The Female Athlete Triad: Clarifying the Relationship between Symptoms and
Identifying Their Influence on Performance

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Rendering gender equality in sport is an ongoing movement, as females are still competing for equal pay, better media coverage, and even just a chance to participate in some areas. However, while some argue that females have a long way to go in regards to garnering the same respect as males, they have also overcome a lot of obstacles. The fortieth anniversary of Title IX in 2012, served as a reminder of how far women’s sports have come over the past few decades. For instance, in 1971 it was estimated that 310,000 females participated in sport, and in 2010, that number had increased to 3,373,000 participants (Matzkin, Curry, & Whitlock, 2015). There are now several organizations that exist, dedicated to improving the lives of women and girls through sport and physical activity, such as the Women’s Sports Foundation. This organization strives to give females equal opportunities to play, but also provides today’s youth with empowering role models in sport amidst mixed messages delivered through social media.

Females are under a lot of pressure to conform to societal norms and achieve unrealistic standards when it comes to physical appearance. Media plays a large role in how women perceive their body, as they compare themselves to images that have been photo-shopped or manipulated to create the ‘ideal’ body type. Despite recent campaigns that promote ‘strong is the new sexy,’ the desire to look a certain way has narrowed the focus of so many women, who have succumbed to the idea of reaching impractical norms, even at the risk of jeopardizing their health.

Kuriel (2013) explains the relevance and impact of this controversial issue as it applies to females in sport. She states that with the increase in females participating in athletics over the past 35 years, there has been a similar increase in gender specific conditions and
ailments developing alongside this growth (Kuriel, 2013). The most common health problems observed in female athletes are disordered eating, amenorrhea, and low bone density (Kuriel, 2013). Collectively, these symptoms make up the female athlete triad, a syndrome that is now considered a spectrum disorder, characterized by dysfunctions in energy availability (Matzkin et al., 2015). Kuriel (2013) discusses how female athletes are often more susceptible to developing these symptoms, as they not only struggle with poor body image, but a desire to be lighter and leaner in order to improve performance.

Originally, all three symptoms of the female athlete triad were required to be present for a diagnosis. However, without a clear understanding of whether or not symptoms are interrelated, have cause-and-effect relationships, or how each component affects psychological and physical performance, the American College of Sports Medicine (ACSM) broadened diagnostic guidelines to reflect the idea that the root cause of this condition is energy deficiency. As of recent, an apparent pathology in one or two components of the triad that contributes to a disruption in energy balance may be enough to meet criteria for diagnosis and therefore, warrants further evaluation for potential development of other symptoms (Matzkin et al., 2015).

**Problem Statement**

Although the female athlete triad is now diagnosed based on where an athlete falls on the spectrum of energy availability, the relationship between symptoms remains unclear. The purpose of this written review is twofold: to determine if the symptoms associated with the female athlete triad are interrelated and have a cause-and-effect relationship, and to discuss the influence of these symptoms on psychological and physical performance.
Literature Review

What is the Female Athlete Triad?

After the Educational Amendment Act (Title IX) was passed in 1972, female participation in sport increased dramatically. Despite the notable health benefits associated with physical activity, the number of female athletes with eating disorders, amenorrhea, or non-traumatic stress fractures seemed to increase coincidently (Javed, Tebben, Fischer, & Lteif, 2013). Although symptoms were reported for several years following the enactment of Title IX, it was not until the mid-nineties that the ACSM formally recognized the triad as a collective group of interrelated health risks commonly observed in female athletes (Javed et al., 2013).

While the original diagnosis required an athlete to show signs of disordered eating, amenorrhea, and osteoporosis, the ACSM updated their definition of the triad in 2007 to include a spectrum of dysfunction related to energy availability, menstrual function, and bone mineral density (Javed et al., 2013). This change was implemented as a means to acknowledge that athletes who do not present all three symptoms could still be at-risk, without meeting complete triad criteria. A recent meta-analysis on the prevalence of triad symptoms across a variety of athletes further supports this idea by reporting that only a small percentage of athletes exhibit all three symptoms (0%-15.9%), with a much larger percentage showing signs of just two or one of the triad symptoms (2.7%-27.0% and 16.0%-60.0% respectively) (Gibbs, Williams, & De Souza, 2013). Further, the incidence of triad symptoms is two to three times greater in aesthetic sports that emphasize maintaining a lean build, such as dance, gymnastics, figure skating, diving, or long-distance running…than in sports that do not (Javed et al., 2013).
Signs and Symptoms: Energy Availability

Originally, disordered eating was considered the red flag when evaluating athletes for triad symptoms. Now, this component is better understood in terms of energy availability and is assessed using a continuum upon which athletes may exhibit optimal energy balance, or appear to have dysfunctional energy availability (Matzkin et al., 2015). Low energy availability is usually a result of inadequate caloric intake which can be caused inadvertently by failure to increase caloric consumption to match exercise, or pathologically by restricting calories (Javed et al., 2013). The latter often leads to eating disorders such as anorexia nervosa. A helpful tool for evaluating energy availability is determining body mass index (BMI). A BMI lower than 17.5 indicates an athlete is likely to have low energy stores; however, it is more difficult to assess energy availability in athletes with a normal BMI (Matzkin et al., 2015). Thus, a detailed history of the athlete’s dietary habits and energy expenditure should be considered when determining whether or not she has suboptimal energy stores (Matzkin et al., 2015). What’s more, Javed et al. (2013) state that monitoring body weight and BMI is not enough to detect an energy deficiency in some cases. They suggest that energy availability is more accurately defined in terms of calories consumed per day, per kilogram of fat free mass (Javed et al., 2013). Still, this makes energy balance difficult to determine without a comprehensive body composition analysis.

Nevertheless, current research shows that female athletes can develop an energy deficiency or restrictive behaviors that lead to disordered eating as early as high school. The demand of their sport, paired with the pressure to keep up with sociocultural norms, fosters a sense of body dissatisfaction and contributes to an idealistic desire to maintain a below-average weight (Javed et al., 2013). The prevalence of eating disorders in athletes is nearly 10% higher
than in non-athletes, which demonstrates the importance of athlete education about proper nutrition and energy balance to prevent long-term health deficiencies (Javed et al., 2013; Matzkin et al., 2015).

**Signs and Symptoms: Menstrual Function**

Along the spectrum of menstrual function for female athletes is eumenorrhea, primary and secondary amenorrhea, and oligomenorrhea. Eumenorrhea is defined as regular menstruation, occurring approximately every 28 days. Primary amenorrhea is the lack of menarche after the age of 15, and secondary amenorrhea refers to the absence of menses for three consecutive cycles in a previously menstruating individual (Javed et al., 2013). Oligomenorrhea is considered abnormal, when menstruation occurs every 35 days, or when a female has fewer than nine menstrual cycles in a year (Matzkin et al., 2015).

These disorders are not uncommon for female athletes, especially those involved in ‘lean sports’ such as ballet or gymnastics (Javed et al., 2013). A study involving 425 collegiate athletes in 15 sports reported that 7.4% of all participants had not menstruated by the age of 16, compared with 1% in the general population (Javed et al., 2013). However, recreational exercisers experience menstrual irregularities as well. For instance, a runner’s training volume correlates with menstrual dysfunction, as the likelihood of amenorrhea increases as mileage goes up each week (Javed et al., 2013).

Menstrual dysfunction is directly related to a hormone imbalance, although pathophysiology is not entirely clear. It is assumed that amenorrhea is often the result of an unpredictable release of gonadotropin-releasing hormone, which eventually affects the release of estrogen from the ovaries (Matzkin et al., 2015). There seems to be substantial evidence that
links menstrual dysfunction to the other triad symptoms, as estrogen plays a significant role in bone remodeling and resorption. Thus, athletes in an estrogen-deficient state have lower bone mineral density and a heightened risk of injury (Matzkin et al., 2015). Connecting menstrual dysfunction to energy availability is the idea that treatment of functional hypothalamic amenorrhea is associated with increasing energy stores. Matzkin et al. (2015) confirm that increasing caloric intake can help with weight gain and resumption of menses as long as energy expenditure is controlled. Although preliminary in nature, this research indicates that while triad symptoms can manifest independently, they are potentially interrelated.

**Signs and Symptoms: Bone Mineral Density**

The final component of the female athlete triad is associated with skeletal health and ranges from optimal bone mineral density (BMD) on one end of the spectrum, to osteoporosis on the other end. Most women develop 90% of peak BMD by the age of 18, accruing most between the ages of 11 and 14 (Matzkin et al., 2015). Optimal BMD develops from good nutritional habits and regular physical activity to include weight-bearing exercise. Once optimal BMD is reached, it can only be maintained or lost; again, making athlete education vital to prolonging bone health (Matzkin et al., 2015).

There is limited data describing the prevalence of low BMD in adolescent female athletes because of the variability in mechanical loading across different activities. Gymnastics and running involve a greater degree of mechanical loading for instance, whereas cycling and swimming do not (Javed et al., 2013). Current research does suggest however, that low BMD can be a direct result of the other triad symptoms. Barrack, Rauh, and Nichols (2008), who examined traits associated with low BMD in a group of female adolescent runners, found that menstrual
irregularity and disordered eating increases the risk of low BMD. Further, Javed et al. (2013) explain that a 10% decrease in weight [caused by an energy deficit] can cause up to a 2% loss in BMD. Additionally, they also state that athletes who experience amenorrhea may not be able to reach peak bone mass, even after restoration of menstrual cycles (Javed et al., 2013). Among all of the triad symptoms, it appears that BMD has the greatest capacity to be affected by low energy availability and menstrual dysfunction, making the potential for a cause-and-effect relationship more plausible.

**Examining the Relationship between Symptoms**

While there is substantial research indicating the prevalence of symptoms associated with the triad in both recreational and elite female athletes, ambiguity still exists in regards to the relationship between symptoms. Basic scientific principles suggest that all three symptoms are potentially interrelated and even causal of one another. For instance, functional hypothalamic amenorrhea (FHA) results from a hormonal disruption when body weight is too low, most likely because of an energy deficiency. This type of secondary amenorrhea ultimately affects an athlete’s ability to reach peak bone mass (Manore, Kam, & Loucks, 2007). Laframboise, Borody, and Stern (2013) published several case studies revealing the negative effects of non-cognitive disordered eating (i.e. inadvertent caloric deficit), and its impact on fragility fracture incidence due to osteoporosis.

However, there are also case studies that demonstrate triad symptoms can present themselves independently, and are not a direct cause of the other two. To and Wong (2011) compared BMD of young female dancers with oligo/amenorrhea and eumenorrhoeic/normal weight dancers with eumenorrhoeic non-exercising controls. Interestingly, dancers with low energy availability and oligo/amenorrhea did not have lower BMD than non-exercising
eumenorrheic controls, while eumenorrheic dancers actually had higher BMD (To & Wong, 2011). Thus, while energy availability, menstrual function, and bone mineral density are often interrelated, there are discrepancies in research that refute a definite cause-and-effect relationship between symptoms.

Additionally, Gibbs et al. (2013) confirm the percentage of female athletes who exhibit only one or two triad symptoms far outweighs the percentage of athletes with all three, strengthening the notion that symptoms may be interrelated but are not interdependent. It is important to note, the diagnostic changes set forth by the ACSM in 2007 certainly influenced this supposition, provided an athlete no longer has to show signs of all three triad symptoms to be considered at risk or on the spectrum of health and disease.

**Psychological and Physical Implications**

The female athlete triad is characterized by three physiological symptoms, yet there are both psychological and physical implications associated with the syndrome as well. The greatest psychological impact is related to energy availability and disordered eating. Laframboise et al. (2013) generalize that female participation in athletics has been empowering and beneficial by increasing self-esteem and reducing risky behaviors such as drug abuse and teen pregnancy. Although, there is a significant amount of psychological stress associated with sport, especially for female athletes participating in activities that emphasize aesthetics. Laframboise et al. (2013) explain that females are at an increased risk of developing disordered eating patterns because of their strong desire to conform to societal norms and improve performance, combined with an overly controlling coach or parent. Therefore, reforming the attitude of these athletes to consider ‘food as fuel’ is essential in preventing long-term health deficiencies caused by psychological pressures (Javed et al., 2013). Further, coaches, parents, and other health professionals should be
educated in regards to recognizing risk factors and warning signs that lead to the triad…eating disorders in particular (Javed et al., 2013). Psychosocial behaviors associated with the triad include dissatisfaction with body size, mood changes, and ultimately a decline in confidence and performance (Javed et al., 2013).

Aside from the mental and emotional effects, common physical limitations that transpire with the female athlete triad include a decrease in max oxygen consumption and an increase in musculoskeletal injuries. Javed et al. (2013) report that performance is negatively affected by energy deficits, and athletes who are malnourished experience a significant decrease (28%) in max oxygen consumption. Additionally, they confirm that high school athletes with disordered eating are twice as likely to incur a sports-related musculoskeletal injury, and those who experience menstrual irregularity further increase this risk (Javed et al., 2013).

In a study that examined the impact of the female athlete triad on injury rate among high school distance runners, Rauh, Barrack, and Nichols (2014) found that oligo/amenorrhea and low BMD were associated with lower extremity musculoskeletal injury. Out of 89 runners that participated, 38 sustained running-related injuries. Those who were injured reported higher mean scores on an eating disorder examination questionnaire (EDE-Q) that was given to all athletes prior to the examination period, and had substantially lower BMD at the spine, total hip, and whole body (Rauh et al., 2014). While this study’s findings are consistent with previous research, this was notably the first study to associate triad symptoms with musculoskeletal injuries, rather than just stress fractures and bone-related injuries (Rauh et al., 2014). Although causal mechanisms for both bone-related and non-bone related injuries remain somewhat inconclusive, researchers suggest the same hormonal profile that disrupts normal bone metabolism, likely
affects the health of muscles and other connective tissues, which would explain the correlation between menstrual dysfunction and non-bone related injuries (Rauh et al., 2014).

Physical implications associated with characteristics of the triad are certainly evident based on current research. However, there are still gaps in regards to causality that subsequent studies could reveal. Nevertheless, athletes, parents and coaches should learn to recognize a physical decline in performance and/or an increased injury rate that could be linked to pathophysiological symptoms of the triad.

**Conclusion**

The purpose of this review was to determine the relationship between triad symptoms and to identify the psychological and physical implications associated with low energy availability. Primary research suggests the three symptoms that collectively make up the female athlete triad are indeed interrelated; however, there is not enough evidence to support the idea that symptoms are a direct cause of one another. This is affirmed by the simple fact that the percentage of athletes who present only one or two symptoms of the triad is much higher than the percentage of athletes who present all three (Gibbs et al., 2013). In other words, most athletes exhibit symptoms that may be interrelated, but not interdependent. Additionally, conflicting results regarding the effect of menstrual disturbances on BMD demonstrate that an increased risk of fragility fractures may be linked to a hormonal deficiency in some athletes, but not all. Thus, the broad generalization that a cause-and-effect relationship exists between triad symptoms is inappropriate and scientifically unsupported.

Psychological and physical implications are better understood and presented consistently across research. Psychological stressors most often manifest in the form of eating disorders, and are most noticeable among athletes involved in aesthetic sports that emphasize maintaining a
lean body composition (Javed et al., 2013). In order to prevent a long-term nutritional imbalance, affected athletes should work with medical professionals to develop a healthier relationship with food and gain a better understanding of energy balance. The most common physical effects linked to the female athlete triad are a decrease in max oxygen consumption and an increase in musculoskeletal injuries (Javed et al., 2013). Malnourishment is presumed to be the primary cause of a decline in max oxygen consumption, while low BMD significantly heightens one’s risk of injury. Preventative screening is the best method for early detection of athletes who may be at risk, while coaches, parents, and other health professionals may play the largest role in helping athletes manage persisting performance-related impairments.

**Clinical Implications**

Educating athletes, coaches, parents, and other health professionals to a greater extent is essential for preventing and managing future cases involving young females who exhibit characteristics of this spectrum disorder. Javed et al. (2013) state that in recent surveys, only a third of athletes could identify a connection between menstrual dysfunction and poor bone health, and nearly half failed to acknowledge the absence of their menstrual cycle as abnormal, specifically those involved in activities that emphasize aesthetics (Javed et al., 2013). Further, most athletes lack nutritional knowledge and do not consider low energy availability a concern (Javed et al., 2013). Along the same lines, just under half of physicians and physical therapists surveyed could identify components of the triad, and less than 10% of coaches were knowledgeable about the condition (Javed et al., 2013). These problematic results demonstrate a primary need for further education.

There are several preventative measures that can be taken to evaluate and screen athletes who may be at risk, as well as apparent warning signs to look for. For example, a pre-
participation evaluation (PPE) or an EDE-Q can provide information about skeletal health, menstrual history, and dietary habits. Research shows that a majority of high schools and universities require some type of PPE before initiation of physical activity; however, the Female Athlete Triad Coalition recommends a specific 12-item questionnaire be administered to all female athletes (Javed et al., 2013). The current PPE form endorsed by the American Academy of Pediatrics, American Academy of Family Physicians, and ACSM includes only 7 of the 12 recommended screening items, indicating that most schools do not specifically screen for components of the triad (Javed et al., 2013). Thus, efforts should be focused on standardizing screening evaluation of female athletes in order to prevent the number of triad cases (Javed et al., 2013).

Despite these evaluation discrepancies, organizations like the International Olympic Committee (IOC) have created risk assessments and guidelines for sport participation on a larger scale in regards to energy deficiency. Their all-encompassing model considers medical factors, sport risk modifiers, and decision modifiers to help evaluate whether or not an athlete should initially participate or return-to-play after a diagnosis. For instance, aside from bone health, menstrual health, and weight fluctuations, type of sport, competitive level, and external pressure from a coach or parent are highly regarded and included in the risk-assessment process (Mountjoy et al., 2014). Likewise, the IOC flags certain warning signs that may indicate an athlete is at high risk of developing triad symptoms and should refrain from sport participation until she is further evaluated. Warning signs to look for include a decline in performance, mood changes, frequent illness or injury, fractures, or dissatisfaction with body size (Javed et al., 2013). Teachers, coaches, parents, and other health professionals who work closely with female athletes should be cognizant of any changes, as a physical examination and laboratory evaluation
may be necessary to reveal additional and more specific information about energy expenditure and BMD.

While prevention should remain a priority, those who work with female athletes should also be knowledgeable about the different means for managing symptoms associated with the triad and what types of resources are available. Management is effective when a multidisciplinary approach is taken and a team of health professionals works collaboratively to help at-risk athletes. For example, a primary physician can help educate an athlete about maintaining a positive energy balance, a sports dietician can facilitate the design of a healthy meal plan, sports psychologists can help with those who suffer from eating disorders, and coaches can modify exercises and intensity when necessary (Laframboise et al., 2013). Parents also play a role in managing symptoms, as they can monitor progress and provide moral support and encouragement for their daughters (Laframboise et al., 2013).

Both pharmacological and nonpharmacological treatments have been suggested and tried with at-risk athletes; although, research is inconsistent in terms of which practice is most effective for managing symptoms (Javed et al., 2013). Due to the complexity of this spectrum disorder, widespread education efforts appear to be the most valuable means for helping teachers, coaches, parents, and health professionals learn the implications of the triad and how they each play a role in prevention, detection, and management of symptoms (Javed et al., 2013).

Future Research

Endothelial dysfunction, which has been linked to an increased risk of heart disease and is caused by a decrease in estrogen, is a new emerging component that some researchers consider the fourth interconnected condition of the female athlete triad…or tetrad (Laframboise et al., 2013). Over the past few years, research has surfaced explaining that endothelial function plays
an important role in regulating vascular function. Low estrogen levels can theoretically disrupt endothelial function, resulting in impaired arterial dilation and ultimately cardiovascular disease (Laframboise et al., 2013). A decrease in estrogen, when unrelated to menopause, is most often a physiological change that stems from low energy availability. Therefore, it is well reasoned why researchers are linking this fourth component to the triad, especially because it is now recognized as a spectrum disorder related to healthy or unhealthy energy balance. Although this budding research presents a logical presumption, a lack of case studies and primary fieldwork investigating the relationship between endothelial dysfunction and other triad symptoms suggests this subject matter warrants further research.

Additionally, treatment for athletes with triad symptoms remains a controversial topic. There is research that supports both nonpharmacological and pharmacological therapy, with no confirmation that one type of intervention is more beneficial than the other. A 5-year retrospective study conducted by Arends, Cheung, Barrack, and Nattiv (2012) demonstrated that nonpharmacological treatment can be an effective means for restoring menses in college athletes with menstrual disturbances, primarily through weight gain or an increase in BMI. However, not all female athletes involved in the study experienced restoration of menses, suggesting that intervention should be individualized and menstrual dysfunction may also be related to genetics, metabolic factors, and psychosocial stressors (Arends et al., 2012). Pharmacological remedies are generally prescribed to treat athletes with eating disorders and range from antidepressants and anxiolytics to calcium and vitamin D supplements (Javed et al., 2013). The oral contraceptive pill has also been used for hormone replacement therapy in athletes over the age of 16, in effort to reverse low BMD. Although, Javed et al. (2013) explain that use of these pills is only a temporary remedy, and simply masks a continued energy deficit that is damaging skeletal
health. Evidently, research has not clearly defined the role of nonpharmacological and pharmacological treatment in treating athletes with the female athlete triad. The apparent variance in opinions should therefore be investigated further.

Finally, while there is limited research that examines the effects of triad symptoms on male athletes, it can be inferred that the ACSM is taking steps to broaden diagnostic guidelines to eventually include both genders. Based on the changes made in 2007, the ACSM really shifted the focus of this condition to energy availability, rather than just female specific disorders such as amenorrhea. Male athletes participate in a number of sports where low body weight has been shown to improve athletic performance (cross country, diving, etc.) and may be just as susceptible to developing an energy deficit. A worthy discussion to guide future research is whether or not diagnoses of the triad should be confined to the female gender.
The Female Athlete Triad

References


