

Female Athlete Triad Syndrome: Prevention

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Received: September 13, 2014

Revised: October 11, 2014

Accepted: October 15, 2014

Published online: February 23, 2015

ABSTRACT

The "female athlete triad" refers to a situation that is often seen among women who perform high performance sports. The triad is composed of three pathologies that are more commonly observed separately; eating disorders, amenorrhea/oligomenorrhoea and decreased bone mineral density. These three components are interrelated and its development is based on low energy reserve of the athlete. Although this triad was described more than a decade ago, the society and the athletes are not aware of the serious long-term consequences. Therefore, a review of the concept analyzing its

components and exposing the short and long-term consequences is required. Moreover, several preventive measures will be proposed in order to reduce the incidence and prevalence. To carry out this study an advanced search on Pubmed and ScienceDirect was performed, obtaining a total of 25 current articles that have been used for review of the Female Athlete Triad. In conclusion, the most serious consequences of this triad are infertility and premature osteoporosis. The severity of this syndrome lies in the late-onset of its consequences, although prevention must be performed from the very beginning of professional sports activity.

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Key words: Female athlete triad; Eating disorders; Amenorrhea; Decreased bone mineral density; Prevention

Muradas K, Costa L, Seijas R, Álvarez-Díaz P, Ares O, Sallent A, Cugat R. Role of Growth Factors in Bone-Tendon-Bone ACL Surgery: Time for Maturation of the ACL Graft and the Patellar Tendon Donor Site. *International Journal of Orthopaedics* 2015; 2(1): 205-209 Available from: URL: <http://www.ghrnet.org/index.php/ijo/article/view/1052>

INTRODUCTION

Physical exercise should be, and in fact is, a benefit for those who regularly practice, without falling into health risks but in fact contributing to cardiovascular benefits, preventing from obesity and other disorders^[1]. However, this is not always alike, especially in elite athletes. In the present study, a specific disorder related to professional athletes is reviewed, Female Athlete Triad syndrome (FAT). FAT is a disorder in which eating disorders, amenorrhoea/oligomenorrhoea and decreased bone mineral density are present. This condition seen in female professional athletes can lead to future infertility, stress fractures, anorexia nervosa or bulimia nervosa and osteoporosis^[2]. Athletes at higher risk for developing FAT are women

with a high competitive level, subjected to stress and under pressure for reaching or maintaining an unreal low body weight. It is well known that a female athlete must hold a perfect physical condition to compete, especially within sports that demand an aesthetic appearance such as gymnastics or ballet^[2].

The exact triad's prevalence is currently unknown, although some studies individualizing in one of the triad's components have been published. According to a study by Nattiv *et al.*, 62% of female athletes present an eating disorder, which is one of three components of the triad^[2].

Although some data exists regarding the increasing figures of FAT, no prevalence studies have been performed. This syndrome is uncommon for both professional athletes at risk as well as for their coaches. The lack of awareness can lead to severe consequences for women who suffer the syndrome.

From the moment a young girl begins with high-level competition, their body experiences demanding exercises and physical conditions that can be beyond reach. Stress from tournaments, sports demands, optimal physical level that must be maintained; are variables that will make the young girl and later adolescent go into a competitive mental status, desire to improve. This can entail a physical and mental deterioration since childhood. Despite the negative sense of the aforementioned, physical exercise, even since childhood, is a very positive aspect and doctrine for good health status. However, it is important to not overtake a certain level of competitiveness and demanding sport exercise, which could lead to important disorders such as FAT.

Therefore, although this syndrome does not affect a specific sport practice, we have found it convenient to review the general aspects. Moreover, a special attention to prevention is performed, which should be the main goal within this syndrome.

METHODS

A bibliographic research has been performed with Medline database (PubMed). Keywords used for the present review were 'female athlete triad', 'eating disorders', 'menstrual disorders' and 'bone mineral density'.

A further research of Science Direct was performed with the following keywords 'female athlete triad', 'energy deficiency', 'eating disorders', 'menstrual dysfunction', 'perfectionism' and 'over-exercise', finding over 500 articles.

Furthermore, the official website of 'Female Athlete Triad' (www.femaleathletetriad.org) was consulted and recommended for further lecture, as numerous interviews are provided.

RESULTS

204 articles were found with the keywords used at Medline database, and a more thorough screening outlining studies of the last years, referring only to women, reviews, clinical trials, meta-analysis and clinical practice guidelines.

Only studies with the keyword 'female athlete triad' within the title and 'prevention' within the abstract were selected, obtaining 9 articles from Science Direct, were only 4 were reviewed for the present study, those belonging to the last 5 years.

DISCUSSION

In 1992, Female Athlete Triad was the focus of a consensus conference called by the Task Force on Women's Issues of the

American College of Sports Medicine^[3]. That same year, a review was performed in order to determine the triad's prevalence, comparing elite athletes with amateurs, observing an increase of the triad's components within elite athletes^[4]. Authors concluded that it was easier to observe one of the components separately, rather than three together (15.9%).

A healthy athlete adjusts her energy consumption within her diet to balance the energy expended during physical activity. When energy is available, bone health is promoted as well as the indirect conservation of eumenorrhea and estrogen production that inhibit bone resorption, and directly by stimulating hormone synthesis that promotes bone formation or osteogenesis. As a result, bone mineral density is usually higher than the expected for age and sex in some athletes. On the other hand, athletes who severely restrict their diet or have any eating disorder, present low energy availability. This affects bone quality and indirectly develops amenorrhea with the consequent increased bone resorption due to estrogen deficiency. Thus, bone mineral density starts decreasing, even to figures lower than the average for age and sex, which could bring stress fractures. Between optimal energy availability and low energy availability is a spectrum of reduced energy availability. This energy status can induce subclinical menstrual disorders and suppress estrogen synthesis and metabolic hormones (Figure 1).

Energy availability, menstrual status and bone mineral density move along these energy availability spectrums in one direction or another, at different speeds according to the athlete's diet and exercise habits. Energy availability can be modified within one day, however, a menstrual disorder can last one month or more to be evident, and the effects over bone mineral density can reveal one year after the onset of the disease^[2].

Therefore, given the broad spectrum of signs and symptoms aforementioned, it can be observed the triad's status in a female athlete depends on the energy availability and thus in the athlete's diet.

Eating disorders

This responds to a broad spectrum of harmful eating disorders and frequently inefficient that is usually consequence of a desire for losing weight or achieving a slim figure. Although adolescents gain more body fat during puberty they are stimulated to lose weight in order to improve performance and/or physical appearance. Several factors contribute to the development of eating disorders, such as social pressure from the media, chronic diets, decreased self esteem, depression, family dysfunction, physical or sexual abuse and biological factors. To all these factors, athletes should add to their contributing list to eating disorders perfectionism, lack of nutrition knowledge, inclination to outstand and win no matter what, not without forgetting the pressure for maintaining an 'ideal' weight by coaches, other athletes or family.

The severity of their behavior can range from eating restriction to the use of laxatives, diuretics and purgatives, or the clinically defined anorexia nervosa and bulimia nervosa.

Anorexia nervosa is the extreme behavior of food restriction with a distorted body self-perception and an irrational fear of weight gain. Amenorrhea has been a compulsory criterion for diagnosis until the new Diagnostic and Statistical Manual of Mental Disorders (DSM)-V Criteria that has reoved the menstrual disorder from diagnosis. The term 'anorexia athletica' or 'sports anorexia' has been used to distinguish between pathologic anorexia and eating disorders due to training and sports performances. The criteria for sports anorexia are excessive exercise, perfectionism, obsessive behavior,

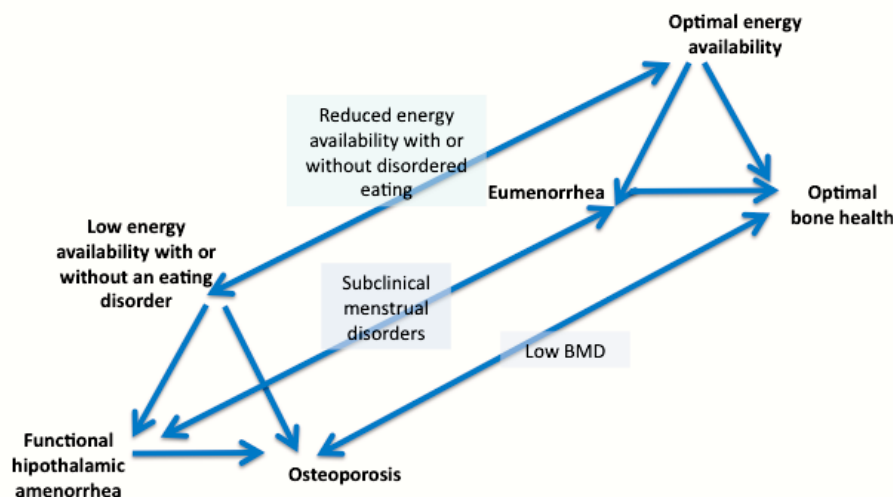


Figure 1 Figure adapted from the original available at: Nattiv A *et al* American College of Sports Medicine position stand. The female athlete triad. *Med Sci Sports Exerc.* 2007; **39**(10): 1867-1882

competitiveness, menstrual disorders and at least one of the unhealthy methods to lose weight (i.e. fasting, vomits, laxatives, diuretics...)^[5].

Bulimia nervosa consists of episodes of uncontrollable eating followed by purging, usually vomiting, taking a laxative, diuretic and/or excessive exercise. The loss of fluids and electrolytes when purging is the main cause of short-term morbidities, which include dehydration, acid-base imbalance and electrolyte disturbances, as well as cardiac arrhythmia. Purgative behavior leads to chronic disorders such as gastrointestinal diseases, parotid gland growth and severe dental erosion. Psychological consequences include low self-esteem, anxiety, depression and even suicide.

Are female athletes and young active girls more prone to eating disorders than general population? It is hard to conduct accurate prevalence studies within athlete populations. It is often for these athletes to deny in the standard questionnaires any type of eating disorder. Two research groups have diagnosed eating disorders (according to the DSM definition) in prevalence studies of eating disorders within elite athletes in different sports. One concluded that 31% of elite athletes of 'thin-build' sports (i.e. emphasizing in sports with aesthetic impression) had any kind of eating disorder, compared to 5.5% of general population. The other study found that 25% of elite female athletes of resistance, aesthetic or strength sports had abnormal eating habits compared to the 9% of general population^[6,7].

Significant caloric restrictions can cause short- and long-term morbidities; reducing metabolic rate and causing changes within the musculoskeletal, cardiovascular and endocrine systems, thermoregulation, depression and substance abuse. Decrease in performance, amenorrhea or even death due to suicide or cardiac arrhythmia can also be secondary to caloric restriction^[6,7].

Treatment should be long-term, individualized and multidisciplinary. Commonly, a physician, psychologist and nutritionist are involved in treating eating disorder, together with a family support. Prognosis depends time of treatment onset, duration and severity of the disorder, as well as the patient's willing to search for help and treatment and continue with it.

Amenorrhea

Amenorrhea is divided into two types according to whether or not the menstruation cycles have started. Primary amenorrhea is the absence of menstruation in a 16-year-old woman with secondary sexual

characteristics. Secondary amenorrhea is the cease of an established menstruation for three months. Amenorrhea associated to sports or anorexia nervosa has a hypothalamic origin. This type of amenorrhea causes a decreased release of luteinizing hormone (LH) and follicle-stimulating hormone (FSH) (necessary for normal ovulation) as well as deficiency of estrogens, similar to the changes observed during menopause. Both hypothalamic amenorrhea and menopause are related to decreased bone mineral density.

Menstrual cycle is a complex interaction between endocrine and reproductive systems.

External stimuli alter the system through hormonal signals to the hypothalamus. A clear relationship between the cease of menstruations and physical training has already been established. However, the exact pathogenesis, prevalence, consequences and treatment of the exercise associated to amenorrhea is still unknown. Whereas secondary amenorrhea is present in 2-5% of fertile women at some point, athlete women are reported to have figures of 1-44% of secondary amenorrhea. This is caused due to a decreased release of LH secondary to an inhibited hypothalamic-pituitary-ovarial axis^[8].

In the 70s, the explanation for amenorrhea was low weight and body. Future studies have rejected this hypothesis and concluded that other variables must participate^[9]. Loucks *et al* aimed to study the role of stress in exercise-associated amenorrhea, with a group control of highly trained eumenorrheic women^[10]. Significant decrease of FSH, LH and 17-beta-estradiol were found in amenorrheic women. Furthermore, authors found that among amenorrheic women, prolactin, cortisol and androstenedione failed to increase in response to exercise, contrary to eumenorrheic women, inconsistent with a general stress hypothesis of exercise-associated amenorrhea^[10].

Another hypothesis of exercise-induced amenorrhea is due to the low caloric intake within female athletes. A low caloric intake inhibits the frequency and amplitude of GnRH pulses. Williams *et al* reported on trained eumenorrheic women studying LH secretion and its effect with and without caloric restriction, observing that high-volume training combined with caloric restriction may predispose to changes in LH pulse frequency, whereas a normal caloric intake would prevent these changes^[11]. Other authors have shown that LH pulse frequency is reduced in non-trained women with dietary restriction and in exercising women with low energy availability^[12]. The same authors concluded also that exercise stress did not disrupt

the pulsatility of LH^[12].

Amenorrhea should not be taken as normal and women should seek medical advice as soon as possible due to its consequences and implications. Furthermore, this is the most recognizable symptom of Female Athlete Triad syndrome. Ovulation and eumenorrhea are the main goals to achieve.

Osteoporosis

Osteoporosis is a disease characterized by low bone mineral density and deterioration of bone tissue, increasing the fragility of skeleton as well as the risk of fracture. A panel of experts organized by the World Health Organization (WHO) has established the following diagnosing criteria: (1) Normal: bone mineral density (BMD) less than 1 standard deviation (SD) below the young adult reference range; (2) Osteopenia: BMD between 1 and 2.5 SD below the young adult reference range; (3) Osteoporosis: BMD higher than 2.5 SD below the young adult reference range; (4) Severe osteoporosis: BMD higher than 2.5 SD below the young adult reference range and one or more fractures due to fragility.

The main cause of premenopausal osteoporosis in active women is a decrease in synthesis of ovarian hormones and low estrogens as a result of hypothalamic amenorrhea. This loss is similar to the bone loss in postmenopausal women or in women with pathological low levels of estrogens, such as premature ovarian failure, pituitary tumors or anorexia nervosa. In previous studies, low BMD was found exclusively in the lumbar spine. However, new and more precise techniques to measure BMD in other localizations point out that the decrease is more generalized throughout the skeleton^[13]. The concurrence of eating disorders and a low calcium intake together with menstrual dysfunction may exacerbate bone loss. Not all amenorrheic athletes have low bone mass. The state of the skeleton depends on the duration and severity of menstrual irregularity as well as factors that influence their BMD before the onset of amenorrhea: the type of skeletal loads during activity, nutritional status and genetic component. The concern of athletes with low BMD due to hypoenestrogenemia affects the risk of fracture during their years of competition and the risk of future premature osteoporotic fractures. Studies report a very high incidence of injuries and stress fractures among amenorrheic and oligomenorrheic compared with eumenorrheic athletes^[13].

A study reported a lower BMD in athletes who had had stress fractures^[14]. Researchers found that the best predictor of current BMD is the previous menstrual history; women with a history of amenorrhea have lower BMD^[15]. As the rate of bone loss in hypoenestrogenic women is much higher 5-6 years after the decline in endogenous estrogen levels, there could be an opportunity to start therapy to prevent irreversible bone loss. In adolescent athletes, poor nutrition and hypoenestrogenic condition could result in a lack of bone growth during the critical years of the skeleton's consolidation, which is considered to be between 11 and 15 years old.

An important question is whether the condition of a hypoenestrogenic low BMD may be treated or reversed and thus achieving a normal bone mass. Several studies show an increase in BMD in amenorrheic athletes who resumed their normal periods, although it seems that these increases could be limited^[16]. Amenorrheic athletes using hormone replacement therapy with doses used in postmenopausal women have been shown to maintain its DMO, without increasing it. Women with amenorrhea and less severe bone loss may prefer to adjust training and nutritional patterns to regain their normal reproductive cycle^[17,18].

Consequences

Research related with long-term effects of the components of the triad has recently come to light^[19]. Women who were diagnosed with the female athlete triad as adolescent girls and young women in the 1990s are now in their 30s and 40s. The negative long-term effects of the female athlete triad, such as low bone mineral density, are beginning to show up. Consequences of the three components do not usually appear all at once, in fact eating disorders often disappear over the years, however, the result of this prolonged malnutrition lead to the abovementioned; amenorrhea and decreased bone mineral density. Hormonal changes could lead to infertility but most important of all consequences of the triad is decreased bone mineral density. Thus, women around 40 years old will start developing osteopenia and even osteoporosis.

Treatment/prevention

Prevention and treatment must be approached in a multidisciplinary way including physical therapists, nutritionists and psychologists/psychiatrist^[20]. Treatments will be the specific for each of the components of the triad. Prevention should be the most important aspect, taking into account that consequences in the short and long term could become very serious. One of the most important measures within prevention is education both to female athletes, coaches and the entire healthcare team. Education about the risk of damaging bone mineral density, decreased BMD, osteoporosis and stress fractures. Emphasis should be placed on optimizing energy availability for prevention. Physical therapists should be responsible for the recognition, treatment and prevention of the female athlete triad^[21]. Special attention should also be taken to maximizing bone mineral accumulation in pediatric and adolescent athletes and to maintain bone health throughout life, including calcium and vitamin D and the benefits of regular exercise for bone health. It would also be desirable that national and international sports governing bodies and sports organizations put procedures and policies to eliminate potentially harmful weight loss practices of athletes.

CONCLUSION

The low energy availability (with or without eating disorders), amenorrhea and osteoporosis; alone or in combination, carry a significant health risk for physically active women. The potentially irreversible consequences of this clinical situation emphasize the urgent need for further research on the causes, treatment, consequences, and most importantly on prevention. Prevention and treatment must be approached from a multidisciplinary point of view including physical therapists, nutritionists and psychologists/psychiatrist. The best prevention strategy would be the education of sports medicine professionals and all those who work in physically active girls and women about female athlete triad and develop plans to prevent, recognize, treat and reduce risks^[22]. In women presenting any component of the Triad should be sought if other concomitantly present. The search for the Triad should be done at the time of the physical exam prior to participation and during the clinical evaluation of menstrual change, eating disorders patterns, weight variances, cardiac arrhythmias, including bradycardia, depression or stress fractures.

CONFLICT OF INTERESTS

There are no conflicts of interest with regard to the present study.

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