



The Female Athlete Triad

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The number of girls participating in sports has increased significantly since the introduction of Title XI in 1972. As a result, more girls have been able to experience the social, educational, and health-related benefits of sports participation. However, there are risks associated with sports participation, including the female athlete triad. The triad was originally recognized as the interrelationship of amenorrhea, osteoporosis, and disordered eating, but our understanding has evolved to recognize that each of the components of the triad exists on a spectrum from optimal health to disease. The triad occurs when energy intake does not adequately compensate for exercise-related energy expenditure, leading to adverse effects on reproductive, bone, and cardiovascular health. Athletes can present with a single component or any combination of the components. The triad can have a more significant effect on the health of adolescent athletes than on adults because adolescence is a critical time for bone mass accumulation. This report outlines the current state of knowledge on the epidemiology, diagnosis, and treatment of the triad conditions.

abstract

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INTRODUCTION

The benefits of exercise in adolescents are well established, including improved self-esteem, fewer risk-taking behaviors, increased bone mineral density (BMD), and decreased obesity.¹⁻³ However, when exercise occurs without adequate energy intake to compensate for exercise-related energy expenditure, there may be adverse effects on reproductive, bone, and cardiovascular health. The female athlete triad (referred to hereafter as the “triad”) was first widely acknowledged as the 3 interrelated conditions of amenorrhea, osteoporosis, and disordered eating in an American College of Sports Medicine position statement published in 1997.⁴ Since that time, a more inclusive definition has evolved because it has become clear that each component of the triad exists on a spectrum; the 3 components were renamed menstrual function, BMD, and energy availability (EA) to more accurately represent the spectrum, which can range from optimal health to disease in each component.⁵ In addition, athletes may present with 1, 2, or all 3 of the components.

Adolescent athletes are in a critical period of bone mass accumulation, so the triad disorders can be particularly harmful in this group.⁶ Appropriate intervention during the adolescent years may improve peak bone mass accrual, an important predictor of postmenopausal osteoporosis, potentially preventing low BMD, postmenopausal osteoporosis, and fractures in adulthood. Two investigators have also identified lower BMD as a risk factor for stress fracture in athletes.^{7,8} It is difficult to estimate the true prevalence of the triad because of the complexity of evaluation of each of the components. Reports have indicated that the prevalence of individuals with all 3 components simultaneously is only 1% to 1.2% in high school girls^{9,10} and 0% to 16% in all female athletes. In high school-aged female athletes, the prevalence of 2 concurrent components of the triad is 4% to 18% and of any 1 component is as high as 16% to 54%.⁹⁻¹⁵

Education of pediatricians, who are most likely to encounter adolescents with triad-related disorders, is especially important. Unfortunately, a 2009 study found that only 20% of pediatricians were able to correctly identify all 3 components of the triad, compared with 50% of family medicine physicians and 41% of orthopedic surgeons.¹⁶ Most physicians reported receiving no education in medical school or through continuing medical education on triad-related issues.¹⁶

RISK FACTORS

Although the triad disorders may occur in any sport, athletes participating in sports with endurance, aesthetic, or weight-class components or sports that emphasize and reward leanness are at increased risk (see Table 1).^{5,17} Other identified risk factors for the triad include early

age at sport specialization, family dysfunction, abuse, and dieting.^{5,17}

Energy Availability

EA is defined as daily dietary energy intake minus daily exercise energy expenditure corrected for fat-free mass (FFM).⁵ Optimal EA has been identified to be 45 kcal/kg FFM per day in female adults but may be even higher in adolescents who are still growing and developing. The spectrum of EA ranges from optimal EA to inadequate EA, with or without the presence of disordered eating/eating disorder. Recently, it has become clear that many athletes affected by the triad do not exhibit pathologic eating behaviors, and their low EA is unintentional. Low EA adversely affects bone remodeling, and EA <30 kcal/kg FFM per day disrupts menstrual function and bone mineralization.¹⁸⁻²⁰ Disruptions in luteinizing hormone can be seen after only 5 days of reduction in EA to 30 kcal/kg FFM per day.¹⁸ The only study of EA in adolescent females found that, although athletes were more likely to have suboptimal EA, both athletes and controls restricted intake, with 6% of female athletes and 4% of sedentary controls having an EA <30 kcal/kg FFM per day. Furthermore, 39% of athletes and 36% of controls had an EA <45 kcal/kg FFM per day.⁹

Disordered eating in adolescent athletes has been evaluated by using a variety of survey tools, such as the Eating Disorder Exam Questionnaire, the Eating Disorder Inventory, and the Three-Factor Eating Questionnaire. Studies that used these tools provide estimates of disordered eating ranging from 0% to 54%.^{9,10,21-23} The use of pathologic weight-control techniques, such as vomiting, diuretics, or laxatives, ranges from 0% to 54% in recent studies.^{9,10,24}

Even in the absence of amenorrhea, disordered eating is associated with lower BMD in athletes.^{5,25} Low BMI

TABLE 1 Examples of Sports Emphasizing Leanness and Endurance

Wrestling
Light-weight rowing
Gymnastics
Dance
Figure skating
Cheerleading
Long and middle distance running
Pole vaulting

is also a strong predictor for low BMD.¹³ Athletes with a high drive for thinness or increased dietary restraint (an intention to restrict food intake to control weight) are significantly more likely to have low BMD or to sustain a musculoskeletal injury than are athletes with normal eating behaviors.^{26,27}

Many triggers for the onset of disordered eating in athletes have been identified.^{17,28} Sundgot-Borgen¹⁷ found that prolonged periods of dieting, weight fluctuations, coaching changes, injury, and casual comments made about weight by coaches, parents, and friends were the most common reasons given by athletes for the development of disordered eating. Rosen and Hough²⁸ found that 75% of gymnasts who were told by coaches that they were overweight resorted to pathogenic weight-control techniques. Beals²¹ found that 13% to 17% of adolescent volleyball players felt pressured by their coaches or parents to achieve or maintain a particular body weight. Pediatricians can help coaches and families understand that comments and recommendations they make to young athletes regarding weight may increase the risk of disordered eating. If an athlete, her parents, or her coach believes that changes in weight are indicated, they should seek medical assessment and nutritional supervision before initiating a weight-loss plan.

Menstrual Function

The spectrum of menstrual disturbances associated with the

triad can range from anovulation and luteal dysfunction to oligomenorrhea and amenorrhea (primary or secondary). Primary amenorrhea is defined as the absence of menarche by the age of 15 years.²⁹ The absence of other signs of pubertal development by 14 years of age or a failure to achieve menarche within 3 years of thelarche is also abnormal.^{29,30} Secondary amenorrhea is defined as the absence of menses for 3 consecutive months or longer in a female after menarche. Oligomenorrhea is defined as menstrual cycles longer than 35 days. Luteal phase deficiency is defined as a menstrual cycle with a luteal phase shorter than 11 days in length or with a low concentration of progesterone. Menstrual disturbances, such as anovulation and luteal phase deficiency, are asymptomatic, making them difficult to diagnose by history alone. After excluding other causes of amenorrhea (Table 2), amenorrhea in the setting of inadequate EA is diagnosed as functional hypothalamic amenorrhea.⁵ The word “functional” indicates suppression, attributable to lack of energy, of an otherwise intact reproductive endocrine axis.

Menstrual irregularities are common during adolescence and are significantly more common in adolescent athletes. Of the published studies of menstrual disturbances in adolescent athletes, only 1 study included a sedentary control group. That study reported an incidence of menstrual irregularity of 21% in sedentary adolescents compared with 54% in adolescent athletes.⁹ Other studies reported menstrual disturbances in adolescent athletes ranging from 12% to 54% for any menstrual irregularity (primary or secondary amenorrhea or oligomenorrhea).^{9–11,21,22,24,31,32} When evaluating specific types of menstrual irregularity, primary amenorrhea in athletes ranges from 1.2% to 6%, secondary amenorrhea ranges from 5.3% to 30%, and

TABLE 2 Causes of Secondary Amenorrhea in Adolescents

Pregnancy
Polycystic ovarian syndrome
Pituitary tumor
Prolactinoma
Hyperthyroidism
Liver/kidney disease
Medications: oral contraceptive pills, chemotherapy, antipsychotics, antidepressants, corticosteroids
Eating disorders

oligomenorrhea ranges from 5.4% to 18%.^{10,15,21,22,24,31} The prevalence of anovulation and luteal phase deficiency has not been evaluated in adolescent athletes but ranges from 5.9% to 30% in adult athletes.¹¹

Amenorrheic adolescent athletes have a significantly lower BMD than eumenorrheic adolescent athletes or sedentary controls.^{13,31,33} Some studies have found that athletes with menstrual irregularities are as much as 3 times more likely to sustain bone stress injury and other musculoskeletal injury than are eumenorrheic athletes,^{26,34–36} but this finding has not been consistent.³⁷ Oligomenorrhea and amenorrhea have also been associated with cardiovascular risk factors, including increased cholesterol and abnormal endothelial function.^{38,39} In addition, menstrual disturbance has recently been related to decreased performance in swimmers with evidence of ovarian suppression compared with those without ovarian suppression.⁴⁰

Bone Health

The decreased rate of bone acquisition that can be associated with the triad in adolescent athletes is particularly concerning, because bone mass gains during childhood and adolescence are critical for the attainment of maximal peak bone mass and the prevention of osteoporosis in adulthood.^{6,41} The maximum rate of bone formation usually occurs between the ages of 10 and 14 years, and peak bone mass

is likely attained between the ages of 20 and 30 years.^{42,43} By the end of adolescence, almost 90% of adult bone mass has been obtained.⁴³

Genetics, participation in weight-bearing activities, and diet all influence bone mass in children.⁴⁴ Appropriate dietary intake and weight-bearing exercise can positively influence maximum bone mass gains during childhood and adolescence. With improved EA and resumption of menses, some “catch up” bone mass accrual may be possible in athletes with the triad; however, some will have persistently lower BMD than their genetic potential, highlighting the need for early, aggressive intervention in adolescent athletes identified with triad components.⁴⁵

BMD in children and adolescents is typically evaluated by using dual-energy radiograph absorptiometry (DXA), which is best performed and interpreted by centers with certified clinical densitometrists with knowledge of the official pediatric positions of the International Society for Clinical Densitometry.^{6,46,47} Because athletes participating in weight-bearing sports are expected to have higher BMDs than nonathletes, the American College of Sports Medicine recommends different criteria than the International Society for Clinical Densitometry, as shown in Table 3. In athletes, a Z-score below –1.0 is considered lower than expected and indicates that, even in the absence of previous fracture, secondary causes of low BMD may be present.⁵ A full discussion of the secondary causes of low BMD is beyond the scope of this report, but evaluations for secondary causes typically include the items in Table 4.⁴⁸ Measures of bone microarchitecture, although primarily used for research purposes at this juncture, can add additional information regarding bone quality beyond that of BMD. Favorable changes in bone microarchitecture are associated

TABLE 3 Definition of BMD Criteria in Adolescents

	ISCD Official Position for Children and Adolescents ⁴⁶	ACSM Guidelines for Athletes ⁵
Osteoporosis	Vertebral compression fracture or Z-score ≤ -2 and clinically significant fracture history ^a	Z-Score ≤ 2 and clinical risk factors ^b
Low BMD	—	Z-Score -1.0 to -1.9 and clinical risk factors
Lower BMD than expected	—	Z-Score ≤ -1.0

ACSM, American College of Sports Medicine; ISCD, International Society for Clinical Densitometry.

^a Two or more long bone fractures by age 10 or ≥ 3 long bone fractures at any age up to 19 years.

^b Nutritional deficiencies, hypoestrogenism, or stress fracture.

with sports participation in female adolescents. Weight-bearing athletic activity is associated with greater total trabecular area and greater cortical perimeter in the tibia.⁴⁹ Conversely, oligomenorrhea and amenorrhea are associated with unfavorable bone microarchitecture, including lower total density, lower trabecular number, and greater trabecular separation at the tibia.⁴⁹ Estimations of bone strength indicate that eumenorrheic, but not amenorrheic, athletes have greater stiffness and load-to-failure thresholds, which are associated with decreased fracture risk, compared with nonathlete controls.^{11,50}

Although it is well known that exercise is a stimulus for bone formation, data support that different types of exercise can have differing effects on bone formation. For example, adolescent and collegiate swimmers have been shown to have a similar BMD compared with nonathlete controls and to have a lower BMD compared with athletes in other sports.⁴⁸ In fact, a longitudinal BMD study in swimmers, gymnasts, and nonathlete controls over an 8-month competitive season showed that swimmers and controls had no improvement in BMD, whereas gymnasts showed significant BMD gains despite more body dissatisfaction and menstrual disturbance.⁵¹

Numerous studies have shown running to have a positive effect on BMD compared with inactive controls,⁴⁸ but there is emerging concern, predominantly from cross-sectional studies, that endurance

TABLE 4 Evaluation for Low BMD (BMD < -1.0)

• Serum 25-hydroxyvitamin D
• Serum calcium
• Complete blood count with differential
• Thyroid-stimulating hormone
• Parathyroid hormone
• Bone-specific alkaline phosphatase
• 24-h urine for calcium
• Screening for cortisol excess: morning cortisol or 24-h urine for cortisol
• Celiac disease: serum tissue transglutaminase antibodies, total IgA, tissue transglutaminase IgG (in the IgA-deficient adolescent)
• Markers of bone formation and resorption: serum osteocalcin and urine N-telopeptide
• Reproductive hormone evaluation: estradiol, FSH, LH in girls, testosterone in boys

FSH, follicle-stimulating hormone; IgA, immunoglobulin A; IgG, immunoglobulin G; LH, luteinizing hormone.

runners have lower BMDs than sprinters, gymnasts, and ball sport athletes.^{31,51-56} Barrack et al⁵³ reported a higher prevalence of low BMD in adolescent endurance runners (40%) than in ball or power sport athletes (10%). This study also showed that runners 17 to 18 years of age had similar bone mineral content (BMC) compared with 13- to 14-year-old runners, whereas BMC in nonrunner athletes showed a significantly higher BMC in the older group compared with the younger group. These findings suggest a possible suppression of bone accumulation in adolescent runners, although other factors may be contributing to this finding, including possible variable bone accrual patterns attributable to genetics, rate of maturation, specific type of current and previous physical activity, and EA and menstrual differences often found between endurance runners and nonendurance athletes.⁵³

Many factors are associated with an increased risk of low BMD in female adolescent athletes, including late menarche, oligomenorrhea, amenorrhea, elevated dietary

restraint, greater length of time participating in endurance sports, lower body weight, and lower BMI.^{1,13,31,32,52} The deficits in BMD seen with the triad are associated with low estrogen levels and energy deficiency. Levels of bone formation and resorption markers are significantly lower in amenorrheic adolescent athletes than in nonendurance athlete controls, indicating a state of overall decreased bone turnover.³³ The restriction of EA has been shown to cause estradiol suppression and increased bone resorption as well as suppression of bone formation.¹⁹

A recent multisite prospective study³⁴ identified the contribution of single and multiple triad-related risk factors for bone stress injury in 259 female adolescents and young adults participating in competitive or recreational exercise. The authors found an increased risk of bone stress injuries as the number of triad-related risk factors increased.³⁴

Cardiovascular Health

Endothelial dysfunction, measured by brachial artery flow-mediated

dilation (FMD), is an important predictor of coronary endothelial dysfunction, atherosclerotic disease progression, and cardiovascular event rates.^{38,57,58} Endothelial dysfunction has been correlated with low whole-body and lumbar BMD, menstrual dysfunction, and low estrogen levels in dancers and endurance athletes.^{38,39} In endurance athletes, oligomenorrheic and amenorrheic athletes had impaired FMD compared with eumenorrheic athletes, with amenorrheic athletes showing the greatest impairment.³⁹ In this group, amenorrhea was also associated with increased total cholesterol and low-density lipoprotein levels.³⁹ Among professional dancers, endothelial dysfunction alone was present in 64%, whereas the prevalence of dancers with endothelial dysfunction and all 3 components of the triad was 14%.³⁸ All of the dancers who reported current menstrual dysfunction (36%) had reduced FMD.³⁸ Amenorrheic runners and dancers treated with 4 weeks of folic acid supplementation showed improvements in FMD.^{15,59} Although these studies were not exclusive to adolescents, adolescents were included in the study populations. These results raise concern that an athlete diagnosed with the triad could be at risk of developing cardiovascular disease.

MALE ATHLETES

Although female athletes have been the exclusive focus of research on the triad, low EA resulting in the suppression of the neuroendocrine reproductive axis is likely not gender selective. Low testosterone and estradiol levels have been documented in adolescent males diagnosed with anorexia nervosa.⁶⁰ This finding begs the question: is there a male athlete triad? Male athletes do not have an easily noted symptom such as missed

TABLE 5 The Female Athlete Triad Coalition's Recommended Screening Questions for the Female Athlete Triad⁶⁸

Question	Included on the Fourth-Edition PPE Form ⁶⁹
1. Do you worry about your weight or body composition?	✓
2. Do you limit or carefully control the foods that you eat?	✓
3. Do you try to lose weight to meet weight or image/appearance requirements in your sport?	✓
4. Does your weight affect the way you feel about yourself?	—
5. Do you worry that you have lost control over how much you eat?	—
6. Do you make yourself vomit or use diuretics or laxatives after you eat?	—
7. Do you currently or have you ever suffered from an eating disorder?	✓
8. Do you ever eat in secret?	—
9. What age was your first menstrual period?	✓
10. Do you have monthly menstrual cycles?	✓
11. How many menstrual cycles have you had in the last year?	✓
12. Have you ever had a stress fracture?	✓

menstrual cycles, but they may show suppression of reproductive function nonetheless. There is a small body of data suggesting that male athletes with inadequate EA may also suffer from hormonal changes and low BMD. Lower testosterone levels have been found in male runners compared with inactive controls.⁶¹ Similar to female athletes, male endurance runners have been found to have lower BMD than male athletes in power or ball sports.⁶² Adolescent males with anorexia nervosa display low BMD at multiple skeletal sites.^{60,63} Although the body of scientific evidence is still developing, it is important to consider that adolescent males participating in sports that emphasize and reward leanness may be at risk of a constellation of findings similar to those seen in females with components of the triad.^{64–66}

SCREENING

It is convenient to screen for the triad at the time of a well-child visit and/or the preparticipation physical evaluation (PPE). The Female Athlete Triad Coalition has developed 12 questions for screening (Table 5).^{67–69} Another screening tool is found in the fourth-edition PPE consensus monograph.⁶⁹ This form contains 8 of the 12 questions suggested by the

Female Athlete Triad Coalition and has been endorsed by the American Academy of Pediatrics (AAP) for use when performing the PPE (Table 5). If an athlete answers “yes” to any of the triad questions on the PPE form, the remaining questions from the Female Athlete Triad Coalition⁶⁸ can be used for further evaluation.

A sports level of participation and return-to-play medical risk stratification scoring rubric has been developed by the Female Athlete Triad Coalition Consensus Panel to help the clinician assess an athlete with triad-related risk factors into low-, moderate-, or high-risk categories. Decisions regarding sports participation, level of participation permitted, and return-to-play are made on the basis of the risk category that the athlete falls into and can be reassessed as the athlete progresses through treatment.⁶⁸

DIAGNOSIS

Obtaining a complete nutritional, menstrual, fracture, and exercise history is the first step in diagnosis. Vital signs may reveal bradycardia, which can also be a normal finding in well-trained athletes; orthostatic hypotension; low body weight (<85% expected body weight, which is 50% for height); or low BMI (less than the fifth percentile).⁶⁸ In athletes with

eating disorders, cold/discolored hands and feet, hypercarotenemia, lanugo hair, and parotid gland enlargement may be found.⁵

However, the physical examination is often normal and unrevealing in athletes with the triad, especially in those who do not intentionally restrict EA.⁵

Laboratory assessment aims to evaluate for other causes of oligomenorrhea/amenorrhea, including pregnancy, polycystic ovarian syndrome, prolactinoma, and thyroid disorders, as reviewed in Table 2. In athletes with an eating disorder, a chemistry profile and electrocardiography can be used to evaluate for possible arrhythmia or metabolic disturbance. BMD testing by DXA is indicated in athletes with any of the following: eating disorder (diagnosed by using criteria of the *Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition*⁷⁰), weight <85% of expected, recent weight loss of $\geq 10\%$, menstrual dysfunction or low EA ≥ 6 months, and/or a history of stress or insufficiency fracture.^{5,68} Table 6 lists other factors that, when coupled with a single stress fracture, increase the risk of low BMD.⁴⁸

TREATMENT

Improving EA is the cornerstone of treatment of the triad disorders and has been associated with the return of normal menses and improvements in BMD.^{5,48,60} A multidisciplinary team approach is suggested and may include a physician, a dietitian, a certified athletic trainer, a behavioral health clinician, and, at times, an exercise physiologist. It is preferable that the medical team be familiar with treating athletes. For athletes with an unintentionally low EA without features of disordered eating or an eating disorder, a behavioral health clinician may not be needed.

Improvements in EA can be accomplished by both decreasing

TABLE 6 Factors Prompting BMD Evaluation in Athletes With Stress Fracture

Low BMI (<18.5 kg/m ²)
Recurrent stress fractures
Oligo- or amenorrhea ≤ 6 months
A history of an ED, DE, or low EA
Chronic medical conditions associated with bone loss
Medications associated with adverse effects on bone health
Cancellous versus cortical bone fractures, particularly proximal femur, tibial plateau, and calcaneus
Cyclists, swimmers
No recent change in activity level or training intensity

ED indicates eating disorder; DE, disordered eating.

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exercise expenditure and increasing dietary intake, with the goal of restoration of normal menses and weight. Improving EA to >30 kcal/kg FFM per day can restore menses, although an EA >45 kcal/kg FFM per day is optimal.^{5,71} FFM can be measured by using DXA, air-displacement plethysmography (ie, BodPod analysis [National Institute for Fitness and Sport, Indianapolis, IN]), bioelectrical impedance analysis, or skinfold caliper measurements. Evaluation by an experienced sports dietitian or exercise physiologist can be helpful in determining EA and FFM. Because the assessment of EA can be challenging, other goals of treatment can include the reversal of recent weight loss (if present), return to a body weight associated with normal menses, attainment of BMI ≥ 18.5 or >85% expected weight, and a minimum daily energy intake of 2000 kcal.^{48,60} A gradual increase of 200 to 600 kcal/day and a reduction in training volume of 1 day per week are usually sufficient to attain the needed improvements in weight and EA.^{48,71} It is important to recognize that the resumption of menses may take up to 1 year or longer after restoration of appropriate EA.⁴⁸ A written treatment plan (contract) signed by the providers and athlete/parent(s) can be a useful tool to outline and define the treatment plan and expectations on the part of the athlete, parent(s), and medical providers (for a sample contract, see the Supplementary Data in ref 48).

Studies of the effects of oral contraceptive pills on BMD have produced mixed results,^{5,6,72–74} and they may give the athlete a false sense of security that EA has been restored, so their use is typically avoided unless they are being prescribed for other indications. It is important to recognize that the hormonal environment provided by oral contraceptive pills is not the same as a naturally occurring menstrual cycle. Misra et al⁷⁵ reported a significant improvement in spine and hip BMD with the use of a transdermal estrogen patch in anorexic female adolescents, indicating that the transdermal route may be a more favorable method. However, this method has not yet been studied in athletes with the triad.

Optimizing calcium and vitamin D intake is an important part of treatment.^{5,6} Significantly more athletes with stress fractures have low calcium intakes than do athletes without stress fractures.³⁵ Assessing 25-hydroxyvitamin D concentration is useful in athletes presenting with components of the triad.^{1,46} The AAP currently recommends a daily intake of 1300 mg calcium for children and adolescents ages 9 to 18 years and 600 IU vitamin D for children and adolescents ages 1 to 18 years, although many experts recommend higher intakes of vitamin D, particularly in climates where sun exposure is limited.¹ The International Osteoporosis Foundation calcium calculator can be used as a tool to estimate calcium

intake from dietary sources (www.iof.org). In addition to calcium and vitamin D, other vitamins and minerals are known to play a role in bone health (B vitamins, vitamin K, and iron), thus underscoring the importance of a well-balanced diet.

Bisphosphonates are antiresorptive agents frequently used in the treatment of postmenopausal osteoporosis. Unlike postmenopausal osteoporosis, the mechanism of low BMD in athletes affected by the triad is predominantly attributable to decreased bone formation rather than increased bone resorption. Therefore, bisphosphonates would likely be less effective in athletes with the triad.²⁰ Other concerns regarding treatment with bisphosphonates include their long half-life and potential teratogenic effects, thus making it prudent to avoid them in females of childbearing age.⁶ It is important to note that the US Food and Drug Administration has not approved any pharmacologic interventions for the treatment of osteoporosis in premenopausal females.

PREVENTION

Athletes and parents often need education regarding the importance of EA and regular menstrual cycles. Many are unaware that amenorrhea is associated with low BMD and stress fractures and how appropriate EA plays an important role in the prevention of bone health consequences.⁷⁶ The ATHENA (Athletes Targeting Healthy Exercise and Nutrition Alternatives) study evaluated the usefulness of a peer intervention on the prevention of disordered eating, pathogenic weight-control behaviors, drug use, and risk-taking behaviors.⁷⁷ This randomized controlled intervention included eight 45-minute, small-group classroom sessions guided by peer leaders. The curriculum included education regarding substance use, nutrition, and

unhealthy behaviors. Refusal skills were practiced, and healthy norms were reinforced. The control schools received pamphlets regarding disordered eating, drug use, and sports nutrition. Questionnaires administered before and after the program revealed decreased use of diet pills, decreased intent to vomit to lose weight, and improved healthy eating behaviors in the teenagers in intervention schools. This trial shows that primary intervention techniques that use education with peer leaders can reduce the risk of disordered eating and other risk-taking behaviors.

CONCLUSIONS AND GUIDANCE FOR THE CLINICIAN

1. The well-child visit or PPE provides an opportune time for the pediatrician to screen for and provide education and guidance regarding the components of the female athlete triad and the risks of inadequate EA for athletes. The AAP has published a PPE form that includes a comprehensive preparticipation history and physical evaluation (sports physical).⁶⁹ If the athlete responds “yes” to any of the triad screening questions included on the PPE history form, further screening can be performed with the use of the remaining questions suggested by the Female Athlete Triad Coalition (see Table 5).
2. Athletes presenting with 1 component of the triad are at risk of having or developing the other triad conditions.
3. Menstrual dysfunction in adolescents may be a sign of inadequate energy intake. Patients presenting with menstrual dysfunction provide an opportunity for the pediatrician to counsel parents and adolescent athletes that menstrual dysfunction and restricted energy intake are not

normal in athletes and may be detrimental to their health and performance.

4. Functional hypothalamic amenorrhea is a diagnosis of exclusion made after other causes for primary and secondary amenorrhea have been evaluated. The restoration of optimal EA is the cornerstone of treatment of functional hypothalamic amenorrhea.
5. The resumption of menses may take up to 1 year or longer after restoration of appropriate EA.
6. Oral contraceptive pills are not the first-line intervention for an athlete with functional hypothalamic amenorrhea.
7. Weight-bearing exercise in the context of appropriate nutritional intake is important for the enhancement of bone mass accrual.
8. The criteria for performing DXA to measure BMD in athletes include menstrual dysfunction or low EA (<45 kcal/kg FFM per day) for ≥ 6 months and/or a history of stress or insufficiency fractures. Z-Scores are used to assess BMD in adolescents, and a Z-score of < -1.0 is the threshold to prompt further evaluation (see Table 4).
9. Regular physical activity plays an important role in optimizing bone health. Patients and parents can be reassured that as long as exercise-related energy expenditures are appropriately replaced with caloric intake, menstrual, bone, and cardiovascular health should not be adversely affected. The target EA is >45 kcal/kg FFM per day. FFM can be determined by using DXA, biometrical impedance measurements, or skinfold measurements.
10. When treating athletes with the triad, a multidisciplinary team capable of addressing the medical, nutritional,

psychological, and sports participation-related issues of the triad is helpful. Weight-gain or -loss concerns in an athlete are better addressed by medical and nutritional professionals rather than athletic coaching staff.

11. Adequate intakes of calcium (1300 mg/day) and vitamin D (600 IU/day) play an important role in bone mass accrual for all adolescents. Athletes with greater dietary intake of calcium will require less supplemental calcium. When determining the amount of calcium supplementation needed, some adolescents may require higher vitamin D intakes than others to achieve normal vitamin D levels.
12. Bisphosphonate use in adolescent females with a low BMD related to the triad is not supported by current literature.
13. Educational opportunities regarding the recognition, prevention, and treatment of issues related to the triad should be available for practicing pediatricians, pediatric residents, and medical students.

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ABBREVIATIONS

AAP: American Academy of Pediatrics
BMC: bone mineral content
BMD: bone mineral density
DXA: dual-energy radiograph absorptiometry
EA: energy availability
FFM: fat-free mass
FMD: flow-mediated dilation
PPE: preparticipation physical evaluation

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