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The Female Athlete Triad: Key Points for Health and Fitness Specialists

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Key words: Disordered Eating, Low Bone Mineral Density, Functional Hypothalamic Amenorrhea, Energy Availability

Abstract

Health and fitness specialists should be aware of health issues related to active females, especially young females engaged in competitive sport. The term, Female Athlete Triad (Triad) refers to the physiological mechanisms by which low energy availability impairs reproductive and skeletal health. Defined as dietary energy intake minus exercise energy expenditure, energy availability is severely reduced by unwise diet and exercise behavior. The initial signs of Triad disorders are subtle and often go unnoticed. Education is a powerful tool in the detection, treatment and prevention of the Triad. Exercise professionals should be leaders in providing that education.

Learning Objectives

After reading this article, you should have an understanding of:

- the term, Female Athlete Triad (Triad);
- the prevalence of disorders in the Triad;
- the origins and mechanisms of Triad disorders; and
- the role of health and exercise professionals in preventing the Triad.

Background Information

In 2007, ACSM published a revised position stand explaining our current understanding of the Female Athlete Triad, also referred to as the Triad (14). This position stand redefined the Triad in terms of the physiological mechanisms by which *low energy availability* (EA) causes *functional hypothalamic menstrual disorders* and *low bone mineral density* (BMD). It is now understood that low EA can occur with or without disordered eating, and that menstrual disorders due to other causes are not included in the Triad. Furthermore, each of the newly specified components of the Triad was recognized as a spectrum of conditions ranging from health through sub-clinical (asymptomatic) to clinical (symptomatic) disease. Only extreme cases manifest themselves as eating disorders, amenorrhea, and osteoporosis, which even then may or may not appear simultaneously. Figure 1 depicts the spectrum and range of conditions that may be present in the Triad.

Insert Figure 1 about here

Definitions

To understand the Triad, some key terms need to be defined.

Energy-availability (EA) is defined as dietary energy intake (DEI) minus exercise energy expenditure (EEE). In effect, EA is the amount of dietary energy remaining after exercise training for all of the body's other functions (14). An EA of about 45 kilocalories per kilogram of fat-free mass per day (kcal/kgFFM/d) maintains a healthy adult in energy balance.

EA declines when DEI is reduced and/or EEE is increased. When EA falls below 30 kcal/kgFFM/d, reproductive and skeletal health is impaired (14). Any athlete may suffer from reproductive and skeletal disorders caused by low EA, but girls and women who participate in sports in which thinness confers a competitive advantage (due to appearance norms or to biomechanical and physiological factors affecting performance) are especially susceptible (16). An athlete may reduce her DEI and increase her EEE obsessively as part of an eating disorder, or intentionally as part of a weight-loss program. Alternatively, she may reduce her DEI unintentionally and unknowingly due to her appetite being suppressed by exercise training (9). Regardless of the cause, *when EA is severely reduced, the body restores energy balance by suppressing energy-consuming physiological processes, including reproductive function.*

Eating disorders are clinical mental illnesses defined by the Diagnostic and Statistical Manual of Mental Disorders [DSM-IV-TR, (1)] and characterized by abnormal eating, dysfunctional relationships with food, and a preoccupation with one's weight and shape. Because it is chronically restrictive, anorexia nervosa is the eating disorder most relevant to the Triad. Anorexia nervosa requires psychiatric treatment, sometimes unwilling inpatient treatment with forced feeding, because it has one of the highest

mortality rates of all mental illnesses, 10.5 times higher than expected for their age and gender. (3)

Disordered eating is a classification within the DSM-IV-TR that describes a wide range of irregular eating behaviors that do not in themselves constitute a clinical mental illness. However, researchers have found that disordered eating patterns, such as excessive dieting, fasting, bingeing, purging and the use of laxatives and weight-loss drugs can lead to more serious eating disorders (15).

Functional hypothalamic menstrual disorders are menstrual disorders that can be reversed through behavior modification. Unfortunately, the affected women are often reluctant to modify their diet and exercise behavior as needed. Menstrual disorders can also be caused by many anatomical, genetic, and medical conditions unrelated to sports. Regardless of their cause, the range of menstrual disorders is listed below in order from the least to the most severe (18). All can impair fertility, even though the less severe forms 1-3 are asymptomatic.

1. Short luteal phase: Regular cycles (i.e., eumenorrhea) with ovulation but with a shortened luteal phase in which progesterone production stops early;
2. Luteal phase deficiency: Regular cycles with ovulation but inadequate progesterone production;
3. Anovulation: Regular cycles without ovulation;
4. Oligomenorrhea: Irregular cycles longer than 35 days with or without ovulation;
5. Amenorrhea: No cycles or ovulation, and inadequate estrogen and progesterone production.

Amenorrhea may be primary or secondary. Primary amenorrhea (delayed menarche) is the absence of menstruation by age 15 in a girl with secondary sex characteristics. Secondary amenorrhea is the absence of menstrual cycles for three or more consecutive months after cycles have been established (17).

Osteoporosis is a disease characterized by low bone strength and micro architectural deterioration of bone tissue leading to bone fragility (13). Because there is no medical device for measuring bone strength, however, osteoporosis is diagnosed by measuring BMD. The International Society for Clinical Densitometry recommends that BMD in pre-menopausal women and children be expressed as Z-scores (8). A Z-score is the number of standard deviations above or below the BMD expected in someone of the same age, sex, weight, and ethnic or racial origin. To reflect an increased risk of fragility fracture, the revised ACSM Triad position stand recommends that osteoporosis be diagnosed by a history of nutritional deficiencies, hypoestrogenism, stress fractures, and/or other secondary clinical risk factors for fracture with BMD Z-scores less than -2.0 (14). ACSM further recommends that the presence of secondary clinical risk factors for fracture with a BMD Z-score between -1.0 and -2.0 be diagnosed as low BMD.

Prevalence

Disordered eating and eating disorders in female athletes often go undetected, and studies have often used nonstandardized criteria. Therefore, it is difficult to estimate their real prevalence. Overall, it can be said that prevalence rates are sport-specific and that rates as high as 62% have been reported (14). Even though adolescence is viewed as the stage of greatest risk in the development of body image and weight concerns, researchers (5) have found that at ages 5-7, girls who participated

in aesthetic sports (e.g., dance, gymnastics, cheerleading) reported higher weight concerns than girls who participated in non-aesthetic sports (e.g., soccer, volleyball, tennis). Excessive body image concerns may lead athletes or active girls and young women to begin restricting their intake of calories at a very young age, which in turn may result in aberrant eating behaviors.

Menstrual disorders in adult athletes across multiple sports have been reported to occur with prevalence rates ranging from 12-79% (14). However, few studies have excluded cases of oligomenorrhea and amenorrhea not caused by energy deficiency, or included cases of luteal deficiency and anovulation in women with regular cycles.

Low BMD in female athletes has usually been studied with the diagnostic criteria of the World Health Organization (WHO) for post-menopausal women, which are based on T-scores instead of Z-scores. A T-score is the number of standard deviations above or below the mean peak BMD of young adults of the same sex and ethnicity. Studies that employed WHO criteria found the prevalence of T-scores between -1.0 and -2.5 (osteopenia) ranging from 22% to 50%, and the prevalence of T-scores less than -2.5 (osteoporosis) ranging from 0% to 13% in female athletes (14). These greatly exceed the prevalence rates of 12% and 2.3% expected in a normal population distribution.

Origins and Mechanisms of Triad Disorders

Disordered eating behaviors are practiced by women with clinical eating disorders, by some sedentary women who are trying to achieve a perceived ideal body weight or body image and by some athletes who strive unwisely to optimize their body size and composition for athletic competition (18). Female athletes may also under-eat for reasons unrelated to sport. About twice as many young women as young men perceive

themselves to be overweight *at every decile of body mass index* (BMI) (19). The numbers actively trying to lose weight are even more disproportionate, and the disproportion even *increases* as BMI declines, so that almost 9 times as many lean women as lean men are actively trying to lose weight.

Appetite is comprised of two feelings, hunger and satiety, that are driven by orexigenic and anorexigenic hormones. Exercise suppresses appetite and *ad libitum* DEI (9). Even though it expends energy, exercise does not raise the concentration of the orexigenic hormone ghrelin that stimulates hunger. However, it does raise concentrations of anorexigenic hormones such as peptide YY, glucagon-like peptide 1, and pancreatic polypeptide that increase satiety. As a result, eating stops before the energy expended in exercise is fully replenished. In addition, diets containing high *percentages* of carbohydrates also suppress appetite (9). The combined effects of these two factors can be large enough to suppress DEI, EA, and paradoxically even carbohydrate availability severely.

For whatever reason, female athletes consume only about 70% as much energy and carbohydrate – normalized for body weight – as do male athletes in the same sports (4). Meanwhile, working muscle competes aggressively against the brain for whatever glucose is available. In a marathon race, for example, working muscle consumes as much glucose in 2 hours as the brain needs for a week. Furthermore, when muscle glycogen stores are replenished from the diet during recovery, the associated glucose becomes unavailable to the brain. This is why endurance athletes need to consume enough carbohydrates to replenish liver as well as muscle glycogen stores every day.

Energy (and especially carbohydrate) deficiencies trigger neurological reflexes in the brain, which depends on blood glucose for fuel. By altering the secretion of hormones, these reflexes suppress energy-consuming functions of the body including reproduction and growth, thereby conserving scarce blood glucose for the brain. The medical consequences of this are the price paid for preserving life.

Functional hypothalamic menstrual disorders are caused by the disruption of the secretion of gonadotropic releasing hormone from the hypothalamus in the brain by low energy (and especially carbohydrate) availability (See Figure 2). The normal pulsatility of luteinizing hormone (LH) by the pituitary gland has been disrupted by extreme dietary restriction alone, by extreme EEE alone, and by the combination of moderate amounts of dietary restriction and exercise (10). Conversely, when adequate EA was maintained by increasing DEI in compensation for EEE, normal LH pulsatility was preserved. Most importantly for proponents of exercise, exercise was found to have no suppressive effects on reproductive function beyond the impact of its energy cost.

Insert Figure 2 about here

Low BMD results from the combined effects of the decreased production of estradiol and anabolic hormones such as insulin, tri-iodothyronine, and insulin-like growth factor 1 on bone turnover. Throughout life, bone tissue is constantly being replaced as old bone is resorbed and new bone is formed. Bone grows during childhood as the rate of formation exceeds the rate of resorption. Because estradiol slows the rate of bone resorption, the rate of bone resorption increases when exercising women reduce EA enough to suppress estradiol. Meanwhile, because anabolic

hormones promote bone growth and repair, the rate of bone formation decreases with the concentrations of these hormones as EA declines below 30 kcal/kgFFM/day (14).

It is important to note that osteoporosis is not always caused by accelerated loss of BMD in adulthood. It can also be caused by not accumulating enough BMD during adolescence (13). Women deposit 26% of their bone mass between 11-14 years of age (2), and bone mass doubles during their teenage years so that women achieve virtually all of their peak bone mass by 20 years of age (11). Consequently, osteoporosis can develop in a teenage girl while her bone mass is increasing.

The Role of Fitness Professionals and Fitness Facilities

The role of allied health and fitness professionals in the detection, treatment and prevention of the Triad depends on training and job expectations. It is not within the scope of an exercise professional's training to counsel clients on nutrition and medical care, but exercise professionals need to be attentive and aware of subtle signs of energy deficiency. Exercise professionals can assist dietitians in assessing EA. Energy availability is much simpler and less costly to measure than energy balance, because it only requires diet analysis software to estimate DEI, an ergometer (such as an accelerometer or heart rate monitor) to measure EEE, and an electrical impedance body composition scale or skinfold calipers to measure FFM.

Because of its high mortality rate, it is especially important for cases of anorexia nervosa to be detected and referred for medical and psychiatric care. Table 1 lists some of the more subtle signs of disordered eating.

Insert Table 1 about here

The American Academy of Pediatrics, the IOC Medical Commission and ACSM all recommend that policies and procedures be put in place to eliminate potentially harmful weight loss practices of female athletes (9). Early screening is a vital component in halting the progression of disordered eating, if it is present. SCOFF (7) and FAST (12) are two screening tools that exercise professionals can use to identify athletes who may need additional psychological screening for an eating disorder or help with their aberrant eating patterns.

The pre-participation physical examination offers an opportunity to screen for components of the Triad In high schools and colleges. The medical history form is considered the *most important aspect* of the PPE examination. A separate section, consisting of both a gynecological and nutritional component, can be directed at the female athlete. The questionnaire should contain questions about the athlete's menstrual history, food intake within the past 24 hours, the foods they may refuse to eat, and their satisfaction with weight and attempts at controlling weight.

It is also important for amenorrheic athletes to learn that oral contraceptives can not correct the diverse metabolic problems caused by the lack of anabolic hormones resulting from energy deficiency. The first line treatment for restoring menstrual function in the Triad is to increase EA by increasing DEI and/or reducing EEE (20). Restoring BMD involves additional special challenges (6).

Education programs at exercise facilities can help to prevent Triad disorders in girls and young women by alerting them and caring individuals such as family members. Education materials can be displayed on bulletin boards, web pages, newsletters etc. Information packets can educate parents and children, even if the facility is restricted to

adults. An information packet about eating disorders is the BodyWise Handbook at www.maine.gov/education/sh/eatingdisorders/bodywise.pdf . The Female Athlete Triad Coalition web page (<http://www.femaleathletetriad.org/>) contains additional helpful information that exercise professionals can use as educational tools. Other organizations can also help (See Table 2).

Insert Table 2 about here

Workshops related to improving body image, healthy eating habits, and coping with stressors during puberty can also be provided by fitness facilities. These workshops do not have to be put on by employees but can be hosted for the facility's own clients, as a community service, and as advertising for the sponsoring facility. A professional workshop for increasing the self-esteem of girls is GirlPower (<https://www.urstrong.com/>). There are licensed GirlPower facilitators in Canada, the United States, and Australia.

A Triad prevention program that could be used as a summer camp for children at a sponsoring fitness facility is the Athletes@Risk® Program. This program can be obtained from Sunnybrook & Women's College Health Sciences Centre in Toronto, Ontario (<https://www.womenscollegehospital.ca/programs-and-services/fitness-and-exercise/athletesrisk-program>). The program consists of five workshops with interactive tools, a teaching guide, a resource list, participant handouts and a workbook.

Condensed Version & Bottom Line

The term, Female Athlete Triad, refers to the harmful effects of EA on reproductive and skeletal health. Energy availability is reduced by restricting DEI and/or increasing

EEE. Exercise professionals can and should take an active role in preventing the Triad.
We are the leaders in promoting health and exercise through behavior change.

Summary Statement

The term, Female Athlete Triad, refers to the harmful effects of low EA on reproductive and skeletal health. Exercise professionals and fitness facilities can play a key role in the prevention of the Triad.

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Table 1.
Subtle Signs of Eating Disorders

- Poor body Image
 - Excessive exercise
 - Fear of eating in public
 - Fine body hair known as lanugo (symptom of starvation)
 - Cooking elaborate meals for others
 - Dry and blotchy skin
 - Feeling cold
 - Swollen cheeks
 - Fixating on 'safe' foods
 - Strange food combinations
-

Adapted from Gardner, A. Subtle signs of an eating disorder. Health. (Accessed February 13, 2013 at <http://www.health.com/health/gallery/0,,20665980,00.html>)

Table 2

Educational Outlets and Screening Tools

<u>Target Audience</u>	Kids (KidsHealth also has separate areas for teens and parents)
<u>Web Site Name</u>	Kids and Eating Disorders
<u>Internet Address</u>	http://kidshealth.org/kid/health_problems/learning_problem/eatdisorder.html
<u>Sponsor</u>	The Nemours Foundation's Center for Children's Health Media
<u>Resources</u>	KidsHealth is the largest and most visited site on the Web providing doctor-approved health information about children from before birth through adolescence.
<u>Target Audience</u>	Female Athletes
<u>Web Site Name</u>	BODYSENSE: A Positive Body Image Initiative for Athletes
<u>Internet Address</u>	http://www.bodysense.ca/
<u>Sponsor</u>	Canadian Women's Health Council
<u>Resources</u> ultimate	Dedicated to the promotion of healthy sport settings for athletes with the goal of preventing eating disorders
<u>Target Audience</u>	College Students
<u>Web Site Name</u>	College Response: National Eating Disorder Screening Program (NEDSP)
<u>Internet Address</u>	http://www.mentalhealthscreening.org/college/
<u>Sponsor</u>	Screening for Mental Health
<u>Resources</u>	The College Response National Eating Disorder Screening Program (NEDSP) is designed to educate and screen college students for eating disorders, and to connect at-risk students with the resources they need.
<u>Note:</u>	Colleges and universities must register to participate, <u>encourage</u> your college to do so today. All results are confidential.

FIGURE 1—Female athlete triad. The spectrums of energy availability, menstrual function, and bone mineral density along which female athletes are distributed (narrow arrows). An athlete's condition moves along each spectrum at a different rate, in one direction or the other, according to her diet and exercise habits. Energy availability, defined as dietary energy intake minus exercise energy expenditure, affects bone mineral density both directly via metabolic hormones and indirectly via effects on menstrual function and thereby estrogen (thick arrows).

Figure 1. The Spectrum of Disorders from the 2007 ACSM Position Stand The Female Athlete Triad

Figure 2. This figure shows the primary components of the female reproductive system and the hormones that communicate between the various organs. The hormones produced by each gland are shown in parentheses.