

The female athlete triad: special considerations for adolescent female athletes

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Abstract: The number of adolescent girls participating in sports has dramatically increased throughout the last few decades. In the early 1990's, an association between amenorrhea, osteoporosis, and disordered eating was recognized and eventually labeled the 'Female Athlete Triad'. In 1997, the Task Force on Women's Issues of American College of Sports Medicine (ACSM) published a position statement on this triad of conditions that were becoming increasingly more prevalent amongst female athletes. Initially, the 'Female Athlete Triad' was characterized by disordered eating, amenorrhea, and osteoporosis. However, as the number of adolescent female athletes has continued to grow, there has been further research and investigation into this field and the triad has evolved in definition. It is essential for all health care practitioners and other professionals who care for adolescent athletes to be attentive to the clinical signs, detection, evaluation, and management of the female athlete triad, as the sequelae can have a significant impact on the health and well-being of a young person both in the short and long-term.

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Background

First identified in 1992, the 'Female Athlete Triad' was originally characterized by disordered eating, amenorrhea, and osteoporosis (1). However, the female athlete triad is now characterized as a spectrum of interrelated conditions and complications that include low energy availability (EA) with or without disordered eating, menstrual dysfunction, and low bone mineral density (BMD), according to the 2007 ACSM's position stand (2). The current definition is a much more encompassing description when compared to the original characterizations. This definition emphasizes the continuum of the condition and the fact that athletes may present with any of the three components, and the components do not need to be present simultaneously

in an athlete for the individual to suffer negative health consequences. The ACSM's 2007 position was further supplemented by the 2014 Female Athlete Triad Coalition Consensus Statement, which focused on treatment and return to play (3). The American Academy of Pediatrics Council on Sports Medicine and Fitness also recently published a clinical report providing guidance for clinicians who provide pediatric care regarding the approach to individuals with female athlete triad (4).

While the actual prevalence of athletes who fall under the female athlete triad remains unknown, by the early definition (disordered eating, amenorrhea, and osteoporosis), studies showed 1–4% prevalence among female athletes. Prevalence is expected to be much higher now that the definition is more inclusive (not all three

components of the triad need be present) and is likely underestimated due to a variety of factors including, failure by professionals to recognize symptoms, a spectrum of clinical presentation, and lack of symptom reporting by athletes (3-5).

In 2014, the International Olympic Committee (IOC) expert working group introduced a broader, more comprehensive term of 'Relative Energy Deficiency in Sport' (RED-S) for the condition previously known as 'Female Athlete Triad.' The term RED-S is meant to refer to the broad and various impaired physiologic functions that can be caused by relative energy deficiency and is meant to be inclusive of male athletes who may also be affected (6,7). However, authors of the Triad Consensus papers have alleged that the umbrella term RED-S may have the potential to confuse and detract from the body of research and clinical work done to date regarding the female athlete triad (8,9). For the purpose of this review, we recognize the broader RED-S terminology and concepts, but focus on the diagnosis known as the female athlete triad.

Decreased EA

The primary disorder driving the pathophysiology of the rest of the triad is decreased EA. Originally, this portion of the triad was labeled "disordered eating." The definition has broadened and it has been recognized that an athlete does not have to have an officially diagnosed eating disorder to manifest the other complications of the syndrome (1-4). An athlete that has a negative energy balance, from a variety of factors, may be at risk for developing the female athlete triad. Negative EA may occur by failure to maintain adequate nutrition and caloric intake for the level of rigorous physical training an athlete puts on their body. Negative EA can also occur via decreased caloric intake as is seen in dieting behaviors, specific lifestyle and dietary practices such as veganism, food restriction, purging, stimulant use, or laxative use. Negative EA through some of these methods may be part of a clinically defined eating disorder (2,10).

Decreased EA results in altered Gonadotropin Releasing Hormone (GnRH) pulsatility, which may lead to a hypoestrogenic state in the athlete, through the effects of LH and FSH. The hypoestrogenic state can contribute to irregularities in menstrual cycles and a decrease in BMD (11). With or without any eating disorder, sustained low EA can impair health and cause medical complications in cardiovascular, endocrine, reproductive, and skeletal

systems, among others (2-4).

Menstrual disorders

Adolescents with the female athlete triad can present with a variety of menstrual abnormalities including amenorrhea, oligomenorrhea, and problems with ovulation. Amenorrhea can present as either primary or secondary. Primary amenorrhea is characterized as a lack of menarche by age 15 years in the presence of other secondary sexual characteristics or the lack of menarche approximately 2.5 years after development of secondary sexual characteristics (typically by age 13 years). Secondary amenorrhea is characterized as an absence in menstruation for more than three cycles or six months in females who have had regular menses. Oligomenorrhea is defined as menstrual cycles that are greater than 35 days apart. In the adolescent population, it can be difficult to correctly distinguish menstrual irregularities, as their hormonal system may still be maturing. The ACSM recommends screening for female athlete triad, and potentially other underlying medical issues, in any athlete with a total of 6 months of amenorrhea or oligomenorrhea (2).

Low EA can result in abnormal GnRH release, which can affect the pulsatile nature of Luteinizing Hormone (LH), release of estrogen, and lead to menstrual irregularities. Amenorrhea via this mechanism is known as functional hypothalamic amenorrhea (FHA), and is associated with the female athlete triad (4,12). Low EA can also alter a variety of other metabolic hormones including insulin, cortisol, growth hormone, insulin-like growth factor, and leptin, which may play a role in development of abnormal menstruation. Amenorrhea in the female athlete may also be secondary to the permissive action of leptin, which is an important hormone for the initiation of puberty and LH secretion (13).

Decreased BMD

Abnormal bone development, osteopenia, and osteoporosis can be part of the female athlete triad and are particularly problematic to the adolescent population. Estrogen plays an important role in the physiology of BMD and bone formation and hypoestrogenemia can have a negative impact on musculoskeletal health (3). A continuous process of osteoblastic and osteoclastic activity, mediated by estrogen, contributes to initial development of ongoing bone health (14). To obtain optimal BMD, adequate nutrition,

including overall EA, vitamin D, and calcium, and moderate physical activity with weight-bearing exercise is required. This process is especially important for adolescents, as 25% of bone mass accrues during the two years surrounding menarche. The greatest addition of bone mass happens in puberty with approximately 90% of peak bone mass attained by 18 years of age (3,4,14). When normal processes are interrupted (such as in a hypoestrogenic state), an athlete's bones may become weaker with decreased BMD, and more prone to injury and risk of fracture (14). A study has shown athletes who self-report amenorrhea or oligomenorrhea had a 3 times greater risk of musculoskeletal injury (5). An adolescent with the female athlete triad is at risk for suboptimal bone mass acquisition and although BMD may stabilize or improve, depending on the duration of the triad, they may never return to normal age appropriate BMD. This could have lifelong effects (15).

Assessment

Medical practitioners, coaches, dietitians, trainers, mental health providers, among other professionals who come in contact with female athletes, should be able to correctly identify at-risk athletes for the female athlete triad. Early screening, identification, and intervention is important in order to avoid long term complications (2). Unfortunately, research has shown that knowledge of the triad by coaches, athletes, and even primary care physicians remains low (16,17).

Screening should occur at sports pre-participation physicals or yearly check-ups (3,18). Screening should also occur if an athlete presents to medical care with particular concerns that place her at risk for the triad. When an athlete presents to a medical provider with one or more potential component of the triad, it is important to evaluate for the rest of the triad components. It is important that an athlete feels comfortable with the health care practitioner and is willing to be honest and forthcoming with information. Therefore, the athlete and all practitioners involved in care should be able to enter into a therapeutic alliance (3).

Individuals who warrant screening for the triad include athletes with a history of stress fractures, multiple pathological fractures, overuse injuries, and/or menstrual irregularities. The ACSM recommends screening all female athletes for the triad if they have had a total of six months of amenorrhea or oligomenorrhea (2). Additional specific risk factors or behaviors include a history of critical comments about eating or weight from a person of influence, a

history of depression, a history of dieting, an obsessive or perfectionist personality, frequent weight fluctuations or pressure to lose weight, early initiation of the sport, overtraining, recurrent injuries, and inappropriate coaching behavior (3). Practitioners should be aware of "thin sports", such as long distance running, gymnastics, figure skating, dance, and cheerleading, which pose an increased risk for an athlete having the triad (10,12,19).

During the initial assessment, a health care provider should obtain a complete history from the patient, particularly focused on diet, exercise/sport type and frequency, menstrual history, body image, medication and supplements taken, including contraceptives, and history of injuries. Although the current pre-participation form endorsed by the American Academy of Pediatrics (AAP) includes eight questions pertaining to the triad, the 2014 Triad Consensus Panel recommends a more Triad-specific set of 12 questions that can be followed by an in-depth evaluation if concerns arise (3,18,20). The screening questions are as follows: "Have you ever had a menstrual period? What was your age when you had your first menstrual period? When was your last menstrual period? How many periods have you had in the last 12 months? Are you taking any female hormones (estrogen, progesterone, birth control pills)? Do you worry about your weight or body composition? 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? And have you ever been told you have low bone density (osteopenia or osteoporosis)?" (3).

During the physical exam, it is important to include orthostatic blood pressure measurements with vital signs and to include a Tanner staging exam. It is important to document body mass index (BMI) and to look for physical exam findings found in individuals with eating disorders (ex: cold extremities, lanugo, knuckle scars, parotid gland enlargement) (20). Initial work-up may include evaluation of complete blood count (CBC), comprehensive metabolic profile (CMP), thyroid function tests, urinalysis (UA), and pregnancy test. In addition, vitamin D and calcium levels can be obtained (4,20). Laboratory testing should be based on individual patient presentation and which components of the triad are present, as well as any other accompanying history or physical findings that would suggest underlying abnormality. During screening and assessment, an electrocardiogram (EKG) may be warranted (4,11).

Formally evaluating EA, especially in adolescents, can be

somewhat difficult. Methods to assess EA are improving, but are not exact. BMI calculation can be a starting point in assessing EA, with low BMI suggesting deficiency. However, it is important to note that overweight athletes can also be energy deficient. The gold standard for calculating EA involves a 72-hour food log in addition to accelerometer data, heart rate monitoring, or exercise journal self-report for calculation of energy expenditure (12). Logistically, calculation of energy expenditure is not always practical or accurate in daily practice. It is important to get a detailed dietary evaluation utilizing a registered dietician if caloric intake in relation to energy expenditure is a concern. Web-based calculators can be used to estimate energy expenditure, but again these calculations come with inherent error (3).

When evaluating menstrual abnormalities, it is important to initially rule out pregnancy. Secondary amenorrhea should prompt exclusion of other specific endocrine disorders, such as thyroid conditions, hypothalamic or pituitary disorders, polycystic ovarian syndrome, or hypercortisolemia. Additionally, in those with primary amenorrhea, structural abnormalities must be ruled out (3,4).

To evaluate bone density in adolescents, the main diagnostic tool used is the dual-energy X-ray absorptiometry (DEXA). In individuals less than 20 years of age, the posteroanterior aspect of the spine and the whole body minus the head are preferred testing sites (2). For adolescent athletes, the Z-score is more appropriate for measurements, as it compares BMD to age and gender matched controls (11). The ACSM defines a low BMD as a Z-score between -1 and -2 with clinical risk factors, and osteoporosis as a Z score less than or equal to -2 with clinical risk factors. Clinically significant fractures include: long bone fracture of the lower extremity, vertebral compression fracture or two or more long-bone fractures of the upper extremities (2,21).

Management/treatment

The management of an individual with female athlete triad should have a multidisciplinary approach. Treatment of the three triad components and recovery of energy status, menstrual status, and bone health occur at different rates. Initial management should focus on the low energy state. Management is mostly supportive in nature and non-pharmacological treatment modalities should be initial management of the triad. When energy balance is restored, it is then possible to restore normal menses and enhance

bone density. In 2014, the Female Athlete Triad Coalition Consensus Statement developed recommendations for treatment and return to play (3).

In managing the low energy state, the focus should be determining and reversing the root cause of the energy deficiency. In most cases, modifications in diet and exercise are needed to normalize energy balance. A focus on restoring a normal body weight is needed to work towards normalizing menses and BMD (3). Athletes may be somewhat resistant to treatment plans that include restricting activity or increasing caloric intake and this will need to be addressed. Specific treatment goals will need to be tailored to the athlete, but may include reversal of weight loss, normalizing body weight for the normalization of menses, returning to a weight that is greater than or equal to 90% of predicted weight or setting a goal daily energy intake (3). The amount of weight gain that typically leads to resumption of menses is variable among individuals with a range of 5–10% of body weight or 1–4 kg of weight gain associated with resumption of menses (3).

If a clinically diagnosed eating disorder has been identified, it is important to have a mental health practitioner as part of the treatment team. Cognitive behavioral therapy (CBT) has been studied and may be beneficial to be included in the athlete's treatment plan. Contracts have also been used to aid in compliancy throughout a treatment regimen (3).

The restoration of menses should be attempted using non-pharmacological modalities initially. It has been emphasized that the use of combined oral contraceptive pills (OCPs) is not a "magic solution" and should be used in a judicious manner. OCPs do not automatically allow an athlete to resume normal menses and they do not optimize bone health. At times, they can instead give a false sense of security. There are some instances when these medications may be beneficial though, including an athlete with infertility, symptoms of estrogen deficiency (such as vaginal dryness), or impaired bone health despite non-pharmacological treatment modalities in place (3,4,22).

Weight gain alone has been shown to improve BMD. Weight-bearing exercise also has a beneficial effect on BMD. Dietary supplements of Vitamin D and calcium should be started. The current recommendation for adolescents is 1,300 mg of calcium per day and 600 IU of Vitamin D per day. There have been initial studies done that show increase in BMD with use of mechanical stimulation, such as vibratory platforms. More research must be done on these modalities before strong recommendations can be put in

place. Improvements in BMD occur more slowly than other components of the triad. Research is lacking to support pharmaceutical treatment, such as use of bisphosphonates, of low BMD in the setting of the triad (3,23).

The athlete must be cleared both psychologically and medically before they can return to their sport and decisions regarding level of sports participation and return to play should be based on level of medical risk in which the athlete is categorized (3). There are no standardized guidelines for return to play and plans should be individualized based on the athlete. However, the ACSM suggests utilizing a multidisciplinary approach with risk stratification based on evaluation of health status or medical factors, evaluation of sports participation risk, and modifying factors such as timing/season or internal/external pressures (3,24). Ideally, abnormal findings on exam should have normalized and the athlete must agree to the treatment and management plan. Education, maintenance of a therapeutic alliance, and utilization of a multidisciplinary approach are key to athlete adherence to treatment and management strategies (3,19).

Long term effects

Even with management and treatment, athletes with the triad are at risk for long term sequelae. First of all, because adolescence is such an important time for bone growth and acquisition, it is possible to stabilize but never quite return to optimal BMD. Athletes with the triad and concomitant eating disorders are at a high risk of maintaining sub-optimal BMD (15).

The alterations to the adrenal, thyroid, and gonadal axes may not only have immediate consequences in athletes, but could have detrimental health consequences on future pregnancy (25). In addition, long term negative cardiovascular effects can occur, as endothelial dysfunction can be seen in these athletes and can be a marker for future cardiovascular risk (3,4).

Conclusions

The Female Athlete Triad is a condition of low EA, menstrual irregularities, and low BMD. This triad affects many adolescent athletes and can lead to serious long term negative sequelae if not correctly identified and managed. Athletes presenting with one component of the triad are at risk for and should be evaluated for the other components. It is important for all those who work with these athletes to be able to identify individuals at risk and

either directly screen the athletes or refer to the appropriate health care provider. Early screening and intervention is vital, especially in adolescents who are still in the process of growing and maturing. The annual health maintenance visit with a primary care health care provider or the sports pre-participation evaluation are opportunities to screen adolescents for the female athlete triad. Health care providers and professionals working with adolescent athletes have an opportunity to provide education regarding the female athlete triad and contribute to preventive strategies for youth athletes at risk.

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Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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