

Psychological Stress, Menstrual Irregularities, and Performance Outcomes Among Elite Female Athletes

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Abstract

Elite female athletes are simultaneously exposed to two demanding physiological systems: a hypothalamic-pituitary-gonadal axis that governs reproductive and menstrual function, and a hypothalamic-pituitary-adrenal axis that mediates the response to psychological and physical stress. A growing body of evidence indicates that these systems are not independent; chronic psychological stress, whether generated by competitive pressure, financial insecurity, selection anxiety, injury, or the cumulative load of training, can suppress gonadotropin-releasing hormone pulsatility and precipitate menstrual dysfunction, including oligomenorrhea, secondary amenorrhea, and functional hypothalamic amenorrhea. This review synthesizes epidemiological, endocrinological, and sport-science literature published between 1982 and 2026 to examine the prevalence of menstrual irregularities among elite female athletes, the neuroendocrine mechanisms linking psychological stress to reproductive suppression, the overlapping constructs of the Female Athlete Triad, Relative Energy Deficiency in Sport, and overtraining syndrome, and the consequences of these conditions for athletic performance, injury risk, and bone health. Reported prevalence of menstrual dysfunction among athletes ranges from 6% to 79%, substantially exceeding the 2% to 5% observed in the general population, with marked variation



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by sport type, culture, and energy availability. Concurrently, 4% to 68% of elite athletes report depressive symptoms and up to 33.6% report combined anxiety and depressive symptoms, with female athletes consistently reporting higher rates than male counterparts. The review further evaluates evidence on menstrual cycle phase and performance, concluding that while injury risk and subjective well-being show more consistent luteal-phase decrements, objective performance findings remain heterogeneous and are frequently confounded by inadequate hormonal verification. The review closes with a discussion of methodological limitations, sociocultural moderators, and implications for athlete monitoring, screening, and interdisciplinary management.

Keywords: *psychological stress, menstrual dysfunction, functional hypothalamic amenorrhea, Female Athlete Triad, Relative Energy Deficiency in Sport, elite female athletes, athletic performance, HPA axis*

1. Introduction

Women's participation in elite competitive sport has expanded considerably over the past three decades, yet the physiological research base underpinning athlete health and performance continues to be disproportionately derived from male populations. Contemporary reviews estimate that female athletes constitute only about 35% of participants examined in sport-science research, a gap that has left central aspects of female physiology, including the menstrual cycle and its interaction with psychological stress, comparatively under-characterized despite their evident relevance to health and performance outcomes.

Two physiological systems are of particular importance to the elite female athlete: the hypothalamic-pituitary-gonadal (HPG) axis, which governs the menstrual cycle through pulsatile secretion of gonadotropin-releasing hormone (GnRH), and the hypothalamic-pituitary-adrenal (HPA) axis, which mediates the neuroendocrine response to psychological, physical, and metabolic stressors. These two systems are anatomically and functionally interconnected at the level of the hypothalamus, such that sustained activation of the HPA axis, whether from competitive anxiety, selection pressure, injury, travel demands, interpersonal conflict, or the cumulative burden of high-volume training, can suppress GnRH pulsatility and precipitate a spectrum of menstrual disturbances ranging from luteal phase deficiency and oligomenorrhea to functional hypothalamic amenorrhea (FHA).

The consequences of this stress-reproductive interface extend beyond fertility. Menstrual dysfunction in athletes is frequently a visible marker of an underlying state of low energy availability and chronic physiological stress that also compromises bone mineral accrual, musculoskeletal integrity, cardiovascular health, and, critically, sporting performance itself. The International Olympic Committee's (IOC) evolving frameworks, from the Female Athlete Triad first described by the American College of Sports Medicine¹, through to the broader Relative Energy Deficiency in Sport (REDs) model introduced in 2014 and most recently updated in 2023², reflect a growing recognition that psychological, endocrine, and performance outcomes in female athletes cannot be considered in isolation from one another.

This review addresses three interrelated questions. First, what is the documented prevalence and clinical presentation of psychological stress and menstrual irregularities among elite female athletes? Second, what neuroendocrine and psychosocial mechanisms account for

¹American College of Sports Medicine, Nattiv, A., et al. (2007). Position stand: The female athlete triad. *Medicine & Science in Sports & Exercise*, 39(10), 1867–1882.

²Mountjoy, M., Ackerman, K. E., Bailey, D. M., et al. (2023). 2023 International Olympic Committee's (IOC) consensus statement on Relative Energy Deficiency in Sport (REDs). *British Journal of Sports Medicine*, 57(17), 1073–1097.

the observed association between the two? Third, what evidence exists linking these conditions to objective and subjective performance outcomes, including strength, endurance, decision-making, injury susceptibility, and recovery? In addressing these questions, the review draws on epidemiological surveys, endocrinological trials, consensus statements from governing bodies, and sport-specific longitudinal studies published through mid-2026, with particular attention to methodological quality and the sociocultural context in which these conditions are recognized, reported, and managed.

2. Physiological Framework: The Intersection of Stress and Reproductive Regulation

2.1 Regulation of the Menstrual Cycle by the Hypothalamic-Pituitary-Gonadal Axis

The menstrual cycle is governed by pulsatile secretion of GnRH from hypothalamic neurons, which in turn stimulates pituitary release of luteinizing hormone (LH) and follicle-stimulating hormone (FSH). These gonadotropins regulate follicular development, ovulation, and the cyclical production of estradiol and progesterone by the ovaries. The frequency and amplitude of GnRH pulses must remain within a relatively narrow physiological range for normal folliculogenesis and ovulatory function to proceed; disruption of this pulsatility, whether through metabolic, physical, or psychological perturbation, produces a graded spectrum of menstrual disturbance rather than a single discrete pathology.

2.2 HPA Axis Activation and Suppression of GnRH Pulsatility

Psychological and physiological stressors activate the HPA axis through hypothalamic release of corticotropin-releasing hormone (CRH), which stimulates pituitary adrenocorticotropic hormone (ACTH) secretion and, consequently, adrenal cortisol output. CRH itself directly inhibits GnRH pulse frequency, while cortisol independently suppresses reproductive function at the hypothalamic, pituitary, and even uterine level. Women with FHA characteristically display elevated basal cortisol concentrations alongside blunted ACTH and cortisol responses to exogenous CRH stimulation, a pattern consistent with chronic negative feedback secondary to sustained hypercortisolism. Cerebrospinal fluid cortisol concentrations have also been reported to be higher in women with FHA relative to eumenorrheic controls, and higher circulating cortisol has been associated with reduced LH secretion, reinforcing a direct inhibitory pathway between adrenal activation and gonadotropin release.

Kisspeptin, a neuropeptide product of the *KISS1* gene acting through the GPR54 receptor, has emerged as a central node in this regulatory network. Kisspeptin neurons stimulate GnRH release, and their activity is itself suppressed by cortisol, providing a molecular mechanism through which chronic stress translates into reduced hypothalamic reproductive drive. Additional neurotransmitter systems, including corticotropin-releasing factor, endogenous opioids such as beta-endorphin, and gamma-aminobutyric acid, further modulate GnRH neuron activity in the context of energy deprivation and psychological distress, while allopregnanolone, a neurosteroid with HPA-dampening properties, may buffer some individuals against the reproductive consequences of stress exposure. This variability in neuroendocrine sensitivity helps explain why not all athletes exposed to comparable training loads or psychosocial stressors develop menstrual dysfunction, with recent research pointing to a genetic contribution to individual differences in GnRH neuron resilience.

2.3 Allostatic Load as an Integrative Concept

The construct of allostatic load, originally articulated by McEwen (2000)³, provides a useful integrative framework for understanding the cumulative physiological burden experienced by elite athletes exposed to concurrent training stress, psychological pressure, and, frequently, inadequate caloric intake. Allostatic load refers to the wear on multiple physiological systems that results from repeated or chronic activation of stress-response mechanisms, including the HPA axis, autonomic nervous system, and metabolic and immune pathways. In the athletic context, this framework helps to explain the substantial phenotypic overlap between overtraining syndrome, REDs, and stress-induced menstrual dysfunction: rather than representing entirely distinct clinical entities, these conditions may constitute different expressions of the same underlying allostatic overload, with the specific pattern of presentation, whether reproductive, psychological, musculoskeletal, or performance-related, shaped by the individual athlete's genetic predisposition, training history, and nutritional status.

3. Psychological Stress Among Elite Female Athletes

3.1 Sources and Character of Competitive Stress

Elite sport imposes a distinctive constellation of psychosocial stressors that differ qualitatively from those encountered in recreational or sub-elite contexts. These include

³McEwen, B. S. (2000). Allostasis and allostatic load: Implications for neuropsychopharmacology. *Neuropsychopharmacology*, 22(2), 108–124.

performance pressure and fear of failure at major competitions, selection anxiety associated with qualification standards and team-composition decisions, financial precariousness in sports with limited professional remuneration, disrupted interpersonal relationships resulting from travel and training schedules, public scrutiny amplified by traditional and social media, and the physical stress of high training volumes superimposed on competition demands. A study of elite female beach volleyball players ranked in the FIVB top 200 found that poor team communication and financial insecurity were significant predictors of psychological burden, whereas objective competitive success, measured by international ranking, showed no association with anxiety or depressive symptoms, indicating that subjective and structural stressors may be more influential on athlete mental health than sporting achievement itself.

3.2 Prevalence of Mental Health Symptoms

The IOC's 2019 consensus statement on mental health in elite athletes reported that the prevalence of depressive symptoms ranges from 4% to 68% and generalized anxiety symptoms from 6% to 14.6% across studies of elite athletes⁴, figures broadly comparable to, and in some samples exceeding, those observed in the general population. A 2019 systematic review and meta-analysis by Goutteborge and colleagues found that 33.6% of current elite athletes and 26.4% of former elite athletes reported clinically relevant symptoms of anxiety or depression⁵. A subsequent, more granular meta-analysis restricted to current elite athletes reported a prevalence range from 4% for drug misuse to 33% for general psychological distress, while former elite athletes displayed a range from 12% for depression to 28% for alcohol misuse, underscoring that mental health burden does not necessarily resolve with retirement from competition.

Sex differences in this burden are consistently observed. One study cited within the IOC's athlete mental health toolkit reported anxiety and/or depression prevalence of 26.0% among female athletes compared with 10.2% among male athletes, a disparity that mirrors, and in magnitude exceeds, the roughly 6% versus 4% depression prevalence differential observed between women and men in the general population. Sport-specific studies corroborate this pattern: research among elite female beach volleyball players found high rates of clinically relevant anxiety and depressive symptoms, and a study of 147 professional dancers across six opera houses and state theatres reported a high combined prevalence of depressive symptoms,

⁴Reardon, C. L., Hainline, B., Aron, C. M., et al. (2019). Mental health in elite athletes: International Olympic Committee consensus statement (2019). *British Journal of Sports Medicine*, 53(11), 667–699.

⁵Goutteborge, V., Castaldelli-Maia, J. M., Gorczynski, P., et al. (2019). Occurrence of mental health symptoms and disorders in current and former elite athletes: A systematic review and meta-analysis. *British Journal of Sports Medicine*, 53(11), 700–706.

generalized anxiety, and eating disorder symptomatology, reflecting particular vulnerability in aesthetically judged and appearance-focused disciplines. National-level surveys illustrate substantial cross-country variability: 6% of French elite athletes met criteria for generalized anxiety disorder, 15% of German high-level athletes reported depressive symptoms, and other cohort studies estimate that up to 20% of female elite athletes report clinically relevant depression or anxiety symptoms at any given time.

Underlying these prevalence estimates is a well-documented pattern of underdiagnosis and undertreatment, attributable to stigma within performance-oriented sporting cultures, athletes' concerns that disclosure could jeopardize selection or sponsorship, and, in many countries, limited availability of sport-informed mental health services. These structural barriers likely result in prevalence estimates that understate the true psychological burden experienced by elite female athletes.

4. Menstrual Irregularities in Elite Female Athletes

4.1 Classification and Epidemiology

Menstrual dysfunction in athletes encompasses a spectrum of presentations, including primary amenorrhea (absence of menarche by age 15 or within three years of thelarche), secondary amenorrhea (absence of menses for three or more consecutive months in a previously menstruating woman), oligomenorrhea (cycle length exceeding 35 days), luteal phase deficiency, and anovulation with otherwise apparently regular bleeding. Reported prevalence of menstrual dysfunction, taken across the full spectrum of presentations, ranges from 6% to 79% among athletes, figures that substantially exceed the 2% to 5% prevalence typically reported in the general, non-athletic population⁶. This wide range reflects heterogeneity in athlete population, sport discipline, definitional criteria, and assessment methodology (retrospective questionnaire versus prospective hormonal verification) across the underlying studies.

Sport type is a particularly strong moderator of risk. Disciplines that emphasize leanness or a specific aesthetic, such as distance running, gymnastics, and ballet, show disproportionately elevated rates of menstrual dysfunction, with secondary amenorrhea reported in up to 69% of athletes in some leanness-focused sports compared with the 2% to 5% general-population baseline. A dose-response relationship between training volume and menstrual disturbance was

⁶Gimunová, M., Paulínyová, A., Bernaciková, M., & Paludo, A. C. (2022). The prevalence of menstrual cycle disorders in female athletes from different sports disciplines: A rapid review. *International Journal of Environmental Research and Public Health*, 19(21), 14243.

documented as early as 1982, when Sanborn and colleagues reported that the prevalence of amenorrhea among runners increased from approximately 3% to 60% as weekly training distance rose from 10 kilometers to more than 100 kilometers, an early empirical demonstration of the interaction between physical training load and reproductive suppression that subsequent research has extended to encompass psychological and nutritional stressors.

Cultural and contextual factors also shape both the true prevalence and its recognition. A comparative analysis reported that menstrual dysfunction prevalence among Indian athletes (63.5%) exceeded that observed among Western athletes (50%), a disparity attributed to inconsistent cycle tracking, limited awareness among athletes and support staff, stigmatized communication around menstruation, reluctance to seek medical management, and inadequate institutional systems for monitoring and intervention. Overestimation of body image, that is, athletes perceiving themselves as heavier or less lean than their objective body composition, was independently associated with a higher likelihood of menstrual irregularity, suggesting that psychological constructs around body image interact with, and may compound, the direct physiological drivers of menstrual dysfunction.

A large German survey of elite athletes across multiple sports disciplines who were not using hormonal contraception found that 69% reported a regular menstrual cycle, while 13% reported current oligomenorrhea, 8% current secondary amenorrhea, 2% current primary amenorrhea, and 8% current polymenorrhea. Lifetime prevalence figures were considerably higher, with 10% of athletes reporting a lifetime history of primary amenorrhea and 74% reporting a lifetime history of oligomenorrhea, and the prevalence of primary amenorrhea, both current and lifetime, differed significantly by sport discipline ($p = 0.002$ and $p < 0.001$, respectively), with aesthetic sports again showing the highest rates.

4.2 Functional Hypothalamic Amenorrhea

Functional hypothalamic amenorrhea is the most common cause of secondary amenorrhea among women of reproductive age and represents the clinical endpoint of chronic suppression of GnRH pulsatility in the absence of identifiable organic pathology. The 2017 Endocrine Society Clinical Practice Guideline on FHA characterizes the condition as arising from a combination of psychogenic stress, excessive exercise, and inadequate caloric intake, frequently occurring in combination among competitive athletes⁷. Because FHA is, by definition,

⁷Gordon, C. M., Ackerman, K. E., Berga, S. L., et al. (2017). Functional hypothalamic amenorrhea: An Endocrine Society clinical practice guideline. *Journal of Clinical Endocrinology & Metabolism*, 102(5), 1413–1439.

reversible once the underlying stressor is identified and addressed, distinguishing it from organic causes of amenorrhea is clinically important, though this distinction is frequently overlooked in athletic settings where menstrual absence may be normalized or dismissed as an expected consequence of training.

Mechanistically, FHA is understood as a natural, adaptive suppression of reproductive function during conditions unfavorable to pregnancy, mediated through the tight coupling of HPA axis activation and HPG axis suppression described in Section 2.2. Because not all women exposed to comparable stress, exercise, and energy restriction develop FHA, recent genetic and epigenetic research has begun to characterize inter-individual variability in GnRH neuron resilience, implicating both rare and common genetic variants in genes controlling GnRH neuron development and function, as well as epigenetic modifications responsive to environmental and psychological stress exposure.

4.3 The Female Athlete Triad and Relative Energy Deficiency in Sport

The Female Athlete Triad, first formalized by the American College of Sports Medicine in a 2007 position stand⁸, describes the interrelationship among low energy availability (with or without disordered eating), menstrual dysfunction, and low bone mineral density. Each component may occur independently or in combination, and the triad is conceptualized on a spectrum ranging from optimal health to the full clinical syndrome rather than as a binary diagnosis. Estimates of the prevalence of the complete, three-component triad are relatively low, ranging from approximately 0% to 16% among female athletes depending on population and sport, while the presence of two concurrent components has been estimated at 4% to 18%, and single components, most commonly menstrual dysfunction, are considerably more prevalent still.

Building on the triad framework, the IOC introduced the broader concept of Relative Energy Deficiency in Sport (REDs) in 2014, subsequently updated in 2018 and again in 2023, to capture the fact that low energy availability produces deleterious effects across multiple body systems, extending beyond the three original triad components to include cardiovascular, gastrointestinal, immunological, hematological, and psychological domains, and affecting male as well as female athletes. The 2023 IOC consensus statement notes that more than 170 original research publications advanced the scientific understanding of REDs between the 2018 and 2023 updates, including expanding evidence for the bidirectional relationship between mental health

⁸American College of Sports Medicine, Nattiv, A., et al. (2007). Position stand: The female athlete triad. *Medicine & Science in Sports & Exercise*, 39(10), 1867–1882.

and low energy availability and the introduction of a validated clinical assessment tool, the REDs Clinical Assessment Tool version 2 (CAT2), designed to support early screening, severity stratification, and diagnosis⁹. Some researchers have nonetheless cautioned that the REDs model, despite its wide adoption, requires further rigorous empirical validation, noting that much of the framework's supporting evidence remains observational and that causal pathways between low energy availability and specific downstream outcomes are not yet fully established for every proposed system.

Low bone mineral density, the third component of the classic triad, carries particular long-term significance because approximately 90% of peak bone mineral content is accrued by the end of adolescence, with the two years surrounding menarche representing a period of especially rapid accretion. Chronic menstrual dysfunction during this developmental window, through prolonged hypoestrogenism, can produce lasting deficits in bone density that are not fully reversible even after normal menstruation resumes; one study found that athletes with a history of menstrual irregularity who had regained regular cycles for at least six years still exhibited lumbar spine bone mineral density approximately 15.2% lower than athletes with a consistent history of eumenorrhea. A prospective study of 390 elite Japanese athletes similarly found that triad-related risk factors, including low energy availability and low bone mineral density, were significantly associated with stress fractures, with athletes aged 16 to 17 years demonstrating the greatest susceptibility, reflecting the compounded vulnerability of the peripubertal skeleton to concurrent energy deficiency and menstrual suppression¹⁰.

4.4 Premenstrual Syndrome and Premenstrual Dysphoric Disorder

Beyond outright menstrual dysfunction, cyclical psychological and somatic symptoms in the form of premenstrual syndrome (PMS) and, in its more severe form, premenstrual dysphoric disorder (PMDD), represent a further intersection of psychological stress and reproductive physiology among athletes who otherwise menstruate regularly. A systematic review and meta-analysis of PMS and PMDD among highly trained and elite female athletes noted that professional sport entails not only physical exertion but substantial psychosocial stress arising from competition, performance pressure, high external expectations, and, frequently, financial precarity, all of which may plausibly interact with, or be exacerbated by, premenstrual

⁹Mountjoy, M., Ackerman, K. E., Bailey, D. M., et al. (2023). 2023 International Olympic Committee's (IOC) consensus statement on Relative Energy Deficiency in Sport (REDs). *British Journal of Sports Medicine*, 57(17), 1073–1097.

¹⁰Nose-Ogura, S., Yoshino, O., Dohi, M., et al. (2019). Risk factors of stress fractures due to the female athlete triad: Differences in teens and twenties. *Scandinavian Journal of Medicine & Science in Sports*, 29(10), 1501–1510.

symptomatology. Using an estimated median menarche age of 11.9 years and average competitive career lengths extending to age 28 for individual-sport athletes and age 32 for team-sport athletes, combined with an average of 13 menstrual cycles per year and an average premenstrual symptom duration of 6.4 days, the review's authors estimated that female athletes may experience premenstrual symptoms on approximately 1,237 to 1,621 training days over the course of a competitive career, a substantial cumulative exposure with direct implications for training consistency and performance planning. Separately, research has demonstrated that dysmenorrhea and heavy menstrual bleeding are associated with increased perceived stress and lower mental health scores among affected athletes, further linking menstrual symptomatology to psychological burden.

5. The Stress-Menstrual Dysfunction Interface: Mechanisms and Convergent Pathologies

5.1 Bidirectionality of the Stress-Reproductive Relationship

The relationship between psychological stress and menstrual dysfunction in athletes should be understood as substantially, though not exclusively, bidirectional. Chronic psychological stress activates the HPA axis and, through the CRH-cortisol-kisspeptin-GnRH pathway detailed in Section 2.2, suppresses reproductive function. Conversely, the experience of menstrual dysfunction itself, along with its associated symptoms of dysmenorrhea, heavy bleeding, and unpredictable cycle timing, generates additional psychological distress, creating a feedback loop that may perpetuate or worsen both conditions. Qualitative research capturing the lived experience of elite athletes with menstrual dysfunction describes a pattern in which athletes report feeling dismissed or inadequately supported by coaching and medical staff, compounding the direct physiological burden of the condition with a secondary psychosocial burden of isolation and self-doubt regarding whether their symptoms constitute a legitimate health concern.

5.2 Overtraining Syndrome as a Convergent Stress Pathology

Overtraining syndrome (OTS), historically referred to as staleness, provides a further illustration of the shared neuroendocrine terrain occupied by psychological stress and reproductive dysfunction in athletes. OTS is understood as a stress-related disorder arising when training load chronically exceeds an athlete's recovery capacity, producing alterations in physiological function, impaired psychological processing, immune dysregulation, and biochemical abnormalities, most notably within the HPA axis. Research employing the Endocrine and Metabolic Responses on Overtraining Syndrome (EROS) framework has

demonstrated that athletes affected by OTS display blunted hormonal responses to standardized exercise and pharmacological stress tests, alongside a decreased cortisol awakening response and altered diurnal cortisol rhythm, patterns interpreted as reflecting exhaustion of an axis that has been persistently over-activated, consistent with the exhaustion stage of Selye's general adaptation syndrome. Systematic reviews of OTS report that its psychological correlates, including negative mood, heightened perceived stress, and persistent fatigue, may represent behavioral markers of allostatic load¹¹, and the substantial symptomatic overlap between OTS, REDs, and stress-induced menstrual dysfunction has led some researchers to propose that these labels may, in a meaningful proportion of cases, describe different clinical faces of a single underlying allostatic overload process rather than fully independent conditions.

6. Performance Outcomes

6.1 Menstrual Cycle Phase and Physical Performance

A systematic review following PRISMA guidelines that examined the relationship between menstrual cycle phase and performance specifically among elite athletes identified only seven eligible studies meeting rigorous elite-level criteria, of which five performed direct hormonal verification through blood, saliva, or urine sampling while the remainder relied on menstrual diaries. The review concluded that menstrual cycle phase is associated with variable effects across several performance-related outcomes, including endurance and power output, ligament stiffness, decision-making capacity, and self-reported psychological state and competitiveness, but that the specific parameters affected, together with the magnitude and direction of effect, are inconsistent across studies and do not yet support standardized, evidence-based training individualization recommendations. The authors emphasized that elite-level research in this domain remains disproportionately cross-sectional and underpowered, and called for longitudinal, prospective monitoring of on-field performance metrics alongside verified hormonal status.

Ligamentous and connective tissue properties provide one of the more mechanistically grounded performance-relevant findings in this literature. Research has documented a significant negative correlation between circulating estradiol concentration and anterior cruciate ligament (ACL) stiffness, alongside a significant positive correlation between estrone and ACL stiffness in the periovulatory window, with one study reporting an approximate 17% reduction in knee

¹¹McEwen, B. S. (2000). Allostasis and allostatic load: Implications for neuropsychopharmacology. *Neuropsychopharmacology*, 22(2), 108–124.

joint stiffness at ovulation relative to other cycle phases as measured by standardized knee arthrometry. Because lower-body musculotendinous stiffness is independently associated with performance capacity in explosive and stretch-shortening cycle activities, cyclical hormonal fluctuation in ligament and tendon mechanical properties represents a biologically plausible pathway through which the menstrual cycle could influence both injury susceptibility and force-production performance, even though the net performance implications of this pathway have not been fully characterized in ecologically valid competitive settings.

A longitudinal study of elite female football (soccer) players examining both retrospective self-report questionnaires and daily prospective monitoring found that menstrual cycle- and, where applicable, hormonal contraceptive-related symptoms were more frequent during bleeding phases and were associated with reduced subjective well-being and reduced high-speed running performance, an objective, GPS-derived match-performance metric, underscoring that symptom burden rather than cycle phase per se may be the more proximate determinant of performance decrement. The same body of research found that retrospective questionnaires yielded substantially higher reported symptom prevalence than daily prospective monitoring, a discrepancy with important methodological implications for how menstrual symptom burden is measured and reported across the broader literature.

6.2 Injury Risk Across the Menstrual Cycle

A prospective season-long study of 59 elite adolescent female team-sport athletes that tracked wellness data, time-loss injuries, and menstrual cycle phase using a standardized four-phase model (early follicular, late follicular, early luteal, and late luteal) found that poorer sleep quality and greater fatigue were reported during the early and late luteal phases ($p < 0.001$), and that the luteal phase overall was significantly associated with a higher incidence of joint and ligament injuries ($p = 0.024$) as well as muscle and tendon injuries ($p = 0.040$), relative to the follicular phase. These findings are broadly consistent with the estradiol-mediated ligament stiffness mechanism described above and suggest that injury surveillance and load-management protocols in elite female team sport could plausibly benefit from menstrual cycle awareness, though the authors cautioned that the adolescent, developmentally distinct sample limits direct extrapolation to fully mature elite adult athletes.

6.3 Psychological Stress, Sleep, and Recovery

Given the high physical and psychological demands of elite competition, adequate restorative sleep is considered essential for maintaining recovery and peak performance, yet elite

athletes frequently report unfavorable sleep quality, sleep durations below the recommended seven hours, and worse sleep efficiency relative to non-athlete controls, a vulnerability compounded by intense training loads, frequent travel, and irregular competition scheduling. A three-month longitudinal observational study of elite female basketball players that combined daily self-report with objective fertility-tracker monitoring and twice-weekly salivary hormone sampling to verify cycle regularity found that menstrual cycle phase showed only limited and inconsistent associations with sleep quality and recovery-stress states across the sample, suggesting that individual variability in symptom experience may be a more powerful predictor of recovery status than cycle phase categorization alone. This finding reinforces a broader theme in the literature: population-level associations between cycle phase and outcomes are frequently attenuated or obscured by substantial inter-individual heterogeneity, arguing for individualized rather than universal monitoring approaches.

6.4 Bone Health as a Long-Term Performance Consideration

Because low bone mineral density secondary to prolonged menstrual dysfunction directly elevates the risk of stress fracture, a musculoskeletal injury with substantial time-loss implications in endurance and impact-loading sports, the reproductive and skeletal consequences of chronic psychological and energetic stress carry performance implications that extend well beyond the immediate menstrual cycle. Athletes who develop stress fractures typically require extended periods away from training and competition, and recurrent stress injury is a recognized long-term consequence of unaddressed low energy availability and menstrual dysfunction, particularly when onset occurs during the critical adolescent window of peak bone mineral accretion.

7. Sociocultural and Contextual Moderators

The prevalence, recognition, and management of both psychological stress and menstrual dysfunction among elite female athletes are substantially shaped by sociocultural context. As noted in Section 4.1, comparative research has documented higher rates of menstrual dysfunction among Indian athletes relative to Western counterparts, attributed to a combination of inconsistent cycle tracking, limited awareness among athletes and support staff, and stigmatized communication norms around menstruation that discourage open discussion and timely medical intervention. Sport type functions as a further moderator, with aesthetically judged and leanness-emphasizing disciplines, including distance running, gymnastics, and professional dance, showing disproportionately high rates of both menstrual dysfunction and comorbid mental health

symptomatology, plausibly reflecting the combined influence of sport-specific body composition pressures, subjective performance evaluation criteria, and the psychological weight of appearance-based scrutiny.

Financial and structural factors also warrant emphasis. Research among elite female beach volleyball players found that financial insecurity, rather than competitive success, was a significant independent predictor of psychological burden, a finding consistent with broader observations that many women's sports offer more limited professional remuneration and career security than their male counterparts, adding a layer of chronic socioeconomic stress atop the physical and competitive demands common to elite sport generally. Institutional and cultural stigma surrounding both mental health and menstrual health further compounds under-recognition: athletes may be reluctant to disclose symptoms for fear of appearing weak, jeopardizing selection, or being perceived as making excuses, a pattern documented across qualitative research on athletes' lived experience of menstrual dysfunction and echoed in survey research on barriers to mental health disclosure in elite sporting environments.

8. Methodological Limitations in the Existing Literature

Several recurring methodological limitations constrain the strength of causal inference that can currently be drawn from the literature on stress, menstrual dysfunction, and performance in elite female athletes. First, a substantial proportion of studies rely on retrospective self-report of both menstrual history and psychological symptoms, a method demonstrably prone to recall bias and, as noted in the football performance study reviewed above, associated with higher reported symptom prevalence than prospective daily monitoring. Second, direct hormonal verification of menstrual cycle phase, considered the methodological gold standard, remains inconsistently applied; the elite-athlete performance review discussed in Section 6.1 found that fewer than half of the small number of eligible elite-level studies performed such verification. Third, sample sizes in elite-level research are frequently small, a near-unavoidable consequence of the restricted population of athletes competing at the highest competitive tiers, which limits statistical power and generalizability; the basketball sleep and recovery study reviewed in Section 6.3, for example, retained only eight athletes in its final analysis. Fourth, cross-sectional study designs predominate over the longitudinal, prospective designs needed to establish temporal and causal relationships between psychological stress exposure, menstrual dysfunction onset, and subsequent performance change. Finally, definitional inconsistency across studies, in terms of what constitutes menstrual dysfunction, elite athlete status, and clinically significant

psychological distress, complicates direct comparison and meta-analytic synthesis across the literature, contributing to the wide prevalence ranges reported throughout this review.

9. Implications for Athlete Monitoring and Interdisciplinary Management

The evidence reviewed here supports several practical implications for the medical and coaching staff responsible for elite female athlete welfare. Routine, non-stigmatizing menstrual cycle screening, incorporating validated tools such as the IOC REDs Clinical Assessment Tool version 2¹², should be considered a standard component of periodic health evaluation rather than an optional addendum, given the demonstrated capacity of menstrual dysfunction to serve as an early, visible marker of underlying low energy availability and chronic stress that might otherwise go undetected until more serious skeletal or psychological sequelae emerge. Because psychological stress and menstrual dysfunction are mechanistically and empirically interconnected, screening protocols and support structures addressing one domain in isolation from the other risk overlooking cases in which the two conditions are mutually reinforcing. Given the consistent finding that individual variability often exceeds population-level cycle-phase effects, individualized athlete monitoring, incorporating self-reported symptom tracking alongside objective physiological and performance data, is likely to be more clinically useful than the application of generalized cycle-phase training templates. Finally, addressing the structural and cultural stressors identified in Section 7, including financial precarity, communication quality within teams, and stigma surrounding disclosure, represents an upstream intervention point that may reduce the psychological stress burden contributing to menstrual dysfunction before it manifests as clinical pathology.

10. Conclusion

Psychological stress and menstrual irregularities among elite female athletes are linked through well-characterized neuroendocrine pathways centered on the interaction between the HPA and HPG axes, and this linkage carries demonstrable, though heterogeneous, implications for athletic performance, injury risk, and long-term skeletal health. The available epidemiological evidence indicates that menstrual dysfunction affects a substantial minority to majority of elite female athletes depending on sport and population, that psychological distress symptoms are common and disproportionately affect female relative to male athletes, and that

¹²Mountjoy, M., Ackerman, K. E., Bailey, D. M., et al. (2023). 2023 International Olympic Committee's (IOC) consensus statement on Relative Energy Deficiency in Sport (REDs). *British Journal of Sports Medicine*, 57(17), 1073–1097.



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the two conditions frequently co-occur within the broader clinical constructs of the Female Athlete Triad, Relative Energy Deficiency in Sport, and overtraining syndrome. Performance-relevant consequences, spanning ligament mechanics, injury incidence, sleep and recovery, and objective match performance metrics, are increasingly documented but remain characterized by considerable inter-individual variability and methodological heterogeneity that limit the formulation of universal, evidence-based training recommendations. Future research employing prospective, hormonally verified, adequately powered designs, together with greater institutional investment in individualized athlete monitoring and destigmatized health disclosure, will be necessary to translate the current mechanistic understanding into practical frameworks capable of protecting the health and optimizing the performance of elite female athletes.

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