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A scoping review of identifying research on menstruation and menstrual cycle among female athletes of low and low-and-middle-income countries

Mehjabin Tishan Mahfuz[1*], Faria Razzaque Shejuty[1], Shayla Sharmin[1], Sudipta Das Gupta[1], Sarker Masud Parvez[1,2], Nishantika Neheer[1] and Quamrun Nahar[1]

Abstract

Background Menstruation involve intricate physiological, social, cultural, religious, and psychological factors that deeply impact women and girls globally. Disparities in access to menstrual products, facilities, information, and social support are evident between high-income countries (HICs) and low-income countries (LICs). Female athletes in low- and middle-income countries (LMICs) encounter distinct challenges due to limited research on the significant effects of menstruation on their daily lives as well as athletic performance. This scoping review investigates existing research on menstruation's influence on female athletes in LMICs, proposes research gaps, and propose future study directions.

Method We conducted a scoping review following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews (PRISMA-Ext) guidelines. We systematically searched multiple databases, including PubMed, Scopus, Cumulative Index to Nursing and Allied Health Literature (CINAHL), Web of Science, and Google Scholar, to identify peer-reviewed publications, grey literature, and relevant sources. Our inclusion criteria required articles to contain at least one performance-related parameter related to menstruation or explore at least one menstrual phase among LMICs and LICs athletes.

Result Our initial search yielded 1490, of which 88 potential articles were considered after title and abstract screening. After duplicate screening, 26 studies met our inclusion criteria. Eighteen studies employed a cross-sectional research design from adolescence to the 30s. Ten studies specifically focused on investigating the menstrual cycle (MC) and its impact on athletes, while five articles focused on physiology and six examined both physiology and the MC. Eight studies explored performance, while two reported on the intersection of performance.

Conclusion The research on female athletes from LMICs requires a more consistent focus on menstruation's impact on athletes' well-being and performance. This scoping review underscores the urgent need for more in-depth, longitudinal, and quantifiable research that explicitly emphasizes the unique needs of athletes from LMICs. By gaining

*Correspondence:
Mehjabin Tishan Mahfuz
tishan.mahfuz@icddrb.org

Full list of author information is available at the end of the article

deeper insights into their experiences, barriers, and impact on performance and health, we can enhance these athletes' overall well-being and broader social, cultural, and gender equality agendas.

Keywords Menstrual cycle, Menstruation, Menstrual hygiene management, Female, Athletes, Low-and-middle-income countries, LMICs

Background

Menstrual health and hygiene involve a more complex interaction that encompasses the physiological, social, cultural, religious, and psychological aspects of adolescent development [1–3]. Women and girls in both high- and low-income countries (LICs) commonly experience symptoms such as pain, fatigue, and neurological issues. Yet, differences in access to menstrual products, facilities, information, and social support significantly shape girls' perspectives on menstruation and underscore the disparity in menstrual hygiene and management between high-income countries (HICs) and LICs [4, 5]. Research on menstruation in LICs, broadly, has explored socio-cultural context, behavioral expectations, knowledge, resource limitation, and menstrual practices of school girls and women. Global research has often overlooked women and girls engaged in diverse work or groups, extending beyond the conventional categories, such as athletes [5].

Menstruation has been reported to negatively impact women's daily lives with many physical, psychological, and social implications [6]. In addition to a perceived negative impact on performance, athletes have reported missing practice and matches during menstruation [7, 8]. Recent studies report that there is a difference in the menstrual cycle (MC) and menstrual disorders among athletes and non-athletes that is heavily influenced by body weight and composition, stress, energy imbalance, and diet, among other factors [1, 9–11]. Studies indicate that, beyond the menstrual bleeding phase, female athletes experience varying endurance levels throughout their menstrual cycles [12]. Recently, there has been increased focus on understanding this impact using methods such as mobile applications and other tracking techniques [13]. However, female athletes in low- and middle-income countries (LMICs) often remain neglected due to a lack of data and interest and generally lower participation rates. Given that poor menstrual health can have long-term consequences, especially in LMICs, it is crucial to understand how this issue affects female athletes [5].

Sports and athletics have been shown to significantly contribute to individual development and societal progress through discipline, structure, rules, and community engagement [14]. Additionally, sports serve as a significant economic enterprise that can benefit various societal sectors [15]. Despite the global increase in female participation in sports, numerous challenges persist, resulting in a significant issue the lack of research on female athletes [15]. This results in gaps in understanding sex differences in physiology and performance and hinders informed policy-making regarding training and participation [16, 17]. Among the many obstacles female athletes, similar to non-athletes, face is managing menstruation [18]. More than 500 million women, girls, and others who experience a menstrual cycle do not have convenient access to menstrual hygiene management (MHM) worldwide [19]. It is challenging for girls and women, particularly in LMICs, to practice effective menstrual hygiene because they frequently lack knowledge about menstruation, rarely discuss taboo topics, and lack access to the necessary infrastructure and unavailable or expensive commercial menstrual management supplies. In addition to impacting their health, well-being, and educational opportunities, this reinforces gender inequality and marginalization [20]. Generally, studies related to female athletes and the impact of menstruation have primarily relied on anecdotal and context-specific, drawing on individual studies that may be limited in scope and have restricted generalizability beyond their context. Due to the absence of data and research on female athletes related to menstruation, Menstrual cycle, or MHM in LMIC, the investigators conducted a scoping review on menstruation and its impact on female athletes of LMIC countries.

The review's aim was to outline the research's scope and methodology while offering an overview of its objectives, identify gaps in the existing literature, and offer suggestions for future research among female athletes of LMICs. Providing an overview of the research objectives is important as it allows readers to quickly grasp the main goals and purposes of the studies conducted, and identifying gaps in the existing literature is a key aspect of future academic research.

Method

This scoping review derived from the study which was approved by the Ethical Review Committee of icddr, b (protocol no: PR-22136; Version 1.0; 16 February 2023), and followed the methodological approach of Arksey and O'Malley and Levac et al. and reported the results according to the Preferred Reporting Items for Preferred Reporting Items for Systematic Reviews and Meta-Analyses- Extension (PRISMA-Ext) guidelines [21–23]. The scoping review included five steps: (1) generating the research objective, (2) identifying the relevant studies,

(3) Selecting the relevant studies, (4) Extracting the data from the literature, and (5) Analyzing and summarizing results.

Research objective

The original research objective was 'the impact of menstruation or menstrual cycle on the performance and physical and mental health and well-being of athletes in Bangladesh and South Asia.' However, due to the lack of paper availability, the search objective was broadened to include lower —and low- and middle-income countries.

Search strategy

We devised the search strategy by building upon three fundamental concepts: "Menstrual hygiene management," "female athlete," and "Lower-middle-income countries." Following preliminary test searches on each database, we curated a collection of synonyms, Medical Subject Heading (MeSH) terms, and additional keywords.

Table 1 Inclusion and exclusion criteria based on the population-exposure-outcome framework

	Inclusion	Exclusion
Population	• Female athletes from lower-middle-income countries and LICs • Research conducted exclusively is LMICs	• Female athletes from HICs
Exposure	• Research primarily conducted about MHM • Female Athletes from lower-middle-income countries and LICs	• Studies not focusing on athletic or mental issues related to the menstrual cycle or at least on MC phase • Excluded unpublished studies, non-peer-reviewed publications, review articles, abstracts, and publications not available in English
Outcome	• Studies reporting at least one performance parameter (either athletic or mental) related to the menstrual cycle or at least one MC phase (e.g., luteal, follicular or menstrual phase) among lower-middle-income countries and LICs	• Studies in which the performance parameter related to the menstrual cycle or any MC phase has not been discussed
Time	• Published between 01 January 2002 to 25 August 2023	• Published before 01 January 2002 • Published after 25 August 2023
Study Type	• Any primary peer-reviewed research • Secondary/synthesis research • Grey literature included • Full text available	• Full text not available
Language	• English	• Languages other than English

For every database, we meticulously refined the search string in adherence to the specific syntax requirements of those databases (please refer to Supplementary Material 1 for the detailed search queries for each database).To ensure comprehensive coverage of available articles, we collaborated with icddr, b's library experts, who reviewed the keywords and search strategies. Their input contributed to the inclusion of the full spectrum of relevant articles. Additionally, we sought feedback on our overall study approach, search terms, and access to journals through institutional databases. Furthermore, we conducted searches for individual countries encompassed within the classification of Lower-Middle-Income Countries (LMICs) and LICs as designated by the World Bank [24]. Our search strategies were continuously updated, extending the most recent search to 25 August 2023.

Our search process was comprehensive, involving three reviewers (FRS, SS, and SDG) who searched five electronic databases for potentially relevant articles as primary data sources. These databases included PubMed, Scopus, CINAHL, and Web of Science for peer-reviewed literature. We also conducted searches on Google and Google Scholar for grey literature, ensuring we left no stone unturned in our search for additional relevant publications (Table 1).

Inclusion and exclusion criteria

Our inclusion criteria were specific, requiring articles to feature at least one performance parameter related to the menstrual cycle or its phases within the context of lower-middle-income and LICs. We also included existing literature, scoping reviews, systematic reviews, and relevant meta-analyses from peer-reviewed sources. We did not impose any age restrictions and limited our inclusion criteria to articles published in English. Exclusions encompassed studies on athletes from HICs and topics unrelated to menstruation. Additionally, unpublished studies, non-peer-reviewed publications, review articles, abstracts, and publications not available in English were excluded from our analysis. For a comprehensive view of our search strategy, please refer to Table 2.

Study selection and eligibility

Two steps were followed to identify relevant literature: (1) title and abstract screening using RAYYAN software, and (2) Full-text screening. After the search, all identified articles were imported to ZOTERO, and duplicates were removed. The updated list of articles was imported to the RAYYAN software. The title and abstract screening were performed in RAYYAN. Then, the results were exported to an Excel 2019 spreadsheet for further screening. The reference lists of all included studies were reviewed for eligible studies. The reviewers FRS, SS, and MTM examined the literature individually and undertook the

Table 2 Literature search strategy for scoping review

Female athletes of LMIC and menstrual cycle or menstruation: A scoping review	
Research objective	1. What studies have been conducted and published on female athletes from LMICs? 2. What were the major focuses of those studies? 3. What are the gaps that can be identified from the published studies?
Search Strategy	Inclusion criteria
	All studies focusing on MHM, menstruation, and menstrual cycle among athletes Articles related LAMICs
	Exclusion criteria
	Articles related to athletes from HICs. Concerned those not discussing anything about menstrual-related topics. Unpublished studies, non-peer-reviewed publications, review articles, abstracts Publications not available in English were excluded
	Time frame
Data Sources	January 2002 to August 2023 Peer-reviewed articles PubMed, Scopus, CINAHL, Web of Science, Google and Google Scholar
Key search terms	Menstruation
	Menstruation, menstrual cycle, MHM, menstrual hygiene management, period, menstrual phase, follicular phase, ovulation phase, luteal phase. Athlete Athlete, performer, player, gymnast, runner, footballer, cricketer, swimmer, Low-middle-income countries LMIC LIC Individual countries

full-text screening. The inclusion and exclusion criteria guided the screening procedure developed based on the population-exposure-outcome (PEO) framework. All disagreements among reviewers were solved through discussion with senior reviewers. Finally, another author independently reviewed selected articles using the JBI Critical Appraisal Checklist.

Synthesis of results

The majority of the data extraction criteria were predefined a priori to align with the study's objectives of exploring research related to menstruation or the menstrual cycle among female athletes in LICs and lower-middle-income countries (LMICs). However, due to the limited number of articles identified in the initial search, some criteria were modified during the extraction process to incorporate additional information and broaden the scope of the review to include studies on menstrual hygiene and the menstrual cycle, as well as to consider LMICs and LICs individually, to extract a broader range of data. Ultimately, the data collected for analysis encompassed the title, first author's name, study design, publication year, study population, sample size, assessment tools, age, mean age, country, and outcome measures. The results from each study were extracted based on their respective findings.

Results

We initially identified 1490 articles, of which 88 were selected after abstract and title screening. Of the 88 selected articles, 34 studies were included as potential eligible articles from the title and abstract screening (Fig. 1). Finally, 26 unique articles were identified after a full-text review. The geographical distribution of articles is provided in (Fig. 2). The ages of athletes varied from 13 to 37 years and included athletes from different levels: collegiate-level athletes, national-level soccer players, adolescent athletes (playing professionally), and elite athletes. Four articles included athletes and non-athletes. The range of topics covered in the articles includes the physiology of menstrual cycle or phases, knowledge of menstruation, menstrual disorders, nutrition, perceptions, and performance indicators. The study characteristics are summarized in Table 3.

Study design and instrument

Eighteen articles were conducted using cross-sectional surveys [8, 25–40], two descriptive [41, 42], two observational [43, 44], two causal-comparative [45, 46], one prospective [47], and one self-control double-masked randomized trial [48]. Two articles followed the 'causal comparative' approach, which explores the cause-and-effect relationship with collected data from groups [49]. Eighteen studies reported using questionnaires, five measured physiological parameters, and five used performance indicators, which included shoulder laxity, knee laxity, endurance, and athletic performance through a series of tests. A summary of topics covered by the articles is given in Fig. 3.

Menstruation

Out of the 26 articles, 10 focused on exploring the menstrual cycle and its impact on athletes. A notable observation was the absence of a universal definition or standardized terminology for menstrual phases. For instance, the bleeding phase was described as the "Follicular" phase in three articles [25, 36, 48], as "menstruation" or "menstrual phase" in five articles [37, 38, 42, 43, 47], and simply as the "bleeding phase" in two articles [29, 33]. Three articles mentioned data collection during the luteal phase, while the remaining defined menstrual phases as "before," "during," and "after" the bleeding phase. It's worth mentioning that none of the articles validated the phases of menstruation based on hormone levels; instead, they relied on reported bleeding dates. This paper will adhere to the term follicular phase.

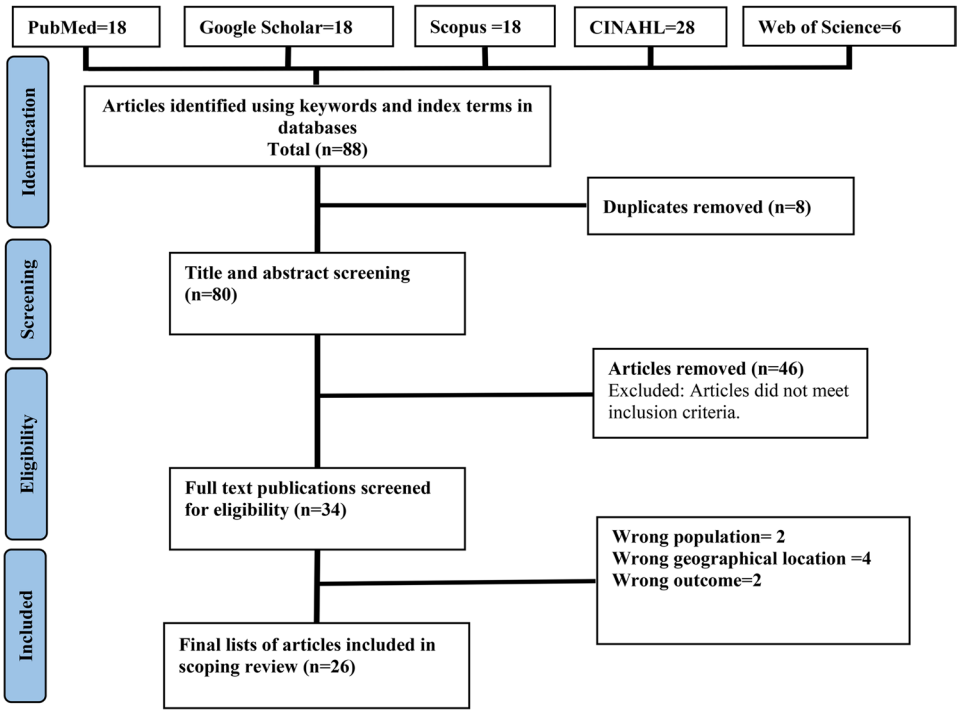
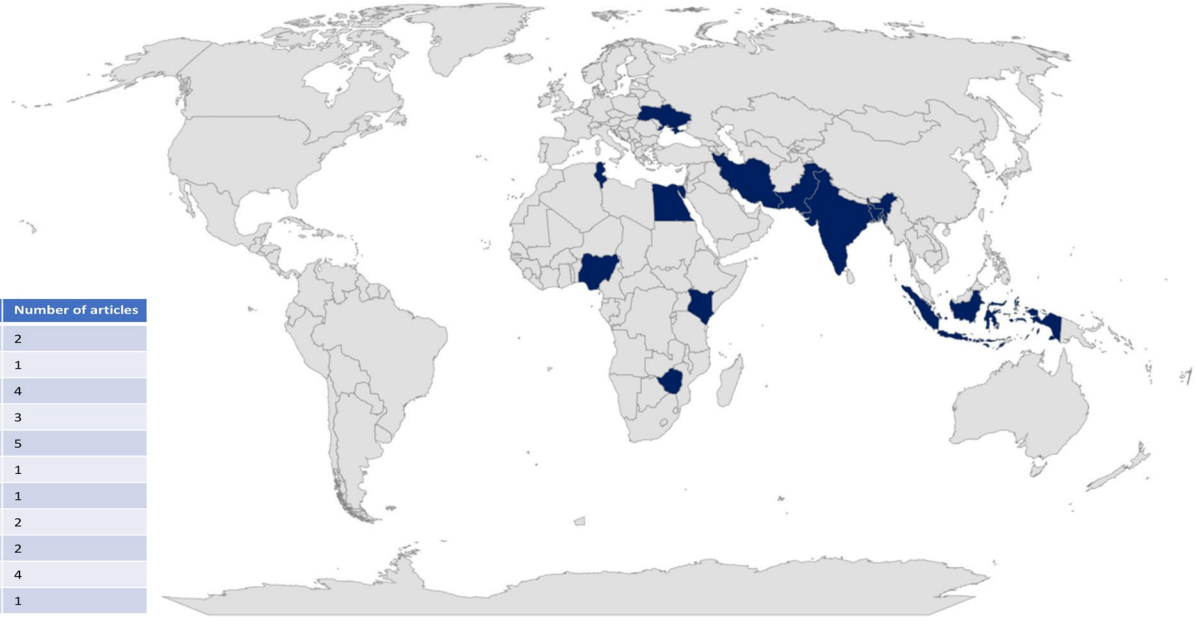


Fig. 1 PRISMA flowchart illustrating the study selection process



Country	Number of articles
Bangladesh	2
Egypt	1
India	4
Indonesia	3
Iran	5
Kenya	1
Nigeria	1
Pakistan	2
Tunisia	2
Ukraine	4
Zimbabwe	1

Fig. 2 Geographical distribution of studies included in the review on menstruation among female athletes (2004–2024). The map illustrates the regions and countries from which the articles were selected, highlighting the global research coverage and focus areas

Physiology of female athletes

Five studies focused on the physiology of female athletes [29, 32, 33, 48, 50], and eight studies reported on performance indicators [25, 35, 36, 39–42, 47]. In comparative studies between athletic and non-athletic females, the average age of menarche was reported to be slightly higher for athletes compared to non-athletes, and significantly more menstrual irregularity was found in the athletic group. Yet, athletes generally reported taking less medication for pain relief than non-athletes. More athletes have reported skipping menstruation, having shorter duration and irregularity, and less menstrual discharge than non-athletes [34, 51, 52]. The studies reported significant differences in indirect measures of

Table 3 Study Characteristics and summary of selected studies on menstruation among female athletes in LMICs from 2004-2024. The table provides an overview of the research focus, sample sizes, study populations, methodologies, and key findings to understand the impact of menstruation on athletic performance, training, and overall health

SL	TITLE	FINDINGS	REMARKS
1	Assessment of Lung functions during different Menstrual phases in female athletes	The study finds that lung function parameters, such as forced vital capacity (FVC) and forced expiratory volume (FEV1), can fluctuate during different	The study correlates lung function tests among swimmers, but the changes cannot be generalized for all athletic types.
2	Age at menarche, menstrual patterns, sexual health knowledge, attitudes and premarital sexual partners of female athletes in Ibadan, Nigeria.	The study reveals that these athletes generally experience menarche at a typical age, with some variability in menstrual regularity and flow. The research also highlights gaps in sexual health	A self-administered questionnaire among adolescents risks with reporting bias.
3	The relation between athletic sports and prevalence of amenorrhea and oligomenorrhea in Iranian female athletes	The study finds that menstrual irregularities are more common in athletes, particularly those involved in high-intensity or endurance sports. The prevalence is linked to intense training low body fat and	A self-administered questionnaire was used among adolescents; with a possibility of reporting bias. No mention of the level of understanding of the term
4	Basic mesocycle construction specifics of female athletes, who specialize in medium distance running, by taking into account female body peculiarities	The study focuses on designing mesocycles (training blocks) for female athletes specializing in medium-distance running, tailored to the physiological characteristics of the female body. It highlights the importance of considering hormonal fluctuations	The study provides valuable insights into the effectiveness of mesocycles tailored to the functional capabilities and special ability dynamics of qualified female athletes. However, it could benefit from a larger sample
5	Clinical manifestations of the female athlete triad among some Iranian athletes	The study shows significant prevalence of the triad, particularly in sports emphasizing leanness and endurance. Symptoms include irregular or absent menstruation, restrictive eating behaviors, and decreased bone mineral density which increase the	The study highlights the prevalence of eating disorders and low bone mineral density with amenorrhea/oligomenorrhea, stress fractures, or weight loss drug use. Still, reliance on self-reported questionnaires and lack of
6	Menstrual characteristics of adolescent athletes: a study from West Bengal, India	The findings suggest that intense physical activity may influence menstrual patterns, with some athletes experiencing delayed menarche and irregular cycles compared to non-athletes.	The study effectively compares menstrual characteristics between athlete and non-athlete adolescents. It explores their relationship with anthropometric and socioeconomic variables using a questionnaire.
7	Comparing menarche age, Menstrual regularity, Dysmenorrhea and analgesic consumption among athletic and non-athletic female students at universities of Tabriz	This study compares athletic and non-athletic female students, showing that athletes tend to have a later menarche and higher rates of menstrual irregularities	Reliance on self-reported data could introduce bias, and the study may benefit from a more diverse sample to enhance generalizability.
8	Effect of physical exercise on some hematological parameters in female athletes in Bangladesh	The findings indicate that regular exercise positively influences these parameters, enhancing oxygen transport and overall athletic performance, though individual responses can vary based on the	The small sample size significantly limits the study's generalizability and statistical power. The authors speculates on the causes of changes in blood parameters with menstruation,
9	Effects of Vitamin-E Supplementation on Cardiorespiratory Responses in Female Athletes during Endurance Exercise in Different Phases of Menstrual Cycle	Results suggest that supplementation may improve endurance exercise performance and reduce oxidative stress, particularly during phases with higher physiological stress indicating potential benefits	Although the study's design enhances its validity, the relatively small sample size may limit the generalizability of the findings.
10	Adolescent elite Kenyan runners are at risk for energy deficiency, menstrual dysfunction and disordered eating	The study identifies significant risks of energy deficiency, menstrual dysfunction, and disordered eating among adolescent elite Kenyan runners. These issues are linked to high training demands and insufficient nutritional intake which can negatively	While the study effectively highlights significant health risks faced by young female athletes, its cross-sectional nature limits the ability to infer causality or its impact on performance based on menstruation or
11	Knee Laxity Variations in the Menstrual Cycle in Female Athletes Referred to the Orthopedic Clinic	The study finds that hormonal changes, particularly during the luteal phase, can increase knee laxity, potentially raising the risk of ligament injuries.	The descriptive study design limits the ability to establish causality. Additionally, the relatively small sample size may affect
12	Physical performance during the menstrual cycle of female athletes who specialize in 800 m and 1500 m running	Results show that performance can vary across menstrual phases, with some athletes experiencing reduced endurance and speed during menstruation	The small sample size limits the statistical power and generalizability of the results. Moreover, the cross-sectional nature of the study precludes the ability to observe changes
13	Women Athletes' Endurance and Menstruation Cycle; PreMenstruation, 2nd day of Menstruation and 5th Day of Menstruation	Findings indicate that endurance performance is lowest during the early days of menstruation but improves by the 5th day	The small sample size limits the generalizability of the finding and the descriptive nature of the study provides only a snapshot rather than a comprehensive
14	Assessment of Musculoskeletal Strength and Levels of Fatigue during Different Phases of Menstrual Cycle in Young Adults	The study finds that strength tends to decrease and fatigue increases during the luteal and menstrual phases	The study aims to explore the changes of muscle strength throughout menstrual phases among non-athletes but not among athletes, who
15	Menstrual Cycle: Does it Influence the Anxiety and Confidence of the Volley Ball Athletes?	The study finds that anxiety levels tend to rise and confidence may decrease during the premenstrual phase	The study aims to explore the changes in muscle strength across menstrual phases among non-athletes, distinguishing them from
16	The Effect of Anaerobic and Aerobic Exercise on Endurance and Non Endurance Athletes on Premenstrual Syndrome (PMS)	Findings suggest that both types of exercise can alleviate PMS symptoms, with aerobic exercise showing slightly better outcomes in symptom relief.	Small sample sizes may limit statistical power and generalizability. A cross-sectional design prevents the establishment of causality. Reliance on self-reported data introduces the potential for bias. Generalizability may be
17	Soccer-related performance in eumenorrheic Tunisian high-level soccer players: Effects of menstrual cycle phase and moment of day	The study finds that performance metrics like speed and agility can fluctuate with the menstrual phase, particularly showing decreases during the luteal phase	The study's small sample size of 11 participants limits the findings' generalizability and statistical power. At the same time, its cross-sectional design limits the ability to establish causality or track performance changes over time. Additionally, the absence of control for potential confounding variables, such as training load
18	Adolescent athlete's knowledge, attitude and practices about menstrual hygiene management (MHM) in BKSP, Bangladesh	This research explores menstrual hygiene knowledge, attitudes, and practices among adolescent athletes in Bangladesh. It identifies gaps in knowledge and practices suggesting the need for improved menstrual	The cross-sectional design restricts the ability to ascertain causality or observed changes over time. Additionally, the findings may lack generalizability beyond the confines
19	The dependence of emotional burnout on ovarian-menstrual cycle phases	The study finds that burnout symptoms may intensify during the luteal and menstrual phases due to hormonal fluctuations	The study's observational nature precludes establishing causal relationships between burnout and menstrual cycle phases.
20	Analysis of psychological state of qualified female handball players depending on the phase of the ovarian-menstrual cycle	Results indicate mood variations, with increased irritability and stress reported during the premenstrual and menstrual phases	The small sample size provides limited insight and the cross-sectional nature limits any establishment causal relationships
21	Comparison of some intrinsic risk factors of shoulder injury in three phases of menstrual cycle in collegiate female athletes	The study finds that hormonal changes can influence joint stability and proprioception, particularly during the luteal phase, increasing the risk of shoulder injuries	The small sample size provides limited insight and the cross-sectional nature limits any establishment causal relationships
22	The Disturbing Effect of Neuromuscular Fatigue on Postural Control Is Accentuated in the Premenstrual Phase in Female Athletes	This research indicates that neuromuscular fatigue adversely affects postural control more significantly during the premenstrual phase in female athletes, due to hormonal influences	The small sample size provides limited insight and the cross-sectional nature limits any establishment causal relationships. Does not exploe changes throughout difference phases
23	Prevalence of Risk Factors of the Female Athlete Triad among Young Elite Athletes of Pakistan	The study identifies a high prevalence of female athlete triad risk factors—disordered eating, menstrual dysfunction, and low bone density—among	The cross-sectional nature limits any establishment causal relationships. Reliance on self-reported data introduces the potential
24	Oxidative Stress and Menstrual Complications Caused by Vaccination of COVID' 19 Among Females Athletes	The research finds that COVID-19 vaccination may lead to oxidative stress and menstrual complications in female athletes, including irregular cycles and	The small sample size provides limited insight and the cross-sectional nature limits any establishment causal relationships. Reliance
25	Indian Endurance Athletes' Menstrual Cycle: Practices, Knowledge, Communication, Health, and Changes in Perceptions Across the Phases	This study explores menstrual health practices, knowledge, and perceptions among Indian endurance athletes	Reliance on self-reported data introduces the potential for bias and prevents in-depth exploration on the factors associated with changes in performance.
26	The menstrual cycle and football: The experiences of African women football players	The study reveal that menstrual symptoms can affect training and competition, with players often lacking adequate support and resources to manage their menstrual health effectively.	Relying on self-reported data introduces the potential for bias as self-administered questionnaire are prone to reporting bias.

[1]Bone Mineral Density
[2] Female Athletic Triad
[3] Council of Southern Africa Football Associations
** No specific sports

body fat, with athletes having lower body weight, BMI, and body fat mass than non-athletes [33, 34, 51]. About 63% of Indian athletes reported irregular bleeding phases with a positive perception of sleep quality, training, fitness, performance, and high-intensity and strength training [53]. Al-Badry et al. reported higher lung functions in the ovulatory phase than bleeding or menstrual phase. In addition, Chatterjee et al. and Keolahragaan reported differences in maximum oxygen uptake, O2 pulse, maximum pulmonary ventilation, and endurance in different phases [52, 54, 55].

Menstruation: knowledge and disorders

Most female athletes cited their mothers as their primary source of information regarding menstruation. Nevertheless, over half of the participants displayed limited

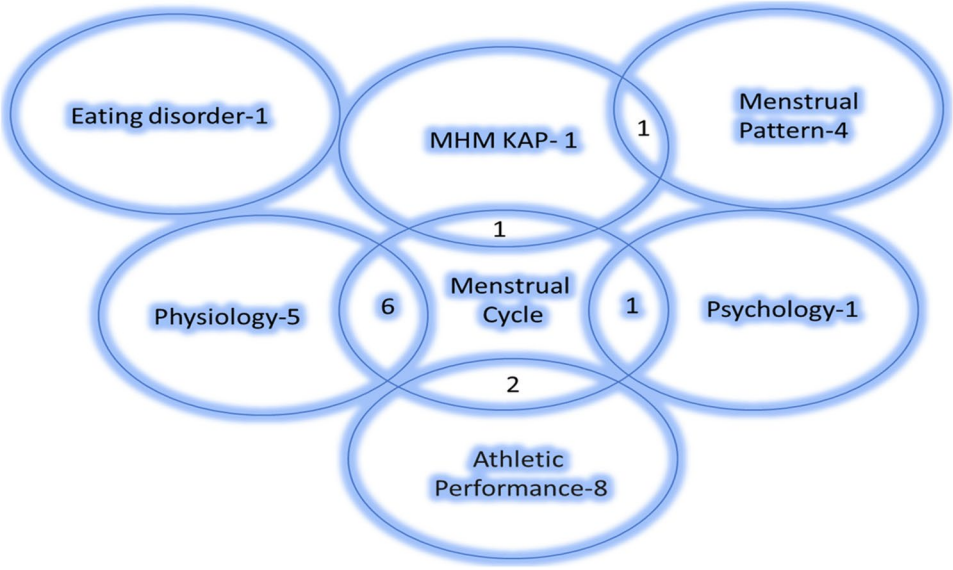


Fig. 3 Topics covered by articles

knowledge [8]. This data contrasts somewhat with a study conducted in Nigeria, where over 50% of the participants demonstrated a solid grasp of sexual health, as evidenced by a ten-item questionnaire [56]. In studies conducted in Iran among athletes, a higher risk of Amenorrhea/Oligomenorrhea was observed among younger athletes engaged in endurance sports, those in specific weight categories, and those using oral contraceptive pills [26, 57]. Female Indian athletes exhibited suboptimal knowledge and communication regarding this topic [53].

Mkumbuzi et al. reported that only about 10% female football players reported the use of hormonal contraceptives and experienced mild to moderate menstrual symptoms during the first three days of their menstrual cycle [30]. Additionally, Khan et al. examine the effects of COVID-19 vaccination on female elite athletes, highlighting that the vaccine contributes to oxidative stress and menstrual irregularities similar to contraceptive methods use. The data collected before and after vaccination indicates notable changes in both oxidative stress levels and menstrual cycle duration [29].

Nutrition

Athletes generally exhibited notably lower weight, reduced energy availability, lower BMI, and diminished fat-free mass compared to non-athletes (30). In a separate study conducted in Bangladesh, female athletes displayed significantly lower haemoglobin concentration, serum iron, serum ferritin, and total iron binding capacity (TIBC) than non-athletes [58].

In Iran, a study sought to evaluate the clinical manifestations of the female athlete triad, or reduced energy deficit syndrome (RED-S), encompassing eating disorders (ED), functional hypothalamic amenorrhea, and osteoporosis, by examining the presence of eating disruptions and bone mineral density in individuals reporting menstrual irregularity, stress fractures, or the use of weight loss medication [32]. Notably, over 50% of female athletes in Pakistan reported being at risk, and 83.3% of them reported eating disorders, which included behaviors such as binge eating, vomiting, laxative abuse, and intense training regimens. Athletes in the same study also reported the use of nutritional supplements like calcium, vitamin D, and hormones, as well as diuretics or weight-reducing drugs [38].

Performance indicators

One study measured the difference in endurance levels among females during the premenstrual phase compared to the bleeding phase, where athletes reported a significant decrease in endurance during the second day of menstruation 2nd while it increased on the 5th day, compared to pre-menstrual days [42]. Studies reported diurnal and hormonal variations in athletic performance, differences in anxiety, confidence, perception of symptoms of various diseases, negative emotion, mood, and physical activity at different menstrual phases [28, 37, 39, 44, 46]. Assessing musculoskeletal strength and fatigue among young Indian females during the various phases of the menstrual cycle, it was reported that late follicular phase has the least fatigue rate, and the early follicular phase (bleeding phase) has the least strength compared to ovulatory and luteal phases [47]. However, no significant relationship was reported between the menstrual cycle phases or female hormone level with the knee joint or ACL laxity. In another study conducted among collegiate female athletes on regular normal menstrual cycles, the strength of abduction, internal rotation, and external

rotation of the shoulder joint in the ovulation phase was higher than in other phases with no significant difference in laxity and functional stability factors [59].

Discussion

Sports hold significant potential to advance gender equality by fostering teamwork, resilience, and confidence, while providing a supportive environment for girls and women to develop strong identities and essential life skills [60, 61]. Female athletes challenge societal stereotypes, serving as role models and exemplifying gender equality [60].This review highlights the diversity in research methods, study designs, and focus areas within the literature on female athletes, with a notable gap in representation from LMICs and LICs.

Out of an initial 1,490 articles, only 26 met the inclusion criteria after a thorough selection process. These studies represent a broad geographic distribution, including LICs and LMICs such as Pakistan [38], Kenya [33], and Bangladesh [8, 50], and feature diverse athletes ranging from adolescents to elite performers. This diversity strengthens the findings but also underscores the challenges of synthesizing data across varied socioeconomic and cultural contexts.

The review reveals a significant gap in standardized terminology and methodologies for defining menstrual phases, with inconsistencies particularly pronounced in studies from LICs and LMICs [62]. This indicates a need for more precise and culturally adaptable approaches in future research. Physiological studies demonstrate key differences between athletic and non-athletic females, such as variations in body composition, menstrual regularity, and timing of menarche. Studies from Indonesia, for example, report that women athletes experience varying endurance levels across different phases of their menstrual cycle, and the phases affects athletes by increasing anxiety levels and decreasing confidence [42, 46]. Athletes typically exhibit lower body weight, BMI, and body fat mass, reflecting the demands of high-level physical activity. However, research from LICs and LMICs often lacks the resources or frameworks to explore these differences comprehensively [63]. The reported menstrual irregularities and use of pain medication and contraception among athletes raise concerns about their long-term health [13, 64]. The lack of cohesive data from LICs and LMICs limits the generalizability of this claim. In these regions, social determinants such as limited access to education, stigma, and inadequate MHM facilities—including privacy, sanitary products, water, and disposal options—significantly impact female athletes' experiences [65].

In LMICs, limited access to healthcare and inadequate nutritional support exacerbate these challenges, highlighting the critical need for targeted interventions [66]. Athletes in endurance and weight-sensitive sports face an elevated risk of menstrual disorders, including amenorrhea and oligomenorrhea, emphasizing the importance of educational programs designed to address the specific needs of athletes in LICs and LMICs [67]. Research on female athletes is often limited due to the complexities associated with hormones during the menstrual cycle, pregnancy, and postpartum, with men historically being used as substitutes [68, 69]. Social determinants and resource limitations particularly impact girls and women from LMICs, who also struggle with inadequate access to MHM facilities, including privacy, sanitary products, water, and disposal options [70].

The prevalence of eating disorders and the use of weight control methods among female athletes, especially in regions like Pakistan, highlights the need for better nutritional support and monitoring [38]. The review suggests that the menstrual cycle does affect athletic performance, particularly in endurance, strength, and fatigue, though there is no consistent relationship between menstrual phases, vaccinations, and musculoskeletal factors like knee joint laxity, indicating a need for further research. The observed variations in performance across menstrual phases emphasize the importance of personalized training and recovery plans for female athletes.

It is noted that exercise research on females is frequently conducted during the early follicular phase when hormone levels are lowest, which may overlook the effects of hormonal fluctuations throughout the cycle [71]. Bruinvels et al. stress the importance of understanding female physiology better and exploring how hormonal variations, both positive and negative, impact athletic performance [68] Investigating and comprehending the influence of the menstrual cycle and hormonal fluctuations is crucial to optimize performance and training to ensure improved long-term health outcomes [13, 64]. In a narrative review conducted by Carmichael et al. regarding women's athletic performance across menstrual cycle phases, 40 articles were examined, encompassing data from all countries. However, the available number of research articles was strikingly limited when focusing on menstruation or the menstrual cycle within LMICs [13]. Future research should start with a mapping of focus qualitatively and quantitively influence female physiology, performance, and well-being from both social, economic, and physical perspectives.

Future research should prioritize mapping the influence of menstruation and menstrual health on female athletes from LICs and LMICs, considering social, economic, and physical perspectives. A comprehensive search strategy, expert consultation, and manual searches were employed in this review to address the limited availability of relevant studies from these regions. Despite challenges in balancing comprehensiveness and

relevance, this review systematically compiles existing research to assess the coverage and quality of current literature, aiming to enhance the understanding of menstruation among athletes in LICs and LMICs. Doing so seeks to address critical gaps and provide a foundation for improving menstrual health and athletic performance in these underserved populations.

Conclusion

This review identifies key gaps in research on female athletes, particularly regarding the standardization of methodologies for studying menstruation, physiology, and performance. It identifies significant knowledge gaps, the need for standardized research methodologies, and the critical importance of comprehensive support systems to optimize female athletes' health and performance.

The need for research centred on female athletes from LMICs is unmistakable and pressing to enhance their well-being and performance by delving into their experiences, barriers, and triumphs and contributing to broader social, cultural, and gender equality agendas. It underscores the importance of personalized training protocols, improved menstrual health education, and comprehensive support systems to enhance female athletes' well-being and performance. Future research must better account for hormonal variations and the unique physiological needs of female athletes to support their long-term health and success in sports.

Supplementary Information

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Supplementary Material 1.

Supplementary Material 2.

Supplementary Material 3.

Supplementary Material 4.

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Authors' contributions

MTM was a significant contributor to the analysis, interpretation, and manuscript writing and is the study's Principal Investigator and overall implementer. FRS and SS substantially contributed to the literature search, adhering to inclusion and exclusion criteria, search strategy development, and SDG-supported manuscript development. QN and SMP participated in the study design and provided significant direction on the manuscript. QN contributed to funding acquisition, protocol development, and guided manuscript revision. MR was a significant contributor in guiding and writing the manuscript. All authors have read and approved the final manuscript.

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Data availability

Not applicable.

Declarations

Ethics approval and consent to participate

The Institutional Review Board (IRB) of the International Centre for Diarrhoeal Diseases and Research, Bangladesh (icddr, b), has granted approval for the study, with the protocol number PR-22136. No consent was necessary for this review.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

Author details

[1]International Centre for Diarrheal Disease Research, 68 Shaheed Tajuddin Ahmed Sarani, Mohakhali, Dhaka 1212, Bangladesh
[2]Children's Health and Environment Program, Child Health Research Centre, The University of Queensland, Brisbane, QLD, Australia

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