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Influence of Menstrual Cycle Phases on Physical Performance and Injury Risk: A Narrative Review

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Abstract

Background. The growing professionalisation of women's sport necessitates a deeper understanding of female-specific physiology. The influence of the menstrual cycle (MC) and hormonal contraceptives (HC) on performance and health is a critical area of research, though historically hindered by significant methodological limitations.

Objective. This narrative review aims to synthesize contemporary evidence (2021–2025) regarding the influence of the menstrual cycle and hormonal contraceptive use on physical performance metrics and musculoskeletal injury risk in female athletes.

Methods. A structured narrative review of 25 key publications (including systematic reviews, meta-analyses, and pivotal original trials) sourced from major scientific databases was conducted. The synthesis focused on identifying the current consensus on performance modulation, injury susceptibility, methodological standards, and holistic athlete management.

Results. The synthesis reveals a clear divergence: while the direct impact of MC phase on maximal strength and aerobic capacity appears minimal or trivial for most athletes, the influence on musculoskeletal injury risk is clinically significant. Evidence confirms a heightened risk of injury during the late follicular and ovulatory phases, linked to altered neuromuscular control. Furthermore, hormonal contraceptives do not appear to offer protection against musculoskeletal injuries. The review highlights that subjective symptoms are often more detrimental to training availability than the physiological phase itself.

Conclusions. The findings challenge the utility of rigid, phase-based training periodization for performance enhancement. Future efforts must prioritize two key areas: (1) improved methodological rigor in research, specifically the biochemical verification of cycle phases, and (2) the implementation of individualized, education-led monitoring systems that focus on managing subjective symptoms and athlete well-being.

Keywords: menstrual cycle, physical performance, injury risk, female athlete, hormonal contraception

1. Introduction

The growth of professional women's sport has significantly outpaced the research dedicated to female-specific physiology [1]. For decades, the male athlete served as the default research model, leaving a critical knowledge gap regarding the female athlete's unique biological context [2]. This omission is particularly relevant when considering the menstrual cycle (MC). The physiological environment of a female athlete is not static; it is defined by the complex, cyclical rhythm of ovarian hormones, primarily estradiol (E2) and progesterone (P4). These steroid hormones are known to influence systems far beyond reproduction, with established impacts on metabolism, thermoregulation, and the structural properties of musculoskeletal tissues [3, 4].

A central and persistent debate within sports science is whether these hormonal shifts translate into meaningful, predictable changes in physical performance. The current body of evidence remains deeply divided. While some isolated studies suggest slight performance modulation in specific phases, recent large-scale meta-analyses examining maximal strength and aerobic capacity often conclude that any observable, group-level effect is trivial or inconsistent [5, 6]. This ambiguity is further complicated by the high prevalence of hormonal contraceptive (HC) use among athletes. HC introduces an exogenous and relatively stable hormonal profile that suppresses the natural endogenous cycle, creating a distinct physiological state that also demands specific investigation [7, 8].

Research is also expanding beyond pure performance metrics to areas where the cycle's impact may be more clinically significant. A robust line of inquiry now focuses on musculoskeletal injury risk [9]. There is compelling evidence correlating the high-estrogen ovulatory phase with altered neuromuscular control and increased joint laxity, factors hypothesized to heighten vulnerability to severe non-contact injuries, such as those affecting the anterior cruciate ligament (ACL) [10, 11]. At the same time, a more holistic view is gaining necessary traction. This perspective emphasizes that an athlete's subjective experience - the severity of symptoms, disruptions to sleep, and changes in perceived exertion (RPE) - often dictates training availability and well-being more profoundly than the hormonal phase itself [12, 13, 14].

This narrative review will synthesize the contemporary (2021–2025) evidence on these interconnected topics. We will critically evaluate the influence of the natural cycle and HC use

on both performance outcomes and injury susceptibility. This synthesis must also confront the significant methodological weaknesses that permeate the field, which have historically limited the reliability of its conclusions [15]. Finally, we will assess the practical, athlete-centred strategies emerging for cycle management, education, and monitoring in applied sport settings [16, 17].

2. Methods

This article is based on a structured narrative review of scientific literature concerning the influence of the menstrual cycle and hormonal contraceptives on athletic performance and injury risk. The literature selection was focused on identifying recent, high-impact systematic reviews, meta-analyses, and pivotal original research studies to provide a contemporary synthesis of the topic.

The core literature (N=25) was sourced primarily from PubMed, Google Scholar, and Scopus databases. The search strategy, conducted to gather the most relevant evidence, prioritized publications from January 2021 to October 2025. Key search terms included various combinations of: “menstrual cycle”, “female athlete”, “hormonal contraception”, “athletic performance”, “strength”, “endurance”, “injury risk” and “ACL”.

Inclusion criteria were: (1) full-text articles published in English; (2) primary focus on eumenorrheic female athletes or users of hormonal contraception; and (3) direct relevance to performance, injury, or the methodological critiques of cycle research. We included systematic reviews, meta-analyses, original research protocols, and key consensus statements that define the current state of the field.

This synthesis was conducted as a narrative review. Consequently, no formal meta-analysis or systematic quality assessment tools (e.g., PRISMA guidelines) were employed, as the aim was to provide a broad, critical overview of the evidence rather than a quantitative summary. The data were organized thematically to address the specific objectives outlined in the introduction.

3. Methodological Challenges in Menstrual Cycle and Sport Research

A significant barrier impeding definitive conclusions in female athlete research is the widespread methodological inconsistency, particularly concerning the verification of menstrual cycle phases. The field has been historically populated by studies relying on imprecise, low-rigour methods, such as calendar-based counting or participant self-reporting, to estimate

hormonal status. This reliance on estimation, rather than direct measurement, has been identified as a critical flaw that renders the findings of many studies fundamentally unreliable [15]. Without accurate biochemical confirmation of the hormonal environment (e.g. via urinary luteinizing hormone tests to confirm ovulation, or serum analysis of E2 and P4 levels), data attributed to a specific phase (e.g. "mid-luteal") may be entirely misplaced, conflating results and masking true physiological effects, or creating trivial ones where none exist.

This lack of rigorous verification is the central challenge. The assumption that all cycles are regular and conform to a textbook 28-day model is inaccurate; intra- and inter-individual variability is high, meaning that direct measurement is not optional, but essential for high-quality research [1, 15]. Consequently, much of the equivocal data regarding performance and injury risk is likely a direct artefact of poor experimental control. Studies that do employ robust verification methods often yield different conclusions than those that do not, highlighting the necessity of filtering the available literature through this methodological lens before drawing conclusions [5, 10].

The methodological complexity is further amplified by the treatment of hormonal contraceptive (HC) use. HC is frequently treated as a single, homogenous condition, yet this overlooks the vast pharmacological differences between formulations, such as the type of progestin used, the dosage, or whether the pill is monophasic or triphasic [7, 8]. Furthermore, athletes using HC are not a physiologically inert "control group" for their naturally menstruating counterparts. The exogenous hormones in HC create a distinct, suppressed endocrine state, and comparing these two groups without acknowledging this fundamental difference is a significant conceptual error [2]. As the field moves forward, addressing this "estimation epidemic" and adopting standardised, verified methodologies is the primary prerequisite for generating clinically meaningful and practically applicable knowledge [15].

4. Impact of Menstrual Cycle Phase on Physical Performance

The central debate regarding the menstrual cycle in sport has focused on whether hormonal fluctuations directly and predictably impact measurable physical performance. This area is characterized by conflicting results, largely stemming from the methodological inconsistencies discussed previously [15]. However, recent high-quality systematic reviews and meta-analyses suggest that for most female athletes, the overall effect of the natural menstrual cycle on aerobic

capacity and maximal strength is likely trivial, although inter-individual variability remains a significant factor [5, 6].

4.1. Aerobic Capacity (Endurance and VO2max)

Regarding cardiorespiratory fitness, the consensus from robust meta-analyses is that performance is consistent across the cycle. A 2023 systematic review and meta-analysis by Schumpf et al. [6] found no significant differences in VO2max between any verified menstrual cycle phases in physically active women. This conclusion is supported by original research investigating specific environmental stressors; for instance, a 2025 study found that the MC minimally affects cardiorespiratory function and body balance even during acute exposure to hypobaric hypoxia (4000 m) [4]. While some studies investigating training interventions have hypothesized phase-based benefits, such as aligning high-intensity training with the follicular phase, other rigorous trials have found that polarized running training adapted to the MC phases yields similar effects on endurance performance as training adapted contrary to the phases [18, 19]. This suggests that for aerobic endurance, physiological stability is maintained despite hormonal shifts.

4.2. Maximal Strength and Power (Anaerobic Performance)

The relationship between the MC and maximal strength has also been extensively debated, with early research suggesting a potential advantage during the follicular or ovulatory phases due to the anabolic and neuroexcitatory properties of estradiol. However, a comprehensive 2024 systematic review and meta-analysis by Niering et al. [5] concluded that menstrual cycle phases do not significantly influence maximal strength performance in healthy female adults. While some small, positive effects were noted in specific contexts (e.g. isometric strength in the late follicular phase), the overall magnitude of this effect was deemed trivial and inconsistent across studies. This indicates that athletes can likely expect consistent maximal strength output regardless of cycle phase [20]. This consistency may not, however, extend to all aspects of anaerobic performance, as some evidence suggests metrics like shoulder endurance (as opposed to maximal strength) might be higher in the late follicular phase [21].

4.3. Specific Motor Skills: Speed and Agility

While broad metrics like VO2max and maximal strength appear stable, the influence of the MC on more complex, coordination-dependent skills like agility and sport-specific speed remains less clear. These skills are critical in team sports. A 2025 study on recreational basketball players found that agility, as measured by the T-Drill Test, was significantly higher during the

late follicular phase compared to the early follicular (menstrual) phase [21]. Systematic reviews focusing on team sports, such as football, have also noted that while many performance metrics remain stable, some athletes may experience decrements in speed or intermittent running capacity, though these findings are often confounded by subjective symptoms rather than direct physiological impairment [1, 22]. This suggests that while central strength and endurance are robust, complex neuromuscular tasks involving rapid changes of direction might be more sensitive to hormonal modulation.

5. Menstrual Cycle and Injury Risk

While the relationship between menstrual cycle phase and acute performance metrics appears trivial for most athletes, the evidence linking hormonal fluctuations to musculoskeletal injury risk is substantially more compelling and clinically significant [3, 9]. This area of research suggests that the cyclical hormonal environment may create distinct periods of heightened vulnerability, particularly to severe joint injuries. The focus has largely been on the mechanisms by which ovarian hormones modulate the structural integrity of connective tissues and neuromuscular control.

5.1. Analysis of Musculoskeletal Injury Risk Across Phases

Systematic reviews consistently identify a non-uniform distribution of injuries across the menstrual cycle. A 2023 systematic review by Martínez-Fortuny et al. [3] synthesized data on sport injuries and found a significant concentration of musculoskeletal injuries, including ligament ruptures and muscle strains, during the pre-ovulatory and ovulatory phases. This finding is supported by a 2024 scoping review, which also identified the late follicular and ovulatory phases as periods of elevated risk [9]. Original research in elite adolescent team sport athletes further corroborates this, demonstrating a higher incidence of injuries during the ovulatory phase compared to the follicular and luteal phases [23]. This pattern strongly implies that the hormonal environment - specifically the peak in estradiol (E2) just prior to ovulation - is a key modulating factor in tissue susceptibility.

5.2. Neuromuscular and Biomechanical Correlates of ACL Injury Risk

The anterior cruciate ligament (ACL) injury, given its high prevalence and severity in female athletes, has been the primary focus of mechanistic studies. The leading hypothesis posits that high E2 concentrations increase the laxity (compliance) of ligaments and tendons by altering their collagen structure, thereby reducing intrinsic joint stability [3]. However, this structural

change alone does not fully explain the elevated injury risk. A 2023 systematic review by Dos Santos et al. [10] specifically examined ACL neuromuscular and biomechanical injury risk surrogates (e.g., landing mechanics, joint kinematics) and found evidence that they are indeed influenced by cycle phase. This suggests that the hormonal state may alter movement patterns, such as increasing knee valgus during landing or cutting, which are known mechanisms of ACL injury. Furthermore, recent studies on neuromuscular control during perturbed tasks - which better mimic the unexpected, chaotic events that often precede an injury - indicate that training adaptations and muscle activation patterns during a perturbed single-leg squat can be dependent on the menstrual cycle phase [11].

5.3. Association Between Menstrual Irregularities and Injury Frequency

Beyond the cyclical risk within a normal MC, menstrual irregularities (MI) - such as oligomenorrhea (infrequent cycles) or amenorrhea (absent cycles) - are a significant independent risk factor for injury. Menstrual irregularities are a key diagnostic component of Relative Energy Deficiency in Sport (RED-S), a syndrome often underpinned by low energy availability [14]. This hypoestrogenic state, a consequence of endocrine disruption, impairs bone health, leading to a well-established increase in stress fracture incidence. However, the 2024 scoping review by MacMillan et al. [9] also highlights that MI is associated with a higher prevalence of other musculoskeletal injuries, likely due to impaired tissue repair, compromised protein synthesis, and the overall catabolic state associated with chronic energy deficiency.

6. Hormonal Contraception (HC) and Its Consequences for Athletes

The widespread use of hormonal contraceptives (HC) by female athletes, both for contraception and for the management of problematic cycle symptoms (e.g. dysmenorrhea, heavy bleeding), necessitates a distinct analysis of their physiological impact [2, 7]. The use of HC - most commonly combined oral contraceptives (COCs) - suppresses the endogenous hypothalamic-pituitary-ovarian axis, creating a non-physiological endocrine state characterized by low, stable concentrations of synthetic hormones rather than natural, fluctuating E2 and P4. This fundamentally alters the athlete's internal environment, leading to critical questions about HC's effect on performance, adaptation, and injury.

6.1. Impact of HC on Physical Performance and Training Adaptations

Similar to the natural cycle, the evidence for a significant impact of HC on physical performance is equivocal and generally points towards minimal effect. A 2023 meta-analysis

by Schumpf et al. [6] found no significant difference in VO2max between the active (hormone-intake) and withdrawal (hormone-free) phases of HC use. When comparing HC users to naturally menstruating women, the differences in aerobic capacity were also deemed trivial [6]. A 2025 systematic review by Szwech et al. [7] further supports this, concluding that while some studies indicate a slight reduction in aerobic capacity or strength in HC users, the overall impact on physical performance is minor. This review also noted that the subjective benefits of HC, such as reduced negative symptoms and better sleep quality, may improve an athlete's availability and comfort during training, even if maximal physiological output is unchanged. The influence on long-term training adaptations remains less clear, though concerns that synthetic hormones may blunt anabolic signalling or interfere with strength gains have not been consistently substantiated by current evidence.

6.2. Hormonal Contraception and Musculoskeletal Injury Risk

A long-standing hypothesis suggested that the suppression of the ovulatory E2 peak by HC might offer a protective effect against hormone-mediated injuries, particularly ACL ruptures. By flattening this peak, it was theorized that HC could prevent the associated increase in joint laxity and neuromuscular disruption [3]. However, this hypothesis has been robustly challenged by recent, large-scale evidence. A major 2023 systematic review by Whittaker et al. [8], which included data from over 5 million females, definitively concluded that the use of combined hormonal contraceptives is not protective against musculoskeletal conditions or injuries. This finding, supported by other scoping reviews, suggests that athletes using HC experience injury rates comparable to their naturally menstruating counterparts [9]. This evidence refutes the notion that HC can be used as a prophylactic tool for injury prevention, shifting the rationale for its use squarely back to contraception and symptom management.

7. Holistic Aspects: Recovery, Well-being, and Sleep

Beyond the direct measurement of performance output or injury statistics, a holistic approach recognizes that the subjective experience of the menstrual cycle is a critical determinant of an athlete's health and availability [14]. The physiological hormonal shifts are often accompanied by a constellation of physical and psychological symptoms, and the impact of these symptoms on factors like sleep, recovery, and perceived exertion can be more disruptive to training consistency than the hormonal phase itself [13, 17].

7.1. Impact of Cycle Phase and Symptoms on Sleep and Recovery

Sleep and recovery are fundamental to athletic adaptation, and emerging evidence suggests these processes can be modulated by the menstrual cycle. A 2025 longitudinal study by Kullik et al. [12] investigated the impact of MC phase and symptoms on elite basketball athletes. The study found that while the phase itself had a limited effect on objective sleep duration, the symptoms experienced (such as pain or mood disturbances) were significantly associated with poorer perceived sleep quality, higher stress levels, and worse recovery scores. This highlights a crucial distinction: it is often the symptomatic burden of the cycle, rather than the underlying endocrinology, that impairs an athlete's ability to regenerate. Athletes experiencing significant premenstrual syndrome (PMS) or dysmenorrhea (menstrual pain) frequently report disrupted sleep, which directly compromises the physiological and psychological recovery necessary for high-performance training.

7.2. Overall Well-being and Rating of Perceived Exertion (RPE)

The subjective perception of effort during exercise is a vital tool for load management. A 2022 systematic review and meta-analysis by Paludo et al. [13] specifically examined the effect of the MC on perceptual responses. The analysis found that Ratings of Perceived Exertion (RPE) were significantly higher during the mid-luteal phase compared to the follicular and ovulatory phases, even when physiological markers (like heart rate) were not significantly different. This suggests that during the high-progesterone luteal phase, athletes may feel that they are working harder to achieve the same objective output. This elevated RPE, combined with other negative symptoms, can reduce motivation and overall well-being, complicating the prescription of training based purely on objective metrics [24].

7.3. Premenstrual Symptoms (PMS/PMDD) and Daily Functioning

For a subset of athletes, the impact of symptoms extends beyond mild discomfort. Severe Premenstrual Syndrome (PMS) or the more debilitating Premenstrual Dysphoric Disorder (PMDD) can significantly impair an athlete's daily functioning. These symptoms, which can include severe mood swings, fatigue, bloating, and pain, are often cited by athletes as a primary reason for missing or modifying training [17, 24]. Qualitative studies, such as the 2025 investigation by Chica-Latorre et al. [17], emphasize that athletes often feel pressure to train through these symptoms, sometimes concealing their discomfort from coaches due to fear of being perceived as weak or unreliable. This underscores the necessity of a holistic support system that de-stigmatizes these experiences and provides athletes with strategies to manage symptoms without compromising their health or long-term development [14].

8. Practical Strategies for Cycle Management in Sport

The translation of scientific knowledge into applied practice requires strategies that are both evidence-based and athlete-centred. Given the significant inter-individual variability and the profound impact of subjective symptoms, the primary goal of cycle management is not a rigid, population-level prescription, but rather the facilitation of individualized monitoring, communication, and support [16, 17].

8.1. Periodization of Training (Loads and Intensity) Adapted to the Cycle Phase

The concept of “phase-based training” - aligning high-intensity workloads with the follicular phase and recovery/low-intensity work with the luteal phase - has gained significant popular traction. This is theoretically based on the anabolic properties of estradiol and the negative perceptual effects of progesterone [5, 13]. However, the scientific evidence supporting its efficacy is currently weak. A 2024 randomized controlled trial by Kubica et al. [19] found that polarized running training adapted to the MC phases produced similar effects on endurance performance and cardiovascular parameters as training adapted contrary to the phases. While some protocols suggest potential benefits [18], the current consensus is that there is insufficient evidence to recommend a widespread application of rigid phase-based periodization for performance enhancement [5, 6]. Instead, a more practical approach involves “training modification”, where loads are adjusted based on an athlete's subjective readiness, symptoms, and perceived exertion, rather than on their predicted hormonal phase [14].

8.2. The Importance of Cycle Monitoring and Education (For Athletes, Coaches, and Staff)

If rigid periodization is unsupported, the true value of cycle tracking lies in its function as a tool for communication, education, and individualization. Implementing menstrual cycle tracking in elite sport settings provides a shared language for athletes and support staff to discuss well-being [16, 25]. Education is the critical first step; empowering athletes with knowledge about their own physiology helps to de-stigmatize menstruation and normalizes conversations about symptoms [1, 17]. For coaches and male support staff, education is crucial for fostering an environment of psychological safety, where an athlete can report symptoms (e.g. severe dysmenorrhea or fatigue) without fear of negative judgment [17]. This open dialogue allows for agile, short-term adjustments to training based on an athlete's acute readiness-to-train.

8.3. Recommendations for Implementing Cycle Tracking Systems in Sport Organizations

When implementing tracking systems, practical and ethical considerations are paramount. A 2024 concept mapping study by Carmichael et al. [16] identified key considerations for coaches, staff, and athletes. Athletes and staff emphasized that the purpose of tracking must be clearly communicated - it should be presented as a tool for health monitoring and individual support, not as a punitive surveillance system [25]. Data privacy was a primary concern; athletes must have full control over who sees their data and how it is used [16]. The most effective systems are simple, non-invasive (e.g. app-based), and focus on collecting actionable, subjective data (e.g. RPE, sleep quality, mood, and symptom severity) alongside objective phase data. The ultimate goal of tracking is to build a longitudinal dataset for the individual, allowing them and their support team to identify personal patterns and proactively manage symptoms that consistently disrupt training [12].

9. Summary and Future Directions

This narrative review has synthesized the contemporary evidence regarding the complex interplay between the menstrual cycle, hormonal contraceptive use, athletic performance, and injury risk. The findings indicate a clear divergence: while the direct impact of the natural cycle on maximal strength and aerobic performance appears to be minimal for most athletes, its influence on musculoskeletal injury risk and holistic well-being is significant and clinically relevant.

9.1. Conclusions of the Narrative Review

The central conclusion of this synthesis is that the fear of predictable performance decrements due to cycle phase is largely unsupported by robust, modern evidence [5, 6]. Instead, the field must pivot its focus to two more critical areas. First is the methodological rigour of future research, as the “estimation epidemic” has rendered much of the historical data unreliable [15]. Second is the holistic management of the athlete, where subjective symptoms, sleep quality, and perceived exertion are recognized as more potent modulators of training availability than the hormonal phase itself [12, 13, 14]. Furthermore, the evidence strongly indicates that the late follicular and ovulatory phases represent a period of heightened vulnerability for musculoskeletal injuries, particularly to the ACL, through mechanisms involving altered joint laxity and neuromuscular control [3, 10]. Finally, while HC is an effective tool for symptom

management, it is not a prophylactic against musculoskeletal injury [8] and its impact on long-term training adaptation requires further clarification [7].

9.2. Gaps in Current Knowledge and the Need for Further Research

Despite recent progress, significant gaps persist. The vast majority of research, including the studies reviewed here, focuses on healthy, eumenorrheic, white, adult athletes. Future studies must intentionally include more diverse populations, including para-athletes, adolescent athletes, and athletes from different ethnic backgrounds, as cycle characteristics and symptom burden may differ. Research is also urgently needed on the long-term (>1 year) implications of various HC formulations on training adaptation, bone health, and endocrine profiles [7]. While the link between the ovulatory phase and ACL injury is established [10], the precise mechanisms (e.g. the specific interaction between E2, collagen synthesis, and neuromuscular firing patterns) require deeper investigation.

9.3. Future Perspectives in Research and Sport Practice

The future of female athlete support lies in individualization. The data overwhelmingly shows that a "one-size-fits-all" approach to phase-based training is ineffective [19]. The practical application of research should focus on implementing simple, non-invasive monitoring systems that prioritize athlete education and open communication [16, 25]. This allows support staff to move from reacting to symptoms to proactively managing them based on an individual's longitudinal data. By fostering an environment that de-stigmatizes menstruation and leverages data for individualized support, sporting organizations can optimize the health, well-being, and ultimately the sustained performance of their female athletes [1, 17].

Disclosure

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