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The Influence of Menstrual Cycle Phases on Strength, Endurance, and Physical Performance in Female Athletes and Physically Active Women: A Structured Narrative Review

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Abstract

Introduction and purpose: Interest in the influence of the menstrual cycle on athletic performance has increased markedly alongside the rising participation of women in sports. This structured narrative review synthesizes evidence regarding the effects of menstrual cycle phases on physical performance, recovery, and perceptual responses in female athletes and physically active women.

Key words: menstrual cycle; female athletes; sports performance; hormonal contraception; endurance performance; strength

Brief description of the state of knowledge: A structured narrative review was conducted using a PubMed/MEDLINE search of English-language human studies published between January 2010 and May 2026. Studies examining menstrual cycle phases and/or hormonal contraceptive use in relation to physical performance outcomes were included. Due to methodological heterogeneity, findings were synthesized narratively. Overall, the evidence does not indicate consistent phase-dependent differences in strength, sprint, or endurance performance. When differences were reported, they were generally small, inconsistent across studies, and more frequently associated with symptom-related perceptual responses than with objective performance outcomes.

Summary: Current evidence does not support universal menstrual cycle phase-based modifications to training or competition at the group level. Individual symptom profiles and contextual elements are likely more relevant determinants of performance variability than cycle phase alone.

Introduction and purpose

Female participation in competitive and recreational sport has increased substantially, underscoring the need for research addressing sex-specific physiological determinants of performance. Despite this progress, female athletes remain underrepresented in sports science literature, which has conventionally relied predominantly on male participants. As a result, some training and performance recommendations may not fully reflect female-specific physiological responses.

Among sex-specific physiological variables, the menstrual cycle has received considerable attention because of its potential influence on exercise performance, recovery, and training adaptation.

The menstrual cycle is characterized by cyclical fluctuations in endogenous sex hormones, primarily estrogen and progesterone. The follicular phase is characterized by low progesterone and progressively increasing estrogen concentrations, culminating in a peri-ovulatory peak. The luteal phase is characterized by elevated progesterone and moderately elevated estrogen levels. These hormonal fluctuations influence several physiological systems relevant to exercise, including neuromuscular function, substrate utilization, thermoregulation, and perceptual responses.

Accordingly, it has been hypothesized that the menstrual cycle phase may influence strength, endurance, sprint performance, fatigue, and recovery. However, empirical findings remain inconsistent; some studies report performance changes, while others show no meaningful phase-related differences.

These inconsistencies likely reflect substantial methodological heterogeneity, including variation in cycle-phase verification methods, participant characteristics, hormonal contraceptive use, and performance assessment protocols.

Although previous reviews have addressed menstrual cycle physiology and exercise performance, the evidence base has expanded considerably in recent years. This includes studies employing improved hormonal verification methods, athlete-specific cohorts, and investigations of ergogenic interventions across cycle phases. Moreover, prior syntheses have often focused on isolated performance domains.

Therefore, an updated synthesis integrating strength, endurance, sprint, and power performance; perceptual responses; recovery; hormonal contraception; and ergogenic interventions is warranted.

This structured narrative review aimed to evaluate the influence of menstrual cycle phases on physical performance, recovery, perceptual responses, hormonal contraception, and ergogenic interventions among female athletes and physically active women.

Materials and Methods

Review Design

This structured narrative review synthesized evidence on the influence of menstrual cycle phases and hormonal contraceptive use on physical performance in female athletes and physically active women. A narrative synthesis approach was applied due to heterogeneity in study designs, participant characteristics, methods for verifying menstrual cycle phase, and performance outcomes. The review followed a structured search strategy and predefined eligibility criteria.

Literature Search

A structured search was conducted in PubMed/MEDLINE, selected for its coverage of sports medicine, exercise physiology, and female athlete health literature. Search terms included combinations of “menstrual cycle”, “follicular phase”, “luteal phase”, “female athletes”, “strength”, “power”, “endurance”, “sprint”, and “performance”, combined using Boolean operators (AND/OR). The search was limited to English-language, human studies published from 2010 to May 2026. Reference lists of eligible articles were also screened for further relevant articles. The final search was conducted in May 2026.

Eligibility Criteria

Studies were included if they:

- involved physically active women or female athletes
- examined menstrual cycle phases and/or hormonal contraceptive use
- assessed physical performance or recovery outcomes (strength, power, endurance, sprint performance, neuromuscular function)
- were original peer-reviewed research articles
- were published in English between January 2010 and May 2026

Studies were excluded if they:

- did not assess menstrual cycle phase or hormonal contraceptive use
- did not include performance or recovery outcomes
- focused exclusively on clinical populations without performance relevance
- were reviews, protocols, commentaries, or conference abstracts

Data Extraction and Synthesis

Extracted data included author, participant characteristics, study design, menstrual cycle classification method, hormonal contraceptive status, performance outcomes, and key findings.

Due to heterogeneity across studies, quantitative meta-analysis was not performed. Findings were synthesized narratively and organized into thematic domains.

Methodological Considerations

Considerable variability was identified across studies in menstrual cycle phase verification methods, participant training status, hormonal contraceptive use, environmental conditions, exercise protocols, and control of confounding variables such as sleep, nutrition, and training load. Those methodological differences were considered when interpreting the findings and supported the use of a narrative synthesis approach.

Description Of The State Of Knowledge

A total of 37 sources were used in the narrative synthesis, including original performance studies and contextual methodological or athlete-health references. Due to methodological heterogeneity, findings were synthesized narratively and organized into thematic domains.

Study Characteristics

Of the included studies, most investigated strength and neuromuscular performance outcomes, whereas fewer studies examined endurance performance, perceptual responses, hormonal contraceptive use, and phase-specific ergogenic interventions.

Participants consisted primarily of female athletes and physically active women representing a range of sporting disciplines, including soccer, cycling, running, resistance training, swimming, and mixed athletic populations. Included study designs comprised randomized controlled trials, crossover studies, observational investigations, and longitudinal training interventions.

Considerable methodological heterogeneity was identified across studies, particularly regarding menstrual cycle phase classification and verification procedures. Although several investigations employed hormonal assays or ovulation-based approaches, most relied on self-reported menstrual tracking or calendar-based estimations. Performance-related outcomes assessed across studies included maximal strength, muscular power, sprint performance, endurance capacity, aerobic fitness, fatigue perception, thermoregulatory responses, and recovery-related markers.

Strength Performance Across Menstrual Cycle Phases

Across studies, strength-related outcomes, including maximal strength, force production, and neuromuscular performance, were largely consistent across menstrual cycle phases (1–4). Comparable results were also observed between naturally menstruating women and users of hormonal contraception (HC) (2,3,5). Where differences were reported, they were generally small, inconsistent, and not systematically replicated. Some studies observed modest performance reductions during the luteal or symptom-heavy phases (7,8), although these findings were frequently accompanied by elevated symptom burden or perceived fatigue (8,9). Short-term morphological changes, including muscle cross-sectional area, showed minimal phase-dependent variation and were not consistently associated with performance outcomes (10). Overall, strength performance appears generally stable across menstrual cycle phases in the available literature.

Endurance Performance Variations

Findings on endurance outcomes, including VO_2max, time to exhaustion, cycling time trials, and aerobic capacity, were heterogeneous. Several studies reported no clear phase-dependent performance differences (11–14), whereas others observed modest reductions in endurance-related performance during the luteal phase or in specific sport-related endurance tests (4,7). Research assessing exercise responses in heat-stress conditions reported limited phase-related differences, suggesting that environmental stress and exogenous hormonal status may be more influential than endogenous cycle-phase variation alone (15,16). Physiological markers associated with endurance exercise showed mixed findings: circulating cardiac troponin T appeared minimally affected by menstrual cycle phase in specific exercise contexts (17), whereas autonomic recovery responses may differ between early follicular and mid-luteal phases (18). Additionally, carbohydrate supplementation and sodium hyperhydration improved endurance performance independently of cycle phase (14,16). Collectively, consistent phase-specific impairments in endurance performance were not demonstrated.

Speed and Power Performance

Evidence evaluating sprint capacity, anaerobic power, jumping performance, and explosive exercise ability indicated that these outcomes demonstrated minimal phase-related variation (1–4). A small number of studies observed modest performance reductions during the luteal or symptom-heavy phases (7,19), though such findings were not consistently replicated. Research involving resistance-trained and team-sport athletes similarly noted stable short-duration, high-

intensity performance across phases (2–4). Evidence on ergogenic aids indicates that caffeine may enhance power output and movement velocity in female participants (20,21). However, direct evidence for phase-independent effects is mainly derived from studies assessing caffeine responses across multiple menstrual cycle phases (20,26,27). Collectively, sprint and explosive performance outcomes appeared broadly stable across menstrual cycle phases.

Perceived Exertion and Fatigue

Perceptual responses exhibited greater variability across menstrual cycle phases than objective performance outcomes. Increased fatigue, reduced motivation, impaired recovery, and heightened symptom severity were most commonly reported during the luteal and premenstrual phases (7–9,19,22).

Notably, these subjective changes often occurred independently of measurable differences in performance outcomes. While some studies identified associations between symptom severity and performance impairment (8), others reported altered motivation without corresponding declines in objective output (9).

Post-exercise recovery perceptions also varied through phases following high-intensity exercise and team-sport activity (19,22), although findings were not uniform across studies. Additional evidence suggests that menstrual dysfunction and dysmenorrhea may influence physiological, neuromuscular, or exercise-related responses (23,24).

Overall, perceptual and recovery-related responses appear more variable across the menstrual cycle than objective performance measures, highlighting a stronger influence of individual symptomatology than phase status alone.

Effect of Hormonal Contraception

Comparisons between HC users and naturally menstruating women reported minimal differences in strength, explosive power, sprint performance, and neuromuscular outcomes (2,3,5). Studies conducted in heat-stress environments documented similar thermoregulatory, respiratory, and cardiovascular responses between groups (15,25). Collectively, performance outcomes were broadly comparable between HC users and naturally menstruating women across the different cycle phases.

Phase-Specific Responses to Ergogenic Interventions

Evidence on the effectiveness of ergogenic interventions across the menstrual cycle remains limited, but it generally indicates that effectiveness is preserved throughout phases.

Caffeine supplementation has been shown to improve strength, power, movement velocity, and endurance performance in female participants (20,21,26,27). Studies directly comparing caffeine responses across multiple menstrual cycle phases suggest no clear phase-dependent attenuation of these ergogenic effects (20,26,27). Similarly, carbohydrate intake and hydration strategies improve endurance and thermoregulatory responses irrespective of menstrual cycle phase (14,16).

Findings for nitrate supplementation are less supportive of a consistent ergogenic effect in women. In one study, inorganic nitrate supplementation did not improve maximal voluntary isometric contraction or muscular endurance and was associated with reduced estimated maximal power and velocity independently of menstrual cycle phase (28). Emerging interventions targeting menstrual symptoms, such as nutritional and recovery-based strategies, show potential benefits; however, evidence remains preliminary and methodologically limited (29–31).

Overall, current evidence suggests that established ergogenic strategies retain their effectiveness across menstrual cycle phases and should be applied according to performance demands rather than cycle timing.

Discussion

This review synthesized evidence examining the influence of menstrual cycle phase on strength and neuromuscular performance, endurance exercise, sprint and power outcomes, perceptual responses, hormonal contraceptive use, and ergogenic interventions in female athletes and physically active women. Overall, the available evidence suggests that objective performance outcomes are generally stable across the menstrual cycle, with limited support for consistent phase-dependent effects at the group level.

Although fluctuations in estrogen and progesterone may influence thermoregulation, substrate utilization, fatigue perception, and recovery-related responses, these physiological changes do not consistently translate into meaningful differences in physical performance. Instead, variability in performance and perceived readiness appears to be influenced more strongly by individual symptom burden, environmental conditions, recovery status, energy availability, psychological stress, and methodological differences between studies.

A key finding across the literature is substantial inter-individual variability. Some athletes report increased fatigue, reduced motivation, or perceived performance impairment during specific phases of the cycle, whereas others demonstrate minimal changes. This variability

illustrates the limitations of depending only on menstrual phase classification to guide training or competition decisions.

Collectively, these findings support a shift away from rigid phase-based models towards individualized athlete monitoring. Tracking symptoms, perceived recovery, sleep quality, training readiness, and contextual stressors may provide more practically useful information than menstrual cycle phase alone.

Strength and Neuromuscular Performance

The overall stability of strength and neuromuscular outcomes observed across studies suggests that acute hormonal fluctuations exert limited influence on maximal force production and neuromuscular performance in trained populations. Most investigations demonstrated minimal phase-related variation in maximal strength, force production, and neuromuscular outcomes across menstrual cycle phases (1–4). Comparable findings were also reported between naturally menstruating athletes and women using hormonal contraception (2,3,5).

Where modest reductions in strength performance were observed, these findings appeared more closely associated with symptom burden, fatigue, and motivational changes than with hormonal status itself (7–9). Similarly, evidence from studies examining short-term morphological fluctuations indicates that phase-related changes in muscle cross-sectional area do not consistently result in meaningful alterations in strength performance (10).

Taken together, the available evidence suggests that strength and neuromuscular performance demonstrate limited phase-related variation, with day-to-day performance probably influenced more substantially by recovery status, sleep quality, psychological stress, and individual symptom profiles.

Endurance Performance and Physiological Stress Responses

Endurance-related outcomes demonstrated greater variability across studies than strength- and sprint-performance outcomes. Although several investigations identified no meaningful phase-dependent differences in aerobic capacity, time to exhaustion, or cycling performance (11–14), other studies documented modest reductions in endurance-related performance during the luteal phase or in sport-specific endurance tests (4,7).

These inconsistencies likely reflect context-dependent interactions rather than a uniform hormonal effect. Elevated progesterone concentrations during the luteal phase may contribute to increased thermoregulatory strain and higher resting core temperature during prolonged

exercise in hot environments; however, these physiological responses are not consistently associated with impaired endurance performance outcomes.

Environmental conditions, hydration practices, nutritional interventions, and individual heat tolerance may therefore exert a greater influence on endurance performance than menstrual cycle phase alone (15,16). Although consistent impairments in endurance performance are not evident, selected recovery-related markers may vary across phases, with evidence suggesting faster post-exercise cardiovagal reactivation in the early follicular phase than in the mid-luteal phase (18).

Overall, the available literature indicates that endurance performance is influenced more strongly by environmental stressors and individual physiological tolerance than by cyclical hormonal variation alone.

Sprint, Speed, and Explosive Power Performance

Studies assessing sprint capacity, anaerobic power, jumping performance, and short-duration high-intensity exercise outcomes consistently presented minimal phase-related variation across the menstrual cycle (1–4).

The relative stability of these performance domains may reflect the physiological characteristics of short-duration, high-intensity exercise, although the underlying mechanisms remain unclear. Although some investigations documented modest reductions in performance during symptom-heavy or luteal phases (7,19), these findings were inconsistent and frequently accompanied by elevated fatigue or symptom severity.

Evidence examining ergogenic interventions further supports the relative stability of neuromuscular performance across phases. Caffeine supplementation generally enhanced power output, movement velocity, and high-intensity performance in the phases examined, with no clear evidence of phase-dependent attenuation of effects (20,26,27).

Collectively, these results indicate that menstrual cycle phase is unlikely to be a primary determinant of performance variability in sprint and explosive tasks.

Perceptual Responses, Fatigue, and Symptom Variation

Compared with objective performance outcomes, perceptual responses demonstrated greater variability across menstrual cycle phases. Increased fatigue, reduced motivation, impaired recovery, and heightened symptom severity were most commonly reported during the luteal

and premenstrual phases (7–9,19,22,32). Importantly, these subjective responses frequently occurred in the absence of measurable decrements in physical performance.

The findings suggest that symptom burden may be a more consistent predictor of perceived performance impairment than circulating hormone concentrations alone (8). Similarly, fluctuations in motivation and perceived recovery occur despite relatively stable objective performance outcomes across studies (7–9,19,22,32).

Additional female athlete health factors, including low energy availability, menstrual dysfunction, and broader health status, may further influence training tolerance and general well-being (33–35). The substantial inter-individual variability observed throughout the literature indicates that menstrual cycle-related responses are highly athlete-specific and should not be interpreted deterministically.

Accordingly, menstrual physiology should be considered within a wider biopsychosocial framework including psychological stress, recovery status, sleep quality, nutrition, and training load.

Hormonal Contraception and Performance

Given the widespread use of hormonal contraception among female athletes, understanding its potential influence on performance remains of practical importance. The current evidence generally indicates minimal differences in strength, power, sprint, and neuromuscular performance outcomes between HC users and naturally menstruating athletes (2,3,5).

Similarly, physiological responses to exercise, including thermoregulation, respiratory responses, cardiovascular strain, and self-regulated exercise performance, appeared broadly comparable between groups (15,25). However, interpretation remains limited by substantial heterogeneity in contraceptive formulations, dosages, durations of use, and study methodologies.

The prevalence of hormonal contraceptive use among competitive female athletes remains substantial, highlighting the practical relevance of understanding its potential performance implications (36).

Overall, the available evidence provides limited support for meaningful alterations in athletic performance outcomes associated with hormonal contraceptive use in trained populations.

Ergogenic Interventions Across the Menstrual Cycle

Most established ergogenic interventions appeared to retain their effectiveness across the menstrual cycle. Evidence indicates that caffeine supplementation may enhance strength, power, movement velocity, and endurance performance in female participants (20,21,26,27). However, direct evidence for phase-independent effects of caffeine is strongest in studies assessing caffeine responses across multiple menstrual cycle phases (20,26,27). Similarly, carbohydrate supplementation and sodium hyperhydration improved endurance and thermoregulatory performance irrespective of menstrual cycle phase (14,16).

Evidence examining phase-specific responses to other ergogenic interventions remains limited and inconsistent. Findings for nitrate supplementation are less supportive of a consistent ergogenic effect in women. Inorganic nitrate supplementation did not improve maximal voluntary isometric contraction or muscular endurance and was associated with reduced estimated maximal power and velocity, independent of menstrual cycle phase, although the findings remain preliminary (28). Emerging evidence also suggests that symptom-targeted interventions, including nutritional and recovery strategies, may provide benefits during symptom-heavy phases; however, the current evidence base remains limited and heterogeneous (29–31).

Collectively, current findings support the use of established ergogenic strategies according to sport-specific demands rather than menstrual cycle phase.

Methodological Considerations and Sources of Inconsistency

Interpretation of the current literature is limited by considerable methodological heterogeneity. Key sources of inconsistency include differences in menstrual cycle phase classification, reliance on self-reported cycle tracking or calendar-based estimations, variation in hormonal contraceptive formulations, small sample sizes, and inconsistent control of confounding variables such as sleep, nutrition, psychological stress, and training load. Differences in hormonal contraceptive status and the use of oral contraceptive users as experimental or control groups may further contribute to methodological inconsistency across studies (6).

Variability in participant characteristics, exercise protocols, environmental conditions, and outcome measures further limits comparability across studies. In addition, most available investigations have examined acute performance responses, whereas less is known about potential long-term training adaptations across menstrual cycle phases. Emerging evidence

suggests phase-specific molecular adaptations to training, highlighting the need for longitudinal research designs (37).

Future studies should therefore prioritize adequately powered longitudinal designs, standardized hormonal verification procedures, consistent phase definitions, detailed reporting of hormonal contraceptive use, and comprehensive monitoring of relevant contextual factors. These improvements would strengthen interpretation and improve the practical relevance of findings for athletes and practitioners.

Practical Implications

Current evidence does not support routine reductions in training load or systematic modifications to competition preparation based solely on menstrual cycle phase. While some athletes may experience symptom-related changes in perceived recovery, motivation, or readiness, these responses are highly individual and are not consistently predicted by phase classification alone.

In applied settings, practitioners should prioritize individualized monitoring strategies that include menstrual symptoms, perceived recovery, sleep quality, training readiness, nutrition, psychological stress, and overall health status. Such an approach may help identify athletes who require targeted support while avoiding unnecessary training modifications based solely on assumptions about menstrual phase.

Environmental stress, low energy availability, inadequate recovery, and menstrual dysfunction may have greater implications for athlete health and performance than normal cyclical hormonal fluctuations. Established ergogenic strategies, including caffeine supplementation, carbohydrate intake, and hydration interventions, should therefore be applied according to sport-specific demands and individual tolerance rather than menstrual cycle timing alone.

Future Directions

Prospective research should prioritize adequately powered longitudinal investigations that capture intra-individual variability across multiple menstrual cycles. Standardized hormonal verification procedures and consistent phase classification methods are required to improve comparability between studies. Greater attention should also be given to controlling relevant confounding variables, including sleep, nutrition, psychological stress, travel demands, and training load. Additional research examining long-term training adaptations across menstrual cycle phases is warranted, as acute performance responses may not fully reflect chronic physiological outcomes. Future research should also prioritize ecologically valid performance

models that better reflect real-world sporting environments. While laboratory-based assessments provide important mechanistic insights, outcomes such as competition performance, match-play metrics, training quality, and season-long adaptations may provide more practically relevant information for athletes and coaches.

Future studies should further improve reporting of hormonal contraceptive use, including formulation type, dosage, and duration of use. Integrating physiological, perceptual, and behavioral measures within ecologically valid sporting environments will be essential for advancing understanding of female athletes' performance variability.

Limitations

This review should be interpreted within several limitations. First, only the PubMed/MEDLINE database was searched, which may have limited the identification of eligible studies indexed in other databases. Second, the review was conducted as a structured narrative synthesis rather than a formally registered systematic review; therefore, PRISMA-guided reporting procedures, formal risk-of-bias assessment, and quantitative meta-analysis were not implemented. Consequently, the findings should not be interpreted as equivalent to those of a systematic review or meta-analysis.

Third, considerable methodological heterogeneity across included studies limited direct comparability between investigations. Important sources of heterogeneity included menstrual cycle phase verification procedures, participant characteristics, hormonal contraceptive use, exercise protocols, environmental conditions, and control of confounding variables. Many studies relied on self-reported menstrual tracking or calendar-based estimations rather than hormonal confirmation, increasing the risk of phase misclassification.

Finally, although this review focused on female athletes and physically active women, several included studies involved recreationally active participants rather than elite or highly trained athletes. Caution is therefore warranted when generalizing findings to elite sporting populations, as physiological demands, training loads, and performance determinants may differ substantially between recreational and competitive athletes.

Summary

Current evidence suggests that the menstrual cycle phase exerts limited and inconsistent effects on objective measures of strength, endurance, sprint, and power performance in female athletes and physically active women. Greater variability appears to occur in perceptual responses, fatigue, symptom severity, and recovery-related outcomes. The available evidence suggests that

individual symptom profiles and contextual factors may be more important determinants of performance variability than menstrual cycle phase itself. Considerable inter-individual variability and methodological heterogeneity across studies limit the ability to draw definitive conclusions. Present evidence therefore supports individualized athlete monitoring approaches rather than universal phase-based modifications to training or competition strategies. Future longitudinal studies using standardized hormonal verification procedures and ecologically valid performance models are required to clarify the relationship between menstrual physiology and athletic performance.

Author's contribution

Conceptualization, ZT; methodology, ZT and OF; formal analysis, ZT; investigation, ZT, NN, AW, OF, JuK, ND, EF, JaK, MK, SK and FN; resources, ZT, NN, AW, OF, JuK, ND, EF, JaK, MK, SK and FN; data curation, ZT and NN; writing—original draft preparation, ZT, NN, AW, and OF; writing—review and editing, ZT, NN, AW, OF, JuK, ND, EF, JaK, MK, SK and FN; visualization, ZT; supervision, not applicable; project administration, ZT. All authors have read and agreed to the published version of the manuscript.

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Conflict of Interest Statement

The authors declare no conflict of interest.

Declaration of generative AI and AI-assisted technologies in the writing process

In preparing this work, the author(s) used ChatGPT for the purpose of language editing and adaptation of the manuscript structure to journal guidelines. After using this tool, the author(s) have reviewed and edited the content as needed and accept full responsibility for the substantive content of the publication.

References

1. Wiecek M, Szymura J, Maciejczyk M, Cempla J, Szygula Z. Effect of sex and menstrual cycle in women on starting speed, anaerobic endurance and muscle power. Physiol Int. 2016;103(1):127-132. https://doi.org/10.1556/036.103.2016.1.13

2. Cabre HE, Joniak KE, Ladan AN, Moore SR, Blue MNM, Pietrosimone BG, et al. Effects of Hormonal Contraception and the Menstrual Cycle on Maximal Strength and Power Performance. Med Sci Sports Exerc. 2024;56(12):2385-2393. https://doi.org/10.1249/MSS.0000000000003524

3. Ekenros L, Hirschberg AL, Heijne A, Fridén C. Oral contraceptives do not affect muscle strength and hop performance in active women. Clin J Sport Med. 2013;23(3):202-207. https://doi.org/10.1097/JSM.0b013e3182625a51

4. Julian R, Hecksteden A, Fullagar HHK, Meyer T. The effects of menstrual cycle phase on physical performance in female soccer players. PLoS One. 2017;12(3):e0173951. https://doi.org/10.1371/journal.pone.0173951

5. Stock MS, Bauerlein HM, Edwards MF, Stambaugh KE, Parsowith EJ, Carr JC, et al. Effects of Oral Contraceptives and Biological Sex on Grip Strength and Excitation during Immobilization and Recovery: An Exploratory Clinical Trial. Med Sci Sports Exerc. 2026;58(4):798-811. https://doi.org/10.1249/MSS.0000000000003889

6. Elliott-Sale KJ, Smith S, Bacon J, Clayton D, McPhilimey M, Goutianos G, et al. Examining the role of oral contraceptive users as an experimental and/or control group in athletic performance studies. Contraception. 2013;88(3):408-412. https://doi.org/10.1016/j.contraception.2012.11.023

7. Freemas JA, Baranauskas MN, Constantini K, Constantini N, Greenshields JT, Mickleborough TD, et al. Exercise Performance Is Impaired during the Midluteal Phase of the Menstrual Cycle. Med Sci Sports Exerc. 2021;53(2):442-452. https://doi.org/10.1249/MSS.0000000000002464

8. Smith ES, McCormick R, McKay AKA, Ackerman KE, Elliott-Sale KJ, Stellingwerff T, et al. Perceived Negative Menstrual Cycle Symptoms, But Not Changes in Estrogen or Progesterone, Are Associated with Impaired Cycling Race Performance. Med Sci Sports Exerc. 2025;57(3):590-599. https://doi.org/10.1249/MSS.0000000000003587

9. Beníčková M, Ihalainen JK, Mikkonen R, Wagner A, Bozděch M, Gimunová M. When time matters: Circadian rhythm outweighs menstrual cycle in strength, but not in motivation. J Sci Med Sport. 2026;29(3):308-315. https://doi.org/10.1016/j.jsams.2025.09.014

10. Dias NF, Bergamasco JGA, Scarpelli MC, Silva DG, Chaves TS, Bittencourt D, et al. Changes in muscle cross-sectional area during two menstrual cycles may not be exclusively attributed to resistance training. Appl Physiol Nutr Metab. 2024;49(12):1729-1739. https://doi.org/10.1139/apnm-2024-0004

11. Vaiksaar S, Jürimäe J, Mäestu J, Purge P, Kalytka S, Shakhlina L, et al. No effect of menstrual cycle phase on fuel oxidation during exercise in rowers. Eur J Appl Physiol. 2011;111(6):1027-1034. https://doi.org/10.1007/s00421-010-1730-1

12. Kubica C, Ketelhut S, Nigg CR. Polarized running training adapted to versus contrary to the menstrual cycle phases has similar effects on endurance performance and cardiovascular parameters. Eur J Appl Physiol. 2024;124(11):3433-3444. https://doi.org/10.1007/s00421-024-05545-9

13. Kubica C, Ketelhut S, Querciagrossa D, Burger M, Widmer M, Bernhard J, et al. Effects of a training intervention tailored to the menstrual cycle on endurance performance and hemodynamics. J Sports Med Phys Fitness. 2024;64(1):45-54. https://doi.org/10.23736/S0022-4707.23.15277-7

14. Fleitas-Paniagua PR, Rasica L, Azevedo RA, Alvares TS, Zagatto AM, Murias JM. Menstrual Cycle Phase Does Not Affect Carbohydrate Supplementation Ergogenic Effect After Heavy Intensity Cycling. Scand J Med Sci Sports. 2026;36(3):e70240. https://doi.org/10.1111/sms.70240

15. Hayashi N, Mündel T, Lei TH, Badenhorst C. Comparison of respiratory responses to exercise under different heat-stressful environments between oral contraceptive and naturally menstruating ovulating female athletes. J Therm Biol. 2025;134:104335. https://doi.org/10.1016/j.jtherbio.2025.104335

16. Convit L, Orellana L, Périard JD, Carr AJ, Warmington S, Beaugeois M, et al. Sodium Hyperhydration Improves Performance With No Change in Thermal and Cardiovascular Strain in Female Cyclists Exercising in the Heat Across the Menstrual Cycle. Int J Sport Nutr Exerc Metab. 2025;35(2):99-111. https://doi.org/10.1123/ijsnem.2024-0125

17. Nie J, Zhang H, Kong Z, Wang C, Liu Y, Shi Q, et al. The impact of exercise modality and menstrual cycle phase on circulating cardiac troponin T. J Sci Med Sport. 2020;23(3):309-314. https://doi.org/10.1016/j.jsams.2019.10.003

18. Nakamura M, Hayashi K, Aizawa K, Mesaki N, Kono I. Effects of regular aerobic exercise on post-exercise vagal reactivation in young female. Eur J Sport Sci. 2013;13(6):674-680. https://doi.org/10.1080/17461391.2013.774054

19. Silva AF, Trybulski R, Trybek G, Moska W, Aidar FJ, González-Fernández FT. Impact of The Menstrual Cycle on Physical Recovery after Small-Sided Games: A Crossover Study in Women's Soccer Players. J Sports Sci Med. 2025;24(3):532-542. https://doi.org/10.52082/jssm.2025.532

20. Romero-Moraleda B, Del Coso J, Gutiérrez-Hellín J, Lara B. The Effect of Caffeine on the Velocity of Half-Squat Exercise during the Menstrual Cycle: A Randomized Controlled Trial. Nutrients. 2019;11(11):2662. https://doi.org/10.3390/nu11112662

21. Norum M, Risvang LC, Bjørnsen T, Dimitriou L, Rønning PO, Bjørgen M, et al. Caffeine increases strength and power performance in resistance-trained females during early follicular phase. Scand J Med Sci Sports. 2020;30(11):2116-2129. https://doi.org/10.1111/sms.13776

22. Benito PJ, Alfaro-Magallanes VM, Rael B, Castro EA, Romero-Parra N, Rojo-Tirado MA, et al. Effect of Menstrual Cycle Phase on the Recovery Process of High-Intensity Interval Exercise-A Cross-Sectional Observational Study. Int J Environ Res Public Health. 2023;20(4):3266. https://doi.org/10.3390/ijerph20043266

23. Shimizu K, Suzuki N, Nakamura M, Aizawa K, Imai T, Suzuki S, et al. Mucosal immune function comparison between amenorrheic and eumenorrheic distance runners. J Strength Cond Res. 2012;26(5):1402-1406. https://doi.org/10.1519/JSC.0b013e31822e7a6c

24. Del Prado-Álvarez R, Estrada-Barranco C, González-de-la-Flor Á, de la Plaza San Frutos M, Almazán-Polo J, Guerineau F, et al. Endurance and electromyographic assessment of abdominopelvic motor control in women with primary dysmenorrhea: a cross-sectional study. Sci Rep. 2024;14(1):28836. https://doi.org/10.1038/s41598-024-79729-w

25. James K, Cannon J, Marino FE. Comparative Responses of Self-Regulated Exercise, Thermoregulation, and Neuromuscular Function to Monophasic Oral Contraceptives Across One Menstrual Cycle. Eur J Sport Sci. 2026;26(1):e70083. https://doi.org/10.1002/ejsc.70083

26. Lara B, Gutiérrez-Hellín J, García-Bataller A, Rodríguez-Fernández P, Romero-Moraleda B, Del Coso J. Ergogenic effects of caffeine on peak aerobic cycling power during the menstrual cycle. Eur J Nutr. 2020;59(6):2525-2534. https://doi.org/10.1007/s00394-019-02100-7

27. Mendes GL, Oliveira HA, Santana Dos Reis A, Nakamoto FP, Staibano A, Alvares LA, et al. Effect of caffeine supplementation on physical performance in a 5 km cycling time trial of healthy young adult women in different phases of the menstrual cycle: A parallel, randomized, double-blind, placebo-controlled clinical trial. Nutr Health. 2025;31(4):1635-1647. https://doi.org/10.1177/02601060241307981

28. Hogwood AC, Ortiz De Zevallos J, Kruse K, Buckley M, De Guzman J, DeJong Lempke A, et al. The effects of inorganic nitrate supplementation on muscular power and endurance across the menstrual cycle. J Appl Physiol. 2024;137(6):1503-1511. https://doi.org/10.1152/japplphysiol.00323.2024

29. Safari K, Hemmatinafar M, Suzuki K, Koushkie Jahromi M, Imanian B. Dark Chocolate Mitigates Premenstrual Performance Impairments and Muscle Soreness in Female CrossFit Athletes: Evidence from a Menstrual-Phase-Specific Trial. Nutrients. 2025;17(8):1374. https://doi.org/10.3390/nu17081374

30. Gills JL, Spliker B, Glenn JM, Szymanski D, Romer B, Lu HC, et al. Acute Citrulline-Malate Supplementation Increases Total Work in Short Lower-Body Isokinetic Tasks for Recreationally Active Females During Menstruation. J Strength Cond Res. 2023;37(6):1225-1230. https://doi.org/10.1519/JSC.0000000000004095

31. de Carvalho Rotoly G, Papoti M, Foresti YF, de Oliveira Guirro EC, Guirro RRJ. Influence of photobiomodulation therapy on the physical performance of women during the follicular phase of the menstrual cycle: A double-blind Sham-controlled randomized clinical trial. Lasers Med Sci. 2023;38(1):173. https://doi.org/10.1007/s10103-023-03840-z

32. Trybulski R, Smoter M, Vovkanych A, Svyshch Y, Clemente FM. Menstrual Cycle Influence on Post-exercise Recovery: Comparing the Efficacy of Dry and Ice Massage in Female Combat Sports Athletes. J Strength Cond Res. 2026;40(5):597-609. https://doi.org/10.1519/JSC.0000000000005367

33. Nolte J, Kirmse M, de Marées M, Platen P. Effects of Short-Term Low Energy Availability on Metabolism and Performance-Related Parameters in Physically Active Adults. Nutrients. 2025;17(2):278. https://doi.org/10.3390/nu17020278

34. Passoni P, Inzoli A, De Ponti E, Polizzi S, Ceccherelli A, Fantauzzi M, et al. Association between Physical Activity and Menstrual Cycle Disorders in Young Athletes. Int J Sports Med. 2024;45(7):543-548. https://doi.org/10.1055/a-2278-3253

35. Ackerman KE, Pierce L, Guereca G, Slattery M, Lee H, Goldstein M, et al. Hip structural analysis in adolescent and young adult oligoamenorrheic and eumenorrheic athletes and nonathletes. J Clin Endocrinol Metab. 2013;98(4):1742-1749. https://doi.org/10.1210/jc.2013-1006

36. Carvalho AC, Gaio N, Müller PC, Benincá SC. The use of hormonal contraceptives in high performance Brazilian female swimmers: a cross-sectional study. Rev Bras Ginecol Obstet. 2025;47:e-rbgo82. https://doi.org/10.61622/rbgo/2025rbgo82

37. Kissow J, Jacobsen KJ, Jessen S, Thomsen LB, Quesada JP, Bangsbo J, et al. Global Proteomics Reveals Distinct Muscle Adaptations to Menstrual Cycle Phase-Based Sprint Interval Training in Endurance-Trained Females. Mol Cell Proteomics. 2025;24(10):101053. https://doi.org/10.1016/j.mcpro.2025.101053