

The Male Athlete Triad—A Consensus Statement From the Female and Male Athlete Triad Coalition

Part II: Diagnosis, Treatment, and Return-To-Play

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Abstract: The Male Athlete Triad is a medical syndrome most common in adolescent and young adult male athletes in sports that emphasize a lean physique, especially endurance and weight-class athletes. The 3 interrelated conditions of the Male Athlete Triad occur on spectrums of energy deficiency/low energy availability (EA), suppression of the hypothalamic–pituitary–gonadal axis, and impaired bone health, ranging from optimal health to clinically relevant outcomes of energy deficiency/low EA with or without disordered eating or eating disorder, functional hypogonadotropic hypogonadism, and osteoporosis or low bone mineral density with or without bone stress injury (BSI). Because of the importance of bone mass acquisition and health concerns in adolescence, screening is recommended during this time period in the at-risk male athlete. Diagnosis of the Male Athlete Triad is best accomplished by a multidisciplinary medical team. Clearance and return-to-play guidelines are recommended to optimize prevention and treatment. Evidence-based risk assessment protocols for the male athlete at risk for the Male Athlete Triad have been shown to be predictive for BSI and impaired bone health and should be encouraged. Improving energetic status through optimal fueling is the mainstay of treatment. A Roundtable on the Male Athlete Triad was convened by the Female and Male Athlete Triad Coalition in conjunction with the 64th Annual Meeting of the American College of Sports Medicine in Denver, Colorado, in May of 2017. In this second article, the latest clinical research to support current models of screening, diagnosis, and management for at-risk male athlete is reviewed with evidence-based recommendations.

Key Words: male athlete, Female Athlete Triad, nutrition, energy deficiency, distance runners

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INTRODUCTION

Over the last 2 decades, it has become more apparent that some male athletes may experience a Triad-like syndrome, similar to the Female Athlete Triad. Scientific experiments and clinical research have helped guide clinicians toward better ways of assessing, diagnosing, and treating this Triad-like syndrome in the male athlete, now termed the Male Athlete Triad. The Male Athlete Triad is illustrated by Figure 1, and also described in depth in The Male Athlete Triad: A Consensus Statement from the Female and Male Athlete Triad Coalition Part 1: Definition and Scientific

Basis. As in the female athlete, the key etiologic factor in the Male Athlete Triad is energy deficiency/low energy availability (EA), which may result in impaired reproductive and bone health. The Female and Male Athlete Triad Coalition Consensus Statement Part II: Diagnosis, Treatment, and Return-to-Play, demonstrates ways in which the science of the Male Athlete Triad translates into clinical practice. We present the latest clinical research to support current models of assessment, diagnosis, and management for male adolescent and young adult athletes.

As mentioned in the first article, the Female and Male Athlete Triad Coalition convened national and international expert panelists for a Roundtable on the Male Athlete Triad, in conjunction with the 64th Annual Meeting of the American College of Sports Medicine (ACSM) in Denver, Colorado, in May of 2017. Recommendations were set forth based on evidence-based data, as well as expert opinion. Similar to the Male Athlete Triad Part I: Definition and Scientific Basis, an evidence-based taxonomy has been used to grade the summary statements throughout the various sections of this article. Invited Roundtable expert panelists and selected attendees participated in reviewing the evidence statements for the Male Athlete Triad Consensus Statements. The evidence grading taxonomy chosen has been used by the ACSM position stands and by the Agency for Healthcare Research and Quality.^{1,2} The specific evidence scoring criteria are as follows:

Evidence level A: consistent pattern of findings on the basis of substantial data from randomized controlled trials (RCTs) and/or observational studies.

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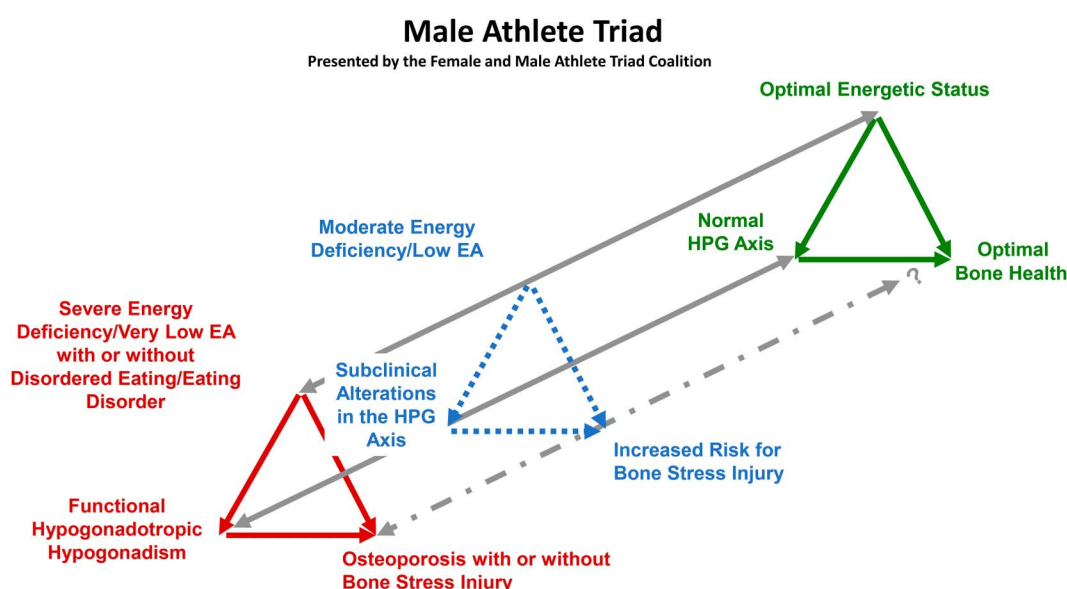


Figure 1. Model of the Male Athlete Triad. The unidirectional arrows from energetic Status/EA toward bone health and the HPG axis indicate the causal role of EA on both bone health and HPG axis function. Similarly, the unidirectional arrow from HPG toward bone health indicates the causal effect of reproductive hormones on bone health. Furthermore, the bidirectional arrows along each continuum of severity represent the “reversibility” of the condition, such that an individual can improve or worsen over time. The line showing reversal of bone health outcomes is dashed with a question mark because the reversal of bone mineral density is less known, and more research is needed. Notably, with the Male Athlete Triad, the subclinical and clinical sequelae present at lower EA levels than what is often required for the development of health consequences in exercising women. EA, energy availability; HPG axis, hypothalamic–pituitary–gonadal axis.

Evidence level B: strong evidence from RCTs and/or observational studies but with some inconsistent results from the overall conclusion.

Evidence level C: evidence from a smaller number of observational and/or uncontrolled or nonrandomized trials which is generally suggestive of an overall conclusion.

Evidence level D: insufficient evidence for categories A–C; panel consensus judgment.

SCREENING FOR THE MALE ATHLETE TRIAD

Who Should be Screened?

At-risk groups for developing one or more components of the Male Athlete Triad include adolescent and young adult male athletes in sports that emphasize a lean physique (lean-sport athletes), especially endurance and weight-class athletes. Most studies to date that have identified one or more components of the Male Athlete Triad have been in adolescent^{3,4} and young adult long distance runners,^{5–7} cyclists,^{8–11} and jockeys.^{12–14} However, there is a lack of clinical studies that assess one or more components of the Male Athlete Triad in other lean-sport athletes, as well as in non-lean-sport athletes. Future studies are needed to assess the risk of the Male Athlete Triad among male athletes in other sports, as well as among military recruits.

Evidence level B: male adolescent and young adult lean-sport athletes, especially endurance and weight-class athletes, are at risk for developing one or more components of the Male Athlete Triad.

When Should Screening be Performed?

Early identification and monitoring of athletes at risk for the Male Athlete Triad are key to preventing the more serious outcomes

associated with the Triad. Screening should begin in middle school or high school and should continue through college to identify at-risk athletes, so their bone health can be optimized during the critical years of peak bone accrual. Data indicate that men reach their peak bone mass in the third decade of life, with most of their bone mass accrued by the end of the second decade.^{15–17} At-risk athletes should be screened for the Male Athlete Triad at the time of their preparticipation physical examinations (PPEs), especially because the primary objective of the PPE is to screen for conditions that may be life-threatening, disabling, or predispose to injury or illness.¹⁸ The International Olympic Committee (IOC) also recommends a periodic health evaluation (PHE) for elite athletes, stating that the purpose is to provide a comprehensive assessment of the athlete’s current health status and risk of future injury or disease.¹⁹ Screening for the Male Athlete Triad at the PPE/PHE is particularly important in male adolescent and young adult athletes who participate in sports at higher risk for the Male Athlete Triad, such as endurance or weight-class sports. In addition to screening at the PPE and/or PHE, screening can occur when the male athlete presents with any one of the Male Athlete Triad medical conditions (Figure 4).

How Should Clinicians Screen for the Male Athlete Triad?

The PPE monograph and the PHE both recommend screening questions relevant to the Male Athlete Triad.^{18,19} However, there is a paucity of screening tools specific to the Male Athlete Triad, and ideally the tool(s) should be practical for use in a clinical setting. The Female Athlete Triad Coalition Consensus Statement recommended specific screening questions for the Female Athlete Triad in 2014.^{20,21} A similar list of suggested screening questions for use at the time of the PPE in athletes at risk for the Male Athlete Triad can be found in Table 1.

Further validation of these questions is needed, and it should not be assumed that questions designed for females can be used for males.

In addition to screening questions for the Female Athlete Triad, the Female Athlete Triad Cumulative Risk Assessment tool has been effectively used to assess Female Athlete Triad-related risk factors.^{20,21} Kraus et al²² demonstrated that a modified Female Athlete Triad Cumulative Risk Assessment, which included low EA, low body mass index (BMI), low bone mineral density (BMD), and history of prior stress fracture, was associated with prospective bone stress injury (BSI) in male athletes. A similar Male Athlete Triad Cumulative Risk Assessment tool, presented in Figure 2, provides another method of screening the at-risk male athlete.

Athletes should also be screened for the Male Athlete Triad any time they present to the medical team with conditions associated with the Triad (Figure 4). A new diagnosis of a BSI may be the initial presenting symptom in a patient with the Male Athlete Triad and should prompt thorough screening for other components of the Triad. Additional conditions that warrant screening for the Male Athlete Triad include decreased libido, the absence of morning erections, decreased frequency of shaving facial hair, a decrease in weight, decreased performance, fatigue, unexpected changes in mood, or recurrent injuries and illnesses. Because athletes with unintentional energy deficiency/low EA may not be actively attempting to restrict their intake or lose weight, they may not screen positive on the Male Athlete Triad screening questions suggested in Table 1. It is therefore very important to consider energy deficiency/low EA in the differential diagnosis when athletes present with related medical concerns.

When screening identifies athletes at risk for the Male Athlete Triad during their PPE or another medical visit, a more thorough assessment is warranted and should include a detailed medical history and physical examination.

Evidence level C: it is recommended that clinicians screen the at-risk male athlete with targeted screening questions and risk assessment tools. Further research is needed to validate a best practice screening questionnaire for the Male Athlete Triad.

DIAGNOSIS OF THE MALE ATHLETE TRIAD

How is the Male Athlete Triad Diagnosed?

Each of the 3 inter-related conditions of the Male Athlete Triad can occur on a spectrum, ranging from optimal health to

the clinically relevant outcomes of energy deficiency/low EA with or without disordered eating or eating disorder, functional hypogonadotropic hypogonadism, and osteoporosis or low BMD with or without BSI (Figure 1). Furthermore, athletes may not present with all 3 components of the Triad at the same time, but identification of any one of the 3 components should prompt a thorough assessment for the others.

The accurate diagnosis of the Male Athlete Triad is best accomplished by a multidisciplinary medical team composed of a team physician, a sports dietitian, and a mental health professional (if disordered eating or a clinical eating disorder is present). Additional members of the team may include a certified athletic trainer, parents (of athletes <18 years old), medical consultants, and specialists, such as an endocrinologist, depending on the circumstances and the resources available.^{20,21,23,24} The multidisciplinary team not only assists with diagnosis, but, as will be discussed later, also helps with treatment and clearance decisions for athletes with the Male Athlete Triad. Team members should communicate frequently with one another and provide consistent information to the athlete because inconsistency can result in a lack of trust and confidence from the athlete.²⁵

A thorough history should be performed, including a review of current symptoms and behaviors, medical history, medication history, family history, and psychosocial factors.

1. Current symptoms and behaviors: the athlete's dietary behaviors should be explored in detail, including any dietary restrictions, changes in weight or weight cycling, current weight goals, and behaviors intended to control weight, such as purging or compulsive exercise. Athletes should be asked about recent illnesses or injuries and performance. If the athlete has undergone puberty, it is important to screen for symptoms of hypogonadism such as sexual dysfunction, decreased frequency of shaving facial hair, or decreased libido. Although questionnaires are available to identify symptoms of hypogonadism in males, these are generally limited by poor specificity or were developed for use in older men and have not been validated in athletes.^{26,27} The International Society for Sexual Medicine, the International Society for the Study of the Aging Male, the Endocrine Society, and the American Urological Association do not recommend the use of a specific screening questionnaire to identify hypogonadism or testosterone (T) deficiency in the general population.^{28–33}
2. Medical history: this should include a detailed assessment of any prior physician-diagnosed BSI or fractures. In addition, it should include a thorough assessment of the athlete's mental health diagnoses, including any history of depression, anxiety, bipolar disorder, obsessive compulsive disorder, or prior eating disorder. Occurrence of known endocrine disorders, such as hypothyroidism, hyperprolactinemia, and hypogonadism, should be included in this assessment.
3. Medication history: the healthcare team should note any medications which might affect long-term bone health, such as glucocorticoids. In addition, athletes should be screened for medications that might affect libido, such as selective serotonin reuptake inhibitors, medications, and substances, that may cause elevations in prolactin and thus impact the hypothalamic–pituitary–gonadal (HPG) axis (antipsychotics, antidepressants, metoclopramide, domperidone, verapamil, cocaine, opiates, and possibly

TABLE 1. Recommended Screening Questions for the Male Athlete Triad

Recommended Screening Questions for the Male Athlete Triad
1. Do you worry about your weight? 2. Are you trying or has anyone recommended that you lose or gain weight? 3. Are you on a special diet, or do you avoid certain types of foods or food groups? 4. Have you ever had an eating disorder? 5. Have you ever had a stress fracture? 6. Have you ever been told that you have low bone density or osteoporosis? 7. Have you ever been diagnosed with low testosterone levels?* 8. Do you have low libido (sex drive)?* 9. Do you have morning erections?* 10. Do you need to shave your facial hair less frequently?*
* Recommend inclusion only on preparticipation physical examinations for postpubertal athletes.

Risk Factor	Low Risk = 0 points each	Moderate Risk = 1 point each	High Risk = 2 points each
Low EA with or without ED/DE	☐ No dietary restriction	☐ Some dietary restriction*; current or past DE	☐ Meets DSM-5 criteria for ED
Low BMI	☐ BMI ≥ 18.5 in adults, OR % Median BMI** $\geq 90\%$ in adolescents/children, OR weight stable	☐ BMI $17.5 < 18.5$ in adults, OR % Median BMI 86-89% in adolescents, OR $5 < 10\%$ weight loss/12mo†	☐ BMI ≤ 17.5 in adults, OR % Median BMI $\leq 85\%$ in adolescents, OR $\geq 10\%$ weight loss/past 12mo
Low BMD	☐ Z-score ≥ -1.0	☐ Z-score $-1.0^{***} < -2.0$	☐ Z-score ≤ -2.0
Stress Reaction/Fracture	☐ None	☐ 1	☐ ≥ 2 ; OR ≥ 1 high risk‡ or trabecular bone site
Cumulative Risk (total each column, then add together for total score)	____ points +	____ points +	____ points = ____ total

Figure 2. The Male Athlete Triad Cumulative Risk Assessment tool. The Male Athlete Triad Cumulative Risk Assessment Tool provides an evidence-based risk stratification tool which may be used to guide an athlete's clearance for sport (Figure 3). It has been adapted from the Female Athlete Triad Cumulative Risk Assessment tool,^{20,21} with the menstrual history questions removed. *Some dietary restriction as evidenced by self-report or energy deficiency/low EA on diet logs or validated surveys. In adolescents, absolute BMI cut-offs should not be used, and clinicians should rely on age-adjusted and gender-adjusted BMI percentiles (**% median BMI, CDC BMI-for-age growth charts, or BMI Z-scores) or † % change in weight in the past 12 months. ***Weight-bearing sport; ‡high-risk skeletal sites associated with low BMD and delay in return-to-play include stress reaction/fracture of trabecular sites (femoral neck, sacrum, and pelvis). BMI, body mass index; BMD, bone mineral density; CDC, Center for Disease Control; DE, disordered eating; EA, energy availability; ED, eating disorder.

- marijuana)³⁴ and medications that may reduce appetite and cause weight loss (such as medications for attention deficit/hyperactivity disorder and topiramate).
4. Family history: athletes should be asked about a family history of eating disorders, endocrine disorders, osteoporosis, or fragility fractures.
 5. Psychosocial factors: it can be helpful to elicit any history of critical comments, regarding body weight or size, or social pressures from coaches, parents, or teammates, because these may be influencing disordered eating behaviors and the maintenance of energy deficiency/low EA. Athletes should be screened for illicit drug use because this might also affect libido.

A comprehensive physical examination should be performed by the physician and should specifically seek to identify any signs of gonadal abnormalities or eating disorders. If a genitourinary examination is performed, a chaperone should be present.³⁵ For the purpose of the targeted PPE in the male athlete, the purpose of the genitourinary examination is primarily to ensure that both testicles are in the scrotal sacs, and, for educating and teaching, the testicular examination to screen for testicular cancer. Findings suggestive of hypogonadism can also be assessed at this time if suspected by history and may include a lower than expected testicular volume depending on the time of onset and severity of hypogonadism. Hypogonadism before genital maturity may lead to an underdeveloped phallus and sparse pubic hair.

A low BMI, defined as BMI < 18.5 in adults,³⁶ may suggest energy deficiency/low EA with or without disordered eating. A major change in the Diagnostic and Statistical Manual of Mental Disorders (fifth edition) was to remove the weight criterion for anorexia nervosa (AN), which previously required the patient to be $< 85\%$ of estimated body weight to meet diagnostic criteria. This was replaced with broader

statements which identify changes in an individual's growth trajectory.³⁷ In children and adolescents with disordered eating and eating disorders, absolute BMI is not an optimal method to reflect the nutritional status.³⁸ Preferred methods for BMI calculation in adolescence include examination of an adolescent's weight in relation to the 50th BMI percentile (also known as the BMI percentile method or percent median BMI),³⁸ use of the Center for Disease Control (CDC) BMI-for-age growth charts,³⁹ or use of BMI Z-scores.⁴⁰ Amount and rate of weight loss should also be considered in evaluation of energy deficiency/low EA and disordered eating.⁴⁰

Physical examination findings suggestive of an eating disorder might include bradycardia, orthostatic hypotension, lanugo, dental erosions, swelling of the parotid glands, or calluses on the proximal interphalangeal joints (Russell's sign).^{20,21}

Based on the history and physical examination, if there is a high degree of suspicion for the Male Athlete Triad, additional laboratory and radiological studies may be indicated. Suggested laboratory studies are listed in Table 2. Indications for proceeding with imaging studies, such as a dual-energy x-ray absorptiometry (DXA) scan or pituitary MRI, are reviewed below.

Evidence level C: male athletes are diagnosed with the Male Athlete Triad if they have one or more components along the spectrums of the Male Athlete Triad. The diagnosis includes a thorough history and physical and is best accomplished by a multidisciplinary healthcare team.

How is Energy Deficiency Identified?

Unfortunately, it can be very challenging to determine accurate EA values, particularly because the calculation is dependent on self-reported measures of dietary energy intake

(EI), exercise energy expenditure (EEE), and body composition.^{20,21,41} As stated in the Male Athlete Triad: A Consensus Statement from the Female and Male Athlete Triad Coalition: Part I Definition and Scientific Basis, we recommend that EA is best suited to assessment in laboratory settings where the measurements can be carefully executed. However, although the limitations of these measures are understood, clinicians and sports dietitians may find that explaining the concept of EA and performing example calculations may be useful when the goal is to encourage the athlete to increase energy intake. Such conversations can take the focus off of body weight and provide examples of how the relative contributions of EI and EEE can be manipulated according to the individual's needs and unique circumstances. Consultation with a sports dietitian is highly recommended to quantify energetic status, especially if nutritional deficiencies are suspected.⁴² Although there are inherent limitations that are well defined in the literature regarding assessment of EI,^{43,44} EI may be estimated by using dietary logs, 24-hour food recalls, and food-frequency questionnaires.⁴⁵ EEE may be estimated by using heart rate monitors and accelerometers or by web-based calculators, various phone-based applications, or by using the Physical Activity Compendium.^{46,47} Fat free mass (FFM)⁴⁸ may be calculated based on the weight of the athlete in kilograms, as well as the percent body fat, which may be estimated by DXA, air displacement plethysmography, skin-fold measurements, Bod Pod, or bioelectrical impedance.^{49,50} Discussing patterns of food intake and behaviors with the athlete, and estimating their EA at the time that the athlete is being assessed for any one of the components of the Male Athlete Triad, can serve as an opportunity for the provider to educate and give immediate feedback to the athlete regarding suspected energy deficiency/low EA and under-fueling, as well as the possible relationship to their presenting complaint.

Given the challenges of accurately measuring EA, there are several proxies that may be used which are reliant on physiological adaptations to energy deficiency. Thus, the term "energy deficiency" as determined by objective measures of metabolic compensation such as resting metabolic rate (RMR)

and metabolic hormone changes, in addition to documenting changes in anthropometrics, is likely valuable conceptually and, in practice, if these measures can be obtained. As mentioned above, in adults, energy deficiency/low EA may be indicated by low body weight, as defined by BMI <18.5.³⁶ In children and adolescents, percent median BMI,³⁸ BMI percentiles using CDC BMI-for-age growth charts,³⁹ or BMI Z-scores⁴⁰ can be calculated, as well as amount and rate of weight loss and/or change of growth trajectory.^{39,40} A stable body weight, however, does not ensure normal EA, because an athlete may reach a state of energy balance while at a low EA state because of suppression of normal physiologic and metabolic functions.^{20,21} Such adaptations to chronic low EA may be suggested by low triiodothyronine (T₃) levels (free and total) and a reduced RMR that can be compared with predicted values in calculations of ratios of measured RMR/predicted RMR (mRMR/pRMR).^{51–57} Ratios of mRMR/pRMR are stable over time and can be used for serial assessments⁵⁷ to predict low T₃ and amenorrhea in exercising women.⁵² Depending on the data available (ie, weight, FFM, and lean body mass), several prediction equations are available for use to calculate ratios of mRMR/pRMR, and it is important to note that specific cut-off values indicative of metabolic suppression secondary to energy deficiency are unique to each prediction equation in women.⁵² Specifically, ratios indicative of energy deficiency in exercising women include 0.94 for use with the DXA prediction equation,⁵⁸ 0.92 for the 1991 Cunningham prediction equation,⁵⁹ and 0.90 for the Harris-Benedict⁶⁰ and 1980 Cunningham⁶¹ prediction equations. In addition, measured RMR was conducted under well-controlled laboratory conditions that included following strict pretest guidelines such as refraining from exercise, caffeine, medications, or alcohol in the prior 24 hours and a 12 hours overnight fast; the efficacy and utility of field-based measures of RMR to calculate ratios of mRMR/pRMR must still be tested. Similarly, the ability of mRMR/pRMR ratios to identify energy deficiency in exercising men has yet to be examined, and much work is needed to identify appropriate cut-off values specific to exercising men.

TABLE 2. Suggested Laboratory Studies for the Evaluation of the Male Athlete Triad

Suggested laboratory studies for the evaluation of the Male Athlete Triad*	
Complete blood count	
Comprehensive metabolic panel	
25-OH vitamin D	
Total and free testosterone†	
Thyroid stimulating hormone	
Free T4	
Total ± free triiodothyronine (T3)	
Follow-up studies to consider if testosterone levels are low or fall in the gray zone* (8-12 nmol/L)	
Luteinizing hormone	
Follicle-stimulating hormone	
Prolactin	
Iron studies, including ferritin	
Erythrocyte sedimentation rate and C-reactive protein	
<i>* Additional studies may also be indicated, depending on the patient presentation.</i>	
<i>† Total testosterone should be routinely ordered. Free testosterone is helpful if total testosterone is low or in the gray zone (8-12 nmol/L). In addition, free testosterone may be considered in conditions expected to alter sex hormone-binding globulin levels, such as thyroid disease, HIV, use of anticonvulsants or glucocorticoids, liver disease, or diabetes.^{26,30,34}</i>	

As previously stated, disordered eating behaviors and eating disorders may contribute to the development of a chronic energy deficiency/low EA. Therefore, identifying behaviors which contribute to undereating may be beneficial in identifying those at risk for energy deficiency. Several screening tools exist^{62–64} and have been used in the Female Athlete Triad literature to identify disordered eating and as proxy indicators of energy deficiency/low EA^{51,53,56,65,66}; however, few tools exist that have been appropriately validated in men. Because disordered eating behaviors may manifest differently in men and women, tools and criteria specific to male athletes must be developed and tested. The Eating Pathology Symptom Inventory is a validated tool appropriate for use in both men and women and, interestingly, has a muscularity scale.^{67,68} Notably, this tool also has a scale to assess dietary restriction. An additional option is the EDE-Q, which also includes a dietary restraint subscale, and has male-specific cut-off values.⁶⁹

Evidence level B: although measurement of energy deficiency or low EA is best quantified in laboratory settings, several proxies can be used clinically when estimating energetic status. These include objective measures of metabolic compensation, hormone changes, anthropometrics, and/or energy prediction equations.

How is Hypogonadotropic Hypogonadism Diagnosed?

Hypogonadism is defined as low testosterone (T) levels and/or defects in spermatogenesis in the presence of symptoms attributed to low T.^{26,30} Rather than using a questionnaire, most guidelines recommend assessing for symptoms or consequences of hypogonadism, such as low libido, erectile dysfunction, infertility, decreased shaving of facial hair, gynecomastia, low trauma fractures or reduced BMD, reduced muscle mass and strength, decreased energy and motivation, depressed mood, poor concentration, sleep disturbance, or diminished physical performance.^{26–28,30,34,70,71} If symptoms are identified, or the patient has additional Triad risk factors, a fasting, morning (7 AM–11 AM) total T level should be assessed.^{26,34,71} Abnormal T levels should be repeated for confirmation^{28,30,34,71}; please refer to The Male Athlete Triad: A Consensus Statement from the Female and Male Athlete Triad Coalition Part 1: Definition and Scientific Basis for guidance on normal total T values. If hypogonadism is identified, further work-up is indicated to understand the cause. Male athletes with functional hypogonadotropic hypogonadism (secondary hypogonadism not associated with organic or structural pathology) generally have low T levels with low or inappropriately normal luteinizing hormone and follicle stimulating hormone levels.^{30,34,71,72} It is important to rule out other potential causes of hypogonadism, including genetic causes, drug use (see Medication History), or supplement use (such as anabolic steroids). Depending on the experience of the practitioner, it may be helpful to consult an endocrinologist for further guidance. A pituitary magnetic resonance imaging (MRI) is indicated in specific situations, such as when patients have hyperprolactinemia (that is not medication induced), symptoms of a possible mass effect, multiple pituitary hormone deficiencies, or severely low total T levels (<150 ng/dL or <5.2 nmol/L in a fully pubertal or adult male).^{30,34,71}

Evidence level A: male athletes with symptoms of hypogonadism, or additional Triad-risk factors, should have a morning fasting T level drawn to assess for hypogonadism. If abnormal T levels are identified, these should be repeated for confirmation.

How is Low Bone Mineral Density and Osteoporosis Diagnosed in the Male Athlete?

The International Society for Clinical Densitometry (ISCD) definition for osteoporosis in adolescents and children up to age 19 years requires the presence of both a clinically significant fracture history and low bone mineral content (BMC) or BMD.^{73,74} In the absence of vertebral compression fractures, a clinically significant fracture history includes one or more of the following: 2 or more long bone fractures by age 10 years or 3 or more long bone fractures at any age up to age 19 years.⁷⁴ Low BMC or BMD is defined as a BMC or areal BMD Z-score of ≤ -2.0 , adjusted for age, gender, and body size.^{73,74} Occurrence of vertebral compression or crush fractures in the absence of local disease or high-energy trauma is consistent with a diagnosis of osteoporosis, regardless of BMD.

In men less than 50 years of age, according to the ISCD, a BMD Z-score ≤ -2.0 is considered “below the expected range for age” and a Z-score above -2.0 is “within expected range for age.” Osteoporosis cannot be diagnosed in men younger than 50 years of age on the basis of BMD alone. A BMD Z-score ≤ -2.0 plus secondary causes of osteoporosis is required for diagnosis.⁷⁵

Given that repetitive mechanical loading or high impact stress in athletes should provide a beneficial stimulus to bone health, the ACSM has proposed that for the female athlete, a Z-score of < -1.0 (at any weight-bearing site) should be used as a threshold for low BMD in athletes engaged in weight-bearing sports, especially in those with additional risk factors for the Female Athlete Triad.²³ Similarly, it is the recommendation of the Female and Male Athlete Triad Coalition Consensus Statement that a Z-score of < -1.0 be used as a threshold for low BMD in the male athlete participating in weight-bearing sports because of concern for an increased susceptibility to a BSI or complete fracture, especially if the athlete has additional risk factors for the Male Athlete Triad. The threshold of concern is therefore lowered for the male athlete in a weight-bearing sport compared with the ISCD criteria for low BMD. However, in the general population and in female and male athletes participating in non-weight-bearing sports, we recommend that the current ISCD recommended value of a Z-score ≤ -2.0 should be used for the threshold to categorize low BMD below the expected value for age.

When is a Dual-Energy x-Ray Absorptiometry Indicated in the Male Athlete?

It is the recommendation of the Male Athlete Triad Coalition Consensus Statement that a DXA be considered in male athletes who are at various stages of risk for the Male Athlete Triad (Table 3). Male athletes with one or more “high risk” factors, or 2 or more “moderate risk” factors, or athletes who have been taking a medication which may affect their BMD may warrant screening (Table 3). For athletes undergoing monitoring for low BMD, follow-up testing should be obtained when the expected change in BMD equals or exceeds the least significant change.⁷⁶ In most cases of the Male Athlete Triad, this would be approximately every 1 to 2 years for those athletes who are at risk and/or for monitoring treatment. If low BMD is identified, it is important to rule out other potential causes of low BMD, such as other causes of hypogonadism, severe vitamin D deficiency, medications

Total Cumulative Risk Score	Recommendation for Low Risk	Recommendation for Moderate Risk	Recommendation for High Risk
0-1	Full Clearance		
2-3		Provisional or Limited Clearance	
≥ 4			Restriction from Training and/or Competition

provided the athlete continues to follow-up with the multidisciplinary team and follow treatment recommendations. With limited clearance, the athlete may have limitations placed on their participation in training or in competition, depending on their health status. High-risk athletes may not be cleared for full participation unless approved by the team physician after further treatment or follow-up. Participation status may change over time, depending on clinical progress and new information gathered. It is recommended that all moderate-risk or high-risk athletes be referred to members of the multidisciplinary team. These clearance recommendations may serve as a guideline to clinicians, but clinicians should use their clinical judgment and knowledge of each individual case when making clearance decisions.

(such as glucocorticoids), malabsorption syndromes (such as celiac disease and inflammatory bowel disorders), certain systemic diseases, and genetic conditions.

Evidence level C: a DXA scan is recommended in male athletes who are at moderate or high risk for the Male Athlete Triad.

TREATMENT OF THE MALE ATHLETE TRIAD

What are the Nonpharmacologic Treatment Recommendations?

Because a chronic energy deficit is the underlying cause of the Male Athlete Triad, treatment for the Triad should emphasize improving the male athlete's energy status, with the goal of eliminating energy deficiency and ensuring that EI meets all energetic requirements (Figure 4). Although energy deficiency can be reversed by increasing EI or decreasing EEE, or a combination of both, initial efforts to optimize energy status should target an increase in EI relative to EEE. This allows for continued sports participation and promotion of behaviors that support typical training and competition. Because of a lower prevalence of disordered eating and clinical eating disorders in male compared with female athletes,^{77,78} males may be more amenable than females to recommended changes in dietary patterns and EI. However, in cases where male

athletes are not able to sufficiently increase EI, a modification of training may be needed, at least temporarily, to reduce EEE.

In addition to increasing EI to meet expenditure needs, it is important that dietary recommendations support sports-specific recommended intake of macronutrients and micronutrients. An overview of the nutrient recommendations for athletes is described in the 2016 ACSM, Academy of Nutrition and Dietetics, and Dietitians of Canada Joint Position Statement: Nutrition and Athletic Performance.^{79,80} A subset of male athletes may be at risk for underconsuming carbohydrates^{78,81–83} and should be monitored accordingly. Athletes should also aim to consume at least the recommended daily allowance (RDA) of micronutrients such as calcium, vitamin D, iron, B vitamins, and magnesium.^{79,80,84–86} Although supplements may help an athlete reach their recommended daily intake, most of these nutrients should be acquired from an athlete's diet whenever possible.

Although the plan for increasing EI will vary based on the individual, the process should be incremental, as more abrupt increases in EI may not be sustained. Current dietary patterns can be assessed and modified with moderate, high-impact changes. EI should be increased gradually, by adding 300 to 500 kcal/d, which is usually well tolerated and can be accomplished by adding 1 to 2 snacks per day or enhancing the energy content of current snacks and meals. For some athletes, especially those with disordered eating/eating

TABLE 3. Who Should Get a Dual-Energy X-Ray Absorptiometry Scan to Assess Bone Mineral Density (BMD)?

Athletes with one or more high risk factors:
Body mass index (BMI) ≤ 17.5 in adults, OR % median BMI $\leq 85\%$ in adolescents, OR $\geq 10\%$ weight loss/month
Two prior bone stress injuries or one prior injury in a high-risk location such as the femoral neck, sacrum, or pelvis
A clinical eating disorder
Prior BMD Z-score ≤ -2.0
Athletes with 2 or more moderate risk factors:
BMI $17.5 < 18.5$ in adults, OR % median BMI $86\%-89\%$ in adolescents, OR $5 < 10\%$ weight loss/month
One prior bone stress injury
Some history of disordered eating behaviors
Prior BMD Z-score between -1.0 and -2.0 in athletes involved in weight-bearing sports*
Athletes who have been taking a medication which may affect their BMD may warrant screening
*For athletes in non-weight-bearing sports, a Z-score of -2.0 should be used.

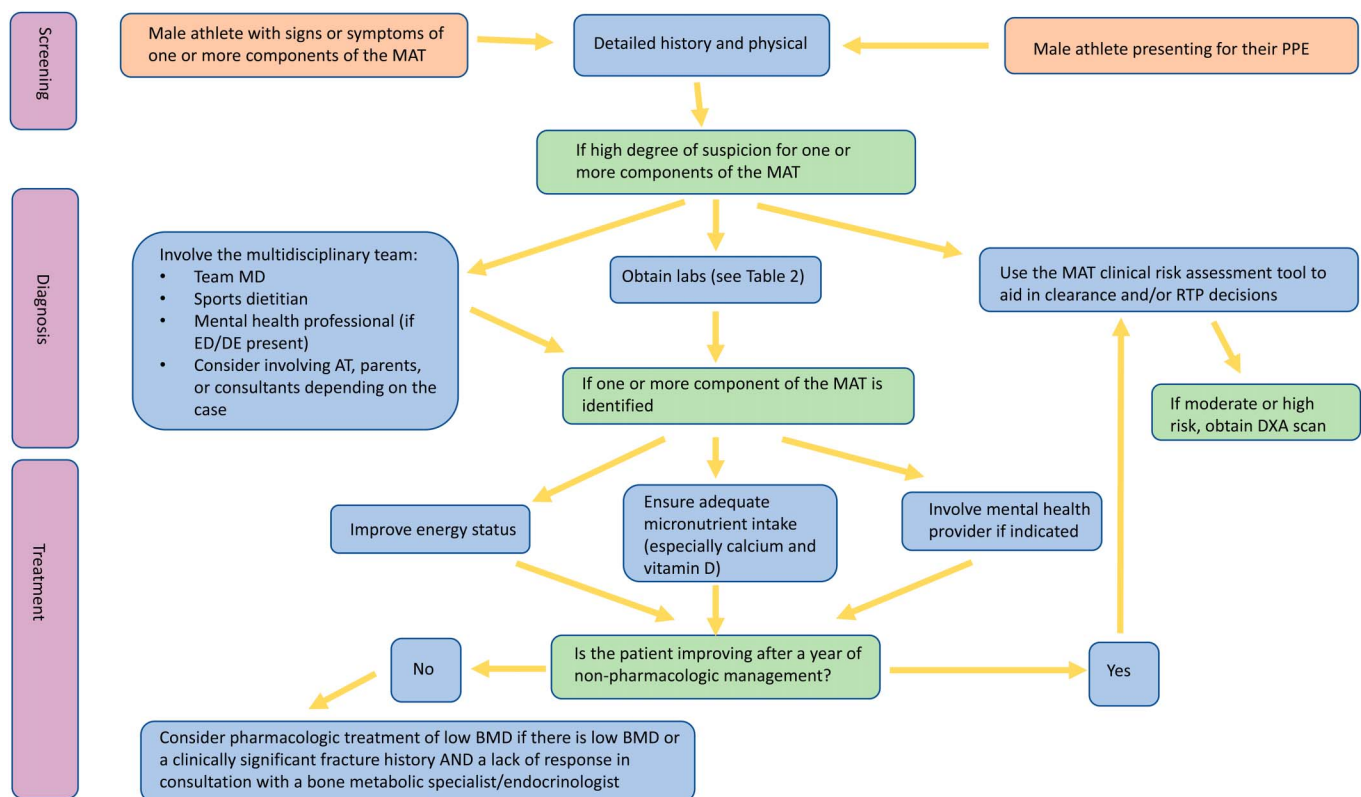


Figure 4. Flowsheet for the screening, diagnosis, and treatment of the Male Athlete Triad. Screening for the Male Athlete Triad should begin when the clinician performs a preparticipation physical examination or when an athlete is presenting with signs or symptoms which could be related to the Male Athlete Triad, such as decreased libido, fatigue, or a bone stress injury. If the clinician has a high degree of suspicion for one or more components of the Triad after completing a history and physical examination, then they should refer the athlete to relevant members of the multidisciplinary team for further evaluation, obtain laboratory tests (Table 2), and apply the Male Athlete Triad Cumulative Risk Assessment tool (Figure 2) to aid in clearance and return-to-play (RTP) decisions. If the athlete is moderate or high risk per the Male Athlete Triad Cumulative Risk Assessment tool (Figure 3), then a dual-energy x-ray absorptiometry scan should be obtained. If one or more component of the Male Athlete Triad is identified, then treatment should begin with improving energy status and optimizing micronutrient intake. If disordered eating or an eating disorder has been identified, the athlete should also be referred to a mental health provider. If the athlete does not demonstrate improvement after a year of nonpharmacologic management, then pharmacologic treatment for low bone mineral density (BMD) may be considered if the athlete has low BMD or a clinically significant fracture history. Pharmacologic treatment should be considered in consultation with a bone metabolic specialist or an endocrinologist. It is very important to note that athletes may have diverse presentations and unique clinical considerations. Thus, this flowsheet is intended to serve as a guideline for clinicians; however, clinicians must use their clinical judgment and apply the specifics of each case when determining diagnoses and creating treatment plans.

disorders, or others who strongly feel that their performance may be negatively affected by increasing their caloric intake, starting on the lower end of this range may be needed. Athletes with energy deficits beyond 500 kcal/d can increase EI by another 300 to 500 kcal/d after maintaining the initial increase, although caution must be used to prevent failure because the EI prescription is too high to favor success. If not already consumed, the introduction of a postexercise snack containing carbohydrate and protein should be prioritized. Other priorities include optimizing intake before exercise, especially if the athlete is skipping meals or exhibiting long periods of fasting during the day, as within-day energy deficits have been associated with suppressed RMR and markers of catabolism in male athletes.⁸⁷ Packing snacks and meals that can be taken on-the-go and use of portable and shelf-stable energy dense foods (such as trail mix, whole grain crackers, granola bars, shelf-stable milk, dried fruit, or nuts) may be particularly useful. The clinician and sports dietitian may also find it helpful to discuss increasing EI as “optimizing the athlete’s fueling” because athletes often have negative connotations associated with increasing calories.

Evidence level C: optimizing energetic status by increasing EI, reducing EEE, or both, is the first-line treatment for male athletes with one or more components of the Male Athlete Triad.

What are the Recommendations for Calcium and Vitamin D Supplementation?

Given concerns of low BMD in the hypogonadal male athlete, it is important to ensure that athletes are obtaining the RDA of micronutrients such as vitamin D, calcium, and magnesium (Figure 4). When this proves challenging, or if athletes are diagnosed with vitamin D deficiency or insufficiency, supplementation may be necessary. Although data are currently lacking regarding a definitive 25-hydroxy vitamin D (25(OH)D) level below which BMD is compromised, a 25(OH)D level of 20 to 22 ng/mL or higher seems sufficient to avoid deleterious effects on the bone.^{88,89} Other studies suggest that parathyroid hormone (PTH) levels start to rise and calcium absorption is lower, although still within the normative range, when 25(OH)D levels fall below 30 to 32 ng/mL.^{90–92} More research is needed

on optimal levels of bone building nutrients in athletes, and whether or not an optimal range exists to prevent BSI, decrease injury severity, and/or enhance recovery from BSI. Until more definitive data are available, we suggest maintaining 25(OH)D levels at or above 32 ng/mL, which may require use of supplemental vitamin D. 25(OH)D levels should not exceed the normal range given concerns for hypercalcemia.

Calcium supplementation may also be necessary if athletes are not able to reach the RDA through their diet (1300 mg/d for children and adolescents 9–18 years old, 1000 mg/d for those 19–70 years old, and 1200 mg/d for those >70 years old).⁸⁶ One study in male adolescent runners demonstrated that receiving <1 serving of calcium-rich food per day was a risk factor for low BMD.³

What is the Role of Pharmacologic Treatment for the Male Athlete Triad?

As in female athletes,^{20,21} and as discussed above, first-line treatment for the Male Athlete Triad should be nonpharmacological and should focus on optimizing energetic status by increasing EI, reducing EEE, or both (Figure 4). When considering pharmacological therapy in the male athlete, it is important to consider what one is treating and the hormonal status of the athlete. Pharmacological therapy, although rarely needed, may be necessary in some cases to treat low BMD and increased fracture risk, symptoms of hypogonadism, or infertility.

Evidence level D: pharmacologic therapy, although rarely needed, may be necessary to treat low BMD and increased fracture risk, symptoms of hypogonadism, or infertility.

What Therapies May Help Normalize Testosterone Levels in the Hypogonadal Male Athlete?

T Replacement Therapy

Although normalizing T levels would be expected to improve BMD, sexual function, and quality of life in the hypogonadal male athlete, hormone replacement is currently fraught with challenges, both because of the limited evidence available and because of restrictions placed around the use of exogenous T in athletes given that this may provide a competitive advantage.

In adolescent and young adult female hyperexercisers/athletes with oligoamenorrhea, good data now exist for physiologic hormone replacement (such as the 17- β estradiol transdermal patch with cyclic oral progestin) as a strategy to improve BMD,^{93–95} after lifestyle modification has been optimized to address energy deficiency. This form of hormone replacement therapy has also been demonstrated to improve eating behavior,⁹⁶ verbal memory and executive function in adolescent and young adult oligoamenorrheic athletes,⁹⁷ and trait anxiety in low-weight amenorrheic girls with AN.⁹⁸ Of note, adult hypogonadal women with AN have low T levels, which correlate with lower BMD measures.⁹⁹ However, a RCT of low dose T replacement in women with AN did not demonstrate a beneficial effect on BMD.¹⁰⁰

Although some studies suggest that T levels are associated with bone outcomes in male athletes, others suggest that it is estradiol (from aromatization of testosterone) that drives these outcomes.^{93,101–103} Studies in adult hypogonadal men

indicate a beneficial effect of T replacement on bone outcomes,^{104–106} mostly related to its aromatization to estradiol.¹⁰⁷ In healthy adult men, estradiol levels above 10 pg/mL and testosterone levels above 200 ng/dL were noted to be sufficient to prevent an increase in bone resorption and a decrease in BMD.¹⁰⁶

T replacement therapy in hypogonadal men also has the potential to improve other outcomes, such as body composition, muscle strength, impaired sexual function, mood, and quality of life.^{108–110} However, studies assessing these endpoints are currently lacking in hypogonadal male athletes. This is further complicated by the finding that many athletes with HPG axis dysfunction fall into the “gray zone,” where decreases in T levels often do not meet cut-offs for clinical significance (please refer to The Male Athlete Triad: A Consensus Statement from the Female and Male Athlete Triad Coalition Part 1: Definition and Scientific Basis). Furthermore, such studies are logistically challenging given concerns of being barred from sports activities consequent to receiving T.¹¹¹ Finally, studies of estradiol replacement are challenging in men given difficulties attaining an estradiol level that is likely to optimize bone health without having deleterious effects on other systems (such as inducing gynecomastia and lipid abnormalities).

Evidence level D: data are lacking in hypogonadal male athletes for a beneficial effect of T replacement on bone outcomes, and this is also complicated because of T being prohibited in sport.

Clomiphene (Clomifene) Citrate Therapy

Clomiphene Citrate (CC) is a selective estrogen receptor modulator that stimulates gonadotropin-releasing hormone (GnRH) and therefore gonadotropin secretion, which increases Leydig cell secretion of T. It can thus increase T secretion in males with hypogonadotropic hypogonadism. Burge et al¹¹² have described successfully treating a 29-year-old male runner, who ran 50 to 90 miles/wk, and had symptomatic hypogonadotropic hypogonadism, low BMD, and a pelvic stress fracture, with CC therapy up to 50 mg twice daily over a 5-month period. The patient had normalization of T levels, improved erectile function, and an improved sense of wellbeing.¹¹² One study compared T therapy with CC in men with symptomatic hypogonadism versus eugonadal men not on either medication.¹¹³ Both were effective at treating hypogonadism; however, T therapy more effectively increased serum T levels and improved hypogonadal symptoms, whereas CC had a deleterious effect on libido.¹¹³ By contrast, development of secondary polycythemia is less likely in those on CC versus T replacement therapy (1.7% vs 11.2%).¹¹⁴ CC is also banned by the World Anti-Doping Agency for use in male athletes.¹¹¹

Other Therapies to Increase T Levels

There is a report of a male hypogonadal athlete being treated with tamoxifen (an antiestrogenic drug) to increase gonadotropin production and T secretion to the normal physiologic level, with improved sexual drive, well-being, and reduction in muscle injury.¹¹⁵ Aromatase inhibitors reduce aromatization of T to estradiol and raise T levels; however, this strategy is unlikely to be beneficial to bone health, for which optimal estradiol levels are necessary.^{107,116} Pulsatile GnRH therapy and gonadotropin administration have been demonstrated to

normalize T levels and induce spermatogenesis in men with hypogonadotropic hypogonadism (nonathletes).¹¹⁷ No studies have reported on the impact of such therapies to improve bone outcomes in hypogonadal athletes.

What is the Evidence for the Use of Bone Anabolic Agents to Improve Bone Outcomes in Hypogonadal States?

Teriparatide and Abaloparatide

Teriparatide (a PTH analog) and abaloparatide (a parathyroid hormone–related protein [PTHrP] analog) are FDA-approved bone anabolic agents that hold promise for athletes who qualify for pharmacological therapy, based on their effects in other populations that have a high risk for fracture, such as postmenopausal women and older men.^{118–125} These medications exert their effects through binding to the PTH/PTHrP receptor which is expressed on osteoblasts, osteocytes, renal tubule cells, and other tissues.¹²⁶ These medications act by improving trabecular bone mass and microarchitecture, increasing bone strength, and reducing fracture risk despite an increase in cortical porosity. Recent data suggest that abaloparatide may be even more effective than teriparatide in this regard.^{127,128} At this time, studies have not examined the impact of teriparatide or abaloparatide on bone outcomes in male athletes. Reports of teriparatide use in athletes are limited to case reports and small trials^{129,130} for healing of BSI, for which its efficacy remains questionable. Of note, a 6-month study of teriparatide (20 mg daily subcutaneous) versus placebo in older women with AN did show a 6% to 10% improvement in PA and lateral lumbar spine BMD in those who received teriparatide.¹³¹ However, teriparatide has been associated with an increased risk of osteosarcoma in animal studies and carries a black box warning for those at increased baseline risk for osteosarcoma (children with open epiphyses, individuals with Paget's disease, or a history of external beam radiation therapy or implant radiotherapy to the skeleton).

Evidence Level D: although teriparatide and abaloparatide improve trabecular bone mass and microarchitecture, increase bone strength, and reduce fracture risk, studies of these agents on bone outcomes have not yet been performed in the male athlete with hypogonadism.

Romosozumab

This is a monoclonal antibody that increases bone density and reduces fracture incidence in postmenopausal women and older men by inhibiting sclerostin and received FDA approval in 2019.^{132–135} Sclerostin is a protein secreted by osteocytes that both inhibits osteoblast proliferation, differentiation, and survival by inhibiting the canonical *Wnt* signaling pathway and stimulates receptor activator of nuclear factor- κ B ligand (RANKL), thus increasing osteoclastic activity and bone resorption.¹³⁶ Romosozumab causes an initial increase in bone formation followed by a more prolonged decrease in bone resorption.¹²⁶ Data are lacking for use of romosozumab in other populations, including the male athlete.

Insulin-like Growth Factor-1 and Leptin

Insulin-like Growth Factor-1 (IGF-1) is a bone anabolic hormone that is low in conditions of low EA compared with controls.^{137,138} Administration of recombinant human IGF-1 (rhIGF-1) increases bone formation markers in adolescents

and adults with AN,^{138,139} and when given with a combined oral contraceptive pill, increases BMD at the spine and hip in adults with AN.¹⁴⁰ However, data are lacking for effects of rhIGF-1 administration on bone in athletes with low BMD or increased risk of BSI.

Leptin is a bone anabolic hormone with stimulatory effects on GnRH secretion. In adult women with hypothalamic amenorrhea, metreleptin was effective in improving reproductive function^{141,142} and increasing levels of bone formation markers. One small study reported an increase in lumbar BMC (but not BMD) in women who received metreleptin versus placebo.¹⁴² There are no studies to date that have examined the effects of metreleptin administration on bone outcomes in male athletes, and its anorexigenic effect makes metreleptin a worrisome choice in athletes at risk of energy deficiency/low EA.

What is the Evidence for the Use of Antiresorptive Medications to Improve Bone Outcomes in Hypogonadal States?

Bisphosphonates may be effective in increasing BMD in those with evidence of increased bone resorption. However, data are limited for bisphosphonate use in male athletes to optimize bone outcomes, with mostly case series and retrospective studies reported to date.^{143,144} One retrospective study of intravenous bisphosphonates (ibandronate) and vitamin D to treat bone marrow edema in 22 male professional athletes reported pain reduction and improved mobility within the first 2 weeks in the trunk and lower extremity bones after the first ibandronate infusion.¹⁴⁴ Time to return to competition was about 3.5 months on average. However, the lack of a control group limited assessment of clinical efficacy for this intervention.

Bisphosphonates have proven efficacy in improving bone density in postmenopausal women and older men.^{145–147} Furthermore, one RCT of risedronate versus placebo in adult women with AN demonstrated a 2% to 3% increase in spine and hip BMD in those who received risedronate versus placebo.¹⁰⁰ However, another RCT of alendronate versus placebo in adolescent females with AN demonstrated no improvement in spine BMD and only a small improvement in femoral neck BMD in the alendronate arm for this younger group.¹⁴⁸ Such therapy should be continued for a defined period before considering alternative measures to improve bone health.

Evidence Level C: there are limited data (case series and retrospective reports) for using bisphosphonates to improve bone outcomes in the male athlete with hypogonadism.

Denosumab (an inhibitor of RANK ligand) is a very effective medication for treatment of postmenopausal osteoporosis,¹⁴⁹ and studies are currently ongoing of denosumab versus placebo in adult women with AN. However, data are not available for effects of denosumab on bone outcomes in male hypogonadal athletes. Of note, denosumab is the most rapidly acting antiresorptive agent currently in use, but its effects are rapidly reversible.¹²⁶

What is the Role of Combination Therapy?

Combination therapy using a bone anabolic agent followed by antiresorptive medications may be more effective in improving BMD and reducing fracture risk than either therapy alone or use of antiresorptive therapies followed by bone anabolic therapy (summarized in¹²¹). Studies are necessary to examine

TABLE 4. Summary of Evidence Statements

Evidence Statements	Evidence Level
Male adolescent and young adult lean-sport athletes, especially endurance and weight-class athletes, are at risk for developing one or more components of the Male Athlete Triad.	B
It is recommended that clinicians screen the at-risk male athlete with targeted screening questions and risk assessment tools. Further research is needed to validate a best practice screening questionnaire for the Male Athlete Triad.	C
Male athletes are diagnosed with the Male Athlete Triad if they have one or more components along the spectrum of the Male Athlete Triad. The diagnosis includes a thorough history and physical and is best accomplished by a multidisciplinary healthcare team.	C
Although measurement of energy deficiency or low energy availability (EA) is best quantified in laboratory settings, several proxies can be used clinically when estimating low EA. These include objective measures of metabolic compensation, hormone changes, anthropometrics, and/or energy prediction equations.	B
Male athletes with symptoms of hypogonadism, or additional Triad-risk factors, should have a morning fasting T level drawn to assess for hypogonadism. If abnormal T levels are identified, these should be repeated for confirmation.	A
A dual-energy x-ray absorptiometry is recommended in male athletes who are at moderate or high risk for the Male Athlete Triad.	C
Optimizing EA by increasing energy intake, reducing exercise energy expenditure, or both, is the first-line treatment for male athletes with one or more components of the Male Athlete Triad.	C
Pharmacologic therapy, although rarely needed, may be necessary to treat low bone mineral density (BMD) and increased fracture risk, symptoms of hypogonadism, or infertility.	D
Data are lacking in hypogonadal male athletes for a beneficial effect of T replacement on bone outcomes, and this is also complicated because of T being prohibited in sport.	C
Although teriparatide and abaloparatide improve trabecular bone mass and microarchitecture, increase bone strength, and reduce fracture risk, studies of these agents on bone outcomes have not as yet been performed in the male athlete with hypogonadism.	D
There are limited data (case series and retrospective reports) for using bisphosphonates to improve bone outcomes in the male athlete with hypogonadism.	C
An athlete may be considered for pharmacological treatment of low BMD after institution of at least a year of nonpharmacological therapy, if the athlete has a diagnosis of low BMD and/or a clinically significant fracture history AND demonstrates lack of response to nonpharmacological therapy over this period.	C
Young male endurance athletes who engage in early sport specialization may incur a greater risk of the Male Athlete Triad. Participation in a variety of sports, especially those with higher impact or multidirectional loading, along with resistance training, is advisable for optimization of BMD.	B
Similar to the female athlete, risk for low BMD and bone stress injury is cumulative in male athletes with one or more components of the Male Athlete Triad.	B
Risk assessment tools can be helpful in guiding clearance and return-to-play decisions in the male athlete with one or more components of the Male Athlete Triad.	B

the effect of drug monotherapy, as well as combination therapy, in male athletes at risk for fracture.

Which Athletes May be Considered for Pharmacological Therapy?

Although evidence is currently lacking to definitively recommend when and which specific pharmacological approach to consider in the Male Athlete Triad, the Female and Male Athlete Triad Coalition developed the following suggestions to guide clinical management until such evidence becomes available.

An athlete may be considered for pharmacological treatment of low BMD after institution of at least a year of nonpharmacological therapy, if the athlete has a diagnosis of low BMD and/or a clinically significant fracture history AND demonstrates lack of response to nonpharmacological therapy over this period (Figure 4). Lack of response refers to a

clinically significant reduction in BMC or BMD Z-scores after at least a year of nonpharmacological therapy OR development of new fractures during such therapy. Such individuals should be referred to a specialist in bone metabolic disorders or an endocrinologist for administration of pharmacological treatment to improve bone health. Treatment may include a bone anabolic agent such as teriparatide (not in children with open epiphyses) or, rarely, an antiresorptive agent such as a bisphosphonate. At this time, there are no data to support the use of T replacement therapy; therapies that increase T levels through other mechanisms; administration of recombinant human IGF-1, metreleptin, or novel bone agents such as RANK-ligand inhibitors; or combinations of such agents to improve bone health in male athletes with low BMD or at high risk for stress fracture.

Evidence level C: an athlete may be considered for pharmacological treatment of low BMD after institution of at least a year of nonpharmacological therapy if the athlete has

a diagnosis of low BMD and/or a clinically significant fracture history and demonstrates lack of response to nonpharmacological therapy over this period.

PREVENTION OF THE MALE ATHLETE TRIAD

Are There Strategies to Prevent the Male Athlete Triad?

Although investigations on methods to prevent the Male Athlete Triad are limited, studies have explored ways to optimize individual components of the Triad. Because energy deficiency/low EA is the underlying cause of the Triad, male athletes should be encouraged to consume sufficient calories throughout the day to provide adequate energy for supporting musculoskeletal health, acquiring lean tissue, and accumulating sufficient bone mass. Detailed nutritional recommendations to improve energetic status have already been discussed above—when possible, it would be advantageous to educate athletes regarding these recommendations proactively, even in the absence of clinical pathology.

It is also important to optimize athlete intake of micro-nutrients such as calcium and vitamin D. A systematic review and meta-analysis examined the association between serum 25(OH)D levels and stress fractures, specifically in the military.¹⁵⁰ The analysis included 8 studies published between 2000 and 2013, consisting of 2634 military personnel, with 761 stress fracture cases and 1873 controls. The authors found that the overall mean serum 25(OH)D level was significantly lower for stress fracture cases than controls.¹⁵⁰ Other studies investigating the military population have demonstrated similar findings to the meta-analysis. A prospective study following 1082 Royal Marine recruits concluded that baseline serum 25(OH)D concentration below 50 nmol L⁻¹ was associated with an increased risk of stress fractures.¹⁵¹ Another study involving 37 British Army recruits demonstrated a shorter recovery time from lower-limb stress fractures with sufficient 25(OH)D at the time of injury, with a statistically significant mean difference of 17.8% in recovery time between recruits with sufficient 25(OH)D (>50 nmol L⁻¹) and insufficiency (<50 nmol L⁻¹).¹⁵² The mean recovery time in weeks was 10.1 (±2.5) in the 25(OH)D sufficient group, 11.9 (±2.4) in the insufficient group (25-50 nmol L⁻¹), and 13 (±1.6) in the deficient group (<25 nmol L⁻¹).¹⁵² In a cumulative case-control study, researchers evaluated serum 25(OH)D concentration in 37 Japanese male university soccer athletes, 18 of whom had a fifth metatarsal stress fracture and 19 controls.¹⁵³ Results showed that a 25(OH)D level less than 30 ng mL⁻¹ was associated with statistically significantly increased odds of stress fracture.¹⁵³ In a 2-year prospective cohort study, researchers evaluated young female athletes aged 18 to 26 years, for an average of 1.85 years, and measured longitudinal changes in bone density and incident stress fractures.¹⁵⁴ The authors found that vitamin D intake predicted gains in spine and hip BMD. In addition, the study demonstrated the protective effects of vitamin D on stress fracture risk in female athletes, with an adjusted hazard ratio of 0.67 (0.34-1.31). The authors also found that a higher intake of calcium, skimmed milk, and dairy products was associated with lower rates of stress fracture. Each additional cup of skimmed milk consumed per day was associated with a 62% reduction in stress fracture incidence ($P < 0.05$). A dietary pattern of high dairy and

low-fat intake was associated with a 68% reduction ($P < 0.05$). Higher intakes of skimmed milk, dairy foods, calcium, animal protein, and potassium were associated with significant ($P < 0.05$) gains in whole-body BMD and BMC. These findings are further supported by research in military recruits during basic training that demonstrated supplemental calcium (2000 mg/d) and vitamin D (800-1000 IU/d) can reduce BSI incidence by 20% in female Navy recruits¹⁵⁵ and lead to greater increases in volumetric BMD in male and female Army recruits.¹⁵⁶ Although a systematic review and meta-analysis assessing the prevalence of vitamin D insufficiency (defined as serum 25(OH)D < 32 ng/mL) in athletes was reported to be high (56%) and varied by geographic location, the relationship to both bone stress injuries and soft-tissue injuries was found to be inconclusive.¹⁵⁷ Further research is needed in the athlete population to assess the relationships between 25(OH)D serum concentrations (with and without calcium supplementation), BSI incidence, and return-to-play time after sustaining a BSI.

As explored earlier in this article, BMD is often compromised in athletes with the Male Athlete Triad. The literature has suggested that participation in weight-bearing sports emphasizing high and multidirectional impacts result in improved bone geometry and greater BMD, whereas nonimpact and repetitive impact activities did not lead to a significant improvement.¹⁵⁸ These findings support consensus statement recommendations for young athletes to avoid early single-sport specialization, particularly in endurance sports, to reduce the risk of overuse injury¹⁵⁹ while also allowing for benefits to overall skeletal health from other forms of high and multidirectional loading, such as basketball and soccer. Resistance training is often prescribed to patients with low BMD because of its osteogenic effects.¹⁶⁰ As noted previously, studies have demonstrated improvements in BMD or attenuation of BMD loss in cyclists and distance runners who engaged in resistance training compared with their athlete peers or to sedentary controls.^{10,161,162} These studies suggest that the high magnitude bone strain provided by resistance exercise (per recommendations outlined in the latest position statement on youth resistance training) is an effective stimulus for generating higher BMD¹⁶⁰ and may play a preventative role for future BSI.

Evidence level B: young male endurance athletes who engage in early sports specialization may incur a greater risk of the Male Athlete Triad. Participation in a variety of sports, especially those with higher impact and multidirectional loading, along with resistance training, is advisable for optimization of BMD.

CLEARANCE AND RETURN-TO-PLAY

There are no current universally accepted guidelines for clearance and return-to-play in the male adolescent and young adult athlete at risk for the Male Athlete Triad. However, with knowledge that young male athletes, especially those in endurance sports and leanness sports, represent a group that is at highest risk for low BMD and BSI, clearance and return-to-play guidelines are recommended to optimize prevention and treatment. Because of the importance of bone mass acquisition in adolescence, and health concerns in this age group, screening should ideally start during this time period.^{20,21,163} Repeated screening assessment is also recommended after BSI or fracture, recurrent injury or unexplained

illness, and if other components of the Male Athlete Triad are identified.¹⁶³

Has Risk Stratification Been Assessed to Evaluate Health and Participation Risk in the Male Athlete?

Cumulative risk factors for low BMD have been reported in adolescent male athletes, with the risk of low BMD increasing with additional risk factors.³ This highlights the importance of implementing screening in young male athletes. Kraus et al²² found that a modified version of the Female Athlete Triad cumulative risk score^{20,21}—including the cumulative risk factors of low EA (defined by the presence of current or past disordered eating or DSM-V eating disorder), low BMI, prior BSI, and low BMD values—was associated with prospective BSI in male collegiate runners.²² Because runners are considered an at-risk group of male athletes,^{3,164} these findings provide an evidence-based method to quantitatively assess male athletes at elevated risk for BSI. An updated version of this screening tool is presented in Figures 2 and 3 and can be used along with a preparticipation clearance examination or during assessment for return-to-play in the male athlete at risk for the Male Athlete Triad.

The finding that risk factors for low BMD and BSI in the male athlete are cumulative is consistent with the literature on female athletes.^{165,166} Prospective return-to-play studies in male and female collegiate track and field athletes have demonstrated that in those athletes who sustain a BSI, low BMD and higher MRI grade are independent predictors of delayed return-to-play in both sexes.⁶ There are various proposed return-to-play protocols for BSI in runners that are primarily based on the average number of weeks for return-to-play, the risk level of the fracture site (low risk or high risk), and/or severity based on imaging.^{167–172} In addition, male and female athletes with a BSI at skeletal sites of predominantly trabecular bone structure (femoral neck, sacrum, and pelvis) had a delay in return-to-play compared with athletes with a BSI of predominantly the cortical bone.⁶ Further research is needed to provide evidence-based protocols that take into account all of the above factors in return-to-play protocols for BSI in the male athlete.

Evidence level B: similar to the female athlete, risk for low BMD and BSI is cumulative in male athletes with the presence of one or more components of the Male Athlete Triad.

What are the Recommendations for Clearance and Return-To-Play Based on Risk Stratification?

It is the team physician's responsibility to clear the athlete for return-to-play when it is safe to do so.¹⁷³ Given our knowledge that cumulative risk factors can prospectively predict low BMD and BSI in the male athlete at risk,²² the authors recommend using the Male Athlete Triad Cumulative Risk Assessment tool at the PPE and/or PHE as an evidence-based translation to help the team physician with return-to-play decisions in athletes at risk for the Male Athlete Triad (Figures 2 and 3). This is similar to the Female Athlete Triad Cumulative Risk Assessment tool which is used for clearance and return-to-play in the female athlete.^{20,21} At the time of the PPE and for return-to-play decisions, the team physician may still need to gather additional information, such as laboratory tests and/or a DXA, before making a final clearance decision. In such instances, the athlete will

schedule a follow-up appointment with the team physician and may also need to see other members of the multidisciplinary team.^{20,21,24}

The athlete's risk factors, prior injury history, test results, and feedback from the multidisciplinary team are all considered in the final clearance and return-to-play decision.

According to the Male Athlete Triad Cumulative Risk Assessment tool (Figures 2 and 3),²² male athletes with a low risk score can be fully cleared, assuming they are otherwise healthy, with follow-up as needed or as determined by the team physician. Athletes at moderate risk for the Male Athlete Triad can be either provisionally cleared or receive limited clearance. Provisional clearance would include full training/competition, with the understanding that the athlete follows the recommendations made by members of the multidisciplinary team. With limited clearance, the athlete is cleared, but there are limitations specified for training and competition, based on the athlete's health status. It is recommended that the athlete at moderate or high risk be referred to one or more members of the multidisciplinary team, that requested testing be obtained, and that they follow-up as scheduled with the team physician to review results and assess progress. The athlete at high risk may not be cleared for training or competition, or for return to his sport, unless approved by the team physician after further treatment or follow-up. In this situation, other members of the athlete's health care team may be used to assess the athlete's readiness for return-to-sport. If the athlete is sustaining recurrent BSIs, is unable to maintain a positive energy balance, and has decreasing bone density despite a comprehensive treatment approach, it is reasonable to consider recommending medical retirement from sport.

The IOC has proposed a return-to-play model for relative energy deficiency in sport¹⁷⁴ to aid in return-to-play decisions for both male and female athletes,¹⁷⁵ but to date, it has not been validated, and many of the factors included are vaguely defined.¹⁷⁶ Future research is needed to refine screening tools for the male athlete, determine at-risk groups in which screening is recommended, and develop return-to-play algorithms.

Although risk assessment tools can be extremely helpful in guiding physicians, clinical judgment should be used in clearance and return-to-play decision-making so that the treatment plan is individualized based on the athlete's unique situation, and not based on risk scores alone.^{20,21,24,177}

Evidence level B: risk assessment tools can be helpful in guiding clearance and return-to-play decisions in the male athlete with one or more components of the Male Athlete Triad.

Are Treatment Contracts Recommended for the Athlete With the Male Athlete Triad?

With female athletes at risk for the Female Athlete Triad, a written contract has been recommended (refer to online appendices).^{20,21,174} There is a lack of literature on the utility of written contracts in the male athlete. Benefits include ensuring follow-up with the team physician and multidisciplinary team members and maintaining consistency. Future research is needed on the utility of verbal versus written contracts in the male athlete at risk for the Male Athlete Triad. If verbal recommendations are not followed, and the athlete does not partake in recommended treatment strategies, a written contract may be needed.

FINAL RECOMMENDATIONS AND SUMMARY

In summary, a subgroup of adolescent and young male athletes, especially in lean-sport and weight-class sports, is at risk for the Male Athlete Triad. Evidence-based risk assessment protocols for the male athlete at risk for the Male Athlete Triad have been shown to be predictive for bone stress injuries and impaired bone health, and their use should be encouraged for male athletes in endurance and weight-class sports and for other male athletes in which the Male Athlete Triad is suspected. Risk assessment protocols may be implemented at the PPE and/or PHE or during other clinical encounters to determine best practice clearance and return-to-play strategies for adolescent and young adult athletes with the Male Athlete Triad.

Diagnostic work-up for male athletes who are suspected to have the Male Athlete Triad includes assessing for symptoms of hypogonadism. If symptoms are identified, or if the athlete has additional Triad risk factors, a morning fasting T level should be assessed and repeated for confirmation. If hypogonadism is identified, further work-up is indicated to determine the cause and to rule out other important causes of hypogonadism.

For young athletes in weight-bearing sports, a Z-score of < -1.0 is considered to be low bone mass, but in non-weight-bearing sports, the ISCD definition for low bone mass is used with a Z-score of ≤ -2.0 .

Because energy deficiency/low EA is the key causal factor leading to impaired reproductive and skeletal health, improving energetic status through optimal fueling is the mainstay of treatment for athletes with the Male Athlete Triad. Pharmacologic management is presented for nonpharmacologic treatment failures but is rarely indicated in athletes with the Male Athlete Triad. In these cases, the team physician should consult an endocrinologist or other bone health specialist (Figure 4).

CALLS FOR RESEARCH AND GAPS IN KNOWLEDGE

1. Research on the utility of screening questions for adolescent and young adult athletes to identify athletes at risk for the Male Athlete Triad.
2. Research on screening for the prevalence of one or more components of the Male Athlete Triad in adolescent and young adult male athletes in various sports.
3. Research on specific energetic and metabolic factors that are associated with one or more of the Male Athlete Triad outcomes.
4. Research on the presentation of disordered eating and eating disorders in male athletes and their relationship to Male Athlete Triad outcomes.
5. Research on cut-off values for measures of energy deficiency specific to exercising men.
6. Research on the efficacy and effectiveness of clearance and return-to-play guidelines in the male athlete.
7. Research on screening for the prevalence of one or more components of the Male Athlete Triad in military recruits, as well as clearance and return-to-play guidelines in this population.
8. Research on risk assessment tools for BSI and poor bone health, incorporating additional risk factors specific to the male athlete.
9. Research on interventions directed at prevention and treatment of the Male Athlete Triad.

In summary, in the Male Athlete Triad Part II: Diagnosis, Treatment, and Return-to-Play, prospective controlled studies and observational studies are presented, and evidence-based statements (Table 4) are provided regarding recommendations for risk assessment, diagnosis, management, and return-to-play in the athlete with the Male Athlete Triad. Future studies are needed in the areas of risk assessment, diagnosis, treatment, and return-to-play for male athletes at risk for the Male Athlete Triad.

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