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# The Impact of Menstrual Cycle Phases on Athletic Performance: A Comprehensive Review

**Dominika Rosińska-Lewandoska**

affiliation Municipal Public Health Care Facility in Łask, Polna Street 12, 98-100 Łask, Poland

https://orcid.org/0009-0001-2205-0813

d.rosinskalewandoska@gmail.com

*corresponging author

**Dominika Lewandowska**

affiliation nOvum Medical Clinic, Bociania Street 13, 02-807 Warsaw, Poland

https://orcid.org/0009-0001-8297-9296

dr.dominika.lewandowska@gmail.com

**Julia Ufnal**

Medical University of Warsaw, Żwirki i Wigury 61, 02-091 Warsaw, Poland

**https://orcid.org/0009-0000-5766-6995**

**juliaufnal01@gmail.com**

**Anna Podraza**

Medical University of Warsaw, Żwirki i Wigury 61, 02-091 Warsaw, Poland

https://orcid.org/0009-0008-4214-3882

ania.podraza001@gmail.com

**Dominika Strep**

Medical University of Warsaw, Żwirki i Wigury 61, 02-091 Warsaw, Poland

https://orcid.org/0009-0001-1931-5059

dominika.strep@gmail.com

**Julia Grabowska**

Medical University of Warsaw, Żwirki i Wigury 61, 02-091 Warsaw, Poland

https://orcid.org/0009-0005-3715-8498

grabowskaj423@gmail.com

**Maciej Kwiatkowski**

Medical University of Warsaw, Żwirki i Wigury 61, 02-091 Warsaw, Poland

https://orcid.org/0009-0004-8304-5454

kwiatman10@gmail.com

**Patryk Romańczyk**

Medical University of Warsaw, Żwirki i Wigury 61, 02-091 Warsaw, Poland

https://orcid.org/0009-0001-6284-5354

patryk.romanczyk@op.pl

**Julia Białczak**

Medical University of Warsaw, Żwirki i Wigury 61, 02-091 Warsaw, Poland

https://orcid.org/0009-0007-1881-1820

bialczakjulia53@gmail.com

**Weronika Kanownik**

Medical University of Warsaw, Żwirki i Wigury 61, 02-091 Warsaw, Poland

https://orcid.org/0009-0007-7298-604X

w.kanownik@gmail.com

**Abstract**

**Introduction**

The menstrual cycle influences various physiological systems, including energy metabolism, neuromuscular function, and psychological states, which collectively impact athletic performance. Despite increased research in this area, findings remain inconsistent due to individual variability and methodological differences. This review synthesizes current evidence on the effects of menstrual cycle phases on athletic performance to identify actionable strategies for female athletes.

**Materials and Methods**

A systematic review of 35 studies published between 2019 and 2025 was conducted using PubMed and PMC databases. Inclusion criteria focused on studies examining the physiological, psychological, or performance-related effects of menstrual cycle phases. Each study was evaluated for its methodology, population, and outcomes to ensure a comprehensive analysis.

**Analysis of the Literature**

This review explores the influence of hormonal fluctuations during the menstrual cycle on energy metabolism, neuromuscular function, endurance, strength, and psychological aspects. It highlights individualized recovery strategies and long-term adaptations to phase-specific training.

**Conclusions**

Menstrual cycle phases exert significant, though variable, effects on athletic performance. While the follicular phase favors carbohydrate metabolism and high-intensity activities, the luteal phase supports fatigue resistance and fat utilization. Personalized training protocols informed by hormonal profiling can optimize outcomes, though further research is needed to standardize methodologies and evaluate long-term adaptations.

**Keywords:** Menstrual cycle, athletic performance, hormonal fluctuations, endurance, strength, neuromuscular function, recovery strategies

## Introduction and Purpose

The menstrual cycle's hormonal fluctuations, characterized by changes in estrogen and progesterone levels, have been hypothesized to influence athletic performance. These changes impact energy metabolism, muscle function, and psychological states, which are critical for athletic outcomes [1], [2], [3], [4]. Recent advances in sports medicine have emphasized the need to systematically study these effects to develop personalized training and recovery strategies for female athletes [5], [6], [7], [8]. Additionally, the interplay between hormonal changes and factors like endurance, strength, and neuromuscular function requires further investigation to address performance inconsistencies [9], [10], [11], [12]. This review synthesizes findings from 35 recent studies to provide an updated understanding of how menstrual cycle phases influence athletic performance and inform future research [13], [14], [15], [16].

## Analysis of the Literature

### Energy Metabolism

During the follicular phase, higher estrogen levels enhance carbohydrate utilization, leading to improved endurance performance [1], [2], [3], [4] This metabolic shift allows for greater glycogen sparing during prolonged physical activity, contributing to better energy efficiency and sustained athletic output. Elevated progesterone levels in the luteal phase, on the other hand, promote fat utilization, which may reduce glycogen availability and impair performance in high-intensity activities that depend on rapid energy turnover [5], [6]. This phase-dependent shift in substrate utilization has significant implications for athletes participating in endurance versus high-intensity sports.

Mendoza et al. [7] highlighted substantial variability in glycogen storage and usage across menstrual phases. The authors noted that during the follicular phase, enhanced insulin sensitivity further facilitates glycogen storage, providing a more readily available energy source for aerobic exercise. In contrast, the luteal phase's hormonal environment, with increased progesterone and reduced insulin sensitivity, limits glycogen replenishment, posing challenges for recovery and performance.

Larsen et al. [8] demonstrated that these hormonal fluctuations not only impact substrate utilization but also influence overall metabolic efficiency during exercise. Athletes in the follicular phase exhibited higher oxidative capacity, favoring aerobic metabolism, whereas the luteal phase appeared to increase reliance on less efficient pathways. These findings underscore the importance of tailoring dietary and training strategies to optimize metabolic responses.

Additionally, Ogden et al. [9] observed significant differences in energy expenditure patterns across menstrual phases. Their research highlighted that the luteal phase is associated with increased basal metabolic rate (BMR), potentially affecting total caloric needs. This increase in BMR could benefit endurance athletes requiring sustained energy output but may simultaneously exacerbate energy deficits if not appropriately managed. For high-intensity athletes, these changes necessitate precise nutritional interventions to align energy intake with phase-specific demands.

Tailored strategies, including carbohydrate loading during the follicular phase and increased fat intake during the luteal phase, are emerging as practical approaches to address these metabolic challenges. Future studies should further explore how individual variability in hormonal responses can be incorporated into personalized performance optimization plans, ensuring athletes maximize their potential throughout the menstrual cycle.

## Neuromuscular Function

Research highlights phase-dependent variations in neuromuscular performance. Reduced strength and increased fatigue resistance occur during the luteal phase due to hormonal effects on muscle activation and contractility [10], [11], [12]. Elevated progesterone levels during this phase are believed to alter calcium handling in muscle cells, reducing the efficiency of contraction and contributing to greater muscle fatigue, particularly in high-intensity efforts.

Studies by Ansdell et al. [13] and Elliott et al. [14] observed that neuromuscular fatigue is more pronounced in resistance-trained women during the luteal phase. These effects were attributed to hormonal fluctuations that impact both central and peripheral mechanisms of fatigue. For instance, central drive, or the brain's ability to activate muscles, may be reduced due to progesterone's sedative effects on the central nervous system.

Similarly, Laurent et al. [15] reported that muscle recovery rates are slower during the luteal phase. This delay in recovery was linked to increased inflammation and slower protein synthesis, processes influenced by hormonal changes. These findings suggest that athletes may benefit from adjusted training loads and extended recovery periods during this phase to minimize overtraining risks.

Despite these challenges, the luteal phase's effects on fatigue resistance could offer advantages for endurance activities. By prioritizing low-intensity, high-volume training during this phase, athletes may harness the body's increased reliance on oxidative metabolism, as suggested by Ogden et al. [9]. This approach underscores the importance of aligning training regimens with the unique neuromuscular characteristics of each menstrual phase to optimize performance outcomes and reduce injury risks.

**Endurance Performance**

McNulty et al. [16] and Nelson et al. [17] reported minimal differences in VO2 max across menstrual phases, suggesting that overall cardiovascular capacity remains stable. However, Ford et al. [18] suggested that targeted hydration strategies during the luteal phase could mitigate potential declines in endurance stemming from increased fluid retention and thermoregulatory challenges.

Sanders et al. [19] emphasized the importance of individualized approaches to manage phase-specific fluctuations. For example, endurance athletes may benefit from altering training intensity during the luteal phase to account for hormonal impacts on energy efficiency and recovery. Additionally, Nash et al. [20] demonstrated that increased carbohydrate intake during the follicular phase can help sustain prolonged performance, particularly in marathon runners and cyclists. These findings highlight the necessity of fine-tuning both nutritional and hydration strategies to match the physiological demands of each phase, enabling athletes to maintain optimal endurance performance throughout their cycle.

### Strength and Power Output

The luteal phase's hormonal profile correlates with reduced maximal strength and power output, particularly in resistance exercises [21], [22], [23]. This reduction is attributed to decreased neuromuscular efficiency and increased perception of effort, both influenced by elevated progesterone levels. In contrast, the follicular phase is more favorable for high-intensity training. Studies by Mehta et al. [24] and Alvarez et al. [25] reported that athletes experience heightened muscle responsiveness and recovery capacity during this phase, enhancing their ability to sustain repeated bouts of intense effort.

Markofski et al. [26] observed that progressive resistance training during the follicular phase leads to improved strength gains over time. These findings underscore the benefits of periodized strength training schedules that align with the menstrual cycle. By capitalizing on hormonal environments that favor muscle activation and fatigue resistance, athletes can maximize their training outcomes and reduce injury risks associated with overexertion during the luteal phase.

### Psychological and Cognitive Aspects

Hormonal fluctuations influence mood, cognition, and injury risk. Ford et al. [27] linked reaction time reductions during the luteal phase to increased progesterone levels, which can impair decision-making and response speed in high-pressure situations. Increased injury risk due to impaired proprioception and decreased coordination was reported by Nash et al. [28] and Davis et al. [29]. These factors can compromise performance in sports requiring precise motor control, such as gymnastics or tennis.

Hendrix et al. [30] highlighted that resilience training and mindfulness-based interventions may mitigate these risks, promoting psychological stability across phases. By incorporating stress management techniques and cognitive training into their routines, athletes may enhance their focus and consistency, regardless of hormonal fluctuations. Furthermore, developing phase-specific mental preparation strategies can help athletes maintain confidence and manage performance expectations effectively.

## Recovery and Adaptations

Recovery strategies tailored to hormonal fluctuations are essential for optimizing athletic performance. Studies by Mendoza et al. [31] and Hendrix et al. [32] supported carbohydrate loading during the follicular phase to enhance glycogen replenishment and fuel recovery processes. This approach is particularly beneficial for endurance athletes who rely on glycogen as a primary energy source during prolonged activities. Improved sleep quality during the luteal phase, attributed to progesterone's sedative effects, was associated with enhanced recovery [33], [34]. The luteal phase also presents an opportunity to focus on restorative practices, such as yoga and flexibility training, which can complement the hormonal environment conducive to relaxation and repair.

Sanders et al. [35] found that active recovery protocols, such as light aerobic activities and dynamic stretching, are particularly effective in counteracting hormonal fatigue effects during the luteal phase. Incorporating regular massage therapy and cold-water immersion has also been shown to support faster recovery during phases of heightened fatigue. These findings suggest that adapting recovery modalities to align with phase-specific physiological changes can enhance overall performance consistency and reduce the risk of overtraining or injury. Furthermore, tailoring nutrition to include anti-inflammatory foods during the luteal phase may optimize recovery outcomes.

## Long-Term Training Adaptations

Long-term adaptations to phase-specific training remain an underexplored area, yet they hold significant potential for optimizing athletic performance. Laurent et al. [15] and Hendrix et al. [30] highlighted the importance of hormonal profiling in refining training regimens for elite athletes. Hormonal profiling involves tracking individual hormonal fluctuations to tailor training intensity, volume, and recovery protocols to align with each athlete's unique physiological responses. This approach not only helps optimize performance but also reduces the risk of overtraining and hormonal imbalances.

Periodized strength training during the follicular phase has demonstrated promising results, as highlighted by studies such as those by Markofski et al. [26], Mendoza et al. [7], and Sanders et al. [35]. The follicular phase, characterized by elevated estrogen levels and enhanced anabolic responses, provides a conducive environment for muscle hypertrophy and strength development. Progressive resistance training programs initiated during this phase have been shown to yield greater long-term strength gains compared to non-periodized approaches.

Studies by Alvarez et al. [25] and Mendoza et al. [7] suggest that integrating phase-specific training strategies with broader performance goals is critical for sustained adaptation. This includes leveraging the luteal phase for endurance-focused activities, where increased fatigue resistance and reliance on fat metabolism can be advantageous. By adopting a cyclical approach, athletes can maximize performance during their peak phases while using lower-intensity periods for recovery and skill refinement.

Furthermore, the long-term benefits of such an approach extend beyond performance. Periodized training aligned with menstrual phases can enhance overall athlete well-being, mitigate hormonal disruptions, and promote consistency in competition. Future research should focus on validating these strategies in diverse athletic populations and exploring the cumulative effects of long-term hormonal phase-based training on elite performance.

## Conclusions

The menstrual cycle phases significantly impact athletic performance through complex physiological mechanisms, including variations in energy metabolism, neuromuscular function, recovery, and psychological states. Hormonal changes in estrogen and progesterone levels present both opportunities and challenges for female athletes. The follicular phase is associated with enhanced carbohydrate utilization, improved muscle activation, and a favorable anabolic environment, making it ideal for high-intensity and strength-based activities. In contrast, the luteal phase increased reliance on fat metabolism and greater fatigue resistance may suit endurance or recovery-oriented training. However, drawbacks such as reduced neuromuscular efficiency, slower recovery rates, and increased injury risk must be addressed.

Individual variability in menstrual cycle characteristics, including differences in cycle length, hormonal profiles, and conditions like amenorrhea or polycystic ovary syndrome (PCOS), complicates universal recommendations. Moreover, inconsistencies in study methodologies, such as phase verification and small sample sizes, further limit the generalizability of findings, highlighting the need for personalized approaches.

Future research should focus on developing standardized protocols for menstrual phase tracking and hormonal profiling. Advanced tools like wearable devices and biomarker analysis can enable precise monitoring of hormonal fluctuations and their physiological effects. Longitudinal studies exploring the cumulative impact of phase-specific training are essential to understand its influence on performance and athlete health over time.

By adopting personalized training strategies based on menstrual cycle phase tracking, coaches and athletes can align training with physiological rhythms, optimizing performance, enhancing well-being, reducing injury risks, and supporting long-term athletic careers. Such science-driven, individualized practices are crucial for meeting the unique needs of female athletes and advancing equity in sports performance research.

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**Author's contribution:**

**Conceptualization**: Dominika Rosińska-Lewandoska; Dominika Lewandowska; Julia Ufnal; Anna Podraza; Dominika Strep; Julia Grabowska; Maciej Kwiatkowski; Patryk Romańczyk; Julia Białczak; Weronika Kanownik
**Methodology**: Dominika Rosińska-Lewandoska; Dominika Lewandowska; Julia Ufnal; Anna Podraza; Dominika Strep; Julia Grabowska; Maciej Kwiatkowski; Patryk Romańczyk; Julia Białczak; Weronika Kanownik
**Formal analysis**: Dominika Rosińska-Lewandoska; Dominika Lewandowska; Julia Ufnal; Anna Podraza; Dominika Strep; Julia Grabowska; Maciej Kwiatkowski; Patryk Romańczyk; Julia Białczak; Weronika Kanownik
**Investigation**: Dominika Rosińska-Lewandoska; Dominika Lewandowska; Julia Ufnal; Anna Podraza; Dominika Strep; Julia Grabowska; Maciej Kwiatkowski; Patryk Romańczyk; Julia Białczak; Weronika Kanownik
**Writing-rough preparation**: Dominika Rosińska-Lewandoska; Dominika Lewandowska; Julia Ufnal; Anna Podraza; Dominika Strep; Julia Grabowska; Maciej Kwiatkowski; Patryk Romańczyk; Julia Białczak; Weronika Kanownik

**Writing-review and editing:** Dominika Rosińska-Lewandoska; Dominika Lewandowska; Julia Ufnal; Anna Podraza; Dominika Strep; Julia Grabowska; Maciej Kwiatkowski; Patryk Romańczyk; Julia Białczak; Weronika Kanownik

**Supervision:** Dominika Rosińska-Lewandoska; Dominika Lewandowska; Julia Ufnal; Anna Podraza; Dominika Strep; Julia Grabowska; Maciej Kwiatkowski; Patryk Romańczyk; Julia Białczak; Weronika Kanownik

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