Menstrual Disorders in Female Athletes: A Literature Review

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Abstract

Menstrual Cycle (MC) disorders among female athletes are highly prevalent. Athletes tend to have heavier bleeding and longer duration between menses (Czajkowska, 2020). Studies examining different sports have defined a few menstrual disorders as the following: Pre Menstrual Syndrome (PMS), Pre Menstrual Dysphoric Disorder (PMDD), Primary amenorrhea (inability to reach menarche), secondary amenorrhea (3+ months without period), and oligomenorrhea (irregular period with increased blood flow). Research on the MC during exercise has identified proposed mechanisms that alter athletic performance and may be implicated in menstrual disorders. This review delves into four proposed mechanisms (body composition, stress, muscle activation, and thermoregulation) and their ability to affect menstrual disorder likelihood or female athletes with existing menstrual disorders. It was found that body composition and physiological stress were most likely to predict menstrual disorder frequency. However, there is a need for further research on the molecular mechanisms governing these conditions to define a relationship between how aberrant cellular conditions cause a menstrual disorder.

Introduction

The female brain exists in a constantly fluctuating neurochemical state due to the menstrual cycle. During exercise this is heightened due to the physical demands and different chemicals released that imbalance the Hypothalamic-Pituitary-Ovarian (HPO) Axis (Stafford, 2005). The HPO axis controls female reproduction, and during exercise, the hormones involved in female reproduction - including estrogen and progesterone - are impacted, causing amenorrhea or oligomenorrhea (Stafford, 2005). Studying how MC phases are altered due to physiological stress caused by exercise may inform athletes on how to train, recover, and perform best based on their menstrual cycle.

Menstrual Cycle Physiology

The female menstrual cycle is variable but normally ranges between 21 and 35 days. This is known as an eumenorrheic cycle and can be separated into the follicular and luteal phases (Carmichael et al., 2021). The eumenorrheic cycle can be broken down further into early follicular, late follicular, ovulatory, early luteal, middle luteal, and late luteal phases (Carmichael et al., 2021). During the early follicular phase, menstruation occurs and a thickened endometrium is shed (Farage et al., 2009). Due to a surge in Luteinizing Hormone, the egg begins to form during the remainder of the follicular phase. (Farage et al., 2009). The luteal phase is characterized by the corpus luteum degenerating, an increase in progesterone levels, and a decrease in estrogen levels (Farage et al., 2009).

Menstrual Cycle Disorders

Menstrual cycle disorders are defined as disrupting the normal reproductive axis. Primary amenorrhea is the inability to reach first menarche (Gasner and Rehman, 2023). Secondary amenorrhea is the absence of a period in over 3 months for normally cycling females, and over 6 months for irregularly cycling females (Rebar, 2000). Oligomenorrhea is both irregular cycling (35+ days) and prolonged bleeding (He et al., 2020).

Exercise and Menstrual Cycle Disorders in Athletes

Endurance athletes are most likely to have oligomenorrhea, while primary amenorrhea is predominantly seen in aerobic sports (Redman and Loucks, 2005). Both secondary amenorrhea and oligomenorrhea are highly prevalent in all sports

disciplines (Redman and Loucks, 2005). The mechanism causing menstrual disorder to be more prevalent in athletes, however, remains undefined. Athletes' bodies are subjected to rigorous training during the MC. Studies have been done to understand how objective physiology and subjective feelings of athletes are altered across the MC. Most studies focus on body composition, stress, muscle activation, and thermoregulation (Carmichael et al., 2021; Meignié et al., 2021; Hansen and Kjaer, 2014; Giersch et al., 2020). As such, this review aims to understand the impact that menstrual disorders in female athletes have on these mechanisms.

Methodology

This review was conducted through the PubMED database with access to Journals provided by Michigan State University. The eligibility criteria for journal inclusion in our analysis consisted of: (1) female athletes, (2) a description of menstrual cycle disorders, (3) variation in MC due to exercise. The following Boolean operators were used to refine the search: "menstrual cycle disorder" OR "menstrual cycle irregularity" OR "menstrual cycle abnormality", AND "athlete" OR "athletic performance" OR "exercise". Articles published from 1998 to 2025 were included in this study. Excluded material consisted of magazine articles, non-English language articles, and articles with no full text available.

How Body Composition impacts Female Athletic Performance

Athletes commonly experience low energy availability (LEA) as defined by a lack of sufficient ingested energy to support the body during exercise. LEA is known to have an association with body composition by lowering fat mass and muscle protein synthesis (Oxfeldt et al., 2023). Insufficient micro- and macro-nutrients negatively impact physiology (Logue et al., 2018). Additionally, during LEA, female athletes face a decrease in LH pulsatility and bone turnover, which can lead to impaired reproductive function and bone metabolism (Logue et al., 2018). Further, one study found that varying energy levels can predict the frequency of menstrual disturbances (Williams et al., 2015). This concluded that a decrease in energy disrupts reproductive function and increases the risk of developing a menstrual disorder.

Body composition and LEA are also increasingly magnified through the idea of thinness as the determination of fitness. A study on Olympic athletes reported that sports where leanness is painted as optimal for performance tend to have higher rates of athletes with eating disorders (Hagmar et al., 2008). Limiting food intake to reach a satisfactory weight creates a lack of energy. Without adequate food intake, athletes fall victim to LEA. Female athletes face the issue of thinness in competition at a higher rate than males due to societal pressures (Byrne and McLean, 2002). Due to this, a screening tool for female athletes to determine the risk for physiological symptoms from LEA (LEAF-Q Test) was created and validated in 2014 (Melin et al., 2014). This tool determined that 'at risk' female athletes exhibit metabolic deficiencies due to a lack of energy. Decreased carbohydrate levels and endocrine changes suppress progesterone and estrogen, resulting in reduced performance (Vanheest et al., 2014). In addition to decreased performance, suppressed ovarian hormones cause an increase in menstrual disorder susceptibility; a study on female collegiate runners found that 54.4% scored 'at risk' on LEAF-Q, while 56.5% reported some menstrual disorder (Dambacher et al., 2025). These findings indicate that LEA and menstrual disorder are associated.

Physiological Stress due to Exercise alters Hormones

Cortisol, the body's stress hormone, is released during exercise as the body is placed under physiological stress. Studies have shown that cortisol reduces Gonadotropin Releasing Hormone's (GnRH) pulsatile frequency causing lesser production of LH and Follicle Stimulating Hormone (FSH), impacting estrogen and progesterone levels (McCosh et al., 2023; Ralph et al., 2016; Wagenmaker et al., 2009). Higher levels of cortisol are seen in female athletes with menstrual

disorders than eumenorrheic athletes (Melin et al., 2015). Amenorrheic athletes with higher cortisol levels were identified to have lower catecholamine concentration and lower blood lactate levels (Schaal et al., 2011). This lessened adrenergic response causes a higher level of exertion for amenorrheic athletes as catecholamines are necessary for sympathetic regulation of cardiovascular and metabolic systems. These results indicate that a reduction in performance due to increased cortisol level in female athletes with MD could be present.

Additionally, cortisol's impact on estrogen extends to serotonin, which has been found to be implicated in Pre Menstrual Syndrome (PMS) and Pre-Menstrual Dysphoric Disorder (PMDD). Specifically, estrogen has been found to increase serotonin levels by increasing transcription of the rate-limiting enzyme in serotonin synthesis: tryptophan hydroxylase 2 (TPH2) (Hiroi and Handa, 2013). As cortisol suppresses estrogen levels, less transcription occurs, leading to lower serotonin levels. Decreased serotonin levels cause PMS symptoms such as fatigue, insomnia and depression (Gudipally and Sharma, 2023).

Muscle Activation is altered through the MC

Estrogen and progesterone are thought to relate to muscle strength and mass (Chidi-Ogbolu and Baar, 2019). Studies contradict one another on the specifics of whether the fluctuating concentrations of ovarian hormones changes muscle activation over the cycle (Oxfeldt et al., 2023; Ikeda et al., 2019 Hansen and Kjaer, 2014). This is largely due to there being unclear rules on how to measure estrogen/progesterone levels accurately and consistently in muscle tissue. Estrogen is known to be involved in signaling skeletal muscles to control muscle activation. Estrogen and progesterone have opposing effects on protein catabolism, as estrogen inhibits protein catabolism while progesterone promotes it (Kissow et al., 2022). By suppressing protein catabolism, estrogen preserves muscle mass and strength. Additionally, the ability to regenerate and recover muscle fibers is highest when estrogen reaches its peak during the late follicular phase (Hansen and Kjaer, 2014). This research indicates that when estrogen is suppressed, as which occurs during menstrual disorders, a decrease in muscle strength and mass may occur.

Thermoregulation upset during MC

Thermoregulation during the MC, specifically the rise in basal body temperature during the luteal phase, is thought to decrease exercise performance (Giersch et al., 2020). Previous studies have demonstrated conflicting results, with many finding no impact of MC on strength and aerobic sports during any phase (Janse de Jong, 2003; Kissow et al., 2022; Giersch et al., 2020). However, one study found endurance exercise was reported to be impacted by an increase in temperature due to increased cardiovascular strain (Janse de Jonge, 2003). A study by A.M. Garcia, using female athletes subjected to 60 minutes of cycling during each MC phase, demonstrated that although those in the luteal phase had an increase in basal temperature, they also experienced an increase in sweat volume during exercise to compensate for the temperature increase (Garcia et al., 2006). This increase in sweat due to increased temperature shows the body's regulatory effect across an hour of exercise but does not delve into cardiovascular impacts of the menstrual cycle.

Furthermore, women experiencing menstrual disorders are at a higher risk for experiencing. symptoms of heat sensitivity and hot flashes due to MC thermoregulation (Hahn et al.,1998). Identifying how women with menstrual disorders are affected by thermoregulation in an exercise context is necessary to understand heat exhaustion and heat illness susceptibility.

Limitations and Future Research

Studies within this field of research are limited in number and lack cohesive experimental measurements and methods. Many experiments are based on subjective questionnaires or consist of a variety of methods for measuring progesterone and estrogen levels. Thus, a significant gap in knowledge is present especially when it comes to the prevalence of menstrual disorders in female athletes.

Future research should focus on creating a validated model to measure estrogen and progesterone levels across the menstrual cycle, as well as a common exercise test for athletic performance. Additionally, a standardized method of training responses, or of measuring physiological response to exercise during the phases, is needed.

Additionally, identifying the relationship between nutrition and menstrual disorders, as well as its implications on muscle mass and strength, is necessary to prevent severe injury in athletes and possible severe imparity of reproductive function. Many studies research the menstrual cycle in eumenorrheic females. However, the implications of exercise on women who already have menstrual disorders is under-studied.

Conclusion

This literature review was conducted to better understand how exercise and menstrual cycle disorders are related. Multiple studies delved into proposed physiological mechanisms altered due to the menstrual cycle with implications for exercise, but studies commonly contradicted one another. The differing methods of measuring progesterone and estrogen, and different exercises used to model acute, mild, and endurance sports varies across sports, leading to conflicting results about the relationship between the two.

Most conclusively, body composition – specifically altered due to LEA – was the most likely cause of menstrual cycle disorder due to exercise. Limiting food intake due to the perception of thinness leading to optimal fitness causes a decrease in performance and impaired reproductive function. The physical stress placed on the body during exercise is also seen to impact menstrual cycle disorders and potentially cause disorders in of themselves. Increased cortisol levels lead to a suppression of estrogen and progesterone occurs, which is known to have negative implications for performance and reproductive function.

Muscle activation and thermoregulation, while commonly investigated as proposed mechanisms by which the menstrual cycle impacts exercise, remain undetermined in their role in menstrual cycle disorders. Muscle activation is thought to be unchanged across the menstrual cycle. Thermoregulation is found to have no impact on performance apart from potentially causing increased cardiovascular strain during endurance sports. Both muscle activation and thermoregulation are thought to be impacted by menstrual disorders; however, future research should focus on how the menstrual cycle is impacted by exercise in non-eumenorrheic athletes.

In summary, the relation between exercise and menstrual disorders is widely unknown and studies researching the menstrual cycle need more standardized methods of measurement and experimentation. A better understanding of how exercise potentially causes menstrual cycle disorders and the implications of exercise for women with menstrual disorders is necessary for both athlete performance and reproductive health.

References

1. Byrne, S., and McLean, N. (2002). Elite athletes: Effects of the pressure to be thin. *J Sci Med Sport* 5(2), 80–94.

2. Carmichael, M. A., Thomson, R. L., Moran, L. J., and Wycherley, T. P. (2021). The impact of menstrual cycle phase on athletes' performance: A narrative review. *Int J Environ Res Public Health* 18(4), 1667.

3. Chidi-Ogbolu, N., and Baar, K. (2019). Effect of estrogen on musculoskeletal performance and injury risk. *Front Physiol* 9, 1834.

4. Czajkowska, M., Drosdzol-Cop, A., Naworska, B., Galazka, I., Gogola, C., Rutkowska, M., and Skrzypulec-Plinta, V. (2020). The impact of competitive sports on menstrual cycle and menstrual disorders, including premenstrual syndrome, premenstrual dysphoric disorder and hormonal imbalances. *Ginekol Pol* 91(9), 503–512.

5. Dambacher, L., Pritchett, K., Pritchett, R., and Larson, A. (2025). Risk of low energy availability, disordered eating, and menstrual dysfunction in female collegiate runners. *J Athl Train* 60(2), 177–184.

6. Farage, M. A., Neill, S., and MacLean, A. B. (2009).

Physiological changes associated with the menstrual cycle: A review. *Obstet Gynecol Surv* 64(1), 58–72.

7. Garcia, A. M., Lacerda, M. G., Fonseca, I. A., Reis, F. M., Rodrigues, L. O., and Silami-Garcia, E. (2006). Luteal phase of the menstrual cycle increases sweating rate during exercise. *Braz J Med Biol Res* 39(9), 1255–1261.

8. Gasner, A., and Rehman, A. (2023). Primary amenorrhea. *StatPearls Publishing*.

9. Giersch, G. E. W., Morrissey, M. C., Katch, R. K., Colburn, A. T., Sims, S. T., Stachenfeld, N. S., and Casa, D. J. (2023). Menstrual cycle and thermoregulation during exercise in the heat: A systematic review and meta-analysis. *J Sci Med Sport* 23(12), 1134–1140.

10. Gudipally, P. R., and Sharma, G. K. (2023). Premenstrual syndrome. *StatPearls Publishing*.

11. Hagmar, M., Hirschberg, A. L., Berglund, L., and Berglund, B. (2008). Special attention to the weight-control strategies employed by Olympic athletes striving for leanness is required. *Clin J Sport Med* 18(1), 5–9.

12. Hahn, P. M., Wong, J., and Reid, R. L. (1998). Menopausal-like hot flashes reported in women of reproductive age. *Fertil Steril* 70(5), 913–918.

13. Hansen, M., and Kjaer, M. (2014). Influence of sex and estrogen on musculotendinous protein turnover at rest and after exercise. *Exerc Sport Sci Rev* 42(4), 183–192.

14. He, Y., Zheng, D., Shang, W., Wang, X., Zhao, S., Wei, Z., Song, X., Shi, X., Zhu, Y., Wang, S., et al. (2020).Prevalence of oligomenorrhea among women of childbearing age in China: A large community-based study. *Women's Health* 16.

15. Hiroi, R., and Handa, R. J. (2013). Estrogen receptor-β regulates human tryptophan hydroxylase-2 through an estrogen response element in the 5' untranslated region. *J Neurochem* 127, 487–495.

16. Ikeda, K., Horie-Inoue, K., and Inoue, S. (2019). Functions of estrogen and estrogen receptor signaling on skeletal muscle. *J Steroid Biochem Mol Biol* 191.

17. Janse de Jonge, X. A. (2003). Effects of the menstrual cycle on exercise performance. Sports Med 33(11), 833–851.

18. Kissow, J., Jacobsen, K. J., Gunnarsson, T. P., Jessen, S., and Hostrup, M. (2022). Effects of follicular- and luteal-phase-based menstrual cycle resistance training on muscle strength and mass. *Sports Med* 52(12), 2813–2819.

19. Logue, D., Madigan, S. M., Delahunt, E., Heinen, M., McDonnell, S. J., and Corish, C. A. (2018). Low energy availability in athletes: A review of prevalence, dietary patterns, physiological health, and sports performance. *Sports Med* 48(1), 73–96.

20. McCosh, R. B., O'Bryne, K. T., Karsch, F. J., and Breen, K. M. (2022). Regulation of the gonadotropin-releasing hormone neuron during stress. *J Neuroendocrinol* 34(5), e13098.

21. Meignié, A., Duclos, M., Carling, C., Orhant, E., Provost, P., Toussaint, J. F., and Antero, J. (2021). The effects of menstrual cycle phase on elite athlete performance: A critical and systematic review. *Front Physiol* 12, 654585.

22. Melin, A., Tornberg, A. B., Skouby, S., et al. (2014). The LEAF questionnaire: A screening tool for identifying female athletes at risk for the female athlete triad. *Br J Sports Med* 48(7), 540–545.

23. Oxfeldt, M., Phillips, S. M., Andersen, O. E., Johansen, F. T., Bangshaab, M., Risikesan, J., McKendry, J., Melin, A. K., and Hansen, M. (2023). Low energy availability reduces myofibrillar and sarcoplasmic muscle protein synthesis in trained females. *J Physiol* 601(16), 3481–3497.

24. Ralph, C. R., Lehman, M. N., Goodman, R. L., and Tilbrook, A. J. (2016). Impact of psychosocial stress on gonadotrophins and sexual behaviour in females: Role for cortisol? *Reproduction* 152(1), R1–R14.

25. Rebar, R. (2018). Evaluation of amenorrhea, anovulation, and abnormal bleeding. *Endotext* [Internet]. MDText.com.

26. Redman, L. M., and Loucks, A. B. (2005). Menstrual disorders in athletes. *Sports Med* 35, 747–755.

27. Schaal, K., Van Loan, M. D., and Casazza, G. A. (2011). Reduced catecholamine response to exercise in amenorrheic athletes. Med Sci Sports Exerc 43(1),

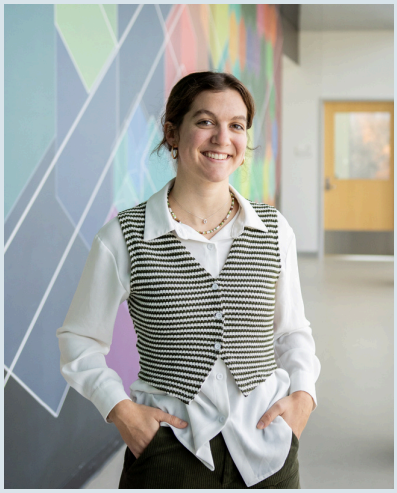
34–43

28. Stafford, D. E. (2005). Altered hypothalamic-pituitary-ovarian axis function in young female athletes: Implications and recommendations for management. *Treat Endocrinol* 4(3), 147–154.

29. Vanheest, J. L., Rodgers, C. D., Mahoney, C. E., and De Souza, M. J. (2014). Ovarian suppression impairs sport performance in junior elite female swimmers. *Med Sci Sports Exerc* 46(1), 156–166.

30. Wagenmaker, E. R., Breen, K. M., Oakley, A. E., Tilbrook, A. J., and Karsch, F. J. (2009). Psychosocial stress inhibits amplitude of gonadotropin-releasing hormone pulses independent of cortisol action on the type II glucocorticoid receptor. *Endocrinology* 150(2), 762–769.

31. Williams, N. I., Leidy, H. J., Hill, B. R., et al. (2015). Magnitude of daily energy deficit predicts frequency but not severity of menstrual disturbances associated with exercise and caloric restriction. *Am J Physiol Endocrinol Metab* 308(1), E29–E39.



About the Author

Gwen Urbain graduated with a Bachelor of Science in Neuroscience this past August and is now working as a Lab Technician in the Laumet Lab. Her interest lies in investigating reproductive physiology within stress and pain contexts during graduate school. Her work as an undergraduate inspired this article as she performed an independent research project on how stress alters the mouse estrous cycle-this literature review helped her better understand her own research and identify future research areas in the field. Gwen hopes that readers leave with an understanding of the importance of studying female reproductive systems in physiologically stressful conditions.