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Abstract

Relevant for female athletes in general and especially in adolescent female athletes are the long-term consequences of insufficient energy intake that results in menstrual cycle disturbances and low bone mineral density. Prolonged exercise as practiced by elite athletes can lead to serious, long-term health problems if diet is not adjusted to compensate for energy expenditure. A good barometer of how energy intake matches energy expenditure in female athletes is menstrual function. Eumenorrhea is the term used to describe normal length, regular menstrual cycles. Oligomenorrhea refers to infrequent menses or menstrual cycles that occur inconsistently at intervals of 39–90 days. Amenorrhea is the absence of menstrual cycles in a nonpregnant, sexually mature woman. When menstrual cycles become disordered as a result of prolonged or excessive exercise, there very well may be an issue related to insufficient energy intake, and consultation of a health care provider knowledgeable in sports medicine is strongly advised to correct the situation. The standard curriculum for high school and college coaches of female athletes should include the health consequences of exercise-induced menstrual function and specific methods of prevention and treatment.

Keywords

Eumenorrhea • Oligomenorrhea • Amenorrhea • PCOS • Hirsutism
• Anorexia nervosa

5.1 Learning Objectives

After completing this chapter, you should have an understanding of:

- The terminology for normal and disrupted menstrual cycles
- Some of the causes of menstrual dysfunction

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- The symptoms associated with the female athlete triad
- The consequences of prolonged menstrual cycle dysfunction

5.2 Introduction

Regular menstrual cycles in young women reflect cyclic ovarian activity and generally are associated with a healthy lifestyle. When a woman experiences a change from regular, cyclic menstrual function to irregular or acyclic function, that change is an indication of either a pregnancy or of some underlying pathology, and the cause for the change in cyclic function should be determined by a health care professional as soon as possible.

To communicate effectively with your peers and students regarding menstrual cycles, you should know and understand normal and abnormal menstrual function and the terminology describing that function. Although there is no complete agreement on the strict definition of all of the following terms, the list below is a reasonable approximation of these definitions (from [1]). These words describing menstrual function are used widely in the scientific literature, but you should assume that the average lay person will probably not be aware of the meaning of these words. Therefore, to avoid misunderstanding and confusion, you should define what you mean when you use these terms in discussion of menstrual problems.

5.2.1 Eumenorrhea (Regular)

This refers to menstrual cycles that occur regularly at intervals of 25–38 days. These cycle lengths are generally observed in sexually mature women except during pregnancy and during the pubertal and the perimenopausal (around the time of menopause; this can be several years before the actual cessation of menstrual function) transitions when menstrual cycles are more variable.

5.2.2 Oligomenorrhea (Irregular)

This term refers to infrequent menses or menstrual cycles that occur inconsistently at intervals of 39–90 days, typically with only a few periods a year.

5.2.3 Amenorrhea (Acyclic)

This is when menstrual cycles occur at intervals of greater than 90 days or when there is the complete absence of menstruation. There are two types of amenorrhea that are defined based on whether the woman has experienced previous menstrual cycles.

5.2.3.1 Primary Amenorrhea

This is when a young woman has not experienced menarche by age 15. In other words, a girl has primary amenorrhea if she has not had her first period by the age of 15.

5.2.3.2 Secondary Amenorrhea

This is the absence of a menstrual period for six consecutive times or months after menarche has occurred. It is estimated that as high as 5 % of the adult women in the United States experience secondary amenorrhea [2] sometime in their reproductive life. There are a number of adjectives to describe the causes of amenorrhea such as dietary, emotional, jogger's, postpartum, and lactational (nursing), but these will be avoided for the most part. However, the term used by clinicians to describe amenorrhea caused by exercise or stress is functional hypothalamic amenorrhea (FHA) and is used widely in the clinical and scientific literature.

5.3 Research Findings

5.3.1 Eumenorrhea

In Chap. 9 we discussed the normal menstrual cycle so we will not repeat that here.

5.3.2 Oligomenorrhea

This term actually means “few menses.” Although very light menstruation is sometimes referred to as oligomenorrhea, medical professionals have a more narrow definition, applying this term only to the frequency of menstrual periods. There are many reasons for irregular menstruation, but the most frequent cause is what clinicians refer to as PCOS or polycystic ovary syndrome [3] which affects approximately 6 % of women [4]. Low energy availability is another cause of oligo- and amenorrhea [5] and is probably an important consideration for elite high school- and college-age female athletes, particularly in those sports where body image is considered important. Female athletes will often restrict their food intake to maintain a desired body image even though they are expending considerable energy training for their sport. This can result in an energy deficit (low energy availability) sufficient to inhibit menstrual function. Psychological stress is another factor to consider, although it is hard to separate from other causes.

5.3.2.1 PCOS

PCOS syndrome was originally described by Stein and Leventhal [6] and its pathophysiology is still poorly understood. This syndrome is associated with irregular menstruation, increased secretion of androgens, and the lack of ovulation (anovulation). The diagnosis of PCOS, as defined by the Rotterdam workshop [7], requires two of the following three criteria: (1) infrequent or lack of ovulation, (2) clinical signs of excess androgen, and (3) polycystic ovaries with ultrasound. The typical symptoms that women who have this syndrome experience are irregular menstruation, infertility, and some evidence of increased androgen secretion or hyperandrogenism. Menstrual irregularity may be difficult to document without charting of the cycle for several months. This can easily be done by keeping track on a calendar of the days when bleeding occurs. Excessive bleeding can also be documented this way. Infertility is a complaint more associated with married women who wish to become pregnant and not generally a

concern of single, college-age women. Physical symptoms of increased androgen secretion in women are acne and/or oily skin and increased hair growth on the face, back, between the breasts, upper arms, upper and lower abdomen, and inner thighs [8]. However, a woman’s perception of hirsutism (increased facial and body hair) may be altered if other women in the family or in the cultural community are hirsute, and therefore, this may not be of particular concern to her. Another concern regarding this syndrome is that it is associated with a high frequency of insulin resistance and increased risk for type 2 diabetes [9], hypertension, and cardiovascular disease [10]. Because early diagnosis could result in amelioration or prevention of the serious consequences and financial burden of this disease [1], it is recommended that women with menstrual cycle disturbances seek medical advice promptly.

5.3.2.2 Low Energy Availability

Low energy availability can result from several different behaviors, and often, there is more than one contributing factor to disrupted cycles resulting from reduced availability of energy. Disrupted menstrual function due to intense exercise, such as that found in elite or even highly competitive female athletes, coupled with restricted food intake is not uncommon in high school and college athletes. Disruption of pulsatile LH secretion in adolescent females is more sensitive to low energy availability than in females who are older [11]. In a recent review of the literature on energy availability and infertility by Loucks [12], this concept of a gradual decline in dependence of LH secretion on energy availability as a woman matures explains the greater prevalence of menstrual disorders in adolescent women and the lower success in restoring menstrual cycles in younger anorexia nervosa patients. The total amount of energy available is partitioned by the body for basic metabolic needs necessary for survival, for locomotion, and for growth and reproduction. If energy intake is restricted below the level needed to support all of these biological processes, those that are necessary for growth and reproduction slow or cease completely.

This is an oversimplification of the idea that reproduction in animals is initiated only when there is sufficient energy to support the successful completion of that process [13], but the basic idea is that reproduction requires a lot of energy and that natural selection favors those females with the ability to allocate energy resources so that survival is not compromised by unsuccessful attempts to reproduce. To accomplish this task of successfully reproducing and surviving at the same time, animals have developed two capabilities: (1) they have some internal way to measure how much energy they take in and how much energy they are using and (2) they use environmental cues to predict the availability of food. This latter capability is particularly important to mammals that have a long pregnancy. Change in day length is one of the most common environmental factors animals use to predict the availability of food, and most animals give birth in the spring when food will be available for several months. As will be discussed in Chap. 11, psychological stress is an important environmental factor that affects reproduction.

5.3.2.3 Other Causes

Other causes of menstrual cycle disturbances are hypothyroidism, elevated levels of prolactin (hyperprolactinemia), Crohn's disease, and eating disorders, and sometimes, there is no known cause (idiopathic).

5.3.3 Amenorrhea

Amenorrhea literally means "the absence of menses." The complete absence of menstrual cycles in a nonpregnant, sexually mature woman is a symptom of something seriously wrong. Since the most common cause for the sudden onset of amenorrhea is pregnancy, that possibility should always be ruled out as the first cause. As many as 5 % of women of reproductive age experience amenorrhea sometime during their reproductive life [2, 14, 15]. However, girls and women engaged in athletics often welcome the absence of periods and do not consider this a serious medical issue. In addition to some of the

aforementioned medical conditions that can cause disruption of menstrual cycles, there can also be serious long-term consequences of suppressed ovarian function.

High levels of prolactin or hyperprolactinemia can also cause amenorrhea. Lactational amenorrhea is common in women who supply most of the nutritional needs of their infant by breastfeeding. Pituitary tumors (prolactinomas) that secrete prolactin also suppress gonadotropin secretion which results in cessation of menstrual cycles. Approximately 50 % of the individuals that have these tumors also have galactorrhea [16], or secretion of milk from the breast, which often goes unnoticed. If the tumor is actively growing, it can progressively cause visual deficits, blurred vision, and headaches. If not treated, long-term consequences of hyperprolactinemia include osteoporosis due to suppression of ovarian steroid secretion. Medical management of prolactin-secreting tumors is effective using dopamine agonists that suppress the tumors and optimize prolactin levels.

Anorexia nervosa is probably the most recognizable cause of amenorrhea in young women who are not pregnant. Serious eating disorders, particularly anorexia nervosa and bulimia nervosa, are often associated with menstrual disorders. Both of these conditions have their highest incidence during adolescent years and can lead to death if not treated by appropriate professionals. In young female athletes, amenorrhea is often part of a syndrome called the female athlete triad. This term was first used in the literature in 1993 associated with sports medicine [17] to describe a condition in young female athletes who exhibited disordered eating, loss of bone (osteopenia), and amenorrhea. Women at greatest risk for this condition are those training in sports where low body weight is desired or required, but it can occur in women involved in a wide range of physical activities. Reversible amenorrhea where there is no physical cause for the condition is called functional amenorrhea. This condition is the result of diminished or suppressed GnRH release from the brain to the extent that there is not sufficient LH and FSH to stimulate ovarian function [18]. Because of low gonadotropin levels follicles in

the ovary do not develop, estrogen levels are low, and the lining of uterus (endometrium) does not proliferate. This endocrine situation is much like the prepubertal condition where menstruation does not occur.

The American College of Sports Medicine (ACSM) published a revised position stand on the female athlete triad in 2007 which does *not* include dietary restriction or disordered eating as a necessary component of the triad [19]. This group emphasizes that menstrual disorders and osteopenia observed in many female athletes who participate in prolonged exercise can result from energy deficiency if energy intake is not sufficient to balance the increased energy expenditure. In addition to the familiar disordered eating and the weight loss programs that put female athletes at risk for serious health problems, a less familiar and less well-understood phenomenon is suppression of appetite by prolonged exercise. A recent excellent review of the complexity of the effect of exercise on health issues in women, and the general lack of understanding of these issues by athletes, their coaches, and physicians, documents the need for careful diet management in female athletes to avoid serious health issues [20]. A recent survey of college coaches of female sports revealed that less than half of those responding could correctly identify the components of the female athlete triad and a third were not familiar with the term [21]. Furthermore, more than half of the respondents seldom or never queried their athletes regarding their menstrual function. This would suggest that there is an urgent need for additional education of college, and probably even more so for high school, coaches regarding the long-term consequences of prolonged or excessive exercise in female athletes.

5.4 Contemporary Understanding of the Issues

Relevant for female athletes in general and especially in adolescent female athletes are the long-term consequences of insufficient energy intake

that results in menstrual cycle disturbances and low bone mineral density. Prolonged exercise as practiced by elite athletes can lead to serious, long-term health problems if diet is not adjusted to compensate for energy expenditure. A good barometer of how energy intake matches energy expenditure in female athletes is menstrual function. When menstrual cycles become disordered as a result of prolonged or excessive exercise, there very well may be an issue related to insufficient energy intake. When menstrual cycles are disrupted in athletes, consultation of a health care provider knowledgeable in sports medicine is strongly advised. The standard curriculum for high school and college coaches of female athletes should include the health consequences of exercise-induced menstrual function and specific methods of prevention and treatment.

5.5 Future Directions

Because there are so many potential interactions between fat, the digestive system, the immune system, and the brain, there is still much to learn about the chemical signals that control appetite and satiety. However, even if we knew most of these interactions, the health implications of insufficient energy to support all necessary biological processes will not be addressed until athletes and coaches can be educated about the consequences of winning at any cost.

5.6 Concluding Remarks

Menstrual cycles are a reflection of cyclic ovarian function and irregular or absent cycles may indicate some underlying pathology. Regardless of the cause, prolonged disruption of ovarian function can have serious health consequences, even if there is no serious medical condition causing the abnormal cycles. Therefore, both athletes and their coaches and trainers should be concerned when there are menstrual cycle disturbances and seek appropriate medical advice.

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