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Health problems among women in sports: the female athlete triad

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ABSTRACT:

Introduction:

Over the years the participation of women in sports and physical activities has significantly increased. The rise in the number of female athletes has brought to attention the health issues specific to this population. The Female Athlete Triad is a syndrome in which the affected woman presents the combination of three intertwined conditions such as (1) low energy availability, (2) menstrual dysfunction, and (3) low bone mineral density. The crucial factor in the pathophysiology is energy imbalance, which leads to impairment of the reproductive and skeletal system, eventually having a very harmful effect on the whole organism and leading to appalling short-term and long-term consequences. It affects women of all ages and from every sports discipline, but most at risk are those in adolescence involved in sports that prioritize leanness and endurance.

Purpose:

The objective of this article is to review the current state of knowledge about the Female Athlete Triad, spreading awareness of this syndrome, which is still very low in society, and highlighting the importance of early identification and multidisciplinary treatment to prevent serious complications.

Materials and methods:

The review was based on a comprehensive analysis of the available literature sourced from PubMed, Google Scholar, and other scientific articles, which was searched by using listed keywords and analysed for topic relevance and knowledge currency.

KEYWORDS: Female Athlete Triad; energy availability; menstrual dysfunction; bone density;

INTRODUCTION:

For centuries, participation in sports activities has been stereotypically believed to be a male domain, excluding women and diminishing their abilities to compete among men. In the 19th century due to the rise of the women's suffrage movement, which fought for gender equality and women's right to vote, the status of females in various aspects of life has gradually improved [1,2]. In 1972 Title IX of the Education Amendments was published – the document prohibited sex discrimination in all aspects of education, leading to an increase by 6 times in involvement of young females in physical activities [1,3]. In 1990, the first group of women competed at the Summer Olympic Games in Paris, evolving the role of female athletes [4].

Since then, the participation of women population in sports and physical activities has significantly increased, and along with it health issues specific to the female population of athletes have emerged. One of them worth recognition is the "**Female Athlete Triad"**(the Triad), originally described in 1992 by the American College of Sports Medicine as a triad of amenorrhea, osteoporosis, and disordered eating. With time, the definition has changed, allowing it to include a broader spectrum of each component and its clinical manifestations. Nowadays, the **Female Athlete Triad** *(Figure 1.)* is known as a syndrome consisting of:

1) **low energy availability** – with or without eating disorders;
2) **menstrual dysfunction**;
3) **low bone mineral density**;

Although the affected women might exhibit one, two, or all components listed above, and can vary widely along the spectrum for each component, these three conditions are strictly interrelated [5,6]. The energy imbalance caused by insufficient calorie intake or very high energy output impacts the normal functioning of various systems and organs in the body, among others, leading to the impaired regulation of the reproductive axis.

It results in menstrual cycle dysfunction and as an outcome low estrogen level, whose deficiency plays an important role in the pathogenesis of osteoporosis [7].
Undiagnosed and untreated, the Female Athlete Triad creates a great danger of lifelong consequences and can be potentially fatal [8]. Symptoms are often missed or ignored as in the beginning they might be very subtle so it's extremely crucial for people from the athletes surrounding to be more alert and sensitive to any signs. The objective of this article is to review the current state of knowledge about the Female Athlete Triad, spreading awareness of this syndrome, which is still very low in society, and highlighting the importance of early identification and multidisciplinary treatment to prevent serious complications.

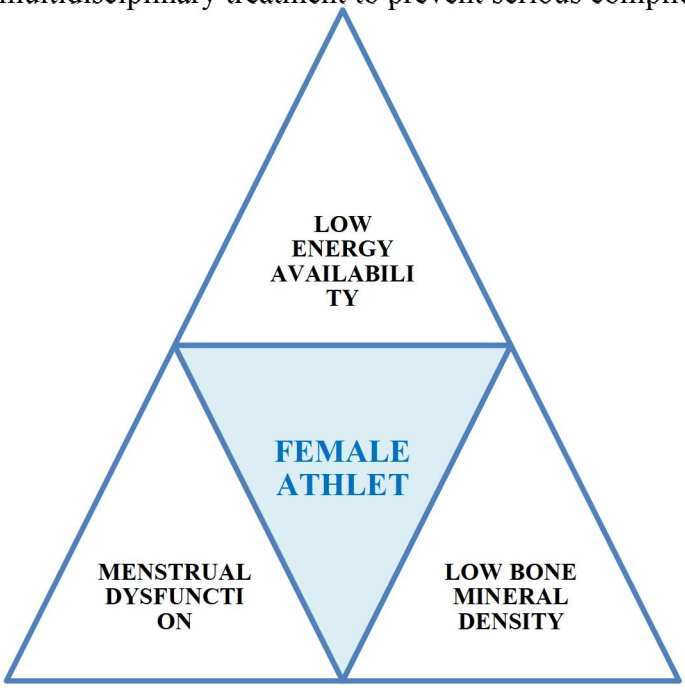

Figure 1. **Female Athlete Triad (Triad)**

EPIDEMIOLOGY AND RISK FACTORS

Estimating the true prevalence of the Female Athlete Triad in exercising women causes numerous challenges, because, as mentioned before, the spectrum of three conditions of the Triad is very complex and the syndrome remains underdiagnosed. The analysis conducted by J. Gibbs et al. shows that only a comparatively low percentage of them display all three triad components (0%-15.9%), while the prevalence of any two ranges from 2.7% to 27.0%. A higher percentage exhibit one component with rates ranging from 16 to 60% [9].
Females of all ages can be affected, but it occurs most frequently during adolescence. No sport discipline is free from risk, however the most susceptible are athletes performing in sports that favour leanness (e.g., dance, gymnastics, cheerleading) and endurance (e.g.; swimming, running) [10].
The risk factors of the Female Athlete Triad are summarised in *Table 1*.

RISK FACTORS OF FEMALE ATHLETE TRIAD	
Disciplines emphasising leanness and endurance	Genetic predisposition
Initiation of training in young age	Injury (especially recurrent and non-healing one)
Increase in training intensity	Low body mass index (BMI)
Low self-esteem	Low bone mineral density (BMD)
Dysfunctional family, abuse	History of stress fractures
Psychosocial pressure to attain a slim physique	Menstrual disturbances
Dieting, dietary restriction, vegetarianism	History of depression
	Personality factors such as perfectionism and obsessiveness

Table 1. **Risk factors of Female Athlete Triad** [11,12,13]

CLINICAL MANIFESTATIONS

➔ LOW ENERGY AVAILABILITY

Consuming an adequate amount of energy is critical to maintain competitive advantage in training and competition. Healthy female athletes have to intake enough calories to cover their energy demands including the costs of everyday life, exercise, muscle tissue remodelling, menstruation, and growth during their younger years [14]. Society imposes extreme pressure on women to fit into the canon of beauty which is usually associated with thinness. Moreover, some sports disciplines require more leanness and aesthetics compared to others. The pursuit of a low body fat percentage by ambitious, often perfectionist athletes may evolve into disordered eating behaviours or a clinical eating disorder [15,16,17].

Low energy availability is the main factor causing menstrual dysfunction and impairing bone structure [18]. Energy availability is defined as the quantity of dietary energy left for the metabolic processes after exercise training. The most recent concept of energy availability is calculated as dietary energy intake minus exercise energy expenditure divided by an individual's lean body mass. Inadequate energy availability whether caused by undernourishment, excessive energy expense, or a combination of both is a strong disruptive factor for endocrine homeostasis [19]. Being a significant physiological stressor it triggers recognisable neuroendocrine response to preserve energy in order to maintain vital functions. Alterations occur primarily through leptin which has a modulatory effect on the neuroendocrine axes (hypothalamic–pituitary–adrenal axis, hypothalamic–pituitary–thyroid axis, hypothalamic–pituitary–gonadal axis, growth hormone–insulin–like growth factor–1 axis) and the autonomic nervous system in addition to reducing muscle protein synthesis and bone metabolism (*Table 2.*) [19,20].

Despite limited research on males, early observations suggest that female physiology is more susceptible to energy availability reduction [19]. Therefore, it is highly important to monitor and investigate this subject and implement prevention strategies in young female athletes.

NEUROENDOCRINE, HORMONAL AND METABOLIC EFFECTS OF THE LOW ENERGY AVAILABILITY	
Circulating leptin decrease	Luteinizing hormone release alteration
Ghrelin increase with a coexistent increased ghrelin resistance	Resting blood glucose and insulin reduction
Oxytocin decrease	Low carbohydrate availability and fat oxidation increase
Triiodothyronine and thyrotropin–releasing hormone decrease	Myofibrillar protein synthesis decrease
Circulating growth hormone increase with a coexistent increased growth hormone resistance	Bone formation markers decrease
	Bone resorption marker increase
Insulin–like growth factor–1 decrease	

Table 2. **Neuroendocrine, hormonal and metabolic effects of the low energy availability** [19,20]

➔ MENSTRUAL DYSFUNCTION

The menstrual cycle is one of the most significant biological rhythms along with the circadian rhythm [21]. A menstrual cycle that occurs regularly at intervals close to the average for young adult women (28 ± 7 days) is considered normal or eumenorrheic. Two phases can be distinguished during its course - the follicular or proliferative phase and the luteal or secretory phase [22,23].

The spectrum of menstrual dysfunction in female athletes is extensive with symptoms varying from one case to another. The most commonly described is the amenorrhea. It is defined as the absence of menses for 3 months or longer. Primary amenorrhea means no menses after the age of 15 years with normal secondary sexual development or within 5 years of breast development if it began before the age of 10. Secondary amenorrhea refers to the loss of menstruation after menarche. Other menstrual cycle abnormalities affecting female athletes include oligomenorrhea, anovulation, luteal phase deficiency, and subclinical menstrual dysfunction [22,24].

The exercising itself does not have a harmful impact on the reproductive system. However, low energy availability caused by excessive energy expense leads to hormonal changes responsible for menstrual dysfunction [20]. The most fundamental dysregulation in the Triad is the incorrect frequency of luteinizing hormone pulse secretion by the pituitary gland. Low energy availability alters hormone levels, triggering downregulation of gonadotropin–releasing hormone secretion. Therefore, the pulsatility of FSH and luteinizing hormone decreases, resulting in reduced estradiol and progesterone levels. Suppression of the hypothalamic–pituitary–ovarian axis leads to functional hypothalamic amenorrhea [11,22].

➔ LOW BONE MINERAL DENSITY

It is well established that exercises, especially strength, and resistance, contribute to an increase in bone mineral density (BMD) by stimulating osteoblastic bone formation and inhibiting bone resorption by osteoclasts [25], meanwhile the female gender and postmenopausal period are in the group of risk factors of developing osteopenia or osteoporosis [26]. Athletes are said to have higher bone mineral densities compared to nonathletes: the study showed that non-athletic premenopausal females present low BMD 2-3 times more frequently than athletic ones [27]. It applies to the healthy population, while in the females with Triad low energy availability and menstrual dysfunction have a very negative impact on bone accretion, interrupting the physiological processes of bone tissue remodelling [6]. Bone health problems in Triad range from low bone mineral density to osteoporosis. To assess bone density, the American College of Sports Medicine recommends using *Z-Score*s, defining low BMD as a *Z-Score* between −1 and −2 and osteoporosis as a *Z-Score* ≤ −2.0. In both cases, the clinical risk factors for fracture (chronic malnutrition, eating disorders, hypogonadism, glucocorticoid exposure, previous fractures) must be present [22].

Impact of low energy availability:

As mentioned before, low energy availability triggers numerous hormonal and metabolic dysfunctions, including significant changes in the crucial markers that are in control of processes of bone formation and resorption, resulting in the predominance of the resorptive ones. Additionally, inadequate energy balance leads to serious nutrient deficiencies in elements such as calcium, which is an essential component of bones. The studies show that a 10 percent reduction in weight causes a 1-2% decrease in bone mineral density [12].

Impact of menstrual dysfunction:

Bone metabolism is dependent on estrogen, a steroid hormone that inhibits osteoclasts and in growing organisms is necessary for the epiphyseal growth plates to close properly [28]. Menarche indicates the onset of bone mass growth, with 25% of bone mass being gained in the two years surrounding menarche beginning. Disturbances present in the Female Athlete Triad, lead to hypoestrogenism [22], consequently resulting in lower bone mass, altered architecture, and diminished bone strength [28]. BMD has been found to have a negative correlation with the number of missed menstrual cycles since menarche [29]. It has been observed that amenorrheic athletes have lower BMD in comparison to eumenorrheic athletes and 2-4 times higher risk for stress fractures *(Table 3.)* [11,30].

THE RISK OF A STRESS FRACTURE IN FEMALE ATHLETES WITH TRIAD	
1 of the 3 of Triad conditions	2.4–4.9 times higher
3 of the 3 of Triad conditions	6.8 times higher
Amenorrheic	2-4 times higher

Table 3. **The risk of a stress fracture in female athletes depending on the number of Triad conditions compared to the healthy ones** [30].

CONSEQUENCES

If left undiagnosed and untreated, the Female Athlete Triad carries significant risks of lifelong health consequences and may even result in death [8]. Physical complications of Triad are infertility, cardiovascular diseases due to endothelial dysfunction and high LDL cholesterol level caused by hypoestrogenism, impaired immune function, stress fractures (mostly tibia), osteoporosis, and many others [22]. Triad is also not without complications for psychological health, as the affected population of women athletes has a high risk of developing eating disorders (e.g. anorexia nervosa, bulimia nervosa) and related problems like negative self-image, anxiety disorders, and depression [11].

The syndrome also impacts negatively, both physically and mentally, the female athlete's performance. Aside from the complications mentioned above, it causes muscle loss, leading to a decrease in muscle endurance and strength [31]. Moreover, there is an increased risk of musculoskeletal injuries such as sprains and tendonitis [10] and the recovery time is extended, limiting the duration of training sessions. Psychologically, excessive concentration on perfectionism, and body image, along with low self-esteem, stress, and pressure from the environment, diverts attention away from the sport itself and causes athletes to lose focus on performance and doing their best [31].

SCREENING AND DIAGNOSIS

The state of knowledge regarding the Triad among physicians, physical therapists, coaches, and trainers is inadequate and many of them are unfamiliar with the methods for detecting and treating the Triad. It is crucial for these professionals to enhance their understanding and integrate Triad guidelines into their routine practices when working with female athletes [12].

Preparticipation Physical Evaluations serve as an effective screening tool for identifying female athletes at risk of developing the Female Athlete Triad. These evaluations should include questions addressing the components of the Triad along with the provision of educational information. The Female Athlete Triad Coalition Consensus Panel recommends yearly screening for every female athlete using a self-report questionnaire presented in *Box 1*. The presence of any component of the Triad should prompt further diagnostic investigation for the other components [13].

Diagnosing one or more components of the Female Athlete Triad requires a multidisciplinary approach, involving a team of specialists including a physician, sports dietician, mental health expert, exercise physiologist, and trainer. The diagnostic process should adhere to the Female Athlete Triad Coalition Consensus Guidelines, thoroughly evaluating energy availability, menstrual function, and bone mineral density [13].

THE FEMALE ATHLETE TRIAD COALITION CONSENSUS PANEL

SCREENING QUESTIONS

Have you ever had a menstrual period?
How old were you when you had your first menstrual period?
When was your most recent menstrual period?
How many periods have you had in the past 12 months?
Are you presently taking any female hormones (oestrogen, progesterone, birth control pills)?
Do you worry about your weight?
Are you trying to or has anyone recommended that you gain or lose weight?
Are you on a special diet or do you avoid certain types of foods or food groups?
Have you ever had an eating disorder?
Have you ever had a stress fracture?
Have you ever been told you have low bone density (osteopenia or osteoporosis)?

Box 1. **The Female Athlete Triad Coalition Consensus Panel Screening Questions** [13].

TREATMENT

Following the revision of the guidelines published by American College of Sports Medicine for diagnosing the Female Athlete Triad, female athletes no longer need to exhibit pathology in all three components to be diagnosed with the syndrome. Consequently, treatment approaches vary based on the specific range of present disorders [32].

Low energy availability

Low energy availability treatment requires a multidisciplinary approach, aiming to restore or normalise body weight. This is usually achieved through increased dietary intake, reduced exercise energy expenditure, or a combination of both. However, it is important to recognize that female athletes with normal or excessive body weight can also be energy deficient. Recommendations should consider individual preferences and involve gradual adjustments. Female athletes and those in their support system should be educated on the importance of adequate nutrition in the treatment process and the prevention [13,32].

When an eating disorder or low self-esteem is identified, psychiatrist involvement is necessary. Additionally, Cognitive Behavioral Therapy has proven to be an effective treatment approach for women who exercise and suffer from eating disorders. Antidepressant medications, especially selective serotonin reuptake inhibitors, can be effective in treating bulimia nervosa. Other psychotropic drugs may be beneficial for managing comorbid conditions such as anxiety, depression, and obsessive-compulsive behavior.[13].

Menstrual dysfunction

The treatment of menstrual dysfunction should begin with achieving an optimal state of energy availability, as this is the main factor causing menstrual dysfunction in the Triad [18,32]. Enhancing energy availability through increased caloric intake normalises the secretion of luteinising hormone and follicle-stimulating hormone, which release alteration is directly responsible for functional hypothalamic amenorrhea. Pharmacological strategies for addressing menstrual dysfunction remain largely experimental. Therefore, a non-pharmacological treatment approach aimed at restoring or normalising body weight should be prioritised [13,32].

Low bone density

The management of low bone mineral density, similar to the approach for the menses resumption, primarily focuses on increasing energy availability. As previously noted, reduced bone mineral density directly results from lower estrogen levels − thus, restoring menstruation is essential to stop additional loss of bone mass. Scientific evidence regarding pharmacological treatment remains unclear, especially for young female athletes with low mineral bone density. Vitamin D and calcium supplementation should be considered. Estrogen therapy is recommended for female athletes with functional hypothalamic amenorrhea or prolonged oligomenorrhea who have not responded to non-pharmacological management [13].

CONCLUSIONS

The Female Athlete Triad affects female athletes of all ages and is presented in every sport discipline. The Triad presents with various clinical manifestations, which may include one or more of the three components: energy deficiency, menstrual dysfunction, and low bone density. Insufficient energy leads to hormonal disturbances, particularly within the reproductive axis, causing menstrual dysfunction. This dysfunction, characterised mainly by reduced estrogen levels, subsequently impacts bone mineral density. Female athletes involved in sports that emphasise leanness and endurance, especially those who start training at a young age, are at a higher risk of developing symptoms of the Female Athlete Triad. Additionally, psychological factors such as low self-esteem, perfectionism, and a history of abuse can contribute to the development of the Triad.

If undiagnosed and untreated, the Triad can lead to numerous complications, affecting female athletes both physically and mentally, and potentially resulting in severe consequences, including death. The syndrome increases the risk of injury while diminishing muscle strength, endurance and performance.

Future efforts should focus on raising awareness of the Triad and providing education to female athletes, as well as their physicians, coaches, trainers and families. Implementing screening and actively searching for symptoms of the Triad in young female athletes is essential, as is closely monitoring those with identified risk factors. Diagnosing and treating the Female Athlete Triad requires a multidisciplinary approach, involving a team of specialists. The process should adhere to the Female Athlete Triad Coalition Consensus Guidelines. Special attention should be given to the treatment of low energy availability, as it is the fundamental issue underlying the other dysfunctions within the Triad.

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