ABSTRACT

Females participating in sports have the potential of developing one or multiple parts of the Female Athlete Triad, defined as the inter-relationship among energy availability, menstrual function, and bone mineral density. Energy availability, defined as dietary energy intake minus exercise energy expended, is believed to be at the cornerstone of the triad, and complications from low energy availability span many of the bodily systems and can have psychological implications. Treatment of the triad requires a comprehensive multi-disciplinary approach.

Physical therapists frequently treat injured athletes and may have prolonged interactions with athletes depending on the length of the rehabilitation process. In addition to examination, assessment, and treatment of injuries, the role of the physical therapist includes prevention, and the promotion of health, well-being, and fitness. Thus, the goal of this clinical commentary is to identify and describe essential knowledge for the physical therapist, clearly identify the role of the physical therapist as part of multi-disciplinary management team, and outline resources for the physical therapist and athletes relevant to the female athlete triad.

Level of Evidence: 5

Keywords: Bone health, energy availability, female athlete triad, menstrual status
INTRODUCTION
Participation in sports is typically associated with psychologic, sociologic, and physiologic health benefits. However, in females, a potential negative result can be the development of the Female Athlete Triad (the triad), defined as the inter-relationship among energy availability (EA), menstrual function, and bone mineral density (Figure 1). A recent systematic review reported the prevalence of all three components in female high school, collegiate, and elite athletes to be between 0% and 16%. The prevalence of two components was 3% to 27%, and the prevalence of any single component was 16% to 60%. Due to the interactive nature of the components of the triad, individuals with just one or two components of the triad are still at risk for health issues and may be at risk for developing all three components.

Physical therapists frequently treat injured athletes and may have prolonged interactions with athletes depending on the length of the rehabilitation process. Despite frequent treatment of female athletes, two surveys that assessed physical therapists’ knowledge of the female athlete triad have yielded less than optimal results. Results of the survey by Troy et al. demonstrated that only 43% of physical therapists could identify all three components of the triad. Likewise, results of a study by Pantano demonstrated that 61% of therapists stated that they knew the three components of the triad, but only 21% could actually state all of them. Surprisingly, these therapists were all members of either the Orthopedic or Sports Sections of the American Physical Therapy Association and approximately one quarter of them identified that they had treated athletes in the past year with symptoms related to the triad. However, the lower percentage of therapists correctly identifying the triad as opposed to the aforementioned study by Troy et al may have been due to variances in the correct terms accepted. For example, disordered eating or low energy availability was accepted, but eating disorders was not. Nonetheless, only 59% reported being comfortable discussing disordered eating and menstrual dysfunction with their athletes.

The Guide to Physical Therapist Practice defines the role of the to include prevention and the promotion of health, wellness, and fitness, in addition to the typical role of rehabilitation of injuries. Prevention may be primary, preventing a condition in a target population; secondary, decreasing the duration or severity of disease; or tertiary, restoring function in a patient dealing with a chronic illness or disability. Primary prevention includes screening for disease(s), identifying areas for initiation of prevention strategies, and potential referral to other health care providers. With appropriate knowledge of the triad, the skills and background of the physical therapist are appropriate for each of these roles in prevention and health promotion. Thus, the goal of this clinical commentary is to identify and describe essential knowledge for the physical therapist as part of multi-disciplinary management team, and outline resources for the physical therapist and athletes relevant to the female athlete triad.

**THE FEMALE ATHLETE TRIAD DEFINED**
A multidisciplinary workgroup assembled by The American College of Sports Medicine (ACSM), described the female athlete triad as consisting of three inter-related conditions that each occur on a spectrum from normal function to dysfunction:
EA, menstrual function, and bone mineral density. The importance of presenting the triad components as conditions that each occur across a spectrum is worth noting because this may allow providers to recognize that athletes may present with subclinical disorders that should be identified and treated before full-blown eating, menstrual, or bone disorders ensue.9

In the triad, low EA may occur with or without an eating disorder. EA is calculated by taking the dietary energy intake (in kilocalories) and subtracting the energy (in kilocalories) expended during exercise.10 The equation for EA is displayed below:

Dietary energy intake

— Exercise energy expenditure

Energy Availability

The result, known as EA, is how much energy remains for other body functions. Low EA may be a result of an eating disorder or eating practices such as fasting or food avoidance that decrease energy intake. Alternatively, low EA can ensue either purposively or inadvertently without an eating disorder if an athlete’s energy demands exceed her caloric intake. Health may be impaired as the energy required for basic physiological functions of the body is not available. Consequences can be far reaching and may include, but are not limited to the following: diminished ability to recover from injury, inability to build or maintain bone mass, impaired menstrual function and infertility, and an increased risk of cardiovascular disease.10

The spectrum of menstrual function is the second aspect of the triad. Women over the age of 15 are expected to have normal menses that occurs every 28 ± 7 days.11 This is considered “normal menses” or eumenorrhea. Menstrual dysfunction incorporates a spectrum of disorders from oligomenorrhea (menstrual cycle greater than 35 days) to amenorrhea (the absence of menstruation for greater than three months).1 Amenorrhea after the onset of menses (menarche) is referred to as secondary amenorrhea. Primary amenorrhea refers to the delay of menarche until after the age of 15.1,11,12 Other reproductive irregularities may be present in female athletes, including anovulation and polycystic ovarian syndrome, both of which may occur in the presence of normal menses. These conditions are difficult to identify, require advanced medical diagnosis, and may lead to problems even though menses is present;9 therefore, the physical therapist should not assume all menstrual dysfunction to be related to the triad.

The third component of the triad is the spectrum of bone health. Low bone density in female athletes is defined by the ACSM as “a history of nutritional deficiencies, hypoestrogenism, stress fractures, and/or other secondary clinical risks for fracture together with a bone mineral density (BMD) Z-score between -1.0 and -2.0.”1 Osteoporosis is defined as BMD Z-score below -2.0.1 When dosed properly, physical activity and exercise has proven to offer positive benefits with regard to bone mass. In fact, many athletes typically display bone mineral density that is higher than the average non-athlete, when compared by age.9 Forty-eight percent of skeletal mass and 15% of adult height should be attained during adolescence, and peak bone mass is achieved by 20-25 years of age.13,14 Thus, bone loss or impaired bone development in female athletes is particularly concerning.

There is a strong interrelationship between the three components of the triad; however, low EA is frequently described as being the “cornerstone” of the three potentially interrelated disorders.1,15 Dysfunction of the menstrual/reproductive system and the skeletal system can be related either directly or indirectly to EA. Optimal EA supports bone health both by maintaining the metabolic and endocrine pathways for eumenorrhea, related to estrogen production. Amenorrhea resulting from energy deficiency (low EA) is known as functional hypothalamic amenorrhea in which the complex hypothalamic-pituitary-ovarian axis is impacted and estrogen levels are diminished, despite no anatomic cause.11 Furthermore, the lack of estrogen further impacts bone density as estrogen has a protective effect on bone by inhibiting the function of the osteoclasts whose role it is to break down bone.

The impact of the triad is not limited to menstrual function and bone health. Complications from low EA and the additional consequences can span many of the bodily systems and can have psychological implications.1 Low EA has specifically been linked to depression, low self-esteem, and anxiety disor-
Due to the potential systemic impact of the triad, it is the opinion of the authors that physical therapists should be able to identify the components of the triad and describe their impact on the health of the female athlete, screen for risk factors of the triad, and articulate the role of the physical therapist in a multi-disciplinary approach to prevention and treatment of the triad.

IDENTIFICATION OF INDIVIDUALS WITH THE TRIAD

Though the components of the female athlete triad may be easy to define and comprehend, it is often difficult to identify those who are dealing with one of the components or its effects. First and foremost, to screen, evaluate, diagnose, or treat an athlete, the athlete must be willing to partake in that process. Often, an athlete does not realize they have low EA, low bone density, or that their lack of menstruation is abnormal. It is the responsibility of healthcare professionals, such as physical therapists, to be able to educate athletes, parents, and coaches regarding the components of the triad so that they do not go unnoticed.

Acknowledging that the physical therapist should not serve as a physician, counselor, dietician, or psychologist, there are several important ways that the PT can assist in identification of the areas of the triad in active women and girls. First, during the history and systems review, general questions should be posed about menstrual status and history. Second, a history of multiple or repeated stress injury to bone should trigger the PT to consider the triad as a potential contributory factor. Several important questions are proposed by the Female Athlete Triad Coalition Consensus group, which can be found in Table 1. The Consensus group suggests that all high school and college athletes be screened. The physical therapist could easily incorporate these questions into an initial examination of a female patient or during a pre-season screening event for female athletes.

Low EA, the main component of the triad, is quite complex and identification of this condition requires an objective view of the athlete as a whole. Traditionally, disordered eating has been described as being more prevalent in aesthetic and weight dependent sports; however, contemporary literature supports the suggestion that many female athletes are susceptible to the triad, regardless of the particular sport in which they participate. Thus, athletes of all types of sports should be properly screened for having low EA due to disordered eating using validated tools. Several validated tools are available for screening, including the LEAF Questionnaire for all aspects of the triad, the Eating Disorders Inventory (EDI-3) and the EAT-26 for eating disorders. Screening can take place during pre-participation exams conducted by a multidisciplinary team or in an annual health exam with a primary care physician.

The presence of subclinical disordered eating often goes missed and untreated because these eating pat-

<table>
<thead>
<tr>
<th>Table 1. Female Athlete Triad Consensus Panel Screening Questions for use during Preparticipation Evaluation</th>
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<tbody>
<tr>
<td>1. Have you ever had a menstrual period?</td>
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<tr>
<td>2. How old were you when you had your first menstrual period?</td>
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<tr>
<td>3. When was your most recent menstrual period?</td>
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<tr>
<td>4. How many periods have you had in the last 12 months?</td>
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<tr>
<td>5. Are you presently taking any female hormones (estrogen, progesterone, birth control pills)</td>
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<tr>
<td>6. Do you worry about your weight?</td>
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<tr>
<td>7. Are you trying or has anyone recommended that you gain or lose weight?</td>
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<tr>
<td>8. Are you on a special diet or do you avoid certain types of foods or food groups?</td>
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<tr>
<td>9. Have you ever had an eating disorder?</td>
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<tr>
<td>10. Have you ever had a stress fracture?</td>
</tr>
<tr>
<td>11. Have you ever been told you have low bone density (osteopenia or osteoporosis)?</td>
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</tbody>
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terns can be obscure and a person frequently does not have all of the criteria to fit into established diagnoses such as bulimia nervosa or anorexia nervosa. However, if an athlete has any eating disorder tendencies, such as dietary food restriction, purging behaviors, or any altered eating habits, they are at risk for developing disordered eating. These tendencies, even without a true eating disorder, may create a state of low EA and impact bone density. Many athletes lack proper knowledge about nutrition and may not realize that they are not eating enough for the amount of energy they expend.

In summary, athletes that are identified to have a risk of nutritional deficiency by simple questions should have more objective data gathered than just a simple body mass index (BMI) calculation, as such a calculation is very general, and there is not an adequate definition of a BMI that predisposes an athlete to development of the triad. Athletes with concern about BMI or body composition should be referred to a registered sports dietitian, who is able to perform a comprehensive nutritional assessment including a detailed dietary log, and who will ultimately determine if the athlete has low EA. Such detailed assessment and determination of EA is beyond the scope of practice of the physical therapist. A comprehensive exam, provided by a physician, may be recommended and should include lab tests, including a complete blood count, and potentially EKG, at the discretion of the physician. It is important to note that if athletes have one component of the triad, they should be screened for the other two as well and this can be accomplished by the physical therapist with simple questions and injury history queries. Note that any alteration in an athlete’s menstrual cycle requires further testing by the physician as there are many potential causes not identifiable by the physical therapist, including but not limited to hypothalamic amenorrhea, polycystic ovarian syndrome, or pregnancy. Finally, it should be noted that, menstrual irregularities in the adolescent female are common, with 65% of girls demonstrating oligomenorrhea during their first year after menarche, making identification of true dysfunction even more difficult to detect.

Low bone density is the final component of the female athlete triad and is equally difficult to diagnose. If an athlete has a history of repetitive or multiple site stress fractures or has had altered eating habits for a total of six months, it is important that she obtains a bone scan with dual-energy X-ray absorptiometry (DEXA) in order to determine her actual bone density. For more information regarding guidelines for obtaining or facilitating a referral to a physician for a DEXA scan, please refer to Table 2. Most typically the DEXA scan is not ordered by the physical therapist, rather, by the medical provider on the health care team.

Overall, it is the opinion of the authors that identifying an individual with the triad, or any of its component parts, can be quite difficult because there are many complex and inter-related contributory factors that span multiple systems. All component parts of the triad are difficult to diagnose individually, and many athletes are unaware that they are undernourished, have bone density issues, or menstrual dysfunction. The physical therapist is not prepared to diagnose all aspects of the triad, rather, should have an index of suspicion that allows for proper referral if needed. It is important for all healthcare professionals to work as a team in educating, identifying, and treating athletes who are at risk for or have aspects of the triad.
needed with younger, athletic populations.\(^1\) Finally, the use of bisphosphonates or other bone restorative medications typically used with those with postmenopausal osteopenia or osteoporosis should be approached with great caution,\(^9\) and only under the direction of an endocrinologist or specialist in metabolic bone diseases, as there are no published studies of the use of these medications in active, athletic females with triad disorders.\(^9\) Thus, since pharmacological intervention is not optimal and caloric alterations leading to weight changes of as little as 10% weight reduction can result in a 1-2% loss of BMD,\(^2\) managing energy availability and proper nutritional intake is of utmost importance in dealing with the likely cause of both menstrual and bone dysfunction.

It should be noted that the PT could have a positive impact in both identification and management of stress injuries/stress fractures in the female athlete, by assessing and managing training changes, biomechanical support, or equipment changes. This type of bony injury, especially when repetitive, could be an indication of bone density issues or biomechanical stresses that cause bony tissue to fail. In the presence of multiple site or repeated stress fractures, the PT could ask simple questions related to nutritional and education, modification of unhealthy behaviors such as dietary restriction and overtraining, and addressing biomechanical factors that may contribute to bone stress.

The first step in treating low EA includes meeting with a sports nutritionist\(^{2\,3,25}\) and possibly a behavioral health specialist,\(^2\) as most physical therapists do not possess the ability to perform in-depth nutritional counseling. Maintaining optimal energy may be accomplished by either decreasing energy expenditure or increasing energy input.\(^{2\,3,25}\) Diet quality also is an issue as this may directly related to bone health; calcium and Vitamin D intake must be adequate.\(^1,2\) With regard to treatment of bone density issues, medical and hormonal management may be a typical first line intervention. However, pharmacologic therapy has had a record of limited success in actually treating and resolving the dysfunctional triad components.\(^9\) Oral contraceptives are sometimes prescribed to restore menstruation; however, the impact of these medications on restoring bone density is not conclusive.\(^1,9,11\) Currently, some have suggested the use of transdermal estrogen to increase a female athlete’s circulating estrogen, but further studies regarding the efficacy of such interventions are needed with younger, athletic populations.\(^1\) Finally, the use of bisphosphonates or other bone restorative medications typically used with those with postmenopausal osteopenia or osteoporosis should be approached with great caution,\(^9\) and only under the direction of an endocrinologist or specialist in metabolic bone diseases, as there are no published studies of the use of these medications in active, athletic females with triad disorders.\(^9\) Thus, since pharmacological intervention is not optimal and caloric alterations leading to weight changes of as little as 10% weight reduction can result in a 1-2% loss of BMD,\(^2\) managing energy availability and proper nutritional intake is of utmost importance in dealing with the likely cause of both menstrual and bone dysfunction.

<table>
<thead>
<tr>
<th>≤ 1 High Risk Triad Risk Factors:</th>
<th>≥2 “Moderate Risk” Triad Risk Factors:</th>
<th>Other</th>
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<tbody>
<tr>
<td>History of a DSM-V diagnosed eating disorder</td>
<td>Current or history of DE for 6 months or greater</td>
<td>An athlete with a history of ≥1 non-peripheral or ≥2 peripheral long bone traumatic fractures (non-stress)</td>
</tr>
<tr>
<td>BMI ≤17.5 kg/m(^2), &lt;85% estimated weight, OR recent weight loss of ≥10% in 1 month</td>
<td>BMI between 17.5 and 18.5, &lt;90% estimated weight, OR recent weight loss of 5-10% in 1 month</td>
<td>Athletes on medications that may impact bone health for 6 months or more</td>
</tr>
<tr>
<td>Menarche ≥16 years of age</td>
<td>Menarche between ages 15 and 16 years</td>
<td>-</td>
</tr>
<tr>
<td>Current or history of &lt;6 menses over 12 months</td>
<td>Current or history of 6-8 menses over 12 months</td>
<td>-</td>
</tr>
<tr>
<td>Two prior stress reactions/fractures, one high-risk stress reaction/fracture, or a low-energy non-traumatic fracture</td>
<td>One prior stress reaction/fracture</td>
<td>-</td>
</tr>
<tr>
<td>Prior Z-score of ≤-2.0</td>
<td>Prior Z-Score between -1.0 and -2.0 (after at least 1 year interval from baseline DXA)</td>
<td>-</td>
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*Information compiled from DeSouza et al\(^9\)*
tion and energy availability, which may illuminate potential nutritional contributions to the triad and prompt more in depth screening.

Although treatment of the triad may seem simple, it is actually quite complex. Psychological pressures may need to be addressed and are not easy to overcome;1,25 even if disordered eating is identified, it may be hard to correct, and the many characteristics of an excellent athlete including passion, dedication, and drive may be difficult to reign in to prevent overtraining. Thus, prevention and early recognition of the triad is of utmost importance to ensure timely intervention.12

Although beyond the scope of this clinical commentary, experts in the field have provided a consensus statement regarding treatment and return to play of the female athlete with the triad. This is an important and relevant document for the physical therapist who works with female athletes.9

**PREVENTION STRATEGIES**

Perhaps the most important aspect for the physical therapist dealing with the triad is preventing it from occurring in the first place. Education is the key piece to preventing the female athlete triad. Athletes, as well as their coaches and caregivers and the entire healthcare team, should be informed of the components of the triad and of ways to detect triad-associated signs and symptoms. In a study by Troy et al, only 48% of physicians and 8% of coaches could identify all three components of the triad. Resources for the athlete, caregivers, and the healthcare team are outlined in Table 3.

With regard toward prevention of low EA, nutrition education for athletes, coaches and parents is paramount.1,27 Nutrition education should include information on nutrient dense foods, hands-on practice in selecting foods, and dietary habits for long-term health27 as well as the caloric demands of sport and training at high levels. This education may be a part of physical therapist practice at a basic level, but may be delivered in greater depth by a registered dietician.

Along with nutrition education is the need for honest discourse regarding sports health and weight. Many athletes believe that “thinner is better” and “every sport has an ideal body weight.”27 There is not an optimal value when it comes to body weight, and as previously discussed, low body weight or low EA may result in immediate performance difficulties or long-term health problems. Furthermore, many people believe that amenorrhea is a normal occurrence in highly trained athletes, but that is not the case.1,6 Amenorrhea is not normal in athletic women (after the onset of menses), and has a negative affect that can decrease sports performance, be related to injury, and delay the injury healing process.1

Athletes Targeting Health Exercise and Nutrition Alternatives (ATHENA), has been developed to educate high school female athletes on self-esteem, societal pressure, healthy norms, and sports nutrition.28 This program has long-term benefits including decreased diet pill use, participants being informed of calcium requirements, and being able to select a heavier body weight image as “healthy” than the control group.28 Programs such as these that are multifaceted and include a psychosocial aspect may be important in educating young athletes.

With regard to prevention of bone density issues, the topics of diet and adequate macro and micronutrients are highly relevant. Adequate calcium in the presence of Vitamin D is necessary for adequate bone banking in the adolescent years, as well as bone density maintenance throughout adulthood. Additionally, gradual increases in training stimulus, and the importance of adequate rest during training is highly relevant for the physical therapist to address during education. Biomechanical dysfunction or alterations could be identified in screening, including foot type (pes planus or pes cavus), jumping and landing abilities, and core/hip muscle strength and neuromuscular control. These facets may contribute

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**Table 3. Female Athlete Triad Resources for Health Professionals, Athletes, Parents, and Coaches**

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<th>Resource</th>
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<tr>
<td><a href="http://femaleathletetriad.org">http://femaleathletetriad.org</a></td>
</tr>
<tr>
<td><a href="http://www.thinkersplay.org/triad-tiik/">http://www.thinkersplay.org/triad-tiik/</a></td>
</tr>
<tr>
<td><a href="http://seam.org/search-results?q=female%20athlete%20triad">http://seam.org/search-results?q=female%20athlete%20triad</a></td>
</tr>
<tr>
<td><a href="http://www.moveforward.org/symptomsconditionsdetail.aspx?cid=6ca4b7e-6d14-4b90-b1ec-ed8fbc3069ae_VMD4YoLuobA">http://www.moveforward.org/symptomsconditionsdetail.aspx?cid=6ca4b7e-6d14-4b90-b1ec-ed8fbc3069ae_VMD4YoLuobA</a></td>
</tr>
<tr>
<td><a href="http://www.sportsnutritionsociety.org/find-a-nutritionist.html">http://www.sportsnutritionsociety.org/find-a-nutritionist.html</a></td>
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<td><a href="http://www.allianceforeatingdisorders.com/portal/dsm-anorexia#.VY2OJGC13ds">http://www.allianceforeatingdisorders.com/portal/dsm-anorexia#.VY2OJGC13ds</a></td>
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to abnormal bone or joint stresses, leading to stress reaction/fractures, overuse injuries.

Clearly, pre-season or primary prevention strategies are highly relevant for the prevention of the triad. The physical therapist should be involved in general nutritional screening, screening for movement dysfunction, and simple menstrual screening questions that could identify aspects of the triad. Additionally, during an initial evaluation of a female athlete, simple history and systems review questions could illuminate aspects that may be of concern in female patients who may be at risk for development of the triad.

**CLINICAL IMPLICATIONS FOR THE PHYSICAL THERAPIST**

Physical therapists can and should be involved by participating in, or holding pre-participation screens for athletes before their season starts. This can help with identifying those at risk of the female athlete triad before it becomes their reality. Physical therapists can play a role in providing referral sources for patients and their families to the proper people to talk to about nutrition, oral contraceptive use, stress fracture assessment, and menstrual dysfunction, which all that play a role not only identification but treatment of the triad.6

Physical therapists should be readily involved in widespread educational endeavors including delivering lectures and presentations pre-season, or during sports seasons, related to proper training, providing nutritional resources, and clinical signs and behaviors of the female athlete triad.1,8,9

In educational settings either with groups or individual patients and clients, it is very important that the physical therapist be ready and able to discuss and clarify the following “myths” associated with the Female Athlete Triad:

1. **Myth:** It is OK to not menstruate.
   **Reality:** If a female athlete has not had a period for 3 months or more, she needs to be seen by a physician.1,12

2. **Myth:** Thinner is better for performance; “the less I weigh the better I perform.”
   **Reality:** Being under your ideal body weight likely means that you have lost muscle mass and may not perform to your optimal abilities. A strong body is best prepared for optimal performance.29

3. **Myth:** It is acceptable to follow a low carbohydrate diet or exclude foods as an athlete.
   **Reality:** Low carbohydrate diets are not appropriate for an athlete, and will likely result in low energy availability. Also, avoiding certain food groups such as dairy products and rich sources of iron (e.g. red meat) may affect your bone health and training abilities.29

4. **Myth:** Multiple stress fractures are typical when training.
   **Reality:** This is likely your bones ineffectively dealing with stress placed on them, and may be an indication of dietary or training errors. Impairment of bone remodeling is considered to be the origin of low BMD in adolescent athletes,12 which may contribute to the prevalence of stress reactions and stress fractures.

**CONCLUSION**

The female athlete has unique physiological, endocrine, and psychological traits. These traits and demands place her at risk for development of the female athlete triad. All physical therapists should be able to identify the component parts of the triad, be prepared to screen female athletes for these components, and have pre-identified strategies for referral and management if appropriate. Energy availability appears to be paramount in the management strategies for all aspects of the triad; therefore, the physical therapist must be able to identify whether or not the female athlete is meeting key energy-related requirements or refer to other health care providers as appropriate. An important potential role for the physical therapist is education about the triad to athletes, their parents, coaches, and the medical community at large. The female athlete triad is an important prevention and wellness concept that all physical therapists should be able to address.

**REFERENCES**


