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Original Article

Female athlete triad in high performance sports: implications from performance and women health

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Abstract
Many studies associate physical exercise with an improvement in quality of life influenced by the development of health status, however, it is almost a consensus that sport has an opposite effect marked by an increase in the number of injuries and a general decrease in the health of the high athlete level. In female athletes, however, a syndrome caused by low energy consumption coupled with many hours of intense training per week can lead to a condition called the Athlete Women's Triad. This condition seems to be related to the sports modality, reaching a prevalence of 16% of the three symptoms that characterize it up to 60% of at least 1 of the three symptoms in some high-performance sports modalities. The pathogenesis of this disease contributes to a decrease in athletic performance, the appearance of amenorrhea which can cause a decrease in bone mineral density and lead to important disorders in the cardiovascular, endocrine and immune systems, for example. Thus, knowing the symptoms of this disease can lead to the promotion of countermeasures that allow the maintenance of the performance and health of the female athlete. To do this, a careful review of the literature (n = 966) was performed observing the most prevalent variables with the objective of discussing different points related to this syndrome, promoting an update on the effects on performance, health and measures for avoid its development in female athlete.
Key Words: Low Energy Availability, Reproductive Cycle Disfunction, Eat Disorders, Impairment in Athletic Performance.

Introduction

The first record of women participating in the Olympics was in 1900 at the Paris Olympics with a representation of only 2% (Curry et al., 2015). From then on there was a very discreet increase, without much representation. It was not until 1972 when the law known as "Title IX," which established that all educational institutions would receive federal funding for equal sports investment for both sexes, came into force in the United States, that a significant increase was seen in women's participation in the Olympics with high levels of American representation (Costa, 2003). The proportion of women athletes in the Olympic Games grew from 2% in 1900 to about 40% in 2000 (Pfister et al., 2003).

It is known that regular physical exercise is directly associated with benefits to one's health (Mallinson et al., 2013). By accompanying the increase in women's participation in sports since 1972, it was possible to identify the growing number of athletes affected by health problems, due to the negative effects of exaggerated and misguided training, which was recognized in 1992 by the American College of Sports Medicine (ACSM) as Female Athlete Triad syndrome (FAT), composed of three interrelated factors: eating disorders, amenorrhea and osteoporosis (ACSM, 1997). In 2007 the term was updated by the American College of Sports Medicine, covering athletes classified as "at risk", without necessarily fulfilling all the criteria of the 1992 clinical diagnosis of FAT. In another hand, the FAT can cause decrease in the athletic performance (Vanheest, Rodgers, Mahoney, & De Souza, 2014).

Contrasting with the positive aspects of regular sports practice, the Female Athlete Triad syndrome has increased in the high-performance sports environment. Thus, this review will discuss the physiological implications of training in female athletes, as well as the components of female athlete triad syndrome.

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Materials and Methods

This is a review article; thus, in order to collect the data, a search was performed in the following databases: BIREME, LILACS, Scielo (Scientific Electronic Library Online), SCOPUS (Elsevier), Web of Science, Pubmed and Medline (Medical Literature Analysis and online Retrieval System) using the following descriptors in isolation and in combination: 1. "Triad" 2. "female". 3. "Athlete." 4. "Energy availability" 5. "menstrual dysfunction," 6. "eating disorders", 7. "bone deterioration", and 8. “Athlete Female Traid and Physical Performance”.

The inclusion criteria were: 1. research covering the articles published from 1990 to 2018, that is, with an approximate margin of 28 years, and 2. full texts. The exclusion criteria were: 1. studies done over a longer period of time than 28 years; 2. annals of congress and 3. books. This allowed us to find the results shown in the following chart scheme showed in the figure 1.

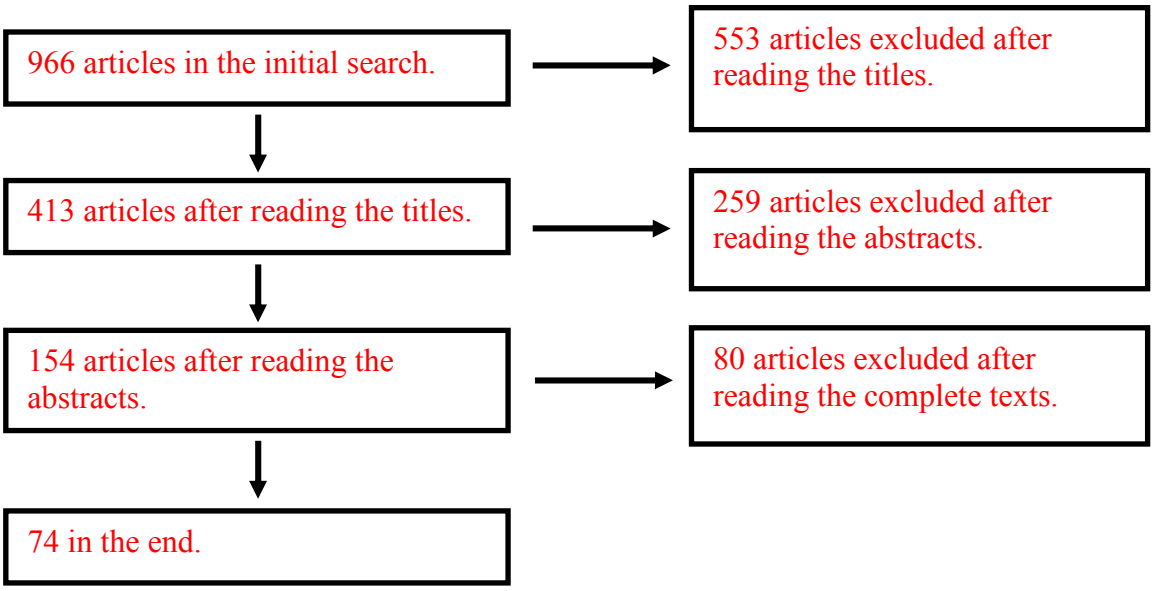

Figure 1: organization chart of the article search and selection process.

From the organization chart above, it can be observed that in the research performed on this topic, 966 articles were initially found, of which 533 articles were excluded after reading the titles, with 413 articles remaining. After reading the abstracts, 259 articles were excluded, leaving 154 articles total. After reading the complete texts, 86 articles were excluded, and the selection was finalized with 68, which were used as the basis for construction of this review article.

The female athlete triad syndrome

Concomitant to the increase in women participating in sports and its beneficial effects on health, the number of women who are susceptible to developing the female athlete triad (FAT) has increased (Oliveira et al., 2017a; Perini et al., 2009b). This syndrome was recognized by the American College of Sports Medicine (ACSM) in 1992, initially as the interrelationship of three components: Eating Disorders (ED) causing predisposition to low energy availability, menstrual dysfunction and bone disorders (ACSM, 1997). Five years later, ACSM declared a new official position, not only documenting the prevalence and consequences of the triad, but also informing the possible causes, prevention, and treatment of the triad in general (ACSM, 2007).

In 2007, the ACSM, in a new assembly, formed by researchers and doctors specialized in treating the triad, updated the last official positioning, with the purpose of emphasizing some new ideas related to the components of the triad, emphasizing the importance of considering the precursor factors in development, able of classifying woman as "at risk", without necessarily fulfilling all the criteria of the clinical diagnosis of FAT (Blauwet et al., 2017; ACSM, 2007). Thus, the definition of the current triad includes a spectrum of dysfunctions related to energy availability (with or without eating disorders), menstrual disorders and low bone mineral density, increasing in those athletes who are at risk but who do not necessarily fulfill all the criteria of the previous positioning. As for the spectrum, depending on the availability of energy, the athlete's condition may follow a certain direction. Eating disorders with severe decrease in dietary intake may influence energy availability, but they are not the only factor. Low energy availability may affect hormonal function and bone mineral density as showed in the figure 2.

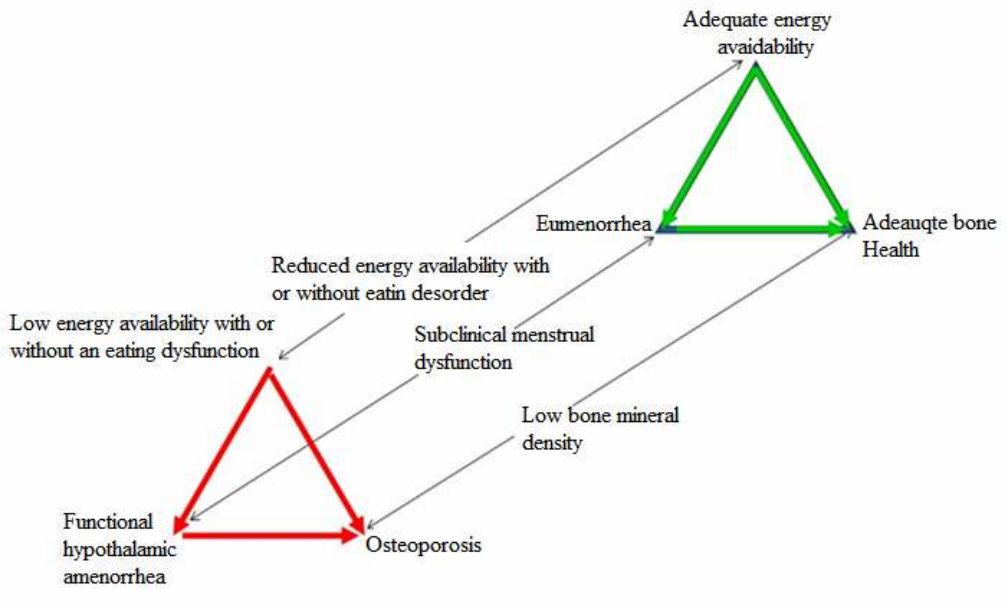

Figure 2. Female Athlete Triad Spectrum (Adapted from Nattiv et al., 2007)

It should be noted that the pathogenesis of the components of the triad would be related to energy availability resulting from several factors, among them, low caloric intake (below 30 kcal/kg of body weight per day) and/or high energy expenditure due to excessive physical activity (Mountjoy et al, 2014; MBB et al., 2013). These factors contribute to the subsequent development of amenorrhea, which can trigger osteoporosis (Souza, et al., 2017). The presence of one or more components of the triad may decrease performance and, together, potentiate the detrimental effects to the health of the athlete (Gibbs et al., 2013, De Souza, et al., 2014). Presence of the three components, which characterize the triad among elite female athletes varies according to the sport modality, and may reach a prevalence of 16% (Stickler et al, 2015) among those that value body aesthetics. For two components, prevalence has been reported between 3% and 27% and in any of the components alone, it is 16% to 60%. (Gibbs et al., 2013)

Studies have shown (Stefani, et al., 2016; Clark et al., 2018) that the development of this syndrome is common in athletes who participate in sports in which optimal performance is physiologically and/or aesthetically dependent on a low percentage of body fat. Female athletes obtain several benefits from physical exercise, but in some cases, it can have a negative effect on health, especially in the reproductive and skeletal systems. According to Perini et al., (2009b) severe forms of menstrual irregularities have been described in the female athlete: secondary amenorrhea, oligomenorrhea, short luteal phase and anovulation, which vary according to the level of activity, training, performance and sports modality.

Some studies have emphasized that modalities characterized by lightness of movement, flexibility, art of balance and mastery of the body (artistic and rhythmic gymnastics and figure skating), sports that advocate low percentage of body fat for optimal performance (long-distance running, swimming..) and sports with classifications by weight (rowing, martial arts..) present a higher incidence of food restriction by their practitioners (Blauet et al., 2017; Oliveira et al, 2017b; Perini et al, 2009a). Relative levels of body fat tend to be lower among athletes who participate in individual sports than in team sports, and lower still in sports requiring movement or lifting of one's own body mass (Gonçalves et al, 2017; KOuidou et al., 2016).

Because they are modalities that reinforce the demand for a lean body some authors characterize these modalities as the ones with the greatest risk for the development and installation of FAT (Loveless, 2017; Oliveira et al, 2017c), which does not exclude the others. There is, therefore, a contradictory representation in which the athletic setting can also present itself as an environment that amplifies the pressures motivated by a lean body standard (Rice et al., 2016), since a close relationship has been observed between body image and physical performance in groups of high-performance female athletes, who are constantly submitted to training and control of their body fat percentage (Maimoun et al., 2016).

In competitive sports, the endeavor for maximum performance is expressed by external pressures from coaches, trainers, sponsors and administrators in the longing for better results, causing physical and mental stress on the athlete aimed at better performance, which is not exclusive among the modalities that value aesthetics. This stress has been associated with changes in dietary behavior by the athlete resulting in severe food restriction, capable of developing into one of the components of the triad, eating disorders. The etiology of another component, menstrual dysfunction, although it is multifactorial, is directly related to a restricted caloric intake, negative energy balance, low energy availability, sudden onset of vigorous exercise, and others (Kroshus, et al., 2018; Marcason, 2016), triggering menstrual and bone dysfunction. Therefore, in these conditions, female

athletes tend to develop the complete triad, or in other words, the simultaneous presence of the three components that characterize this syndrome.

Body Composition

There is a consensus that body composition is fundamental in performing diverse activities (Marques et al 2018; Mallinson et al., 2013). Shirakawa et al. (2017) highlighted the negative effects on health related to maintaining an abnormal body composition with a high body weight and possible triggering of cardiovascular diseases. However, the opposite is equally detrimental, that is, the maintenance of a reduced body weight, below the standard mean for one's age group, poses a risk to the health of the individual (Blauwet et al., 2017; Gonçalves et al., 2017). When it comes to athletes, skill performance, regardless of the aesthetic factor, depends essentially on a specific body composition. For example, depending on the sporting modality, there is a need for muscle mass development and considerable strength. Therefore, in the sports sphere, the fundamental role of body composition is clear. However, in the literature, the extent to which altered body composition aids performance, without provoking damage to the athlete's health has been questioned (Oliveira & Perini, 2009).

According to Rice et al., (2016), the desire to achieve optimal body composition is probably one of the initiators for the development of female athlete triad. This desire may be encouraged by external pressures from pre-determined sociocultural body patterns, or by coaches who aim for better performance from their athletes, associating weight loss with better athletic performance, though, no scientific data supports that weight loss in women with an already optimal weight aids in athletic performance. On the contrary, studies have shown that weight loss in thin individuals can result in negative health effects and less optimal sports performance (Giffin et al., 2017, Macknigth, 2017). It has been reported that individuals with low body weight and body fat percentage present elevated risk for developing morbidities, similar to being overweight or obese (Blauwet et al., 2017).

Tenforde et al., (2015) found that athletes who had a body mass index below 17.5 kg/m^2 and/or menstrual irregularities and a history of stress fractures were significantly more likely to have low bone mineral density than other athletes. The risks associated with female athletes due to low body weight are related to the development of eating disorders, menstrual dysfunctions, and an increased risk of stress fractures due to the presence of early osteoporosis, all of which are components of the female athlete triad (Tenforde et al., 2015, Misra, 2015).

Menstrual Dysfunction

Regular menstrual cycles, in normal and healthy women, considered eumenorrheic, occur at intervals of 21 to 35 days, with menstruation lasting up to 7 days (Stefani et al., 2016). The abnormality of this function of the menstrual cycle is considered a disorder or dysfunction, with multifactorial causes, and the woman is recognized as amenorrheic (Souza et al., 2017). Among the main causes are: genetic predisposition, food deprivation, the presence of eating disorders, rapid loss of body weight, low percentage of body fat, psychological stress, vigorous training routines (as in the case of athletes), suppression of hormones (estrogen and progesterone) and others (Kong et al., 2015). The prevalence of menstrual dysfunction has increased in adolescents, especially in the sports sector, with a prevalence between 6% and 79% among high-performance athletes (Folscher et al., 2015; gibbs, 2013). These dysfunctions are among the main negative consequences related to training, including: delay of the age of menarche, primary amenorrhea, secondary amenorrhea and oligomenorrhea (Mountjoy et al., 2014).

The first menstrual period, called menarche, occurs from the maturation of the hypothalamic-pituitary-ovarian (HPO) axis, where there is usually the development of the secondary sexual characters in M3 and M4 of breast development, according to Tanner's classification (Cintra et al., 2013). The mean age for occurrence of menarche in the Brazilian population is 12.2 years old (Ibitoye et al., 2017). However, among adolescent athletes, the average age has been observed between 12.6 and 13.8 years old (Pereira et al., 2010). In the study performed with athletes of different modalities, it was observed that the average age of menarche varies in relation to the sport modality of which the athlete is a part. Among the sports modalities evaluated (rhythmic gymnastics, running, rowing, and synchronized swimming), the athletes presented an elevated mean age of menarche, 13.8 years old, showing a greater delay for these athletes in this modality (Singhal et al., 2014)

Oligomenorrhea refers to menstrual cycles lasting longer than 35 days, and may be related to normal and high levels of estrogen, but not progesterone (SOKOLOFF et al., 2015). Studies indicate that oligomenorrhea is the most common menstrual dysfunction in female athletes (Blauwet et al., 2017).

There are two types of amenorrhea: primary and secondary. Primary amenorrhea is characterized by a delay in the age of menarche (not menstruating at age 15 in the presence of secondary sexual development) (Barros et al., 2018). Secondary amenorrhea corresponds to the cessation of three or more consecutive menstrual cycles after normal occurrence of menarche (Rajiwade et al., 2018).

Some attempts were made to determine the minimum percentage of body fat at which regularity of the menstrual cycle would still be present. Drinkwater, in 2005, proposed that in order to maintain normal menstrual function it was necessary for a woman to possess at least 22% body fat. However, there are controversies, since studies (Drinkwater et al., 2005) have shown that many eumenorrheic athletes present fat levels below 22% body

fat. Therefore, these studies have not been able to determine this limit, which Kouidou et al. (2016) justified due to variations of this limit among individuals. It is possible that another mechanism is related to this condition.

Amenorrhea is attributed to malnutrition associated with inadequate food consumption, with an increased prevalence in groups with compromised food consumption; in a small percentage, about 20% of cases, it precedes the appearance of loss of body weight. In athletes, the prevalence of amenorrhea has been estimated between 3.4% and 66%, depending on the modality and level of training, whereas in the general female non-athlete population it is between 2% and 5%, and 8.5% among adolescents. The prevalence of oligomenorrhea among athletes is 5% to 40% (Gibbs et al., 2013).

Although amenorrhea may be related to a variety of causes, including diseases and genetic abnormalities, in high-performance female athletes, amenorrhea is the result of changes in energy availability, commonly associated with excessive training and low caloric intake, being characterized as caused by hypothalamic function. In this, the absence of menstruation is related to alteration of the hypothalamic-pituitary-ovarian (HPO) axis, without identification of an anatomical cause (Clark et al., 2018).

In order to maintain the menstrual cycle with follicular (estrogenic), ovulatory and luteal (progestogenic) phases, an integration of hormones and hypothalamic, pituitary and ovarian factors in perfect frequency and amplitude is necessary. The hypothalamus secretes gonadotrophin releasing hormone (GnRH), which stimulates pituitary secretion of luteinizing hormone (LH) and follicle-stimulating hormone (FSH) in a mechanism showed briefly in the figure 3.

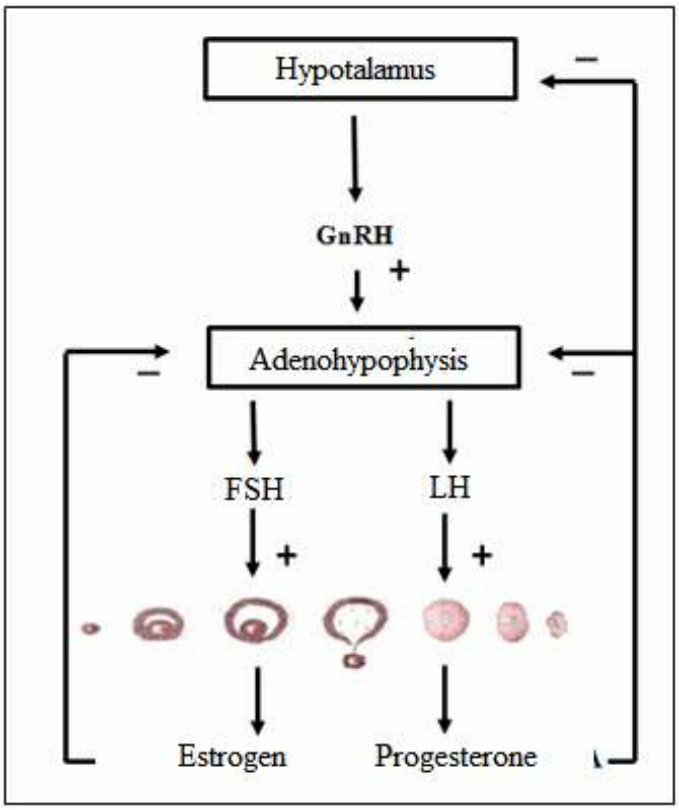

Figure 3. Hormonal control of the menstrual cycle

FSH promotes the growth and maturation of ovarian follicles that secrete estrogen at an increasing rate until it reaches its peak. This, in addition to other functions, promotes an increase in the thickness of the endometrium preparing it to receive a possible embryo (Bahrami et al., 2017).

When the mature ovarian follicle ruptures, estrogen levels drop. Since this hormone has an inhibitory effect on the secretion of LH and FSH, they have a peak in concentration, promoting the release of the oocyte within 24 hours, characterizing the ovulation phase. The luteal phase of the menstrual cycle begins with the formation of the corpus luteum which secretes progesterone under the action of LH. During fertilization, estrogen and progesterone levels remain high inhibiting the HPO axis and maintaining LH and FSH low during gestation. In the absence of fertilization, the oocyte involutes within 72 hours. The levels of progesterone and estrogen begin to fall and the stimulus maintaining the wall of the endometrium ceases, promoting the desquamation that characterizes menstruation. The low levels of LH and FSH stimulate a new cycle, as shown in the figure 4.

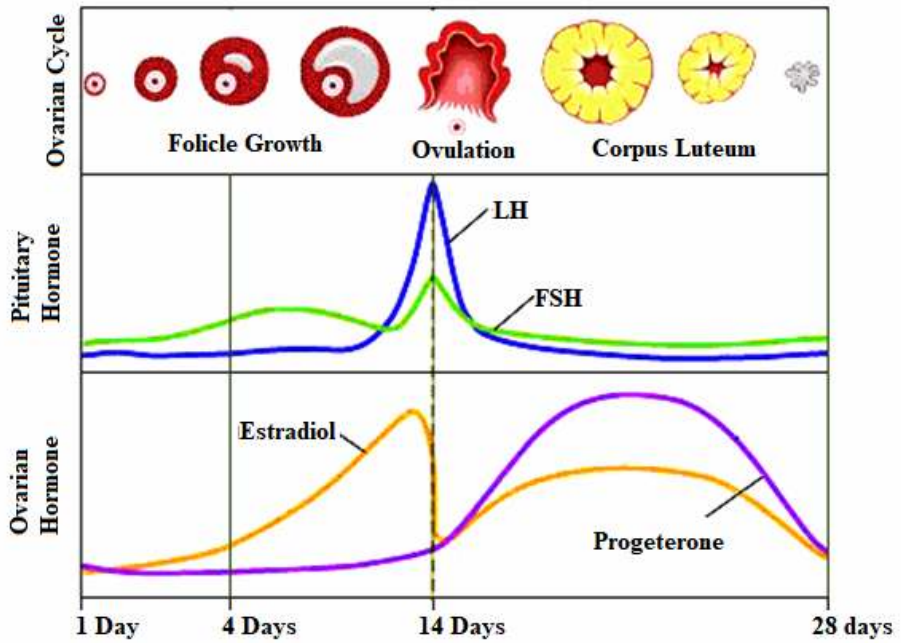

Figure 4. Phases of the menstrual cycle (Adapted de Simões, 2011). (Luteinizing hormone (LH) and follicle-stimulating hormone (FSH)).

Studies have indicated that these dysfunctions are more frequent in sports and among athletes competing in sports that advocate a low percentage of body fat (SOUZA et al., 2017; SOKOLOFF et al., 2015). Although there are already studies reporting a high prevalence in other populations as well, such as non-athlete adolescents (Souza et al., 2017)

Interruption of GnRH secretion due to stress from training promotes alteration of the menstrual cycle with the development of menstrual dysfunctions. This state of estrogen deficiency may be one of the causes of reduced bone mineral density (BMD) leading to an increased risk of stress fractures and early osteoporosis. (Ackerman et al., 2015).

Changes in body composition, especially fat mass reduction, can lead to changes in leptin production, since this cytokine is predominantly produced in white adipose tissue (Gibbs et al., 2013, Souza et al., 2017). Since leptin has a positive effect on gonadotrophin releasing hormone (GnRH) and regulates the release of gonadotrophins, its deficiency has contributed to amenorrhea (Mountjoy et al., 2014). Thus, not only would the population of female athletes be susceptible to the development of the syndrome called FAT, but also those concerned with fitness and performance that undergo control of their body shape with severe reduction of body fat percentage, such as frequent attendees of gyms.

Bone Disorders

Bone is a tissue that has intense activity (Goolsby, 2017). In young individuals, this activity is related to bone growth and remodeling, whereas in adults it predominantly involves bone remodeling (Heikura et al., 2017)

Bone remodeling is a physiological apposition process in which the old bone (resorption) is removed and replaced by newly formed bone (Yagishita et al., 2017). Bone integrity is enabled by the correspondence between formation and resorption, maintaining the integrity of the microarchitecture of the bone tissue, regulated by several factors, among them, hormonal influence.

Several components contribute to bone health and resistance, including bone remodeling, bone mineral content, and bone mineral density. The estrogen deficiency observed in women with menstrual dysfunction and alteration of the hypothalamic-pituitary-ovarian axis may influence this process, resulting in bone disorders with possible development of osteopenia or osteoporosis (Nichols et al., 2007)

It is known that estrogen has a protective effect on bone tissue, since it acts on the inhibition of osteoclast function by the induction of apoptosis, decreasing bone resorption and maintaining BMD at an ideal level for the individual's age group and sex (Takeda et al., 2016; Duckham et al., 2012). In addition, estrogen acts on osteoblasts stimulating synthesis of the bone matrix. Therefore, changes in bone remodeling with reduction in bone mineral density have been related to deficiency of estrogen production, although energy restriction, including inadequate calcium intake, may also compromise bone health.

According to the American College of Sport Medicine (1997), low caloric intake (or low calcium nutrition) favors menstrual dysfunction, potentiates bone mass loss and is a major cause of stress fractures. It is noteworthy that these factors are related to two of the three components that characterize the female athlete triad.

The official positioning of the American College of Sports Medicine in 1992 (ACSM, 1992) defined osteoporosis as a disease characterized by a deterioration of the microarchitecture of bone tissue, leading to a growing fragility of the bone tissue and increased risk of fractures. Therefore, the incidence of bone fractures due to stress could be indicative and predictive of the presence of bone disorders (Mudd et al, 2007).

It is known that from 50% to 63% of bone mass is obtained during childhood and 37% to 50% in adolescence (Gilsanz et al., 2011). A recent study indicates that in women, 92% of the bone mineral content is obtained by around 18 years of age and peak bone mass occurs between 20 and 25 years of age. However, after this period, depletion begins, that is, loss of bone mineral density, by 0.8% per year (Macknigth, 2017). After menopause, this rate increases to 3% per year, remaining stable for a decade. Then, the rate declines to about 1% per year. In some women, a loss of up to 30% of total bone mineral density is observed around age 70 (Drinkwater, 2005).

Studies done with high-performance female athletes have shown a prevalence of 22% to 50% for osteopenia and up to 13% for osteoporosis confirmed by bone densitometry (DEXA-densitometry by dual emission of X-rays) (Goolsby, 2017, Macknigth, 2017). This is a noninvasive, low-radiation, gold standard examination for the diagnosis of bone disorders. (Pinheiro & EIS, 2010). For the evaluation of bone mineral density by DEXA, the values obtained are compared with mean BMD measurements of peak bone mass in young adults, obtaining the T-score. This is an international benchmark established by the World Health Organization (World Health Organization, 1994). By means of the T-score it is possible to verify a deviation from the ideal BMD, with a value of zero representing the mean and negative or positive values distant from this ideal. Among these, negative values are the most worrisome indicating a distancing from the ideal due to loss of bone mass.

Among children and adolescents, the Z-score is used to evaluate bone mineral density, by comparing the results obtained with individuals of the same age and sex, since this population is in development and, therefore, has not yet reached a BMD beyond their age group (Lewiecki et al., 2008). The International Society for Clinical Densitometry established a Z-score of ≤-2 SD as "below age-related expectations" and a Z-score> -2 as "within age-related expectations".

Since training promotes an increase in BMD from 5% to 15% (Gilsanz et al., 2011; Tenforde et al., 2015) the American College of Sports Medicine defined "low bone mineral density" as the female athlete who presented a Z-score between -1 and -2 SD along with clinical factors for fracture (presence of eating disorders, menstrual dysfunction and history of fractures) and “osteoporosis” with Z-score ≤-2 SD, with clinical risk factors for fracture. (Nattiv, et al., 2007).

In the high-performance athletic field, it is of fundamental importance that the female athlete has conditions favorable to bone health during the period of childhood and adolescence to maximize the gain in bone mass.

Eating Disorders

In modern society, there is a growing concern with the aesthetics of one’s body, resulting from the imposition of the media on a stereotyped body image, corresponding to an unreal appearance of thinness without, however, considering aspects related to health and the different physical compositions of each population (KANDEMIR et al., 2018).

Dissatisfaction with body image and shape resulting from the attempt to adjust to established standards, leads an increasing number of young people to take extreme and harmful measures to their health, resulting from the control of their body weight (Borowsky et al., 2016). Without professional orientation, these young women tend to adopt inadequate dietary practices, such as severe dietary restriction (diets), extreme compulsion to practice physical exercise associated or not with the indiscriminate use of laxatives and diuretics, which are considered precursor behaviors of eating disorders (De Bruim, 2017).

Studies affirm (Estima et al., 2014; Carvalho et al., 2017) that the multifactorial model is the most accepted etiological model for explaining the genesis of eating disorders. This model is based on the hypothesis that there is a contribution of biological, genetic, psychological, sociocultural and familial factors to the development and maintenance of ED (Kouidou et al., 2016). Although there is interaction among these factors, some authors have highlighted sociocultural factors as the greatest influence on the etiogenesis of this syndrome (Estima et al., 2014, Kouidou et al., 2016, De Bruin, 2017).

ED refer to a persistent eating disturbance or behavior related to it, which causes a change in food consumption that significantly impairs the individual’s physical health and psychosocial stability (Perini et al., 2009a)

According to Kandemir et al. (2018), anorexia nervosa and bulimia nervosa are the most evident pathologies of this altered eating behavior and are closely related because they present common symptoms such as altered representation of body shape, a pathological fear of gaining weight and excessive concern with weight. Individuals who develop ED use an arsenal of methods for weight control, including excessive physical activity resulting in physical, social and psychiatric impairment. The age range with the highest risk for anorexia nervosa has been reported between 13 and 15 years old and for bulimia between 17 and 25 years old (Pereira et al.,

2010). In sports, the prevalence of eating disorders is about 20% and 13% among elite adult and adolescent athletes, respectively. (Mountjoy et al., 2014; Gibbs et al., 2013).

Sport Performance and the Female Athlete Triad

The importance of proper fueling for sport has been emphasised as a cornerstone of athletic health and performance for decades. So, due this, often, energy deficiency in elite athletes may be related to the unbalancing training and schedules with meal times. Several athletes consume meals at irregular intervals, without good periodization along the day, resulting in impairment in the energy offer to the body (De Souza, Koltun, Etter, & Southmayd, 2017; Vescovi & Van Heest, 2016). Fluctuations in this caloric intake marked by periods of deficiency throughout the day can lead to decreased lean mass, and increased body fat percentage when experienced chronically over prolonged periods of time (Vescovi & Van Heest, 2016) and, in fact, can be detrimental to performance in sport. Development of athlete training planning need attempt give optimal energy to enhance the sport performance.

About the knowledge that an adequate preparation and development of the cardiovascular and musculoskeletal systems, regular endurance training to tolerate strenuous exercise and aerobic and anaerobic metabolism (high energy phosphate and glycolysis) seem to be the determinants of this intermittent high-intensity sport, all this is influenced by the energy acquired from the meal, evidencing the importance of the correct planing of the energy offer in according to the energy expendure (Silva & Silva, 2017; Yagüe, Del Valle, Egocheaga, Linnamo, & Fernández, 2013).

Studies has been showing that the fatigue has relation with the carbohydrate storage (Hearris, Hammond, Fell, & Morton, 2018), and this, obviously are dependent of the energy intake strategies.

Physiologically, the muscle cells possess a highly coordinated and regulatory network which function to ensure ATP demand is matched by ATP synthesis having the energetic substrates from the several meal as source. So, in a physiological perspective, factors, such as exercise intensity, duration, nutritional status, training status, for exemple, can all regulate substrate utilization during exercise, largely through influencing the potential regulatory control points (Hearris et al., 2018).

Hawley, Schabort, Noakes, & Dennis (1997) cited that more CHO consumption can improve exercise capacity by approximately 20%, and, in another hand, low CHO will decrease the sportive performance. The time trial performance can increase by 2–3% with good levels of energy available.

Yet, providing substrate availability for ATP synthesis, it is recognized that glycogen availability, especially the intramyofibrillar storage pool, can directly modulate contractile function. Studies from Ørtenblad and colleagues have collectively shown preferential utilization of this storage pool during exercise in a manner that also correlates with impaired Ca2+ release from the sarcoplasmic reticulum a very important site of the muscle contraction mechanism. Such impaired excitation–contraction coupling is likely to be of particular importance during situations where higher power outputs and sprint finishes are required in the very late and finishing stages of races ou to maintance the performance until the end line (GEJL et al., 2014; Ørtenblad, Nielsen, Saltin, & Holmberg, 2011; Ørtenblad, Westerblad, & Nielsen, 2013).

Several evidences of the Female Athlete Triad are present in different competitive athletes were the performance was decreased by 9.8% when ovarian hormones and TT3 were suppressed, but, junior elite swimmers with ovulatory menstrual cycles and healthy energetic status the performance increased by 8.2%.

Due the importance of the after discussed, and the irrefutable relation with the muscle function and performance, these data suggest that poor energetic status that can result in a menstrual cycle impairment could impact negatively the athletic performance (Vanheest et al., 2014).

Conclusions

That high-level sports training, aiming at a maximum performance, requires the athlete training to overcome their individual limits, which, when not accompanied by a multidisciplinary team, can be a promoter of the development of the components of the female athlete's triad. For high-level competitive success and maintenance of the ideal conditions for athlete's health, it is necessary, therefore, to monitor the training, especially to those athletes participating in modalities considered to be at risk for the development of this syndrome.

Therefore, it is necessary to emphasize the real importance of the monitoring of high level athletes, especially during adolescence, exercised by professionals such as nutritionists, psychologists, physicians, physiotherapists, together with the coach and the physical trainer in the sports teams, the order to promote optimal performance without compromising athlete's health and development.

It is emphasized that the practice of regular physical exercise, or even high-performance sports training, adequate to the biopsychosocial conditions of the athlete has a positive effect on his health.

The periodic monitoring of changes in body composition, nutritional conditions to verify dietary behaviors, and energy availability and menstrual function of female athletes submitted to elite training is essential for the maintenance of an athlete's health and optimal sports performance.

Female athletes participating in sports that value aesthetics and low fat percentage may be at risk for developing female athlete triad. Since the components of this syndrome are interrelated, the identification of at least one of the components enables, by means of professional intervention, prevention of the development of the complete triad, that is, with all three components. In this way, the early detection of one of its components is fundamental to avoid long-term negative consequences for health, besides improving the performance of the athlete.

It is imperative that the follow-up of athletes undergoing high-level training by doctors, nutritionists and psychologists, as well as the coach and physical trainer, be a common practice in all sport modalities and categories, since this is the only way one can preserve female athletes' health, especially among those still growing and developing. This practice will result in better athletic performance and a longer, more productive and healthier athletic life. The knowledge of signs and symptoms of FAT by coaches and physical trainers becomes important so that preventive actions can be taken.

It is important to clarify that although the Female Athlete Triad was initially described as a syndrome specific to female athletes, it is now known that it may also affect any adolescent or woman concerned with fitness and performance. Thus, it should be emphasized that these women should also be evaluated periodically, especially among those who regularly attend gyms, in order to act in a preventive manner.

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