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FUNCTIONAL HYPOTHALAMIC AMENORRHEA - DIAGNOSTIC OVERLAP WITH PCOS AND ITS RELEVANCE IN THE FEMALE ATHLETE TRIAD: CURRENT CHALLENGES AND THERAPEUTIC STRATEGIES

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ABSTRACT

Introduction and Purpose: Functional hypothalamic amenorrhea (FHA) accounts for a significant proportion of secondary amenorrhea and remains frequently overlooked, particularly in active women. Its clinical overlap with polycystic ovary syndrome (PCOS) complicates accurate diagnosis. In athletes, FHA arises primarily from low energy availability, forming a key component of the Female Athlete Triad. This review aims to summarize current evidence on the pathophysiology, diagnostic challenges, and therapeutic strategies for FHA, with emphasis on implications for women engaged in high levels of physical activity.

Methods: A narrative literature review was conducted using the PubMed database, covering publications from 2012 to 2025. Search terms included amenorrhea, functional hypothalamic amenorrhea, polycystic ovary syndrome, and female athlete triad. Thirty-two relevant sources were included.

Description of the State of Knowledge: FHA develops due to reduced pulsatile secretion of gonadotropin-releasing hormone (GnRH), resulting in suppressed LH and FSH release and impaired ovulation. Key contributing factors-energy deficit, excessive training, and psychological stress-disrupt neuroendocrine regulation and activate the hypothalamic-pituitary-adrenal axis. Recent studies highlight altered cortisol rhythms and changes in neurokinin B and nesfatin-1 as potential mechanisms. Differentiating FHA from PCOS remains a diagnostic challenge, particularly given the high prevalence of polycystic ovarian morphology in both conditions. Hormonal parameters such as SHBG, testosterone, and the LH:FSH ratio provide useful discrimination. Treatment focuses on restoring energy availability through nutritional rehabilitation and activity modification, supported by psychological interventions when indicated. For fertility restoration, pulsatile GnRH therapy offers a physiological approach, while IVF remains an effective alternative. Emerging options-including kisspeptin and L-carnitine-show promise in modulating neuroendocrine pathways.

Conclusion: FHA is a prevalent yet underrecognized condition with substantial reproductive and skeletal consequences. Early identification and multidisciplinary management are essential to improving long-term health outcomes, particularly among physically active women.

KEYWORDS

Functional Hypothalamic Amenorrhea, Polycystic Ovary Syndrome, Female Athlete Triade, Amenorrhea

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Introduction and purpose

Secondary amenorrhea is a complex issue with multifactorial etiology. It is defined as the absence of menstruation for at least three months in individuals with previously regular menstrual cycles or for at least six months in those with previously irregular cycles. Functional hypothalamic amenorrhea accounts for approximately 35% of all cases of secondary amenorrhea, making it one of the most common causes of this condition(Lord et al., 2025). Despite its prevalence, FHA remains insufficiently characterized and often underrecognized in clinical practice. Moreover, there is a notable lack of high-quality research aimed at advancing both diagnostic methods and therapeutic strategies. An additional challenge is the clinical overlap and frequent diagnosis of polycystic ovary syndrome (PCOS), which may coexist with or mimic FHA, as it represents one of the most common causes of amenorrhea as well. A particular case of FHA is observed in athletes whose daily energy intake does not meet the high caloric demands. This energy imbalance is associated with the Female Athlete Triad, a condition seen in physically active adolescent girls and women. The triad is characterized by three key components: low energy availability with or without disordered eating, menstrual dysfunction, and low bone mineral density(De Souza et al., 2014).

The purpose of this review is to summarize the current state of knowledge on FHA and the female athlete triad, and to highlight potential new directions for diagnosis and treatment based on the most recent research findings.

Materials and methods

The literature review was conducted using the PubMed database, focusing on publications from 2012 to 2025. The search included keywords such as amenorrhea, functional hypothalamic amenorrhea, polycystic ovary syndrome, and female athlete triad. A total of 32 sources were ultimately cited.

Description of the state of knowledge

Pathogenesis

As the term implies, FHA is a disorder without clearly identifiable organic causes. The primary mechanism underlying menstrual cycle disruption in FHA is a decrease in gonadotropin-releasing hormone (GnRH) secretion, leading to a reduction in the pulsatile release of luteinizing hormone (LH). Consequently, levels of both LH and follicle-stimulating hormone (FSH) decline, impairing folliculogenesis and inhibiting ovulation. A significant connection exists between activation of the hypothalamic-pituitary-adrenal (HPA) axis and the impairment of GnRH secretion(Gordon et al., 2017).

Numerous factors can disrupt the HPA axis. The current FIGO classification of ovulatory disorders outlines potential causes of the condition using the acronym GAIN-FIT-PIE, which stands for Genetic, Autoimmune, Iatrogenic, Neoplastic, Functional, Infectious/Inflammatory, Trauma and vascular, Physiological, Idiopathic, and Endocrine(Munro et al., 2022). This indicates a variety of potential causes, many of which are challenging to diagnose. Therefore, the diagnosis of FHA should be made only after excluding other anatomical and organic factors(Gordon et al., 2017). A detailed clinical history is essential in the diagnostic process, with particular focus on dietary habits, physical activity, body image concerns and weight-related attitudes, as well as psychosocial stressors-all of which are closely associated with FHA pathogenesis. Weight loss, excessive exercise, and psychological stress are the three main contributing factors, all of which can suppress GnRH secretion(Lord et al., 2025). A common underlying factor in both weight loss and increased physical activity in the pathogenesis of FHA is an energy deficiency, which plays a key role in the development of FHA.

Diagnostic Approach

Diagnostic evaluation of FHA should be considered only in cases of amenorrhea lasting at least three months or when menstrual cycles are consistently prolonged beyond 45 days. Once the diagnosis is confirmed, it is recommended to educate the patient about the various potential patterns of menstrual recovery during treatment and to reassure them that irregular menstruation does not rule out the ability to conceive(Gordon et al., 2017).

The diagnostic approach should begin with excluding pregnancy and performing a comprehensive gynecological examination to rule out anatomical causes of amenorrhea. This should be complemented by basic laboratory screening tests, including complete blood count, electrolytes, glucose, bicarbonate, blood urea nitrogen, creatinine, liver function tests, β-hCG and inflammatory markers if needed. The next step involves endocrine evaluation and should include measurement of LH, FSH, estradiol (E2), anti-Müllerian hormone (AMH), thyroid-stimulating hormone (TSH), and free thyroxine (T4). In the presence of clinical signs of hyperandrogenism, it is recommended to assess total testosterone and dehydroepiandrosterone sulfate (DHEA-S) levels. If late-onset congenital adrenal hypoplasia is suspected, measurement of 17-hydroxyprogesterone should also be included(Gordon et al., 2017).

An additional diagnostic tool is the progesterone challenge test, used to assess for withdrawal bleeding, which can help rule out an obstruction within the outflow tract. In patients presenting with a history of severe and persistent headaches, episodes of vomiting, visual disturbances, dysregulation of thirst and urinary output, neurological symptoms, or laboratory evidence suggestive of pituitary dysfunction, contrast-enhanced magnetic resonance imaging (MRI) of the brain should be considered essential to exclude structural abnormalities of the hypothalamic-pituitary region(Gordon et al., 2017).

Underlying mechanisms potentially involved

Beyond GnRH suppression, recent studies suggest additional neuroendocrine factors may play a role in the pathogenesis of FHA.

Emerging evidence has identified neurokinin B (NKB) as a potential contributing factor in the pathogenesis of FHA. This tachykinin plays a pivotal role in reproductive regulation, primarily through its modulatory effect on kisspeptin secretion-a key neuropeptide involved in the activation of the hypothalamic-pituitary-gonadal axis. Notably, reduced serum levels of kisspeptin have been consistently observed in women

with FHA, suggesting upstream dysregulation. In a comparative analysis, the study assessed NKB concentrations in women diagnosed with FHA and in healthy controls. The findings revealed significantly lower levels of NKB in the FHA group, supporting the hypothesis that impaired NKB signaling may contribute to reproductive suppression in this condition. These insights open new perspectives for understanding the neuroendocrine mechanisms underlying FHA and point toward potential therapeutic interventions targeting this pathway(Szeliga et al., 2023).

A recent retrospective case-control study investigated prolactin levels in patients with FHA, based on the assumption that stress-induced hyperprolactinemia might reflect the stress-related etiology of the condition. However, the results demonstrated no significant difference in prolactin concentrations between the FHA group and healthy controls. Interestingly, the study suggested that certain FHA-associated factors, such as disordered eating behaviors and excessive physical activity, may actually contribute to a reduction in prolactin levels. This highlights the complex interplay between metabolic stress, metabolic state and prolactin dynamics in the pathogenesis of FHA(Selzer et al., 2024).

A pilot study investigated whether cortisol levels, a well-known biomarker of psychological stress, are altered in women with functional hypothalamic amenorrhea. Salivary cortisol was measured in both FHA patients and healthy controls at various times throughout the day. Interestingly, the FHA group exhibited significantly elevated morning cortisol levels, while cortisol concentrations later in the day were comparable between the two groups. These findings suggest a possible disruption of the diurnal cortisol rhythm in FHA, potentially associated with underlying psychological stress and hypothalamic dysregulation(Koukoubanis et al., 2023).

Potential diagnostic approaches

Studies have identified potential biomarkers that may facilitate the diagnostic differentiation of FHA, potentially offering new avenues for differential diagnosis.

One study investigated nesfatin-1 as a novel biomarker for FHA. Nesfatin-1, a peptide involved in regulating metabolism, gastrointestinal function, and feeding behaviors, was measured in women diagnosed with FHA and compared to healthy controls. The results revealed a significantly reduced concentration of nesfatin-1 in the FHA group. This reduction may reflect the metabolic and neuroendocrine alterations characteristic of FHA and suggests that nesfatin-1 could serve as a promising target for future research into both the pathophysiology and diagnostic evaluation of the disorder(Szeliga et al., 2022).

Another study aimed to identify an early marker for reduced bone quality, specifically osteopenia, prior to performing a DXA scan. The levels of irisin, a myokine involved in osteoblast differentiation, were measured in both the FHA group and the control group. The results showed that patients with FHA had significantly lower irisin levels compared to healthy controls. Furthermore, the FHA group also demonstrated significantly lower total body mass density. As a conclusion, irisin could serve as an early biomarker for osteopenia in this population. However, larger studies are required to validate these preliminary observations(Notaristefano et al., 2022).

Diagnostic Challenges in Differentiating Functional Hypothalamic Amenorrhea from Polycystic Ovary Syndrome

The differential diagnosis in women presenting with amenorrhea or irregular menstrual cycles poses a considerable clinical challenge. In some cases, diagnostic tests fail to clearly identify the underlying etiology. FHA and PCOS are both among the most common causes of secondary amenorrhea. FHA accounts for approximately 35% of these cases, while 30–40% are attributed to chronic anovulatory disorders, most commonly PCOS. PCOS affects an estimated 8–13% of women of reproductive age. Clinical features of hyperandrogenism often support the diagnosis of PCOS; however, due to the broad phenotypic spectrum, it is possible that up to half of PCOS patients without overt hyperandrogenic signs may actually have FHA. Assessment of both free and total testosterone levels may aid in the differential diagnosis. Additionally, gonadotropin levels tend to be lower in patients with FHA compared to those with PCOS(Gordon et al., 2017).

Importantly, FHA and PCOS may coexist. A retrospective study demonstrated that PCOS may coexist in up to 10% of women diagnosed with FHA. Two potential explanations for this association have been proposed: either FHA may facilitate the emergence of PCOS, or conversely, a mild phenotype of PCOS may predispose individuals to the development of FHA. Although the underlying pathophysiological mechanisms remain unclear, both conditions may share common predisposing factors which could contribute to their overlap. Further research is warranted to elucidate the nature of this relationship and the mechanisms

involved(Carmina et al., 2016). Compared to women with FHA alone, patients with overlapping FHA and PCOS tend to exhibit higher BMI, bone mineral density, LH, and testosterone levels, along with more frequent manifestations of hyperandrogenism(Gordon et al., 2017).

Differentiating between FHA and PCOS can be particularly difficult due to overlapping clinical features. A significant complicating factor is that up to 50% of women with FHA may exhibit polycystic ovarian morphology (PCOM) on ultrasound. The most diagnostically challenging scenario arises when differentiating between FHA with PCOM and non-hyperandrogenic PCOS. In a retrospective study aimed at estimating the rate of misdiagnosis, it was found that between 1.7% and 36.9% of women had been referred for PCOS management instead of FHA. This substantial proportion of misclassified cases underscores the need for refined diagnostic frameworks and heightened clinical vigilance to ensure accurate identification and appropriate management of FHA(Holzer et al., 2024).

PCOM, identified via ultrasound, is found in approximately 30% of healthy women and in 30–50% of women with FHA(Holzer et al., 2024)(Robin et al., 2012)(Hager et al., 2023). PCOM in this population is frequently detected as an incidental finding, with uncertain clinical significance, mirroring its occurrence in the general population. In a retrospective analysis, it was demonstrated that PCOM is a common but nonspecific ultrasound feature in women with FHA. The authors emphasized that its presence should not be considered diagnostic of PCOS in the absence of other defining clinical and biochemical features. Thus, the identification of PCOM on ultrasound should be interpreted with caution and not used in isolation to diagnose PCOS(Robin et al., 2012).

Psychological stress is recognized as one of the potential etiological factors of FHA. In a study investigating the presence of PCOM among women with FHA, two patient subgroups were analyzed: one in which FHA was induced by psychological stress, and another in which it was triggered by excessive physical activity. PCOM was identified in nearly half of all participants; however, the prevalence was significantly higher in the stress-induced FHA group. These findings suggest not only a more pronounced role of stress in the pathophysiology of FHA but also raise the possibility of a mechanistic link between FHA and PCOS. Moreover, the study highlighted increased stress sensitivity in women with PCOS, proposing that this vulnerability may predispose them to developing FHA under certain circumstances(Hager et al., 2023).

In another retrospective observational study, the relationship between AMH levels and gonadotropins was evaluated in women with FHA, with or without PCOM. Among women with FHA, 42% were found to have PCOM, and this subgroup demonstrated lower gonadotropin and estradiol levels. In patients with FHA without PCOM, lower AMH levels and a weaker LH response to GnRH stimulation were observed compared to those with FHA and PCOM. Furthermore, after three months of pulsatile GnRH therapy, AMH levels significantly increased, suggesting that the initially low AMH levels in this group were due to gonadotropin deficiency rather than reduced ovarian reserve. The study concluded that the differences observed between FHA patients with and without PCOM might result from additional pre-existing abnormalities that preceded the diagnosis of FHA(Hager et al., 2022).

Additionally, in patients with FHA and coexisting PCOM-particularly in the presence of elevated AMH levels-there may be an increased risk of developing hyperandrogenic PCOS after the restoration of normal hypothalamic-pituitary-ovarian axis function(Gordon et al., 2017).

Another significant challenge in differential diagnosis is distinguishing between FHA with PCOM and type D PCOS -defined by the absence of hyperandrogenism. These two patient groups are particularly difficult to distinguish due to their highly similar clinical presentation and the absence of clearly defined discriminative parameters. A retrospective case-control study was the first to attempt a direct comparison of patients from these two groups. The study focused hormonal parameters, including testosterone, LH, the LH:FSH ratio, SHBG, and estradiol. The study found that women with FHA-PCOM had significantly higher SHBG levels, whereas those with type D PCOS presented with elevated LH, estradiol, testosterone, and a higher LH/FSH ratio. Among the evaluated parameters, testosterone, LH, the LH/FSH ratio, and SHBG were identified as the most useful for differential diagnosis. Collectively, the hormonal profile characterized by lower testosterone, LH, and LH/FSH ratio, along with elevated SHBG levels, was more indicative of FHA-PCOM than type D PCOS. Nonetheless, the authors noted that additional studies are required to confirm these findings and improve diagnostic accuracy(Beitl et al., 2022).

Another observational study investigated the potential of differentiating FHA from PCOS based on LH and FSH levels. However, considerable interindividual variability in absolute hormone concentrations limits their diagnostic utility. Instead, the study focused on the LH:FSH ratio and found that the majority of patients with FHA exhibited a ratio below 1. This finding contrasts with the hormonal profile typically observed in

PCOS, where the LH:FSH ratio is frequently elevated. These results support the potential utility of the LH:FSH ratio as part of a broader diagnostic framework, although further research with larger cohorts is necessary to confirm its specificity and clinical applicability(Boegl et al., 2024).

Therapeutic Approaches

The management of women diagnosed with FHA should be holistic and multidisciplinary, with a primary focus on addressing the underlying causes of the condition. In cases where low body weight or excessive physical activity is identified as a contributing factor, correcting the energy deficit is essential—either by increasing caloric intake or reducing the level of physical exertion. Psychological support, such as cognitive-behavioral therapy (CBT), plays a key role, especially in patients where stress is a major contributing factor(Gordon et al., 2017). A randomized controlled trial demonstrated that CBT is an effective treatment for FHA. In the majority of participants, CBT led to the restoration of ovarian activity and improvement of the neuroendocrine and metabolic disturbances commonly associated with FHA, including a reduction in cortisol levels. Despite the study's relatively small sample size, particular emphasis is placed on the high rate of ovulatory recovery observed among patients receiving CBT(Michopoulos et al., 2013). If spontaneous menstruation does not resume following non-pharmacological interventions, hormonal replacement therapy is recommended. This typically involves transdermal estrogen administration in combination with cyclic oral progestin(Gordon et al., 2017).

When pregnancy is desired, the therapeutic strategy should be adjusted accordingly. Pulsatile GnRH therapy represents the first-line treatment for ovulation induction in this context(Gordon et al., 2017). Clinical evidence supports its efficacy in restoring fertility in women with FHA, with both subcutaneous and intravenous administration proving effective. However, the subcutaneous route is generally favored due to its superior safety profile and greater convenience in outpatient use(Christou et al., 2017). Another study confirmed the efficacy and safety of subcutaneous pulsatile GnRH administration using a portable infusion pump. This method was also compared with conventional treatment using injectable gonadotropins. The findings indicated that pulsatile GnRH therapy is a safer and more physiological alternative. It is associated with a significantly lower risk of multifollicular ovulation, which in turn reduces the likelihood of multiple pregnancies and ovarian hyperstimulation syndrome(Quaas et al., 2022). Further research has shown that the presence of PCOM in women with FHA does not impair the efficacy of pulsatile GnRH therapy. Outcomes in this subgroup were comparable to those in women with FHA without PCOM(Dumont et al., 2016).

In cases of infertility in woman with FHA, in vitro fertilization (IVF) remains a viable treatment option. Although these patients may require prolonged stimulation and higher doses of gonadotropins, IVF outcomes are generally comparable to those observed in women with infertility of other etiologies(Zhang et al., 2022).

Another particularly interesting study focused on the evaluation of gut microbiota composition in patients with FHA and the impact of hormone replacement therapy (HRT) on its modulation. The study revealed significant differences in the gut microbial profile of women with FHA compared to healthy controls, and importantly, demonstrated that HRT led to favorable alterations in the microbiota composition. These changes were associated with reduced inflammatory markers and the restoration of physiological estrogen levels. The findings underscore the multifactorial nature of FHA and further support its connection to the gut–brain axis. Hormonal imbalances and chronic stress-both central to the pathophysiology of FHA-may disrupt this axis and contribute to a state of chronic low-grade inflammation. As the first study to explore this area, the authors called for further research to explore these connections in more detail(Notaristefano et al., 2024).

An adjunctive approach that may support recovery in FHA is the short-term administration of estriol for a duration of 10 days. One study demonstrated that this intervention improves the neuroendocrine regulation of the hypothalamic-pituitary axis. Specifically, estriol supplementation was associated with a significant increase in plasma levels of LH and FSH, suggesting reactivation of gonadotropin synthesis and secretion. Additionally, a marked improvement in hormonal responsiveness to bolus GnRH administration was observed following therapy. These findings underscore the importance of even slight increases in circulating estrogens in facilitating the recovery of hypothalamic-pituitary function in women with FHA(Genazzani et al., 2016).

Recent research has explored alternative therapeutic avenues for the management of FHA. One such investigation evaluated the use of L-carnitine and L-acetylcarnitine supplementation as a potential treatment. Following a 12-week intervention in women with FHA, improvements were observed in both hormonal and metabolic parameters, including increased plasma LH levels and reduced cortisol concentrations. The greatest benefit was observed in participants with initially low LH levels, who also demonstrated an improved LH response following GnRH stimulation. Although the results are promising, it is important to note that this was

an interventional study without a control group. Therefore, further well-designed, controlled trials are needed to validate these findings and determine the true therapeutic potential of carnitine supplementation in FHA(Genazzani et al., 2017).

Another study exploring a novel therapeutic pathway investigated the use of kisspeptin-54 administered via continuous intravenous infusion. The results demonstrated a favorable effect in women with FHA, with a temporary increase observed in both basal and pulsatile LH secretion, and also provided preliminary insights into the therapeutic dose range of kisspeptin-54. While the findings suggest a potential role for kisspeptin in restoring reproductive axis function, the authors emphasized the major limitation of the study-its very small sample size. Nevertheless, the results provide preliminary evidence supporting the potential of kisspeptin-54 as a novel treatment option for FHA and underscore the need for further comprehensive research in this area(Jayasena et al., 2014).

The Female Athlete Triad

Another topic that deserves attention is menstrual disorders occurring in the context of the female athlete triad and their relationship with FHA. The female athlete triad is a condition affecting physically active adolescent girls and women. The prevalence of the Female Athlete Triad ranges from 1% to 14%, with the highest rates observed in professional ballet dancers. While it can affect any female athlete, those participating in weight-class sports or disciplines emphasizing leanness-such as rowing, ballet, long-distance running, gymnastics, and swimming-are at greatest risk(Berz & McCambridge, 2016). As defined in 1997, it consists of three interrelated components: low energy availability (which may or may not be associated with disordered eating), menstrual dysfunction, and reduced bone mineral density. In 2007, a revised conceptual framework was introduced, describing the triad as a spectrum disorder involving low energy availability (with or without disordered eating), osteoporosis, and FHA(De Souza et al., 2014)·(Mountjoy et al., 2018). The primary etiological factor underlying this condition is low energy availability (LEA). In terms of reproductive dysfunction, LEA disrupts the pulsatile secretion of GnRH in the hypothalamus, leading to impaired release of LH and FSH, along with reduced levels of estradiol and progesterone. This hormonal imbalance results in a form of FHA(Mountjoy et al., 2018).

A direct relationship between LEA and menstrual dysfunction has been investigated in randomized controlled trial. LEA appears to have the most pronounced effect on LH pulse frequency. It has been demonstrated that even a single episode of reduced energy availability can lead to a decrease in LH pulse frequency. Importantly, no distinct threshold for energy availability was identified, indicating that even moderate reductions may adversely affect the menstrual cycle. Alterations in LH pulsatility were most strongly associated with luteal phase defects. These findings highlight that even relatively small and sustained decreases in energy availability-such as those occurring in women attempting weight loss-can result in meaningful impairments of the reproductive axis(Koltun et al., 2020).

There is also evidence suggesting a relationship between components of the female athlete triad and oxytocin secretion. In a comparative study, average nocturnal oxytocin levels were found to be lower in athletes-both those with amenorrhea and those with regular menstrual cycles-compared to non-athletic controls(Lawson et al., 2013). Another study aimed to evaluate whether oxytocin plays a role in energy homeostasis among this population. In athletes experiencing amenorrhea, oxytocin levels were found to be strongly associated with energy balance in the context of energy deficiency. A significant correlation was observed between low energy availability and decreased oxytocin concentrations. These findings suggest that oxytocin may be involved in the regulation of energy status, particularly under conditions of chronic energy deficit such as those seen in female athletes. However, as in other studies, the authors emphasized the need for further large-scale research to clarify the exact role of oxytocin in this context(Lawson et al., 2014).

Low bone mineral density (BMD) is one of the clinical endpoints of the Female Athlete Triad and is closely interrelated with the other components. Energy deficiency plays a causal role in the development of both menstrual dysfunction and low BMD. Additionally, the hypoestrogenic state resulting from functional hypothalamic amenorrhea is a critical factor contributing to impaired bone health. In untreated cases of amenorrhea, annual bone loss may reach 2–3%, posing a particular threat during adolescence, a critical window for skeletal development. If not addressed in time, these deficits may become irreversible, significantly increasing the risk of osteopenia, osteoporosis, and fractures later in life(De Souza et al., 2014).

A cross-sectional study among patients with FHA, 15% were found to have BMD. The study showed that lumbar spine and femoral neck BMD positively correlated with muscle mass, BMI, BMR, and gonadotropin levels-highlighting the importance of early screening and muscle mass restoration to prevent

osteoporosis in this population(Lu et al., 2024). The relationship between oxytocin and bone architecture and strength has also been investigated in physically active women with amenorrhea. In this group, lower oxytocin concentrations were significantly correlated with reduced cortical bone density and decreased trabecular thickness. These skeletal impairments were most evident in the distal radius, a region particularly vulnerable to stress-related changes due to repetitive mechanical loading during physical activity. These observations have led to the hypothesis that oxytocin may play a role in bone loss and compromised skeletal integrity, particularly under conditions of estrogen deficiency commonly observed in this population. This line of research raises the possibility that oxytocin could serve as a potential therapeutic target for the prevention or treatment of bone loss in this population(Lawson et al., 2013).

The primary underlying factor contributing to menstrual disturbances is LEA, often resulting from insufficient caloric intake. However, additional contributing factors may lie in the nutritional composition of the diet. In a study comparing diet quality among active women with normal ovulatory cycles and those with oligo/amenorrhea, with or without features of subclinical hyperandrogenism, clear differences emerged. The group with oligo/amenorrhea and elevated androgen levels demonstrated the poorest diet quality and the lowest intake of key micronutrients, including vitamins A, B2, B6, B12, magnesium, and potassium(Łagowska et al., 2022). Such evidence highlights that, beyond meeting caloric requirements, the nutritional value and micronutrient richness of the diet are equally crucial. While current dietary recommendations focus primarily on calcium and vitamin D due to their impact on bone mineral density, a broader assessment of micronutrient status is warranted. Women affected by these disturbances should undergo comprehensive nutritional assessment, ideally conducted by a sports dietitian, to ensure individualized and effective dietary strategies are implemented(De Souza et al., 2014).

Conclusions

FHA is a prevalent yet often underdiagnosed cause of secondary amenorrhea, particularly in young, physically active women. Diagnostic challenges stem from its clinical overlap with PCOS and the frequent incidental finding of PCOM. These complexities highlight the need for thorough, individualized diagnostic evaluation. The foundation of effective management lies in restoring energy availability, typically through nutritional rehabilitation and, when appropriate, psychological support. In women seeking pregnancy, pulsatile GnRH therapy remains the most physiological and effective option for ovulation induction. Novel therapies-such as kisspeptin, L-carnitine, and estriol-offer promising avenues but require further investigation. The Female Athlete Triad illustrates the broader impact of chronic energy deficiency on reproductive and bone health. Early recognition, multidisciplinary care, and individualized interventions are key to preventing long-term complications and improving overall outcomes in affected women.

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