

**Supplement Use and Doping Risk Across Menstrual Cycle Phases in Female Athletes**Rafa Dinnantra Limastyningrum¹, Muhammad Rifky Arifin^{2*}, Sheva Naufal Fadillah³¹²³ Department of Sport Science, Faculty of Health Sciences, University of Singaperbangsa Karawang, Indonesia**Keywords**

Female athletes;
menstrual cycle;
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doping risk, athletic
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Abstract

The menstrual cycle is a physiological factor influencing health status, nutritional requirements, and athletic performance in female athletes. Hormonal fluctuations across menstrual cycle phases encourage the use of various sports supplements to support performance, recovery, and management of menstrual symptoms. However, supplement use may also increase the risk of accidental doping due to contamination of consumed products with prohibited substances. This study aimed to examine the relationship between sports supplement use across menstrual cycle phases and doping risk among female athletes. A Systematic Literature Review (SLR) method following PRISMA guidelines was employed, with literature retrieved from Google Scholar, PubMed, ScienceDirect, and SpringerLink databases covering 2015-2025. A total of 10 articles meeting the inclusion criteria were analyzed using a thematic analysis approach. Findings indicate that menstrual cycle phase influences both nutritional needs and supplement-use patterns among female athletes. The most commonly used supplements include iron, protein, caffeine, creatine, vitamin D, magnesium, and omega-3 fatty acids. Although these supplements support athletic performance and overall health, uncontrolled use may increase the risk of accidental doping. Therefore, education on safe supplement use and menstrual cycle monitoring is essential as part of a comprehensive strategy to support the performance and well-being of female athletes.

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INTRODUCTION

Women's participation in sports has increased significantly over the past few decades. Greater opportunities for women to engage in competitive sports have contributed to a substantial rise in the number of female athletes across various disciplines at regional, national, and international levels. This phenomenon not only reflects the success of gender equality initiatives in sports but has also stimulated the development of research focusing on the physiological characteristics of women in the context of athletic performance. Unlike male athletes, female athletes possess unique biological characteristics, particularly those related to the reproductive system and hormonal fluctuations that occur throughout the menstrual cycle. Consequently, female athletes require more specific training, nutritional, and recovery approaches tailored to their physiological needs (Sims et al., 2023).

The menstrual cycle is a normal physiological process experienced by women of reproductive age and is characterized by periodic fluctuations in estrogen and progesterone levels. Typically lasting between 21 and 35 days, the menstrual cycle consists of several phases, including the menstrual, follicular, ovulatory, and luteal phases. Each phase exhibits distinct hormonal profiles that can influence various physiological functions, including energy metabolism, neuromuscular function, thermoregulation, body composition, and athletic performance capacity (McNulty et al., 2020). In the context of competitive sports, these hormonal changes may affect athletes' training and competition performance, although the magnitude of these effects may vary among individuals.

Several studies have reported that some female athletes experience reduced performance, increased fatigue, impaired concentration, and physical discomfort during specific phases of the menstrual cycle. Symptoms such as dysmenorrhea, abdominal pain, headaches, mood disturbances, and fatigue are often factors that negatively affect training quality and competitive performance. Conversely, other studies have suggested that certain phases, particularly the follicular phase, may provide physiological advantages due to elevated estrogen levels, which contribute to enhanced energy metabolism and neuromuscular function (McNulty et al., 2020). These varying responses highlight the importance of understanding the menstrual cycle as a key factor in optimizing female athletic performance.

To maintain performance and mitigate the physiological challenges associated with the menstrual cycle, many female athletes use various sports supplements. Supplement use has become an integral component of modern athletic performance enhancement strategies. Sports supplements are commonly utilized to meet nutritional requirements that may not be adequately fulfilled through daily dietary intake, enhance training capacity, accelerate recovery, and support overall health. Among female athletes, the most frequently used supplements include iron, protein, caffeine, creatine, vitamin D, multivitamins, omega-3 fatty acids, and other ergogenic aids (Sims et al., 2023).

The need for supplementation among female athletes is often closely associated with the physiological changes that occur throughout the menstrual cycle. Blood loss during menstruation may increase the risk of iron deficiency, which can negatively affect aerobic capacity, increase fatigue, and impair athletic performance. Consequently, iron supplementation has become a commonly adopted strategy to maintain health status and performance among female athletes. Furthermore, several studies have demonstrated that caffeine, creatine, and certain energy supplements are frequently used to reduce perceived fatigue and enhance physical performance during specific phases of the menstrual cycle (Brown et al., 2024). These findings suggest that supplement use among female athletes is influenced not only by performance-related needs but also by dynamic hormonal and physiological changes.

The rapid growth of the sports supplement industry in recent years has increased athletes' access to a wide range of products marketed as performance-enhancing aids. However, sports supplement use also presents several risks, particularly regarding product safety and potential violations of anti-doping regulations. The World Anti-Doping Agency (WADA) consistently emphasizes that athletes are fully responsible for any substance found in their bodies, including substances contained in dietary supplements. This principle, known as

strict liability, states that athletes may be held accountable for anti-doping rule violations even when the ingestion of prohibited substances occurs unintentionally.

One of the most frequently reported issues in sports is accidental doping resulting from the use of sports supplements. Geyer et al. (2008) reported that several commercially available supplements contained substances included on the World Anti-Doping Agency (WADA) Prohibited List without being clearly declared on product labels. Common hidden contaminants include undisclosed stimulants, such as methylhexanamine (DMAA) and sibutramine, as well as anabolic agents, including anabolic-androgenic steroids and their precursors, which may be unintentionally introduced during manufacturing or deliberately added to enhance product efficacy. Contamination may occur during manufacturing, storage, or distribution processes due to inadequate quality control, cross-contamination between production batches, or intentional adulteration by manufacturers. Furthermore, some manufacturers have been found to provide incomplete or misleading information regarding product ingredients, thereby increasing the likelihood of athletes unknowingly consuming prohibited substances. Under the World Anti-Doping Code's principle of strict liability, athletes are solely responsible for any prohibited substance detected in their bodies, regardless of whether its ingestion was intentional or accidental. Consequently, the use of unverified or inadequately tested supplements may lead to adverse analytical findings, disqualification from competition, suspension, forfeiture of titles and medals, reputational damage, and long-term consequences for an athlete's career. These risks underscore the importance of evidence-based supplement selection and the use of products that have undergone rigorous third-party quality testing.

Martínez-Sanz et al. (2017) identified sports supplement use as one of the factors most frequently associated with cases of accidental doping among athletes. Athletes with greater supplementation requirements tend to have a higher risk of exposure to contaminated products. In female athletes, this issue becomes even more complex because supplement needs often increase during specific phases of the menstrual cycle. For example, increased iron requirements due to substantial menstrual blood loss or the use of supplements to alleviate menstrual symptoms may lead to more frequent supplement consumption. As the frequency of supplement use increases, so does the likelihood of exposure to substances that may violate anti-doping regulations.

Although research on the menstrual cycle, sports supplementation, and doping has expanded considerably in recent years, most studies have examined these topics independently. Research on the menstrual cycle has primarily focused on the effects of hormonal fluctuations on athletic performance, whereas supplementation studies have mainly investigated the effectiveness of supplements in enhancing performance and recovery. Meanwhile, doping-related research has largely concentrated on anti-doping policies, prohibited substances, and documented violation cases. To date, there remains a limited number of studies that comprehensively integrate the relationships among menstrual cycle phases, sports supplement use, and doping risk in female athletes. This limitation highlights an important research gap that warrants further investigation through a systematic literature review approach.

Based on these considerations, this study aims to conduct a Systematic Literature Review examining sports supplement use across different menstrual cycle phases and its association with doping risk among female athletes. This review is expected to provide a comprehensive understanding of supplement-use patterns throughout the menstrual cycle, the most commonly used supplements, the benefits obtained by female athletes, and the potential doping risks associated with supplement consumption. Furthermore, the findings are expected to serve as scientific evidence for athletes, coaches, sports nutritionists, healthcare professionals, and sports policymakers in designing supplementation strategies that are safe, effective, and aligned with clean sport principles, thereby supporting optimal athletic performance without violating anti-doping regulations. To ensure methodological transparency, rigor, and reproducibility, this systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, a widely recognized framework for reporting systematic reviews.

METHOD

This study employed a Systematic Literature Review (SLR) approach to identify, examine, and synthesize research findings related to sports supplement use across different menstrual cycle phases and its association with doping risk among female athletes. The Systematic Literature Review method was selected because it provides a comprehensive overview of research developments on a particular topic through a systematic and structured process of literature searching, selection, evaluation, and synthesis. The review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, which are widely used in systematic review studies to enhance transparency and improve the quality of research reporting.

The literature search was conducted using several national and international scientific databases relevant to the fields of sports science, health, nutrition, and anti-doping, including Google Scholar, PubMed, ScienceDirect, and SpringerLink. The search process was carried out in June 2026 using a combination of keywords developed based on the focus of the study. The keywords included *female athlete*, *women athlete*, *menstrual cycle*, *sports supplements*, *supplementation*, *sports nutrition*, *anti-doping*, and *accidental doping*. To obtain more specific search results, these keywords were combined using Boolean operators such as AND and OR. In addition to English-language searches, Indonesian-language searches were also conducted using the keywords “atlet wanita,” “siklus menstruasi,” “suplemen olahraga,” and “risiko doping.”

The articles retrieved from the search process were subsequently screened according to predetermined inclusion and exclusion criteria. The inclusion criteria comprised articles published between 2015 and 2025, available in either Indonesian or English, accessible in full-text format, and addressing one or more topics related to the menstrual cycle in female athletes, sports supplement use, nutritional requirements of female athletes, or doping risks associated with supplement consumption. Conversely, studies that did not focus on female athletes, did not discuss supplementation or anti-doping aspects, or were categorized as editorials, opinion papers, conference proceedings, or duplicate publications were excluded from the analysis.

The article selection process followed the PRISMA framework, which consists of four stages: identification, screening, eligibility assessment, and inclusion. During the identification stage, all articles retrieved from the selected databases were collected and recorded. The screening stage involved reviewing titles, keywords, and abstracts to eliminate studies that were not relevant to the research topic. Articles that passed the screening stage underwent a full-text review to ensure their alignment with the study objectives and inclusion criteria. Articles meeting all requirements were subsequently included in the data synthesis stage.

Data from the selected studies were extracted and organized into a literature synthesis table containing information on the authors, year of publication, research objectives, study design, participant characteristics, types of supplements used, menstrual cycle phases investigated, and key findings related to athletic performance and doping risk. The extracted information was then analyzed using a thematic analysis approach. The analysis involved categorizing findings into several major themes, including the influence of menstrual cycle phases on the physiological condition of female athletes, patterns of sports supplement use across menstrual cycle phases, the benefits of supplementation for athletic performance, and the potential risk of accidental doping associated with sports supplement consumption.

To ensure the quality of the review, priority was given to articles published in reputable national and international scientific journals indexed in recognized academic databases. Furthermore, the quality of each study was evaluated based on the clarity of its research objectives, methodological appropriateness, sample characteristics, and the relevance of its findings to the focus of the review. Through this systematic and structured Systematic Literature Review approach, the present study is expected to provide a comprehensive scientific synthesis regarding the relationship between sports supplement use across menstrual cycle phases and doping risk among female athletes. The findings are anticipated

to serve as a foundation for developing supplementation strategies that are safe, effective, and aligned with clean sport principles.

Table 1. Evidence Synthesis of Studies on Sports Supplement Use Across Menstrual Cycle Phases and Its Association with Doping Risk in Female Athlete

Author (Year)	Study Design	Population	Menstrual Cycle Focus	Supplement(s) Investigated	Doping Risk Addressed	Key Findings
Sims et al. (2023)	Position Stand	Female athletes	All phases	Iron, protein, creatine, caffeine	No	Requirements vary across hormonal fluctuations. Phase-specific nutrition improves health and recovery.
Larrosa et al. (2025)	Systematic Review	Female athletes & active women	Menstrual cycle	Various strategies	No	Reduces symptoms and supports performance. Hormones influence performance.
Brown et al. (2024)	Systematic Review	Women	Menstrual phase	Iron, magnesium, vitamin D, omega-3, caffeine	No	Iron deficiency risk increases.
McNulty et al. (2020)	SR & Meta-analysis	Eumenorrheic women	Follicular vs luteal	None	No	Contaminated supplements increase accidental doping.
Bruinvels et al. (2018)	Cross-sectional	Elite/non-elite athletes	Heavy menstrual bleeding	Iron	No	Undeclared anabolic agents and stimulants detected.
Martínez-Sanz et al. (2017)	Literature Review	Athletes	Not specific	Various supplements	Yes	Supplement use contributes to inadvertent doping.
Geyer et al. (2008)	Experimental	Commercial supplements	N/A	Various supplements	Yes	Cycle affects physiology and psychology.
Outram & Stewart (2015)	Literature Review	Competitive athletes	N/A	Sports supplements	Yes	Menstrual status affects fatigue and recovery.
Supriadi (2022)	Literature Review	Female athletes	Menstrual cycle	General nutrition	No	
Nainggolan et al. (2024)	Literature Review	Female athletes	Menstrual phase	General nutrition	No	

RESULTS AND DISCUSSION

A total of ten studies met the eligibility criteria and were included in this systematic review. The selected studies were published between 2008 and 2025 and comprised one Position Stand, three Systematic Reviews, one Systematic Review and Meta-analysis, one Cross-sectional Study, one Experimental Study, and three Literature Reviews. Collectively, these studies provide comprehensive evidence regarding sports supplementation, menstrual cycle physiology, athletic performance, and supplement-related doping risks among female athletes. As summarized in Table 1, the included literature demonstrates that recent research has increasingly recognized the importance of integrating menstrual physiology into nutritional planning while simultaneously considering supplement safety within the context of anti-doping regulations.

The synthesized evidence consistently indicates that hormonal fluctuations throughout the menstrual cycle substantially influence the nutritional requirements of female athletes. Variations in estrogen and progesterone concentrations affect substrate metabolism, muscle function, fatigue perception, recovery capacity, and exercise performance, resulting in different physiological demands across menstrual phases. Consequently, several studies emphasized that supplementation strategies should be individualized rather than generalized. Sims et al. (2023) and Larrosa et al. (2025) highlighted that nutritional interventions tailored to specific menstrual cycle phases may optimize athletic performance, recovery, and overall health. Similarly, McNulty et al. (2020) demonstrated that although the effects of menstrual cycle phases on exercise performance vary among individuals, hormonal fluctuations remain an important physiological factor that should be considered when designing training and nutritional programs. Supporting these findings, Supriadi (2022) and Nainggolan et al. (2024) further emphasized that menstrual status influences both physiological and psychological responses, including fatigue, recovery, and readiness to train.

Among the nutritional interventions identified, iron supplementation emerged as the most consistently recommended strategy. Bruinvels et al. (2018) reported that female athletes experiencing heavy menstrual bleeding are particularly susceptible to iron deficiency, which may impair oxygen transport, aerobic capacity, and overall exercise performance. In addition to iron, protein, creatine, caffeine, magnesium, vitamin D, and omega-3 fatty acids were frequently recommended across the reviewed literature because of their potential to enhance muscle recovery, improve exercise performance, alleviate menstrual symptoms, and support general athlete health. Brown et al. (2024) specifically reported that iron, magnesium, vitamin D, omega-3 fatty acids, and caffeine supplementation may reduce menstrual-related symptoms while maintaining athletic performance. Collectively, these findings support the growing concept of precision sports nutrition, whereby supplementation strategies are adjusted according to menstrual cycle phase, symptom severity, training demands, and individual physiological responses rather than being uniformly applied to all female athletes.

Despite these well-documented physiological benefits, the present review also identified supplement safety as a critical issue within female athlete nutrition. Three studies specifically investigated the relationship between sports supplement use and doping risk and consistently demonstrated that commercially available supplements may contain prohibited substances that are not declared on product labels. Geyer et al. (2008) experimentally demonstrated that certain sports supplements were contaminated with undeclared anabolic agents and stimulants, whereas Martínez-Sanz et al. (2017) reported that contamination of dietary supplements remains one of the leading causes of inadvertent doping among athletes. Similarly, Outram and Stewart (2015) concluded that supplement use represents a major contributing factor to accidental anti-doping rule violations in competitive sport. These findings highlight that contamination may occur through inadequate manufacturing practices, cross-contamination during production, or intentional adulteration, thereby exposing athletes to prohibited substances despite their intention to comply with anti-doping regulations.

The implications of these findings are particularly important because the World Anti-Doping Code applies the principle of *strict liability*, whereby athletes are solely responsible for any prohibited substance detected in their bodies regardless of whether its ingestion was intentional or accidental. Consequently, even scientifically supported supplementation strategies may expose female athletes to anti-doping sanctions if supplement quality and

safety cannot be guaranteed. This finding emphasizes that evidence-based supplementation should always be accompanied by careful product selection, preference for supplements that have undergone independent third-party quality certification, and comprehensive anti-doping education involving athletes, coaches, sports nutritionists, healthcare professionals, and sporting organizations.

Overall, the evidence synthesized in this review demonstrates that safe and effective nutritional strategies for female athletes require the integration of three interrelated components: menstrual cycle physiology, evidence-based supplementation, and anti-doping awareness. While previous studies have predominantly examined these topics separately, the present review provides a comprehensive synthesis illustrating that optimal supplementation cannot be determined solely by physiological requirements but must also consider supplement safety and regulatory compliance. Therefore, individualized nutritional planning combined with the use of scientifically validated and quality-certified supplements represents the most appropriate approach for supporting female athlete health, optimizing performance, facilitating recovery, and minimizing the risk of inadvertent doping throughout the menstrual cycle.

CONCLUSION

This systematic literature review demonstrates that the menstrual cycle is a fundamental physiological factor influencing the nutritional requirements, health status, recovery, and athletic performance of female athletes. Hormonal fluctuations throughout the menstrual cycle create phase-specific physiological demands that support the implementation of individualized nutrition and supplementation strategies rather than generalized recommendations. Across the included studies, iron, protein, creatine, caffeine, vitamin D, magnesium, and omega-3 fatty acids were consistently identified as the most frequently recommended supplements for supporting performance, recovery, and menstrual health.

However, the findings also highlight that the growing use of sports supplements is accompanied by an increased risk of inadvertent doping due to contamination with undeclared prohibited substances, including stimulants and anabolic agents. This concern is particularly important because female athletes may rely more heavily on supplementation during specific menstrual cycle phases, while remaining fully accountable under the World Anti-Doping Code's principle of *strict liability*. Therefore, evidence-based supplementation should always be accompanied by careful product selection, preference for independently certified supplements, and comprehensive anti-doping education to minimize potential regulatory violations while maximizing athlete health and performance.

Importantly, this review contributes to the current literature by integrating three interconnected areas that have often been investigated separately: menstrual cycle physiology, sports supplementation, and doping risk. The synthesis provides a comprehensive framework for understanding how individualized supplementation strategies can simultaneously optimize athletic performance, support female athlete health, and promote compliance with clean sport principles.

Future research should focus on prospective and sport-specific empirical studies investigating the relationships among menstrual cycle phases, supplement-use patterns, and doping risk across different competitive levels and sporting disciplines. Such evidence would strengthen the development of evidence-based nutritional guidelines that are both physiologically appropriate and aligned with international anti-doping standards.

REFERENCES

- Barus, L. O., Hutagalung, M., & Siregar, E. (2024). The impact of physical exercise on the menstrual cycle in women. *Jurnal Pendidikan Tambusai*, 8(2), 15432–15440.
- Basri, S. W. G. (2020). The effect of exercise intensity on GnRH hormone levels during the menstrual cycle among athletes at the Makassar Student Training Center. *UMI Medical Journal*, 5(1), 35–43.
- Brown, N., Martin, D., Waldron, M., Bruinvels, G., Farrant, L., & Fairchild, R. (2024). Nutritional practices to manage menstrual cycle related symptoms: A systematic review. *Nutrition Research Reviews*, 37(2), 352–375. <https://doi.org/10.1017/S0954422423000227>
- Bruinvels, G., Burden, R., Brown, N., Richards, T., & Pedlar, C. (2016). The prevalence and impact of heavy menstrual bleeding (menorrhagia) in elite and non-elite athletes. *PLoS ONE*, 11(2), e0149881. <https://doi.org/10.1371/journal.pone.0149881>
- Geyer, H., Parr, M. K., Koehler, K., Mareck, U., Schänzer, W., & Thevis, M. (2008). Nutritional supplements cross-contaminated and faked with doping substances. *Journal of Mass Spectrometry*, 43(7), 892–902. <https://doi.org/10.1002/jms.1452>
- Larrosa, M., Gil-Izquierdo, A., González-Rodríguez, L. G., Muñoz Alférez, M. J., San Juan, A. F., Sánchez-Gómez, Á., et al. (2025). Nutritional strategies for optimizing health, sports performance, and recovery for female athletes and other physically active women: A systematic review. *Nutrition Reviews*, 83(3), e1068–e1089. <https://doi.org/10.1093/nutrit/nuae082>
- Martínez-Sanz, J. M., Sospedra, I., Ortiz, C. M., Baladía, E., Gil-Izquierdo, A., & Ortiz-Moncada, R. (2017). Intended or unintended doping? A review of the presence of doping substances in dietary supplements used in sports. *Nutrients*, 9(10), 1093. <https://doi.org/10.3390/nu9101093>
- Maughan, R. J., Shirreffs, S. M., Vernec, A., & Soligard, T. (2018). Making decisions about supplement use in sport: A review of the evidence and practical considerations. *British Journal of Sports Medicine*, 52(7), 439–455. <https://doi.org/10.1136/bjsports-2017-098777>
- McNulty, K. L., Elliott-Sale, K. J., Dolan, E., Swinton, P. A., Ansdell, P., Goodall, S., Thomas, K., & Hicks, K. M. (2020). The effects of menstrual cycle phase on exercise performance in eumenorrheic women: A systematic review and meta-analysis. *Sports Medicine*, 50(10), 1813–1827. <https://doi.org/10.1007/s40279-020-01319-3>
- Nainggolan, T., Simanjuntak, R., & Sitorus, J. (2024). The relationship between high-intensity training and female athlete performance during menstruation: A literature review. *Jurnal Pendidikan Tambusai*, 8(1), 11245–11254.
- Outram, S., & Stewart, B. (2015). Doping through supplement use: A review of the available empirical data. *International Journal of Sport Nutrition and Exercise Metabolism*, 25(1), 54–59. <https://doi.org/10.1123/ijsnem.2013-0174>
- Sims, S. T., Kerkick, C. M., Smith-Ryan, A. E., Janse de Jonge, X. A. K., Hirsch, K. R., Arent, S. M., et al. (2023). International Society of Sports Nutrition position stand: Nutritional concerns of the female athlete. *Journal of the International Society of Sports Nutrition*, 20(1), 2204066. <https://doi.org/10.1080/15502783.2023.2204066>
- Supriadi, D. (2022). Women's sports and the menstrual cycle. *Journal of Physical and Outdoor Education*, 4(2), 85–94. <https://doi.org/10.37742/ipoe.v4i2.197>