Health & Fitness Journal
of Canada



Volume 15 March 30, 2022 Number 1

**ARTICLE**

# Managing Youth Athlete Menstrual Dysfunction From an Energy Deficiency Perspective

**Danika A. Quesnel[1,*], Tristen D. Hefner[2], Maria Fernandez-del-Valle[2,3], and Jacalyn Robert-McComb[4]**

**1 Department of Psychology, Western University, Canada**
**2 Department of Kinesiology and Sport Management, Texas Tech University, USA**
**3 Department of Functional Biology, School of Medicine, University of Oviedo, Spain**
****Corresponding Author: danika.quesnel@gmail.com***

**Abstract**

**Background:** Today, many young females consider themselves athletes, and participate in recreational, club, collegiate, or professional sport. Yet many of these girls, as well as their coaches and supports, are not aware of theoretical concepts in sport that relate to the reproductive health of females. Two such concepts are the Female Athlete Triad and the Relative Energy Deficiency in Sport (RED-S) Model. Both the Female Athlete Triad and the RED-S Model conceptualize the negative sequala that can result from engaging in sport without adequate fueling. One symptom that can result from inadequate fueling can result in the onset of menstrual dysfunctions (MDs). Early intervention and the prevention of MDs is crucial to mitigate long term health consequences. Long-term adverse health consequences may result, especially if MD persists throughout the developmental years necessary to achieve peak bone mass in the young female. **Purpose:** Thus, the following narrative review will outline how models of energy deficiency (The Female Athlete Triade and RED-S) interplay in the development of MDs as well as outline the current knowledge of the screening, treatment, and education for MDs in young female athletes. **Health & Fitness Journal of Canada 2022;15(1):3-17**.
https://doi.org/10.14288/hfjc.v15i1.361

Keywords: Female Athlete Triad, RED-S, Menstrual Dysfunction, Youth Athletes, Athletic Management, Women

## Introduction

Female youth have continuously increased their participation in sport over the last 50 years (van Eck & Fu, 2018). Today, young females between the ages of 16-20 engage in individual sport at (44%) or outside (36.6%) of school. With young females engaging in team sports at school (67.5%) or outside of school (63.8%) (Eime et al., 2013). Despite exercise benefitting young females through improved physical and psychological well-being and greater likelihood of being active as adults (Rodriguez-Ayllon et al., 2019; Scheerder et al., 2006), it has also brought to light some unique health consequences. Among these health consequences are symptoms of the Female Athlete Triad (Triad) and a Relative Energy Deficiency in Sport (RED-S). These models describe a cluster of negative symptoms that manifest due to inadequate fueling for participation in sports-related activity and day-to-day activities.

In its origin, the Triad consisted of three components: an eating disorder, amenorrhea and osteoporosis. Each of the components was considered cyclical with one area of dysfunction driving another, and all disorders being intermingled (Otis, Drinkwater, Johnson, Loucks, & Wilmore, 1997). However, a new conceptualization, the RED-S model, has extended the scope of the Triad to include a broader range of dysfunctions [low energy availability (EA), disordered eating, and irregular menstrual cycles such as oligomenorrhea], precursors of the originally defined Triad, and the inclusion of the male population (Mountjoy et al., 2014). Central to the RED-S model is an underlying lack of fueling for the body to support itself in its day-to-day functions as well as perform on an athletic level (Mountjoy et al., 2014).

The estimated prevalence of encountering all three components of the Triad is 0-1.2% for young female athletes. In adolescents, the estimated prevalence is 2.7-27% with any two factors present (eating disorders, osteoporosis, amenorrhea) (Gibbs, Williams, & De Souza, 2013; Thein-Nissenbaum & Hammer, 2017; Weiss Kelly et al., 2016). For adolescents that have only one component of the triad, the prevalence increases to 16-60% (Gibbs et al., 2013; Thein-Nissenbaum & Hammer, 2017; Weiss Kelly et al., 2016). A recent study investigating the RED-S model in a sample of over 1000 young women noted that experiencing low EA was common in 47.3% of athletes, meaning they had an inadequate amount of fueling for the energy they were expending (Holtzman et al., 2019). Furthermore, in a study of 112 elite or pre-elite female Australian athletes, researchers examined the prevalence of RED-S consequences (issues with menstrual function, bone mineral density, theroid function, resting metabolic rate, mental health, illness, gastrointestinal symptoms). Of the 112 athletes, 87% demonstrated one indicator of RED-S consequences, and 81% indicated the presence of between 1-3 RED-S outcomes. Relatedly, low EA risk was estimated to be between 11-55% in this sample (Rogers et al., 2020).

### *Menstrual Dysfunction in Youth Athletes*

Historically, menstrual dysfunctions (MDs) have been a central component of the Triad and now of the newly proposed RED-S model (Mountjoy et al., 2014; 2018; Otis et al., 1997). MDs are a risk of participating in sport over an extended period without adequate nutrition (Georgopoulos & Roupas, 2016). Preventing and managing MDs effectively by addressing nutritional needs and other lifestyle factors is of utmost importance due to the related long-term health consequences such as declines in cardiovascular health, endothelial function, abnormal hormonal profiles, fertility, bone health, muscles and joint injuries (Cialdella-Kam, Guebels, Maddalozzo, & Manore, 2014). Although the age of menstrual cycles onset is varied in young women, in one study, more than half of the athletes reported a change in menses during training or competition (Thein-Nissenbaum, Rauh, Carr, Loud, & McGuine, 2012). Those who experienced a higher incidence of menstrual irregularity reported a greater rate of musculoskeletal injuries (Thein-Nissenbaum et al., 2012).

To combat the onset of MDs and their related health consequences, several governing sport bodies have made an effort to standardize screening for health concerns in athletic youth with some success. In a study of the National Collegiate Athletic Association (NCAA) Division 1 schools in 2003, 138 of 170 schools responded and 79% stated they did screen for MD (Beals & Hill, 2006). However, only 24% of schools used a comprehensive menstrual history questionnaire with less than 6% of schools using a structured interview or a validated questionnaire

(Beals, 2003). Conclusively, there is a pressing need for more standardized eating disorder (ED) and MD screening. Concerns surrounding MDs and their related consequences are aggravated by the typical procedures surrounding their assessment and treatment in sport settings. Screening for MDs is complex because, often, the athlete may be at various points along the spectra between health and disease (Nattiv et al., 2007). Because of this complexity, there is the potential for athletes to not consult a physician until they are fully aware of their illness due to its severity (Thein-Nissenbaum & Hammer, 2017). Furthermore, high school students have reported that the absence of menstruation indicates "being in shape" and paradoxically can be viewed favorably by this demographic (Thein-Nissenbaum & Hammer, 2017). This favorable view of MDs can result in incidences of deception and deceit when asked questions regarding their reproductive health. Given the complex nature of young females' reproductive health, research currently calls for improved protocols regarding assessment and management of components, specifically MDs (Mountjoy et al., 2018; Slater, Brown, McLay-Cooke, & Black, 2017).

The Female Athlete Coalition and other governing bodies have advocated to screen and treat/manage components of the Triad and RED-S in a more effective manner. Unfortunately, a recent survey found that as little as 4% of pediatricians feel confident to treat elements of the Triad, making it difficult to provide the unique and tailored care recommended for treating low EA and the related health outcomes (Thein-Nissenbaum & Hammer, 2017; Troy, Hoch, & Stavrakos, 2006). As with many disorders involving low EA, early intervention is preferred, and without clear guidance, support, and tailoring, treatment outcome can be compromised (Cleary, Chi, & Feinstein, 2018).

Lastly, Desouza and colleagues (2017) have suggested that a key component of successful treatment includes education. Indeed, the aforementioned review of prevention and treatment programs among NCAA Division 1 schools suggested that, at the very least, NCAA-member institutions should implement mandatory ED and MD education for all athletes and athletic personnel (Beals & Hill, 2006). As such, the final piece of treating and managing MDs is complimentary strategies for the education of young female athletes, which for the purpose of this study, refers to young women aged 14-20 regarding their reproductive health.

Given the athletic focus of this manuscript, we will examine the interaction between low EA and the reproductive system, also known as the EA hypotheses (Winterer, Cutler, & Loriaux, 1984). Our first goal is to provide a narrative review of how the models of energy deficiency (The Female Athlete Triade and the Relative Energy Deficiency in Sport) interplay with the development of MDs. Our second goal is to outline the current management of MDs, thus, our knowledge of the screening, treatment, and education for MDs in young female athletes. Given that the goals of this manuscript cover such broad areas, the process of a narrative review, rather than a systematic review, was taken.

Currently, no guidelines are available for the synthesis of information in a narrative review style, thus we followed the guidance of Ferrari (2015) in the development of our review. Given the range of articles we covered (Coalition and governing body statements, peer reviewed articles and chapters, published assessment tools and practise statements) and the purpose of developing a new type of interventions, such as the tri-step model proposed here, a narrative review process was best to reach the range of included literature. We conducted a literature search using EBSCOhost, PubMed, Web of Science, MEDLINE databases which include journals in the fields of medicine, nursing, the health care system, and the pre-clinical sciences. Since we used a narrative review methodology, we did not define inclusion and exclusion criteria, and keywords utilized varied from "menstrual dysfunction", "energy availability", "RED-S", "young athletes", "athletic management", "treatment", and "education programs" among others. The content was categorized in the different sections as presented in this review.

### *Menstrual Dysfunction*

MDs range from healthy functioning cycles (Eumenorrhea) to a complete lack of menstruation (Amenorrhea). In the United States, normal menstrual cycles begin at age 12.5 years, and have an average length of 32 days in the first year and shorten thereafter. Normal menstrual flow lasts less than 7 days (Takemoto & Beharry, 2015). Primary amenorrhea is defined by the failure to start menses by the age of 16. Secondary amenorrhea refers to either the temporary or permanent ending of periods in a woman who has menstruated normally in the past. Oligomenorrhea is a term used for women whose menstrual periods were regularly established at some time and thereafter their menstrual cycles became infrequent or light (McComb, Qian, Veldhuis, McGlone, & Norman, 2006; Vickers, Gray, & Jha, 2018).

Fischer et al. (2017) reported the prevalence of MDs in adolescent athletes to be 12.2%. Menstrual dysfunction was defined as having experienced more than 35 days between their periods in the last 12 months. Discrepancy exists in published studies for young female athletes, with the range in prevalence of menstrual dysfunction established between 7-79%. The discrepancy arises from the varied definitions of what constitutes MDs, differing age groups, and the many methods of assessing and conceptualizing MDs (Richard, Palmer, & Adams, 2018).

In female athletes, not taking in enough calories to meet their physiological needs may result in an MD, as outlined in the Triad and RED-S model. This type of MD is termed hypothalamic amenorrhea or functional hypothalamic amenorrhea (FHA): FHA is one of the most common causes of secondary amenorrhea (Meczekalski, Katulski, Czyzyk, Podfigurna-Stopa, & Maciejewska-Jeske, 2014). Epidemiological correlates to the dysfunctional anovulation that is characteristic of FHA include stress, both psychological or physical, loss of weight, or an overabundance of exercise without adequate energy intake to meet the needs of the exercise (Robert-McComb & Loucks, 2014; Vickers et al., 2018). The EA hypothesis conceptual framework is summarized as such: if the brain's energy requirements are not met, an alteration in brain function occurs which disrupts the Gonadotropin-releasing hormone (GnRH) pulse generator (Loucks & Thuma, 2003). Deficiency in GnRH pulsatile secretion may ultimately lead to FHA.

### *Energy Availability Hypothesis*

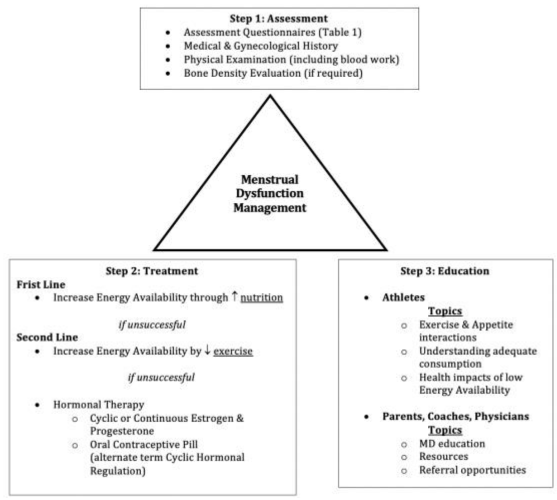
Normal menstrual cycling is altered if there is a restriction in EA (Loucks & Callister, 1993; Loucks & Heath, 1994; Loucks, Verdun, & Heath, 1998; Loucks, Laughlin, Mortola, Girton, Nelson, & Yen, 1992). EA was defined by Loucks (1992) as the amount of dietary energy intake leftover after energy is expended during exercise. When the amount of energy acquired from diet is not enough to offset the amount of energy burned during exercise, the body will try to maintain a homeostatic energy level by neglecting transfer of energy to bodily functions that are not needed for survival. These functions include maintenance of cells, maintaining core body temperature, growing and a shutdown of reproductive faculties (Loucks & Heath, 1994; Loucks et al., 1998). In order to maintain the proper functioning of these faculties, women should achieve 30 kcal/kg/lean body mass (LBM), interchangeably known as fat-free mass (FFM) (Loucks et al., 1998)

Low EA is defined as being below 30 kcal/kg FFM/day (Logue et al., 2018). When energy reserves continuously fall below this, the body's reaction is to reduce the amount of energy needed for general metabolic processes such as growth, thermoregulation, cellular maintenance, and reproduction (Loucks, Kiens, & Wright, 2011). Indeed, the 2007 American College of Sports Medicine Female Athlete Triad Position Stand researchers suggested that a minimum EA of 30 kcal/kg FFM/day is necessary for maintaining normal menstrual function. If a low EA continues over a continuous period, it hinders sport performance as a result of dehydration and higher circulatory lactate, ultimately resulting in lower aerobic and anaerobic function (El Ghoch, Soave, Calugi, & Dalle Grave, 2013). Conclusively, when dietary energy intake is reduced, and/or exercise energy expenditure is increased, and EA declines to 30kcal/kg FFM energy balance is considered to be below threshold to support athletic performance, overall health and reproductive function resulting in MD.

### *Management Procedures*

Management procedures for MD can be organized into three main areas: assessment (Step 1), treatment (Step 2), and education (Step 3), as shown in Figure 1. In this section, we will examine each of them.

**Figure 1: Tri-step management of menstrual dysfunction.**




### *Step 1: Assessment*
### *Screening Tools*

*When*. Athletes should be screened for MDs prior to participation, at annual health screenings or when other issues arise such as stress fracture, reoccurring illness or injury severe weight loss, or a decrease in physical performance (Richard et al., 2018; Valliant, 2016).

*Who.* The process of assessing an athlete for MD should involve a multidisciplinary approach including a doctor, a psychologist, the training team and support (family, etc.). The team should be aware of the current screening tools and resources available for the athletes, as shown in Table 1 (Vailliant, 2016). Additionally, if an athlete presents with one component of the Female Athlete Triad (i.e., an ED, MD, or bone density loss), they should be screened for all other aspects of the triad (Richard et al., 2018).

*What.* Screening tools for EA and preparticipation physical examinations (PPE) forms currently in existence have a variety of questions concerning menstrual history. However, these tools vary in their exigences from one question to several questions in entirely separate formats (Beals & Hill, 2006; Bernhardt & Roberts, 2010; Ljungqvist et al., 2009; Logue et al., 2018; Mond, Hay, Rodgers, & Owen, 2006; Mountjoy, Hutchinson, Cruz & Lebrun, 2008). None of the existing forms have been validated for menstrual dysfunction screening. However, Table 1 provides a comprehensive list of questionnaires which include components of inquiring about an athlete's menstrual dysfunction.

**Table 1: Screening tools for menstrual dysfunction, eating habits, and physical activity levels in female athlete.**

| Tool | Details |
|---|---|
| Low Energy Availability in Female athletes Questionnaire (LEAF) (Melin et al., 2016) | To identify disordered eating and atypical exercise and eating behaviors. Internal reliability; concurrent validity to Eating Disorder Inventory |
| Health, weight, dieting, and menstrual history questionnaire (HWDMH)Q (Beals & Hill, 2006) | First study to assess combined prevalence of all three components of female athlete triad.<br>Developed from Eating Disorder Inventory symptom checklist and EDE-Q |
| Physiologic screening test (PST) (Black et al., 2003) | 18 items: Four physiologic measurements,<br>14 Questions<br>15 minutes to complete |
| Female athlete triad coalition screening questionnaire (Margo Mountjoy, Hutchinson, Cruz, & Lebrun, 2008) | Internet accessible<br>12 questions: nutrition (8), menses (3), bone health (3), STI (1)<br>If positive, follow by in-depth evaluation with detailed history of 19 questions and full medical evaluation |
| Athletic milieu direct questionnaire AMDQ (Nagel, Black, Leverenz, & Coster, 2000 | 19 questions<br>Designed to assess Disorder Eating /Eating Disorders<br>Compared to EDI-2 and BULIT-R, superior results on 7 of 9 epidemiologic analyses<br>First instrument to operationalize the construct of disordered eating<br>Not validated in a clinical population |
| ATHLETE (Hinton & Kubas, 2005) | Female athletes at three division I universities.<br>6 subscales from EDI-2, modified to athletes.<br>Developed to assess psychological predictors of disordered eating in female athletes.<br>Construct validity confirmed by convergent and discriminate validity |
| College health-related information survey CHRIS (Steiner, Pyle, Brassington, Matheson, & King, 2003) | College student athletes<br>Based on juvenile wellness and health survey<br>32 questions broken into four areas: mental health (9); eating problems (13); risk behaviors (4); performance pressure (6)<br>Need further validation |
| Survey of eating disorders among athletes (SEDA) (DePalma et al., 2002) | 33 questions; self-reported eating pathology<br>Athletic environment-related risk factors<br>Not validated in athletic population<br>Student athletes |
| De Palma (DePalma, Koszewski, Romani, Case, Zuiderhof, & McCoy , 2002) | Identify pathologic eating in college students and athletes<br>16 questions; 8 from SEDA and 8 from DSED |
| PPE monograph (Bernhardt & Roberts, 2010) | 4 questions related to weight; 3 questions related to menses |
| International Olympics committee screening (Ljungqvist et al., 2009) | Athlete periodic health evaluation form<br>11 Nutrition questions for both sexes<br>Female-specific questions: 6 menses, 2 bone health, 1 STI |

Notes: EDE-Q: Eating Disorder Examination-Questionnaire; EDI-2: Eating Disorder Inventory -2;

BULIT-R: The Bulimia Test- Revised; SEDA: Survey of Eating Disorder among Athletes; DSED: Diagnostic Survey of Eating Disorders; PPE: Preparticipation Physical Activity; STI: Sexually Transmitted Infection.

*How*. Unfortunately, there is no gold standard assessment of EA for the general athletic population (Logue et al., 2018). Just as non-athlete members of the population lack a consolidated assessment for EA, athletes must also rely on assessments used in tandem with one another to provide a more coherent picture. Notwithstanding the differences in risk for low EA related to different sports, such as sports focused on weight targets, aesthetic sports, or endurance athletes (Loucks et al., 2011; Potgieter, 2013), all athlete types should be screened for low EA (Mountjoy et al., 2018; Valliant, 2016). The Low Energy Availability in Females – Questionnaire (LEAF-Q) was recently developed in hopes of assessing low EA in females (Mountjoy et al., 2018). Beyond this, self-reported food and exercise logs, accelerometers, heart rate monitors and training questionnaires have been implemented in hopes of gaining a better understanding of the EA for athletes (Logue et al., 2018). Despite efforts, caution is warranted as there are many methodological flaws related to the accuracy of the assessment methods reported here. Considerations must be made for the age demographic in question and how athlete goals and motivation may impact the self-reported nature of these assessments (Logue et al., 2018; Loucks et al., 2011; Potgieter, 2013). Not only this, but recall that issues may arise particularly without corroborating information from supports (family, team medical staff etc.) (Logue et al., 2018; Loucks et al., 2011; Potgieter, 2013). Lastly, accelerometer device accuracy, particularly for higher intensity activity, has been questioned. With that, inherent risks of these devices exist, such as removal (Bonomi, Plasqui, Goris, & Westerterp, 2009).

### *Medical and Health History Screening*

If the screening process evokes concern, an in-depth evaluation with a physician or intervention team can be sought out and a routine health history garnered (Thein-Nissenbaum & Hammer, 2017). A comprehensive menstrual, obstetrical, and gynecologic history is required along with a physical examination, appropriate lab-work. In addition, an evaluation of bone mineral density is indicated when a history of a stress fracture is present. Because the diagnosis of FHA is one of exclusion, it can be viewed as a cumbersome task to pursue an appropriate evaluation. However, some basic lab tests can help rule out some of the most common causes of menstrual dysfunction (Practice Committee of the American Society for Reproductive Medicine, 2004). Considerations for initial bloodwork include complete blood count and a comprehensive metabolic panel to rule out chronic disease, Beta Human Chorionic Gonadotropin to rule out pregnancy, thyroid stimulation hormone to rule out thyroid dysfunction, and prolactin to rule out prolactinoma (Practice Committee of the American Society for Reproductive Medicine, 2004).

If an athlete has had a stress reaction in a bone, a stress fracture, or a fracture from minimal trauma, evaluation of bone mineral density is appropriate. The gold standard in measuring bone mass density is using a dual-energy x-ray absorptiometry (DEXA) (McArdle, Katch, & Katch, 2010; Nattiv, 2007; Scheid & De Souza, 2010). In adolescents, measurement of the spine and whole body is preferred while spine and hip are typical for young adults, both of which can be conducted in a DEXA scanner (Nazem & Ackerman, 2012).

### *Step 2: Treatment*

Once an assessment has taken place, the treatments outlined for MD typically involve a nutritional strategy or pharmacological strategy (Logue et al., 2019). MDs occur because of compounding factors, which demand the need for a multidisciplinary treatment team including coaches, family, the athlete, and health care professionals (Cleary et al., 2018)

Cohesion, or the alliance between the treatment team and the athlete, is said to be key to successful treatment (Joy et al., 2014). However, especially with youth, having the athlete agree to the treatment plan can be difficult due to sporting pressures such as appearance expectations and stigma relating to mental health concerns in athletes (Cleary et al., 2018). It must be emphasized that it is vital to positive treatment outcomes that the athlete feels heard, understood, and considered in the treatment plan (Thein-Nissenbaum & Hammer, 2017).

### *Behavioral Treatment*

Along the same lines, the treatments for amenorrhea or other MDs should consider the benefits and risks for the athlete. Physically active females with amenorrhea are often able to prevent or reverse menstrual disorders by dietary modification (see Figure 1), making this the primary strategy, or first line of treatment, for increasing EA (Loucks et al., 2011; Manore, Kam, & Loucks, 2007; Redman & Loucks, 2005). Trials have demonstrated that EA can be improved with an individualized nutrition intervention (Cialdella-Kam, Guebels, Maddalozzo, & Manore, 2014; Logue et al., 2019). However, the length of the nutritional intervention is impactful for the resumption of menses (Cialdella-Kam et al., 2014; Logue et al., 2019). Trials implementing a three-month dietary intervention did not achieve a resumption of menses, however, a six-month intervention successfully helped athletes resume a healthy cycle (Cialdella-Kam et al., 2014; Łagowska, Kapczuk, Friebe, & Bajerska, 2014). Given the enormous differences in micronutrients and macronutrients in athletes, it is vital that a nutrition intervention be tailored to the needs of each athlete (Melin, Heikura, Tenforde, & Mountjoy, 2019). Due to the appetite suppressant effects of activity, a new concept, “eating by discipline”, has been proposed to counter this physiological inclination (Loucks et al., 2011). Since appetite is an unreliable indicator of energy requirements for athletes, they are advised to eat specific amounts of particular foods at planned times rather than the typical strategy of waiting for hunger and eating until satisfied (Loucks et al., 2011) .

If modifying intake alone is not successful, a second line of treatment may be implemented. The athlete may need to decrease her energy expenditure by modifying her training regimen (Nattiv, 2007). Training is an unavoidable part of athletics. It has been demonstrated that athletes’ training time is between two to three times that of a physically active, non-athlete (Torstveit & Sundgot-Borgen, 2005), which is why it is recommended to try and modify food intake first. To decrease energy expenditure accurately, objective quantification of all physical activity, including incidental physical activity and leisure activity, is necessary. Devices such as accelerometers could be useful in controlling exercise quantity in an effort to evaluate and control exercise energy expenditure (Bonomi et al., 2009). More specifically, an increase of 360 kcal/day combined with a decrease in an exercise training schedule can help normalize hormonal panels and subsequently improve MDs (Dueck, Matt, Manore, & Skinner, 1996).

Co-periodizing exercise with nutritional needs may be most helpful in achieving EA goals. In co-periodization, exercise expenditure and caloric intake is synchronized. The training volume, made up of total hours trained per week including training and competitive periods, should be assessed first to gauge how much nutrition is needed to support this volume of activity. In addition, energy requirements might not be stable during the season, so energy intake should be adapted to the different periods and situations (high-intensity and/or long-duration training (McArdle et al., 2010). The constant adjustment of exercise and dietary intake will help maintain overall health status, maximize training effects, and enhance the recovery process (Thein-Nissenbaum & Hammer, 2017).

If an athlete is resistant to decreasing their exercise regimen or increasing their consumption, they may be suffering from disordered eating (i.e., extreme dieting, restriction etc.), an ED, or a dysfunctional relationship with activity (i.e., exercise addiction, compulsive exercise etc.) (Thein-Nissenbaum & Hammer, 2017). Indeed, the prevalence of EDs among athletes is higher than non-athletes, ranging from 6-42% (Bratland-Sanda & Sundgot-Borgen, 2013; Glazer, 2008; Joy, Kussman, & Nattiv, 2016). Thus, it may not be an unlikely concern that an athlete may be experiencing an ED. It is vital to bring awareness to the athletes' care team about these apprehensions as early as possible. The PPE or questionnaire developed by the Female Athlete Triad Collation are recommended to be administered to the athlete prior to their continued participation (Joy et al., 2014.). When delivering these questionnaires, a high level of suspicion should be taken, as EDs are typically very secretive (Joy et al., 2014). As a result, referral to a physician, psychiatrist or psychologist is an important step to prevent detrimental physical and mental health consequences (Joy et al., 2014).

### *Pharmacological Treatment*

Hormone replacement therapy, both cyclic and continuous, has been described to help athletes resolve MDs (Bieber, Sanfilippo, Horowitz, & Shafi, 2015; Speroff & Fritz, 2005). Since many athletes with FHA may need to consider the use of oral contraceptive pills (OCPs), it must be outlined that, without nutritional rehabilitation, athletes will not typically normalize the metabolic factors impairing bone function, health, and performance (Bonci et al., 2008; Gordon, 2010; Klein & Poth, 2013; Nattiv et al., 2007). Furthermore, they are unlikely to fully reverse the low bone mineral density. Rather, research has outlined that it can result in premature closure of the growth plates for some young athletes, specifically in the femoral and spinal bone (Valliant, 2016). Youth populations may be uncomfortable with the idea of being on a contraceptive pill. In these cases, being mindful of language and framing the pill as a cyclic hormone regulation (CHR) rather than a contraceptive pill may put the athlete at ease (Valliant et al., 2012).

Collectively, energy uptake should be adapted for sport requirements and aim to improve energy balance enough to maintain physiological homeostasis, prevent menstrual dysfunction and maintain skeletal health (Mountjoy et al., 2018). This does not appear to be occurring for all female athletes, necessitating improved education for athletes and their athletic teams (e.g. coaches, trainers, parents, etc.) (Beals & Manore, 2002; Valliant, 2016).

### *Step 3: Education Related to Female Athletes' Health*

Providing education to athletes, their coaches, and families around the Female Athletes Triad, RED-S and MDs and their associated screen procedures is the first line of preventing the MDs from manifesting to the point of needing treatment (Mitchell & Robert-McComb, 2014; Richard et al., 2018). Education programs should be developed to ensure that a multidisciplinary team working with female athletes (nutritionists, coaches, athletic trainers, physiotherapists, physicians, etc.) have a confident knowledge base, referral opportunities, and resources. By educating multidisciplinary teams in this fashion, athletes have a better chance at being provided with the most effective care.

Despite the best prevention efforts, at times MDs still occur. Stickler et al. (2019) suggest that educational sessions should occur on a weekly basis, as this can benefit the adherence of the athlete to the program. However, even with education, the return to normal menses may not be rushed. Indeed, Łagowska and colleagues (2014) showed that interventions designed to educate athletes about the negative effects of inadequate EA each week saw improvement in LH and FSH at the three-month mark, although it wasn't until month 9 that athletes saw a return of menses (Łagowska et al., 2014; Łagowska, Kapczuk, & Jeszka, 2014).

Central to education programs successfully affecting the resumption menses, is addressing athlete's nutritional intake. Athletes need education about the suppressive effects of exercise on food intake. Information about the short- and long-term consequences of adequate and appropriate food consumption on wellbeing (i.e., achieving peak bone mineral density, fertility, immune health etc.) is needed (Logue et al., 2018; Weaver et al., 2016). Influencing and increasing EA through education has been successful through some common theory based therapeutic techniques. Two core components include providing psychoeducation around nutrition (i.e., low or high glycemic indexed food, micronutrient contents etc.) and increasing the athlete's awareness of the amount of energy needed to optimally function (Temme & Hoch, 2013; Valliant et al., 2012). More specifically, education sessions that focused on increasing self-efficacy on the athlete's ability to make good dietary decisions (Abood, Black, & Birnbaum, 2004) were beneficial. Additionally, athletes experiencing an ED could benefit from education sessions that utilize cognitive dissonance as a catalyst to bring about behavior change (Kilpela et al., 2016). However, the International Olympic Committee (IOC) (2018) suggests that these styles of educational interventions should continue to be developed and refined. While these education interventions have been effective, they may require advanced training to implement properly.

## Conclusion

Overall, our review highlighted the models of energy deficiency and their role in the development of menstrual function of young female athletes. Furthermore, we outlined the most current components of assessment, treatment and education surrounding MDs in young female athletes and how themes components may be better managed. The lack of energy availability underpinning both the RED-S model and the Triad highlight the importance of using adequate management strategies for athletes. Without it, several detrimental outcomes, including MDs, will ensue. Relatedly, it is nearly impossible to manage MDs in young female athletes through screening, treatment, and education on menstrual health without also addressing the EA component. However, there is a need for the improvement in the steps and procedures which surround the management of MDs, particularly in screening. The needs of these young athletes are inherently multidisciplinary, and thus a plan of action in MD management should reflect these multifaceted needs, while making regular screening, needed treatment, and education a standard in the athletic domain. Ultimately, undertaking these steps of management will be a mean by which to improve overall health and performance for young female athletes and into their adult hood.

## Authors' Qualifications

The authors' qualifications are as follows: Danika A. Quesnel MSc, CSEP-CPT; Tristen D. Hefner BS; Maria Fernandez-del-Valle PhD; Jacalyn Robert-McComb PhD, FACSM.

## References


Abood, D. A., Black, D. R., & Birnbaum, R. D. (2004). Nutrition education intervention for college female athletes. *J Nutr Educ Behav*, *36*(3), 135–139. doi:10.1016/S1499-4046(06)60150-4

Ackerman, K. E., Holtzman, B., Cooper, K. M., Flynn, E. F., Bruinvels, G., Tenforde, A. S., . . . Parziale, A. L. (2019). Low energy availability surrogates correlate with health and performance consequences of Relative Energy Deficiency in Sport. *Br J Sports Med*, *53*(10), 628-633. doi:10.1136/bjsports-2017-098958

Beals, K. A. (2003). Eating disorder and menstrual dysfunction screening, education, and treatment programs. *The Physician and Sportsmedicine*, *31*(7), 33–38. doi:10.3810/psm.2003.07.434

Beals, K. A., & Hill, A. K. (2006). The prevalence of disordered eating, menstrual dysfunction, and low bone mineral density among US collegiate athletes. *Int J Sport Nutr Exerc Metab*, *16*(1), 1–23. doi:10.1123/ijsnem.16.1.1

Beals, K. A., & Manore, M. M. (2002). Disorders of the female athlete triad among collegiate athletes. *Int J Sport Nutr Exerc Metab*, *12*(3), 281–293. doi:10.1123/ijsnem.12.3.281

Bernhardt., D., & Roberts, W. (2019). *PPE Participation physical evaluation. 5thEd.* American Academy of Pediatrics.

Bieber, E., Sanfilippo, J., Horowitz, I., & Shafi, M. (2015). *Clinical gynecology* (2nd ed.). Cambridge, United Kingdom: Cambridge University Press. Retrieved from https://books.google.com/books?hl=en&lr=&id=RfkGBwAAQBAJ&oi=fnd&pg=PR8&dq=Bieber,+E.+J.,+Sanfilippo,+J.+S.,+Horowitz,+I.+R.,+%26+Shafi,+M.+I.+(Eds.).+(2015).+Clinical+Gynecology.+Cambridge+University+Press.&ots=qMO24j-d05&sig=yvKEPY-TVHg58iHOca_4OhnlyCw

Black, D. R., Larkin, L. J., Coster, D. C., Leverenz, L. J., & Abood, D. A. (2003). Physiologic screening test for eating disorders/disordered eating among female collegiate athletes. *J Athl Train*, *38*(4), 286-297. Retrieved from https://pubmed.ncbi.nlm.nih.gov/14737209/

Bonci, C. M., Bonci, L. J., Granger, L. R., Johnson, C. L., Malina, R. M., Milne, L. W., … Vanderbunt, E. M. (2008). National athletic trainers' association position statement: preventing, detecting, and managing disordered eating in athletes. *J Athl Train*, *43*(1), 80–108. doi:10.4085/1062-6050-43.1.80

Bonomi, A. G., Plasqui, G., Goris, A. H. C., & Westerterp, K. R. (2009). Improving assessment of daily energy expenditure by identifying types of physical activity with a single accelerometer. *J Appl Physiol (1985)*, *107*(3), 655–661. doi:10.1152/japplphysiol.00150.2009

Bratland-Sanda, S., & Sundgot-Borgen, J. (2013). Eating disorders in athletes: Overview of prevalence, risk factors and recommendations for prevention and treatment. *European Journal of Sport Science*, *13*(5), 499–508. doi:10.1080/17461391.2012.740504

Cialdella-Kam, L., Guebels, C. P., Maddalozzo, G. F., & Manore, M. M. (2014). Dietary intervention restored menses in female athletes with exercise-associated menstrual dysfunction with limited impact on bone and muscle health. *Nutrients*, *6*(8), 3018–3039. doi:10.3390/nu6083018

Cleary, S., Chi, V., & Feinstein, R. (2018). Female athletes: Managing risk and maximizing benefit. *Curr Opin Pediatr*, *30*(6), 874–882. doi:10.1097/MOP.0000000000000700

DePalma, M. T., Koszewski, W. M., Romani, W., Case, J. G., Zuiderhof, N. J., & McCoy, P. M. (2002). Identifying college athletes at risk for pathogenic eating. *Br J Sports Med*, *36*(1), 45–50. doi:10.1136/bjsm.36.1.45

De Souza, M. J., Koltun, K. J., Etter, C. V., & Southmayd, E. A. (2017). Current status of the female athlete triad: update and future directions. *Current osteoporosis reports*, *15*(6), 577-587. doi:10.1007/s11914-017-0412-x

Dueck, C. A., Matt, K. S., Manore, M. M., & Skinner, J. S. (1996). Treatment of athletic amenorrhea with a diet and training intervention program. *Int J Sport Nutr*, *6*(1), 24–40. doi:10.1123/ijsn.6.1.24

Eime, R. M., Harvey, J. T., Sawyer, N. A., Craike, M. J., Symons, C. M., Polman, R. C. J., & Payne, W. R. (2013). Understanding the contexts of adolescent female participation in sport and physical activity. *Res Q Exerc Sport*, *84*(2), 157–166. doi:10.1080/02701367.2013.784846

El Ghoch, M., Soave, F., Calugi, S., & Dalle Grave, R. (2013). Eating disorders, physical fitness and sport performance: A systematic review. *Nutrients*, *5*(12), 5140–5160. doi:10.3390/nu5125140

Ferrari, R. (2015). Writing narrative style literature reviews. *Medical Writing*, *24*(4), 230-235. doi:10.1179/2047480615Z.000000000329

Fischer, A. N., Yang, J., Singichetti, B., & Young, J. A. (2017). Menstrual dysfunction in females presenting to a pediatric sports medicine practice. *Translational Journal of the American College of Sports Medicine*, *2*(13), 79-84. doi:10.1249/TJX.0000000000000037

Georgopoulos, N. A., & Roupas, N. D. (2016). Impact of intense physical activity on puberty and reproductive potential of young athletes. In D. Vaamonde, S. S. du Plessis, & A. Agarwal (Eds.), *Exercise and human reproduction: Induced fertility disorders and possible therapies* (pp. 239–251). New York, NY: Springer New York. doi:10.1007/978-1-4939-3402-7_15

Gibbs, J. C., Williams, N. I., & De Souza, M. J. (2013). Prevalence of individual and combined components of the female athlete triad. *Med Sci Sports Exerc*, *45*(5), 985–996. doi:10.1249/MSS.0b013e31827e1bdc

Glazer, J. L. (2008). Eating disorders among male athletes. *Curr Sports Med Rep*, *7*(6), 332–337. doi:10.1249/JSR.0b013e31818f03c5

Gordon, C. M. (2010). Functional hypothalamic amenorrhea. *N Engl J Med*, *363*(4), 365–371. doi:10.1056/NEJMcp0912024

Hinton, P. S., & Kubas, K. L. (2005). Psychosocial correlates of disordered eating in female collegiate athletes: Validation of the ATHLETE questionnaire. *J Am Coll Health*, *54*(3), 149–156. doi:10.3200/JACH.54.3.149-156

Holtzman, B., Whitney, K. E., Parziale, A., & Ackerman, K. E. (2019). Relationship between age and red-s or female athlete triad risk level. *Orthopaedic Journal of Sports Medicine*, *7*(3), doi:10.1177/2325967119S00011

Joy, E., Kussman, A., & Nattiv, A. (2016). 2016 update on eating disorders in athletes: A comprehensive narrative review with a focus on clinical assessment and management. *Br J Sports Med*, *50*(3), 154-162. doi:10.1136/bjsports-2015-095735

Joy, E., De Souza, M. J., Nattiv, A., Misra, M., Williams, N. I., Mallinson, R. J., … Borgen, J. S. (2014). 2014 female athlete triad coalition consensus statement on treatment and return to play of the female athlete triad. *Current Sports Medicine Reports*, *13*(4), 219–232. doi:10.1249/JSR.0000000000000077

Kilpela, L. S., Blomquist, K., Verzijl, C., Wilfred, S., Beyl, R., & Becker, C. B. (2016). The body project 4 all: A pilot randomized controlled trial of a mixed-gender dissonance-based body image program. *Int J Eat Disord*, *49*(6), 591–602. doi:10.1002/eat.22562

Klein, D. A., & Poth, M. A. (2013). Amenorrhea: an approach to diagnosis and management. *Am Fam physician*, *87*(11), 781-788. Retrieved from https://www.aafp.org/afp/2013/0601/p781.html

Łagowska, K., Kapczuk, K., Friebe, Z., & Bajerska, J. (2014). Effects of dietary intervention in young female athletes with menstrual disorders. *J Int Soc Sports Nutr*, *11*(1), 21. doi:10.1186/1550-2783-11-21

Łagowska, K., Kapczuk, K., & Jeszka, J. (2014). Nine–month nutritional intervention improves restoration of menses in young female athletes and ballet dancers. *Journal of the International Society of Sports Nutrition*, *11*, 21. doi:10.1186/s12970-014-0052-9

Ljungqvist, A., Jenoure, P., Engebretsen, L., Alonso, J. M., Bahr, R., Clough, A., … Thill, C. (2009). The

International Olympic Committee (IOC) Consensus Statement on periodic health evaluation of elite athletes March 2009. *Bri J Sports Med*, *43*(9), 631–643. doi:10.1136/bjsm.2009.064394

Ljungqvist, A., Jenoure, P. J., Engebretsen, L., Alonso, J. M., Bahr, R., Clough, A. F., … Dubi, C. (2009). The International Olympic Committee (IOC) consensus statement on periodic health evaluation of elite athletes, March 2009. *Clin J Sport Med*, *19*(5), 347–365. doi:10.1097/JSM.0b013e3181b7332c

Logue, D. M., Madigan, S. M., Heinen, M., McDonnell, S. J., Delahunt, E., & Corish, C. A. (2019). Screening for risk of low energy availability in athletic and recreationally active females in Ireland. *Eur J Sport Sci*, *19*(1), 112–122. doi:10.1080/17461391.2018.1526973

Logue, D., Madigan, S. M., Delahunt, E., Heinen, M., Mc Donnell, S. J., & Corish, C. A. (2018). Low energy availability in athletes: A review of prevalence, dietary patterns, physiological health, and sports performance. *Sports Med*, *48*(1), 73–96. doi:10.1007/s40279-017-0790-3

Loucks, A. B., & Thuma, J. R. (2003). Luteinizing hormone pulsatility is disrupted at a threshold of energy availability in regularly menstruating women. *J Clin Endocrinol Metab*, *88*(1), 297-311. doi:10.1210/jc.2002-020369

Loucks, A. B., & Callister, R. (1993). Induction and prevention of low-T3 syndrome in exercising women. *Am J Physiol*, *264*(5 Pt 2), R924–R930. doi:10.1152/ajpregu.1993.264.5.R924

Loucks, A. B, & Heath, E. M. (1994). Induction of low-T3 syndrome in exercising women occurs at a threshold of energy availability. *Am J Physiol*, *266*(3 Pt 2), R817-823. doi:10.1152/ajpregu.1994.266.3.R817

Loucks, A. B., Verdun, M., & Heath, E. M. (1998). Low energy availability, not stress of exercise, alters LH pulsatility in exercising women. *J Appl Physiol*, *84*(1), 37–46. doi:10.1152/jappl.1998.84.1.37

Loucks, A. B., Laughlin, G. A., Mortola, J. F., Girton, L., Nelson, J. C., & Yen, S. S. (1992). Hypothalamic-pituitary-thyroidal function in eumenorrheic and amenorrheic athletes. *J Clin Endocrinol Metab*, *75*(2), 514-518. doi:10.1210/jcem.75.2.1639953

Loucks, A. B., Kiens, B., & Wright, H. H. (2011). Energy availability in athletes. *J Sports Sci*, *29* Suppl 1, S7–S15. doi:10.1080/02640414.2011.588958

Loucks, A. B. (2006). The response of luteinizing hormone pulsatility to 5 days of low energy availability disappears by 14 years of gynecological age. *J Clin Endocrinol Metab*, *91*(8), 3158-3164. doi:10.1210/jc.2006-0570

Manore, M. M., Kam, L. C., & Loucks, A. B. (2007). The female athlete triad: Components, nutrition issues, and health consequences. *J Sports Sci*, *25* Suppl 1), S61–S71. doi:10.1080/02640410701607320

McArdle, W., Katch, F., & Katch, V. (2010). *Exercise physiology: Nutrition, energy, and human performance* (7th ed.). *Philadelphia:* Wolters Kluwer Health/Lippincott Williams & Wilkins. Retrieved from https://books.google.com/books?hl=en&lr=&id=XOyjZX0Wxw4C&oi=fnd&pg=PR17&dq=+McArdle,+W.+D.,+Katch,+F.+I.,+%26+Katch,+V.+L.+(2010).+Exercise+physiology:+Nutrition,+energy,+and+human+performance.+Lippincott+Williams+%26+Wilkins.&ots=MwumX5eq_k&sig=aR76dvZA9

McComb, J. J. R., Qian, X. P., Veldhuis, J. D., McGlone, J. J., & Norman, R. L. (2006). Neuroendocrine responses to psychological stress in eumenorrheic and oligomenorrheic women. *Stress*, *9*(1), 41–51. doi:10.1080/10253890600591678

Meczekalski, B., Katulski, K., Czyzyk, A., Podfigurna-Stopa, A., & Maciejewska-Jeske, M. (2014). Functional hypothalamic amenorrhea and its influence on women's health. *J Endocrinol Invest*, *37*(11), 1049-1056. doi:10.1007/s40618-014-0169-3

Melin, A. K., Heikura, I. A., Tenforde, A., & Mountjoy, M. (2019). Energy availability in athletics: Health, performance, and physique. *Int J Sport Nutr Exerc Metab*, *29*(2), 152–164. doi:10.1123/ijsnem.2018-0201

Melin, A., Tornberg, Å. B., Skouby, S., Møller, S. S., Faber, J., Sundgot-Borgen, J., & Sjödin, A. (2016). Low-energy density and high fiber intake are dietary concerns in female endurance athletes. *Scand J Med Sci Sports*, *26*(9), 1060–1071. doi:10.1111/sms.12516

Mitchell J. J., Robert-McComb J. J. (2014). Screening for disordered eating and eating disorders in female athletes. In: Robert-McComb J. J., Norman R. L., Zumwalt M. (eds) The active female. New York, NY: Springer. doi:10.1007/978-1-4614-8884-2_13

Mond, J. M., Hay, P. J., Rodgers, B., & Owen, C. (2006). Eating Disorder Examination Questionnaire (EDE-Q): Norms for young adult women. *Behav Res Ther*, *44*(1), 53–62. doi:10.1016/j.brat.2004.12.003

Mountjoy, M., Sundgot-Borgen, J. K., Burke, L. M., Ackerman, K. E., Blauwet, C., Constantini, N., . . . Budgett, R. (2018). IOC consensus statement on relative energy deficiency in sport (RED-S): 2018 update. *Br J Sports Med, 52*(11), 687-697. doi:10.1136/bjsports-2018-099193

Mountjoy, M, Sundgot-Borgen, J., Burke, L. M., Carter, S., Constantini, N., Lebrun, C. M., … Ljungqvist, A. (2014). The IOC consensus statement: Beyond the female athlete triad— Relative Energy Deficiency in Sport (RED-S). *Br J Sports Med*, *48*(7), 491-497. doi:10.1136/bjsports-2014-093502

Mountjoy, M., Hutchinson, M. R., Cruz, L., & Lebrun, C. (2008). Female athlete triad coalition position stand on female athlete triad pre participation evaluation. Retrieved from http://health4performance.co.uk/wp-content/uploads/2018/09/Female-Athlete-Triad-Pre-participation-Evaluation.pdf

Nagel, D. L., Black, D. R., Leverenz, L. J., & Coster, D. C. (2000). Evaluation of a screening test for female college athletes with eating disorders and disordered eating. *J Athl Train*, *35*(4), 431–440. Retrieved from https://pubmed.ncbi.nlm.nih.gov/16558658/

Nattiv, A., Loucks, A. B., Manore, M. M., Sanborn, C. F., Sundgot-Borgen, J., & Warren, M. P. (2007). American College of Sports Medicine position stand. The female athlete triad. *Medicine and Science in Sports and Exercise*, *39*(10),1867–1882. doi:10.1249/mss.0b013e318149f111

Nazem, T. G., & Ackerman, K. E. (2012). The female athlete triad. *Sports Health*, *4*(4), 302–311. doi:10.1177/1941738112439685

Otis, C. L., Drinkwater, B., Johnson, M., Loucks, A., & Wilmore, J. (1997). American College of Sports Medicine position stand: The female athlete triad. *Med Sci Sports Exerc*, *29*(5), 1-9. doi:10.1097/00005768-199705000-00037

Potgieter, S. (2013). Sport nutrition: A review of the latest guidelines for exercise and sport nutrition from the American College of Sport Nutrition, the International Olympic Committee and the International Society for Sports Nutrition. *South African Journal of Clinical Nutrition*, *26*(1), 6–16. doi:10.1080/16070658.2013.11734434

Practice Committee of the American Society for Reproductive Medicine. (2004). Current evaluation of amenorrhea. *Fertil Steril*, *82* Suppl 1, S33-39. doi:10.1016/j.fertnstert.2004.07.001

Redman, L. M., & Loucks, A. B. (2005). Menstrual disorders in athletes. *Sports Med*, *35*(9), 747–755. doi:10.2165/00007256-200535090-00002

Richard, N., Palmer, C., & Adams, H. P. (2018). Female athlete triad: low energy availability, menstrual dysfunction, altered bone mineral density. *Physician Assistant Clinics*, *3*(3), 313–324. doi:10.1016/j.cpha.2018.02.001

Robert-McComb, J. J., & Loucks, A. B. (2014). The female athlete triad: Key points for health and fitness specialists. *ACSM'S Health & Fitness Journal*, *18*(3), 12–17. doi:10.1249/FIT.0000000000000033

Rodriguez-Ayllon, M., Cadenas-Sánchez, C., Estévez-López, F., Muñoz, N. E., Mora-Gonzalez, J., Migueles, J. H., . . . Esteban-Cornejo, I. (2019). Role of Physical Activity and Sedentary Behavior in the Mental Health of Preschoolers, Children and Adolescents: A Systematic Review and Meta-Analysis. *Sports Medicine, 49*(9), 1383-1410. doi:10.1007/s40279-019-01099-5

Rogers, M., Vlahovich, N., Hughes, D., Pyne, D., Halson, S., Lovell, G., . . . Drew, M. (2021). 080 The prevalence of indicators of relative energy deficiency in sport (RED-S) in Australian elite and pre-elite female athletes. *British Journal of Sports Medicine, 55*(Suppl 1), A33. doi:10.1136/bjsports-2021-IOC.76

Scheerder, J., Thomis, M., Vanreusel, B., Lefevre, J., Renson, R., Vanden Eynde, B., & Beunen, G. P. (2006). Sports participation among females from adolescence to adulthood: A longitudinal study. *International Review for the Sociology of Sport*, *41*(3–4), 413–430. doi:10.1177/1012690207077702

Scheid, J. L., & De Souza, M. J. (2010). Menstrual irregularities and energy deficiency in physically active women: the role of ghrelin, PYY and adipocytokines. *Cytokines, Growth Mediators and Physical Activity in Children during Puberty, 55*, 82–102. doi:10.1159/000321974

Slater, J., Brown, R., McLay-Cooke, R., & Black, K. (2017). Low energy availability in exercising women: Historical perspectives and future directions. *Sports Med*, *47*(2), 207–220. doi:10.1007/s40279-016-0583-0

Speroff, L., & Fritz, M. (2005). *Clinical gynecologic endocrinology and infertility* (7th ed.). Philadelphia, PA: Lippincott Williams & Wilkins. Retrieved from https://books.google.com/books?hl=en&lr=&id=8sIkqPT2gh4C&oi=fnd&pg=PA1&dq=Sperof

f,+L.,+%26+Fritz,+M.+A.+(Eds.).+(2005).+Clinical+gynecologic+endocrinology+and+infertility.+Lippincott+Williams+%26+wilkins.&ots=Cy2qSbcCDy&sig=3DX1dD7RxOpk97IOALF3bQ8hsvU

Steiner, H., Pyle, R. P., Brassington, G. S., Matheson, G., & King, M. (2003). The College Health Related Information Survey (C.H.R.I.S.-73): A screen for college student athletes. *Child Psychiatry Hum Dev*, *34*(2), 97–109. doi:10.1023/A:1027389923666

Stickler, L. G., Hoogenboom, B. J., & Brown, J. (2019). The impact of nutritional intervention on menstrual dysfunction in female athletes: a systematic review. *SN Comprehensive Clinical Medicine*, *1*(9),669-676. doi:10.1007/s42399-019-00107-z

Takemoto, D. M., & Beharry, M. S. (2015). What's normal? Accurately and efficiently assessing menstrual function. *Pediatr Ann*, *44*(9), e213-217. doi:10.3928/00904481-20150910-08

Temme, K. E., & Hoch, A. Z. (2013). Recognition and rehabilitation of the female athlete triad/tetrad: A multidisciplinary approach. *Curr Sports Med Rep*, *12*(3), 190–199. doi:10.1249/JSR.0b013e318296190b

Thein-Nissenbaum, J., & Hammer, E. (2017). Treatment strategies for the female athlete triad in the adolescent athlete: Current perspectives. *Open Access J Sports Med*, *8*, 85–95. doi:10.2147/OAJSM.S100026

Thein-Nissenbaum, J. M., Rauh, M. J., Carr, K. E., Loud, K. J., & McGuine, T. A. (2012). Menstrual irregularity and musculoskeletal injury in female high school athletes. *J Athl Train*, *47*(1), 74–82. doi:10.4085/1062-6050-47.1.74

Torstveit, M. K., & Sundgot-Borgen, J. (2005). Participation in leanness sports but not training volume is associated with menstrual dysfunction: A national survey of 1276 elite athletes and controls. *Br J Sports Med*, *39*(3), 141–147. doi:10.1136/bjsm.2003.011338

Troy, K., Hoch, A. Z., & Stavrakos, J. E. (2006). Awareness and comfort in treating the Female Athlete Triad: Are we failing our athletes? *WMJ, 105*(7), 21–24. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/17163082

Valliant, M. W. (2016). The female athlete triad and relative energy deficiency in sport: Knowledge of both can improve the health of female athletes. *Strength & Conditioning Journal*, *38*(2), 35–39. doi:10.1519/SSC.0000000000000201

Valliant, M. W., Emplaincourt, H. P., Wenzel, R. K., & Garner, B. H. (2012). Nutrition education by a registered dietitian improves dietary intake and nutrition knowledge of a NCAA female volleyball team. *Nutrients*, *4*(6), 506–516. doi:10.3390/nu4060506

van Eck, C. F., & Fu, F. H. (2018). The benefits of youth sports participation should outweigh the risks. *Ann Transl Med*, *6*(Suppl 1), S11. doi:10.21037/atm.2018.08.44

Vickers, H., Gray, T., & Jha, S. (2018). Amenorrhoea. *InnovAiT,* *11*(2), 80–88. doi:10.1177/1755738017737101

Weaver, C. M., Gordon, C. M., Janz, K. F., Kalkwarf, H. J., Lappe, J. M., Lewis, R., . . . Zemel, B. S. (2016). The National Osteoporosis Foundation's position statement on peak bone mass development and lifestyle factors: A systematic review and implementation recommendations. *Osteoporos Int*, *27*(4), 1281–1386. doi:10.1007/s00198-015-3440-3

Weiss Kelly, A. K., Hecht, S., & Council On Sports Medicine And Fitness, (2016). The Female Athlete Triad. *Pediatrics*, *138*(2). doi:10.1542/peds.2016-0922

Winterer, J., Cutler, G. B. Jr., & Loriaux, D. L. (1984). Caloric balance, brain to body ratio, and the timing of menarche. *Med Hypotheses*, *15*(1), 87–91. doi:10.1016/0306-9877(84)90011-2