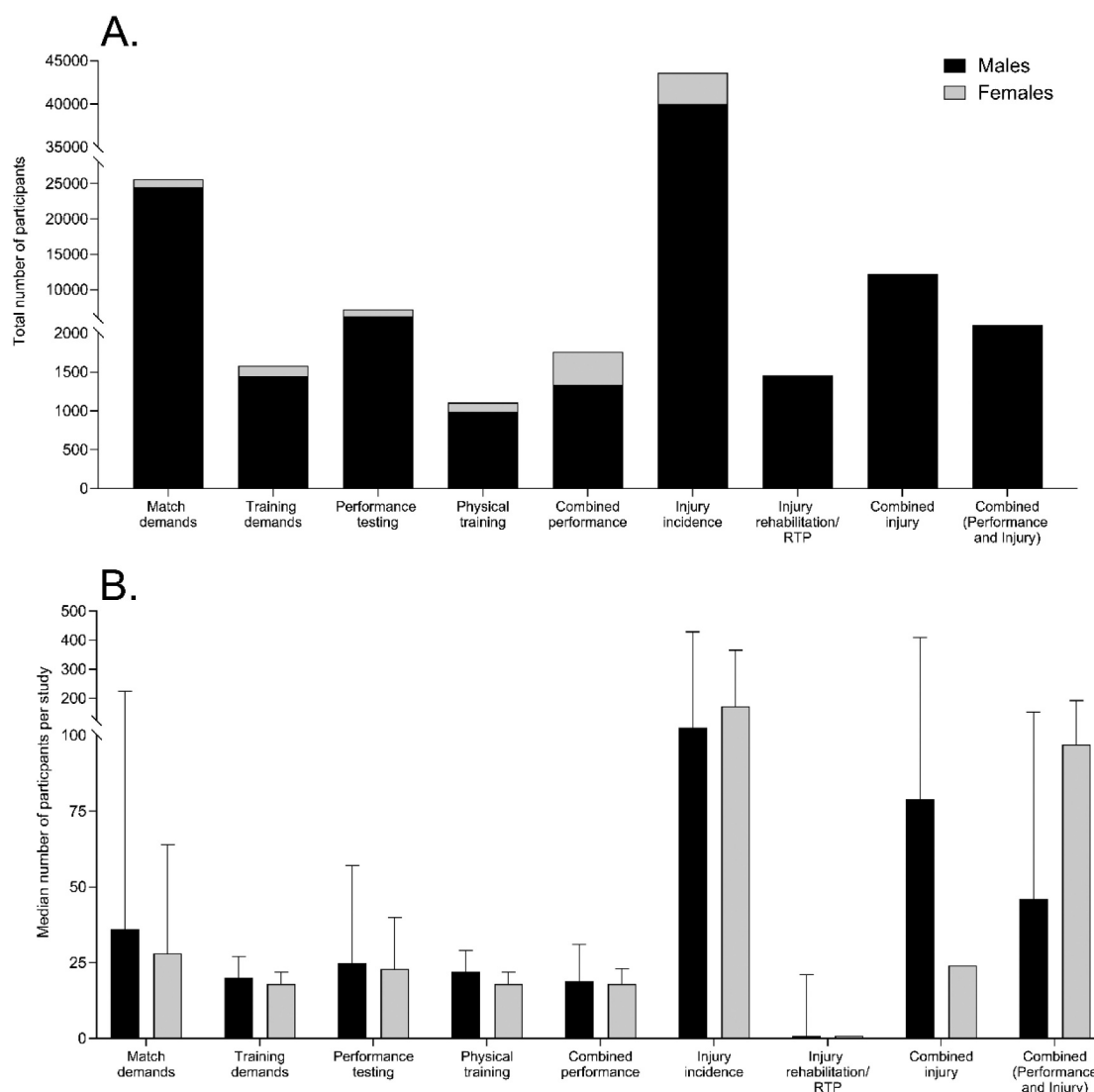
sample sizes were similar between men and women across performance sub-themes, though match demands studies had a broader range for men, with some studies including over 200 men (Figure 5(B)).

#### Injury

Injury research was male dominated with 94% of participants ( $n = 53,672$ ) compared to 6% of female participants ( $n = 3,586$ ) (Figure 5(A)). The most common sub-theme was injury incidence (57%), followed by injury characteristics and recovery (36%), and combined injury studies (7%) (Figure 5(B)). Female representation was highest in injury incidence studies (8%,  $n = 3,560$ ), accounting for over half (54%) of all female participants. However, the number of studies including women was limited in injury characteristics and recovery research ( $n = 2$ ) and combined injury studies ( $n = 24$ ). Only one female-only study focused on injury characteristics and recovery (Taberner et al. 2020). Median sample sizes were similar between men and women across sub-themes, though injury incidence studies included a higher median number of women (Figure 5(B)).



**Figure 4.** Number of published studies by population type (male-only, female-only, mixed-sex cohorts, MvF sub-analysis, and MvF design features) separated by sub-themes. MvF = male vs. female.



**Figure 5.** (A) Total number of participants per research sub-theme separated by sex. (B) Median number of participants per study separated by sex and research sub-theme. Error bars represent the interquartile range.

### Combined

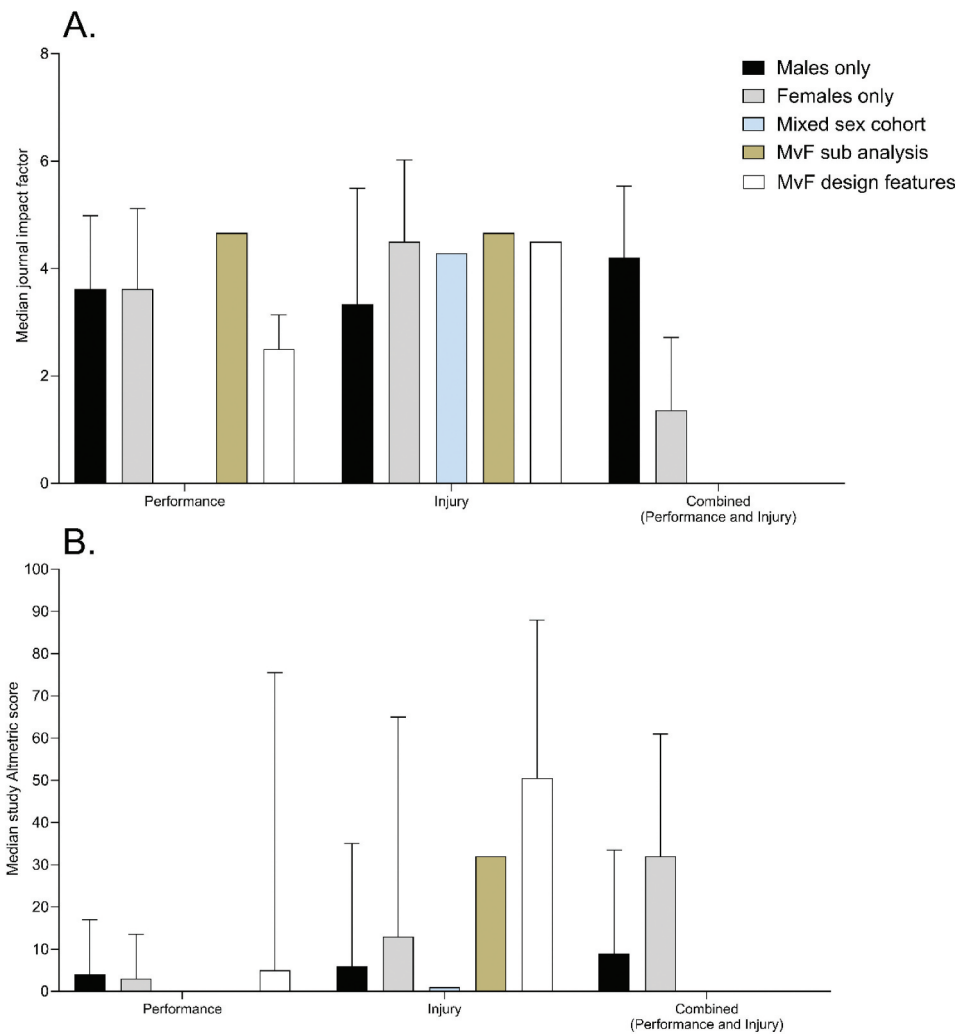
Of the studies where performance and injury themes were combined, 95% ( $n = 194$  studies) were male-only, including 4,076 men, while 5% ( $n = 2$  studies) were female-only, including 194 women. No studies included a mixed-sex cohort, MvF sub-analysis, or MvF design features, reinforcing the persistent lack of female-specific or comparative research across all broad themes.

### Outcome 4 – study impact

Journal impact factor was available for 97% ( $n = 702$ ) of studies. The median journal impact factor (IF) of the studies ranged between 3.62 and 4.66 across

population type. When comparing between performance, injury and combined theme studies, the median IF for male-only studies was 3.6–4.2, for female-only studies it ranged from 1.4 to 4.5, for mixed-sex cohort studies it was 3.5–4.3, for MvF sub-analysis studies it was 4.66, and for studies incorporating MvF design features it ranged from 2.5 to 4.5 (Figure 6(A)).

Altmetric scores were available for 80% of the studies ( $n = 574$ ). Among these, 23% ( $n = 167$ ) achieved an Altmetric score  $>20$ . Studies investigating MvF sub-analysis had the highest proportion of studies achieving an Altmetric score  $>20$  (50%) but this reflects the small number of MvF sub-analysis studies ( $n = 2$ ). Male-only and female-only studies had similar proportions of



**Figure 6.** (A) Median journal impact factor and (B) Altmetric score for each research theme separated by population type studied. Error bars represent the interquartile range. MvF = male vs. female

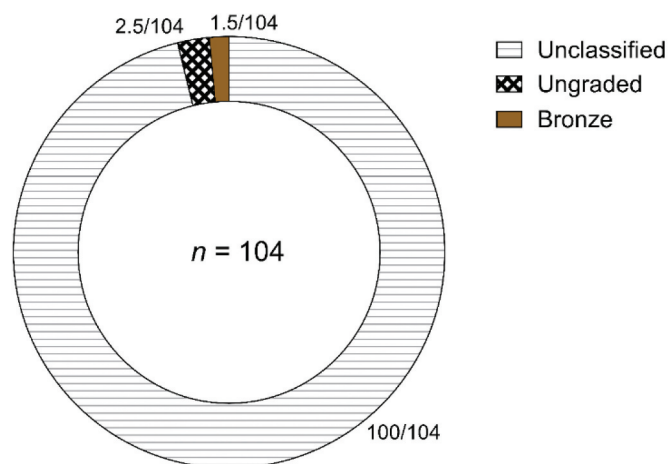
studies with an Altmetric score >20, with 23% ( $n = 143$ ) of male-only studies and 22% ( $n = 21$ ) of female-only studies receiving scores above this threshold (Figure 6(B)).

### Outcome 5 – menstrual status

Among the 104 studies involving female participants, only four (<4%) provided sufficient information to define menstrual status, indicating that these studies specifically designed their protocols to either control for or assess ovarian hormone influences (Figure 7). The remaining studies did not include sufficient detail to define menstrual status or consider ovarian hormones in their design. Of the four studies, three focused on performance and one focused on injury. When classifying by methodological control, 2.5 studies received ungraded tiers, while the remaining 1.5 received bronze tiers (Figure 7). For studies

involving mixed menstrual status (e.g., both naturally menstruating women and those using hormonal contraceptives), fractional points were assigned (0.5 points per group), which explains the use of 2.5 and 1.5 for the classification of studies. No study achieved a gold tier, which denotes best practice standards for methodological control of ovarian hormones.

Mohr et al. (2022) and Krstrup et al. (2022) received an ungraded tier as they did not examine ovarian hormone profiles, but aimed to standardise testing in the mid-follicular phase of the menstrual cycle (defined as day 5–10 of the menstrual cycle) to enhance research quality. Participants were included if they had a regular menstrual cycle (Krstrup et al. 2022) or were “eumenorrheic” (Mohr et al. 2022), though no specific criteria were provided, and those using hormonal contraceptives were excluded. Neither study reported participants’ cycle lengths, which prevented them from receiving a bronze tier.



**Figure 7.** The proportion of studies classified into each tier according to the standard of methodological control concerning ovarian hormonal profiles, as a proportion of the total number of studies including women. Gold-standard (best-practice methodologies as detailed by Elliott-Sale et al. 2021), silver/bronze (achieve some, but not all, methodological considerations), ungraded (menstrual status is defined, but methodological control is insufficient to award bronze/silver/gold) or unclassified (insufficient information to provide a distinct participant classification, or a mixed female cohort in which individual menstrual status cannot be differentiated).

Scott et al. (2024) and Barlow et al. (2024) received a bronze tier for methodological control in naturally menstruating participants. Scott et al. (2024) examined menstrual cycle effects on performance, while Barlow et al. (2024) investigated injury incidence, severity, and type across the menstrual cycle. Both studies reported cycle lengths of 21–35 days but did not objectively verify menstrual phases. In addition, Barlow et al. (2024) received an ungraded tier for hormonal contraceptive users as they included women using progestin-only contraceptives within their sample of naturally menstruating women, without differentiating between the two groups in the results. Furthermore, no details on brand or concentrations of hormonal contraception were provided.

## Discussion

This audit showed that 13% of performance and injury research in elite football focused exclusively on female players with women representing 7% of the total research participants. While research in elite female footballers has increased over the last 3 years, with 47% of all female-only studies published since 2022, only four studies have considered ovarian hormones within their methods and none of these studies utilised best practise guidelines (Gold tier, Smith et al. 2022a). These findings highlight a significant underrepresentation of elite female football players in performance and injury research, as well as a lack of adequate consideration for ovarian hormones.

## Outcome 1 – population type

Female-only studies accounted for 13% of all research, while male-only studies dominated, representing 83% of performance, 90% of injury, and 95% of combined theme research. Studies including both sexes were rare ( $\leq 2\%$ ). This imbalance may stem from the segregated nature of elite football, wherein men's and women's teams generally train and compete separately, limiting opportunities to collect data on both sexes simultaneously. Additionally, differences in playing standards and facilities such as distinct training grounds and stadiums further contribute to the tendency to study these populations independently. Encouragingly, there has been an increase in research exclusively involving female participants since 2022, with 47% of all female-only studies published in this timeframe. The proportion of studies focused exclusively on female cohorts in this audit (~6%) is consistent with figures reported in previous investigations using the same audit tool ~4% (Kuikman et al. 2023) and ~5% (Kelly et al. 2024). Interestingly, the audit identified 69 studies that failed to specify the sex of participants, leading to their exclusion. Some studies, however, were included despite not stating the male sex of the participants explicitly, as this was inferred from the league or competition referenced. This omission highlights a persistent bias in considering men as the norm or default population in elite football research. Reporting the sex of participants should be viewed as a basic requirement to provide essential context for interpreting findings and improving transparency within the literature.

## Outcome 2 – sample size

Across the 722 studies included in this audit, women represented 7% of all participants, despite women being included in 14% of studies. This level of female representation (7%) is lower than that reported in other recent audits across broader sports science topics using the same audit tool ~11% (Kuikman et al. 2023), ~13% (Kelly et al. 2024), and ~23% (Smith et al. 2022b). This indicates that even when female participants were eligible for inclusion, their sample size were often disproportionately low compared to males. A total of 91% of participants came from male-only studies, while the inclusion of female participants was largely concentrated in a smaller number of female-only studies. This imbalance may partly reflect the larger global pool of male professional footballers and teams. The audit included national teams and professional leagues for men but only national teams and top tiers for women, highlighting structural disparities in football, wherein even lower tiers of men's football are often professional, while women's football has fewer professional tiers. However, this does not fully explain the underrepresentation of elite female players, emphasising the need for greater inclusion of women in future football-based research. It is not fully known and is often questioned whether applying research from men's football to women's football provides an accurate and comprehensive understanding of the women's game. While research on male players can serve as a useful foundation, it cannot be directly applied without consideration for the differences in the physiological, environmental, and economic contexts between the two. As such, we must find a balance; while we cannot simply copy and paste findings from men's football into the women's game, we also cannot disregard all male-based research. Instead, it should serve as a starting point, with more research focused on women's football needed to ensure that the specific needs and challenges of female players are addressed.

Interestingly, median sample sizes in injury-related studies were higher for females than males, likely due to the types of research conducted. Injury incidence studies, which often monitor multiple teams across seasons, tend to have larger samples, whereas injury characteristics and recovery studies often involve smaller cohorts or case studies. The audit identified 74 male-only injury characteristics and recovery studies compared to only one female-only study, which included a single participant. Conversely, 100 male-only injury incidence studies accounted for 53% of all male only injury studies, whereas 16 female-only studies made up 94% of all female-only injury research. This skew, where female-focused research favours injury incidence over injury characteristics and recovery, contributes to the

higher median sample size for women compared to men. To advance understanding of injuries in women's football, future research should ensure more balanced representation across all injury-related themes and achieve more balanced sex representation overall.

## Outcome 3 – research themes

Women remain significantly underrepresented across all research themes. Female-focused studies are largely concentrated in match demands and performance testing, accounting for 50% of all female-only research. This focus likely stems from the relative ease of data collection, as these assessments are often integrated into routine sports science practices. Given the recent professionalisation of women's football, early research has understandably prioritised understanding physical demands and performance characteristics. However, as the sport evolves, research must expand to other important areas, such as injury characteristics and recovery.

Injury-related research on female players remains sparse. Alarming, only one female-only study has examined injury characteristics and recovery, focusing on a single elite player recovering from an ACL injury (Taberner et al. 2020). Despite comprising 18% of total research output, injury studies account for 52% of female participants, likely due to the large sample sizes required for injury incidence research, which spans multiple teams or leagues. In contrast, performance studies typically involve smaller cohorts, leading to lower participant numbers. Recent reviews have highlighted additional challenges in performance and injury research in women's football, including variation in study design and injury location (Okholm Kryger et al. 2023; Mulvenna et al. 2025). These findings highlight the persistent underrepresentation of female athletes, particularly in injury research. Addressing this gap is crucial to developing a comprehensive understanding of injury dynamics and ensuring research reflects the growing female football population. As the sport continues to professionalise, future studies must adopt a more balanced approach by targeting currently underrepresented research themes.

## Outcome 4 – study impact

Journal impact factor appeared consistent across studies regardless of population type. Male-only studies accounted for the highest number of papers with an Altmetric score above 20, likely reflecting their greater prevalence rather than higher interest in male



populations. When adjusted for the proportion of studies within each population type, male vs. female comparisons (MvFsub and MvFdes) showed the highest proportion of studies with an Altmetric score above 20 (40–50%), although this finding may be inflated due to limited number of studies in these categories. Encouragingly, female-only studies were published in journals with similar impact factors to male-only studies, indicating that research on female athletes is receiving comparable recognition. However, the journal impact factor data also suggest that the additional time, money, and effort required to conduct research exclusively on females may not yield significant benefits in terms of publication outcomes. Studies with older publication dates are inherently disadvantaged in Altmetric scoring, as this metric favours more recent publications with active online dissemination. Due to the limited number of studies that have considered ovarian hormone profiles, it is difficult to determine whether considering these factors within research increases study impact. However, it is important to recognise that both journal impact factors and Altmetric scores offer only limited insight into a study's true influence. Altmetric scores, for example, reflect online attention but not necessarily scientific quality or practical relevance, while journal impact factors do not always reflect the individual impact of a specific study.

### Outcome 5 – menstrual status

Of the 104 studies involving female participants, only four examined ovarian hormones, none of which was classified silver or gold tiers. The low quality of existing research remains a major concern, as highlighted by Elliott-Sale et al. (2020) and McNulty et al. (2020), who identified methodological inconsistencies as a key barrier to understanding the relationship between ovarian hormones and athletic performance. Without improvements in research quality, confidence in the findings will remain limited, reinforcing the need to prioritise quality over quantity.

The majority of studies (96%) including female players failed to define menstrual status, a basic yet overlooked step in enhancing research transparency. This gap could be addressed using the recent ovarian hormone profile classification tool developed by Elliott-Sale et al. (2024), which provides a simple yet reliable method for self-reporting menstrual status to standardise reporting. Even among the four studies that did define menstrual status, none objectively verified menstrual cycle phases. This reliance on assumptions has been criticised by Burden et al. (2024) and Elliott-Sale

et al. (2025), as assuming ovarian hormone profiles and events such as ovulation, without verification or objective measurement, makes it impossible to draw valid and meaningful conclusions. Future research should incorporate objective measures, such as ovulation testing or progesterone monitoring, to verify phases and enable valid conclusions to be drawn from the results.

It is important to clarify that we are not advocating for menstrual cycle phase and ovarian hormone profiles to be objectively measured and verified in every study involving female footballers. For example, in studies aimed at quantifying match demands in a specific competition, such as total distance covered, details of ovarian hormone profiles may not add significant value to the primary outcomes. However, in cases where ovarian hormone profile is appropriate to measure because of possible meaningful influences on the outcome measures, these should be objectively measured and reported. Earlier studies in elite women's football may have overlooked ovarian hormone profiles for a variety of reasons including the sport's limited professionalism and resource constraints at the time. However, with increasing investment and greater access to research funding, these factors must now be considered. The current article establishes a baseline for current practices, and if this audit is repeated in 5–10 years, we anticipate improved representation of elite female players, better reporting of ovarian hormone profiles, and greater adherence to gold-standard research methodologies.

Some methodological improvements require minimal effort to significantly enhance research quality. For example, Barlow et al. (2024) received an ungraded tier for failing to specify the brand and concentration of hormonal contraceptives used and for not separating results for hormonal contraceptive and naturally menstruating players, both of which are simple adjustments that would improve transparency and reproducibility. Recent data from over 300 elite female footballers across 11 European leagues indicate that 60% are naturally menstruating, 26% use hormonal contraceptives, and 14% experience menstrual dysfunction (submitted manuscript currently under review in this journal by two of the authorship team). Failing to account for these variations limits the generalisability of findings. Research must accurately report ovarian hormone profiles and distinguish between different hormonal statuses in results, following the Smith et al. (2022a) tier system.

### Limitations

Defining 'elite' in football remains a complex challenge, particularly in women's football, where league structures and competitive standards continue to rapidly evolve. In

this audit, we adapted the framework proposed by Okholm Kryger et al. (2021), which defines elite female players as those competing at the highest level national teams and top-tier domestic leagues. While this provides consistency with previous research, it may have narrowed the eligible sample pool for women compared to men, whose professional structures are more widely established and better resourced. As such, representation gaps observed between male and female participants may, in part, reflect broader structural inequalities in professional access rather than true disparities in research interest or quality. Only studies published in English were included, a decision based on the language fluency of the primary screening team. While this is a common approach in large-scale reviews, it introduces the possibility of language bias and may have led to the exclusion of relevant work published in other languages. It may also be valuable for future research to map the geographical representation of studies to ensure findings are not overly concentrated in particular regions.

### Additional considerations

When interpreting the audit findings, readers should be aware of several contextual factors. The findings presented are reflective of the literature available at the time of the search. As with all reviews and audits, a defined stop point was necessary, and therefore more recent developments in the field may not be captured. Encouragingly, since the completion of this audit, recent studies ( $n=3$ ) have begun to implement improved research methodologies when investigating physical performance across the menstrual cycle and oral contraceptive pill usage (Brown and Duffield 2024; Bouvier et al. 2025; Romero-Moraleda et al. 2025). These studies represent a positive step towards generating higher quality data in this area, addressing some of the gaps highlighted in the current audit. Additionally, the year of data collection is an important consideration, particularly in women's football, where the competitive standard of leagues has changed dramatically over time. Data collected from a competition in 2012 may reflect a significantly different level of performance compared to 2023. Where possible, authors should state the year of data collection in order to provide more context surrounding performance level. Finally, a consistent and widely accepted definition of 'elite' remains a pressing need. A Delphi consensus statement could help formalise this classification, though regular updates would be required to reflect the changing structure of both men's and women's football. Given the ongoing growth of women's football, we recommend repeating this audit in 5–10 years to evaluate progress in female

representation, methodological rigor, and reporting standards within football performance and injury research.

### Conclusion

Elite female footballers remain significantly underrepresented in performance and injury research, comprising just 7% of participants and 13% of studies. Although female-focused research has increased in the last 3 years, it still lags behind male studies, particularly in injury research. Crucially, ovarian hormones remain largely overlooked, with minimal consideration in study designs. To build a more comprehensive understanding of female performance and injury risk, future research must prioritise elite female players, expand injury-related studies, and integrate robust objective ovarian hormone profiling (if appropriate to the research question). As the women's game continues to grow, research must evolve alongside it to ensure high quality evidence-based support for female players.

### Acknowledgements

EC, TF and KES contributed to the conceptualization of the study. EC, TF, KK, AMcC, GS, and KES contributed to the methodology. EC and TF performed the formal analysis and investigation, including the literature search and data extraction. EC and TF drafted the original manuscript. EC, TF, KK, GL, AMcC, GS, and KES contributed to the review and editing of the manuscript. All authors have read and approved the final version of the manuscript.

### Author contributions

CRedit: **Emma Clausen:** Conceptualization, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing; **Tessa R. Flood:** Conceptualization, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing; **Katrine Okholm Kryger:** Methodology, Writing – review & editing; **Gary Lewin:** Methodology, Writing – review & editing; **Alan McCall:** Methodology, Writing – review & editing; **Georgina K. Stebbings:** Methodology, Writing – review & editing; **Kirsty J. Elliott-Sale:** Conceptualization, Methodology, Writing – review & editing.

### Disclosure statement

KK and AMcC are Associate Editors of Science and Medicine in Football but had no involvement in the editorial or peer-review process for this manuscript. No other potential conflicts of interest were reported by the author(s).

## Funding

EC has received funding from Arsenal Women's Football Club through a match funded PhD studentship with Manchester Metropolitan University this has not impacted the manuscript in any way.

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## Data availability statement

All data supporting the findings of this study, including the full list of included studies and extracted variables, are openly available via the Open Science Framework (OSF) at: <https://osf.io/8teuv/>.

## Ethics statement

No ethics were required due to the nature of the study undertaken being an audit of published literature only.

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