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National Athletic Trainers' Association Position Statement: Safe Weight Loss and Maintenance Practices in Sport and Exercise

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Objective: To present athletic trainers with recommendations for safe weight loss and weight maintenance practices for athletes and active clients and to provide athletes, clients, coaches, and parents with safe guidelines that will allow athletes and clients to achieve and maintain weight and body composition goals.

Background: Unsafe weight management practices can compromise athletic performance and negatively affect health. Athletes and clients often attempt to lose weight by not eating, limiting caloric or specific nutrients from the diet, engaging in pathogenic weight control behaviors, and restricting fluids. These people often respond to pressures of the sport or activity, coaches, peers, or parents by adopting negative body images and unsafe practices to maintain an ideal body composition for the activity. We provide athletic trainers with recommendations for safe weight loss and weight maintenance in sport and exercise. Although safe weight gain is also a concern for athletic trainers and their athletes and clients, that topic is outside the scope of this position statement.

Recommendations: Athletic trainers are often the source of nutrition information for athletes and clients; therefore, they must have knowledge of proper nutrition, weight management practices, and methods to change body composition. Body composition assessments should be done in the most scientifically appropriate manner possible. Reasonable and individualized weight and body composition goals should be identified by appropriately trained health care personnel (eg, athletic trainers, registered dietitians, physicians). In keeping with the American Dietetics Association (ADA) preferred nomenclature, this document uses the terms *registered dietitian* or *dietician* when referring to a food and nutrition expert who has met the academic and professional requirements specified by the ADA's Commission on Accreditation for Dietetics Education. In some cases, a *registered nutritionist* may have equivalent credentials and be the commonly used term. All weight management and exercise protocols used to achieve these goals should be safe and based on the most current evidence. Athletes, clients, parents, and coaches should be educated on how to determine safe weight and body composition so that athletes and clients more safely achieve competitive weights that will meet sport and activity requirements while also allowing them to meet their energy and nutritional needs for optimal health and performance.

Key Words: body composition, body fat, diet, hydration, metabolism, sport performance

Weight classifications in sport (eg, youth football, wrestling, rowing, boxing) were designed to ensure healthy, safe, and equitable participation[1]; however, not all sports or activities in which weight might play a role in performance use a weight classification system. In activities such as dance, distance running, gymnastics, and cycling, weight and body composition are believed to influence physical performance and the aesthetics of performance. Yet the governing organizations of these activities have no mandated weight control practices. In 2005, the American Academy of Pediatrics[2] published a general weight control practice guide for children and adolescents involved in all sports.

In addition to the potential performance benefits of lean body mass and lower levels of body fat, long-term health benefits include decreased cardiovascular risk factors, reduced triglyceride concentration, possible increases in cardioprotective high-density lipoprotein cholesterol concentration, increased fibrinolysis, reduced resting blood pressure, reduced resting glucose and insulin, and increased insulin sensitivity.[3] In females, lower body fat may also protect against breast and other reproductive cancers.[4] Although lean body mass has been associated with positive health benefits, negative health outcomes are associated with excessive loss or gain of body mass.[5]

RECOMMENDATIONS

Based on the current research and literature, the National Athletic Trainers' Association (NATA) suggests the following safe weight loss and weight maintenance strategies for participants in all sports and physical activities. These recommendations are built on the premise that scientific evidence supports safe and effective weight loss and weight management practices and techniques, regardless of the activity or performance goals. The recommendations are categorized using the Strength of Recommendation Taxonomy criterion scale proposed by the American Academy of Family Physicians[6] on the basis of the level of scientific data found in the literature. Each recommendation is followed by a letter describing the level of evidence found in the literature supporting the recommendation: *A* means there are well-designed experimental, clinical, or epidemiologic studies to support the recommendation; *B* means there are experimental, clinical, or epidemiologic studies that provide a strong theoretical rationale for the recommendation; and *C* means the recommendation is based largely on anecdotal evidence at this time.

Assessing Body Composition and Weight

1. Body composition assessments should be used to determine safe body weight and body composition goals. *Evidence Category: B*
2. Body composition data should be collected, managed, and used in the same manner as other personal and confidential medical information. *Evidence Category: C*
3. The body composition assessor should be appropriately trained and should use a valid and reliable body composition assessment technique (Table 1). *Evidence Category: C*
4. Body weight should be determined in a hydrated state. *Evidence Category: B*
5. When determining goal weight, body weight should be assessed relative to body composition. This assessment should occur twice annually for most people, with no less than 2 to 3 months between measurements (Tables 2, 3). *Evidence Category: C*
6. To track a person's progress toward a weight or body composition goal, private weigh-ins and body composition assessments should be scheduled at intervals that provide information to guide and refine progress, as well as to establish reinforcement and reassessment periods. *Evidence Category: C*

Table 1. Body Composition Assessment Techniques[7]

Model	Assessment Technique	Standard Error of Estimate, %
2 Compartment	Hydrodensitometry	±2.5
	Air displacement plethysmography	±2.2–3.7[a]
	Skinfold measurements	±3.5[b]
	Near-infrared interactance	±5[b]
3 Compartment	Bioelectric impedance	±3.5–5[b]
	Dual-energy x-ray absorptiometry	±1.8[a]
Multiple compartment	Computed tomography or magnetic resonance imaging	Not fully developed[a]

[a] More research is needed.
[b] Differs with each equation.

Table 2. Body Fat Standards (%) by Sex and Age

Body Fat Standard	Males	Females
Lowest reference body fat (adults)[5,8–11]	5	12
Lowest reference body fat (adolescents)[2,12]	7	14
Healthy body fat ranges[13]	10–22	20–32

Table 3. Determining Goal Weight from Body Composition

Current % body fat – Desired % body fat = Nonessential body fat, %
________ – ________ = ________

Current body weight × Nonessential body fat, % (in decimal format) = Nonessential fat, lb
________ × ________ = ________

Current body weight – Nonessential fat, lb = Ideal body weight, lb
________ – ________ = ________

7. When hydration is a concern, regular or more frequent (or both) assessments of body weight are indicated. *Evidence Category: C*
8. Active clients and athletes in weight classification sports should not gain or lose excessive amounts of body weight at any point in their training cycles. *Evidence Category: C*
9. Management of body composition should include both diet and exercise. *Evidence Category: B*
10. Total caloric intake should be determined by calculating the basal metabolic rate (BMR) and the energy needs for activity. *Evidence Category: B*
11. Caloric intake should be based on the body weight goal (Table 4). *Evidence Category: C*
12. A safe and healthy dietary plan that supplies sufficient energy and nutrients should be maintained throughout the year (Table 5). *Evidence Category: B*
13. The U.S. Department of Agriculture's Food Pyramid Guide is one of the methods that can be used to ensure adequate nutrient intake. *Evidence Category: C*
14. The metabolic qualities of the activity should be considered when calculating the need for each energy-producing nutrient in the diet (Tables 6–8). *Evidence Category: B*
15. Safe and appropriate aerobic exercise will facilitate weight and body fat loss. *Evidence Category: C*
16. Body composition adjustments should be gradual, with no excessive restrictions or use of unsafe behaviors or products. *Evidence Category: C*
17. Combining weight management and body composition goals with physical conditioning periodization goals will assist athletes or clients in reaching weight goals. *Evidence Category: C*
18. Education on safe dietary and weight management practices should be communicated on a regular and planned basis. *Evidence Category: C*
19. Individual body composition or dietary needs should be discussed privately with appropriately trained nutrition and weight management experts. *Evidence Category: C*
20. Ergogenic and dietary aids should be ingested cautiously and under the advisement of those knowledgeable of the requirements of sports and other governing organizations. *Evidence Category: C*

Background and Literature Review

Weight management and nutrition is a multibillion-dollar industry that has become pervasive in almost every aspect of modern life. Diet and exercise have always affected sports and physical activity, but with the intensity of competition increasing at all levels has come a renewed interest in controlling the factors that influence performance and health. Diet, exercise, body composition, and weight management now play larger roles in an active person's life and performance. Because ath-

Table 4. Determining Total Caloric Needs

Harris-Benedict[14]	
Female basal metabolic rate = 655.1 + (9.6 × weight [kg]) + (1.9 × height [cm]) − (4.7 × age [y]) + Activity needs	
Male basal metabolic rate = 66.5 + (13.8 × wt [kg]) + (5 × ht [cm]) − (6.8 × age [y]) + Activity needs	
Activity needs	
Sedentary (mostly sitting): add 20%–40% of basal metabolic rate	
Light activity (sitting, standing, some walking): add 55%–65% of basal metabolic rate	
Moderate activity (standing and some exercise): add 70%–75% of basal metabolic rate	
Heavy activity: add 80%–100% of basal metabolic rate	
Mifflin-St. Jeor[15]	
Female basal metabolic rate = (10 × wt [kg]) + (6.25 × ht [cm]) − (5 × age [y]) − 161	
Male basal metabolic rate = (10 × wt [kg]) + (6.25 × ht [cm]) − (5 × age [y]) + 5	

Table 5. Determining Energy-Producing Nutrient Intake

Protein intake
- a. Calculation of protein needs based on activity levels:
  BW, kg × g/kg BW = g of protein/kg BW
  __________ × __________ = __________
- b. Convert the g of protein into kcal needed:
  _____ g protein × 4 = __________ kcal from protein
- c. % Protein needed of total caloric intake:
  ______ kcal from protein ÷ ______ total kcal = _____%

Carbohydrate intake
- a. Calculation of CHO needs based on activity levels:
  BW in kg × grams/kg BW = g of CHO/kg BW
  __________ × __________ = __________
- b. Convert the g of CHO into kcal needed:
  _____ g CHO × 4 = __________ kcal from CHO
- c. Convert % kcal into actual number of calories:
  ______ kcal from CHO divided by ______ total kcal = _____%

Fat intake
- a. Based on the remaining number of calories needed, calculate the fat intake needed:
  CHO, kcal + protein, kcal = kcal from CHO and protein
  ________ + ________ = (A) _____
- b. Total caloric need − value A = fat needed, kcal
  _________ − ________ = (B) _____
- c. Value B ÷ 9 = fat, g
  _________ ÷ 9 = ___________

Abbreviations: BW, body weight; CHO, carbohydrate

Table 6. Energy-Producing Nutrients

Nutrient	General Population Requirement
Carbohydrates	5–7 g/kg of body weight per d
Proteins	0.8–1 g/kg of body weight per d
Fats	15%–35% of total caloric intake per d

letic trainers (ATs) and other members of the health care team have regular contact and ongoing relationships with athletes and clients engaged in active lifestyles, they are frequently asked for assistance in achieving personal and performance goals. These goals often include diet, exercise, and weight management. Some AT-client relationships and their shared body composition goals are formalized, as with weight-class sport athletes; others are not.

Weight Management in Weight-Class Sports

Many safe and effective methods are available to achieve and maintain goal weight and body composition. However, although published and widely accepted weight and body composition standards exist,[9] there are few published or mandated weight or body composition management requirements. Even within sports with weight-class systems (eg, boxing, lightweight crew, sprint football, wrestling), only wrestling and sprint football consider the components of an athlete's weight and body composition, as well as the safety considerations for achieving and maintaining that body size.[19,20]

Since 1997, specific rules and guidelines have been implemented to ensure that weight control practices in wrestling are safe, applied early in the competitive season, and conducted on a regular and planned schedule around competitions and do not include dehydration as a means of weight loss.[1] These weight management and dehydration prevention regulations are effective in reducing unhealthy "weight-cutting" behaviors and promoting equitable competition.[21]

In 2006, the National Federation of State High School Associations adopted similar standards (ie, body composition, weigh-in procedures, and hydration status) for determining minimum body weights in high school wrestlers, but the body fat minimums were higher (≥7% in males, ≥12% in females) than the levels for collegiate athletes determined by the National Collegiate Athletic Association (NCAA).[21] These differences were implemented to address growth needs in adolescents and sex differences. The National Federation of State High School

Table 7. Carbohydrate Intake[5,16]

Activity Type	Recommendation
Optimal glycogen storage for single term or single event	7–10 g/kg of body weight per d
Carbohydrate for moderate-intensity or intermittent exercise >1 h	0.5–1 g/kg of body weight per h (30–60 g/h)
Daily recovery and fuel for aerobic athlete (1–3 h moderate-intensity to high-intensity exercise)	7–10 g/kg of body weight per d
Daily recovery and fuel for extreme exercise program (>4–5 h moderate-intensity to high-intensity exercise)	10–12+ g/kg of body weight per d

Table 8. Protein Intake[5,8,14,17,18]

Athlete Type	Recommendation
Strength athletes	1.7–1.8 g/kg of body weight (maximum = 2 g)
Endurance athletes	1.2–1.4 g/kg of body weight
General population	0.8–1 g/kg of body weight
Vegetarians	0.9–1 g/kg of body weight

Associations standards have not been accepted or enforced universally in the United States. Therefore, universally safe or effective weight management practices in high school wrestling are not assured.

Sprint football is a collegiate sport sponsored by 6 teams in the Collegiate Sprint Football League: Cornell University, Mansfield University, Princeton University, University of Pennsylvania, U.S. Military Academy at West Point (Army), and U.S. Naval Academy (Navy). Sprint football has the same rules as NCAA football but also has a weight limit for players of 172.0 lb (78 kg), which is far lower than the weights typically seen in NCAA football players.[20] To the previously required minimum body composition of 5% body fat, sprint football in 2008 added compulsory assessment of body composition and playing weight in a hydrated state with a urine specific gravity of <1.020.[20]

In 1997, collegiate lightweight crew and rowing athletes began using U.S. Rowing weight classifications and a 5% minimum body fat guideline to determine a safe rowing weight. Unlike wrestling, the revised 2007 crew weight requirements did not take into account the athlete's body composition or hydration status in determining minimum body weight. Although some institutions have adopted weight certification guidelines similar to those in wrestling, no formal rules are in place. Today's standards stipulate that male lightweight rowers must not exceed 160 lb (73 kg), and female lightweight rowers must not exceed 130 lb (59 kg). Minimum weights are in place only for coxswains. All crew members must be weighed once a day, between 1 and 2 hours before the scheduled time of the first race, each day that the athlete competes.[22]

Sport Performance and Aesthetics

Practices of weight manipulation and body fat control are not exclusive to sports with weight-class requirements. Participants in other activities requiring speed and aesthetics also use weight manipulation to improve performance. Leaner athletes in sports such as middle-distance and long-distance running, cycling, and speed skating are often perceived by coaches and peers to perform better.[10]

Although body fat contributes to weight, it does not always contribute to energy in the muscular contractions needed for exercise and sport. A disproportionately greater amount of muscle mass and smaller amount of body fat are needed by participants in activities that may be influenced by body size. In sports such as the broad jump or vertical jump, in which the body must be propelled through space, generating power is essential. More power can be achieved by a body with a higher ratio of muscle to fat than one of the same mass with a lower ratio of muscle to fat. In swimming, although body fat allows for greater buoyancy in water, which reduces drag, athletes with a greater proportion of muscle mass to fat can produce more speed.

Similarly, in sports such as ski jumping, a lean, slight build was once thought desirable to reduce air resistance and to allow the athlete to stay airborne as long as possible and to cover a greater distance before landing.[10] This performance standard also holds true for activities such as dance, figure skating, gymnastics, and diving. The aesthetic aspect of performance is also a consideration for weight management practices in these activities. Leaner participants are viewed as more attractive and successful[23,24] and perceived to demonstrate better body symmetry, position, and fluidity of motion.

Because no scientific or health principles support weight management for the purpose of aesthetics in performance, we will address this topic only in its association with body composition and weight management. Many considerations for aesthetic performance activities are related to the body composition of female participants, but research[25,26] also recognizes the effect of similar social pressures on male body images.

Pressures on participants to control weight stem from various sources, including society, family,[25,27–29] peers,[3] and coaches,[30–33] as well as the judging criteria used in some activities.[34] These pressures may place participants at higher risk for developing unrealistic weight goals and problematic weight control behaviors. Most aesthetic performance activities require fit body types for success, and these requirements may trigger an unhealthy preoccupation with weight.[35] Generally, participants in competitive activities that emphasize leanness for the sake of performance or aesthetic enhancement are at the highest risk for developing dysmorphia, eating disorders, and disordered eating.[36–40]

Because of the need to control all factors that may affect performance, perfectionism is a common psychological trait among athletes. Along with the desire to look thin and the belief that decreased weight enhances performance, perfectionism increases the risk of developing an eating disorder.[41–43] Perfectionism is typically associated with setting high goals and working hard to attain them, which enables athletes to succeed.[40,44] People who are aware of concerns about their weight from coaches, parents, teammates, friends, or significant others are more likely to develop subclinical eating disorders.[45]

In general, women in non–weight-class activities identify their ideal body sizes and shapes as smaller than their actual bodies, whereas men tend to want to be larger (ie, more muscular) and are more concerned with shape than with weight.[46–49] The demands of a male's activity determine whether desirable body size or weight (or both) is smaller (eg, gymnastics) or larger (eg, football). Because the topic of dysmorphia has been addressed more comprehensively in the NATA's position statement on preventing, detecting, and managing disordered eating in athletes,[50] it is addressed here only in the context of weight management practices.

Regardless of the rationale to support weight management practices, goal weights and body compositions for athletes and active clients must be determined and maintained in a safe and effective manner. The purposes of this position statement are to identify safe methods by which goal weight can be determined and maintained and to discuss unsafe weight management practices and the effects of those practices on performance and overall health.

Body Composition

To fully understand the topic of body composition, it is essential to understand how body composition is assessed. Using the most common description of body composition, the 2-compartment (2-C) model is a quantifiable measure that can be divided into 2 structural components: fat and fat-free mass (FFM). Fat-free mass consists primarily of muscle, bone, water, and remainder elements.[9] In the general population, excess body fat is associated with adverse health consequences, which include cardiovascular disease,[51] diabetes,[52] gallstones,[53] orthopaedic problems,[54] and certain types of cancer.[55] Although active people have a lower incidence of these conditions, excess body fat combined with a family history of cardiovascular or metabolic diseases and inactivity can reverse the benefits of acquired health associated with an active, healthy lifestyle.

To develop a method for determining the risks associated with excess body fat, the body mass index (BMI) assessment was created. The original purpose of the BMI assessment was to predict the potential for developing the chronic diseases associated with obesity.[9] Body mass index may be an appropriate method for determining body size in the general population, but this technique does not assess fat mass and FFM. Therefore, BMI assessment is less accurate for athletes and active clients who have higher levels of FFM.[14] Even though a sedentary person and an active person may have the same height and weight, their fat to FFM ratios may be very different. When applied to the BMI formula, the active person's additional FFM skews the assessment of body composition, resulting in a BMI evaluation that is inaccurate as a predictor of increased risk for chronic diseases. More individualized body weight and body composition assessments are needed for active people with high levels of lean body mass to accurately evaluate the effect of body weight on the risk of developing chronic diseases (Table 9).

Body Weight, Fat, and FFM

Fat mass can be categorized as essential fat, sex-specific fat, and storage fat.[9] Essential fat, which averages 3% of total fat, makes up the bone marrow, heart, lungs, liver, spleen, kidneys, intestines, muscles, and lipid-rich tissues of the central nervous system.[9] In women, essential fat also may include sex-specific fat (eg, breasts, hips, pelvis) and averages 12%.[5,8–11] Storage fat, which averages 12% in men and 12% to 15% in women, is layered subcutaneously; it is stored by the body to provide an energy substrate for metabolism.[9] When essential fat is added to storage fat, men average 15% total body fat, whereas women average 20% to 27% total body fat. Low-reference body fat composition is 5% in men and 12% in women.[5,8–11] Low-reference body fat composition, which is necessary to maintain normal reproductive health and hormone function, is 7% in adolescent males and 14% in adolescent females.[2,12] Lower levels of fat have been associated with good health and normal body function.[5,8–11] Although no maximum body fat requirements exist, the highest safe weights should not exceed the body fat ranges considered satisfactory for health: 10% to 22% and 20% to 32% in physically mature adolescent males and females, respectively.[13]

Body fat is distributed in sex-specific patterns. Typically, women distribute more body fat in the gluteofemoral region in a gynoid fat distribution pattern, sometimes referred to as "pear shaped." Women also store more fat in the extremities than men. In contrast, men distribute more fat in the abdominal region in an android or "apple" pattern and have greater subscapular to triceps skinfold thickness than do women.[56] The android fat distribution has been related to more significant health consequences associated with cardiovascular disease, including diabetes, hypertension, and hyperlipidemia,[7,57] and may contribute more to increased disease risk than does obesity alone.[58]

Table 9. Body Mass Index (BMI)[a] Classifications[7]

BMI	Classification
<18.5	Underweight
18.5–24.99	Average (normal)
25.0–29.9	Overweight
30.0–34.9	Grade I obesity
35.0–39.9	Grade II obesity
≥40	Grade III extreme obesity

[a] BMI = weight, kg/height^2, m.

Assessment of Body Composition

Several methods are available to measure body composition, but most research on assessment in athletes has focused on densitometry, indirect measurement of body density using a 2-C model consisting of fat mass and FFM. Body density is the ratio of body weight to body volume (Table 1).

Total body volume is typically measured by hydrostatic (underwater) weighing[59] with a correction for pulmonary residual lung volume.[60] Most other body composition techniques have been validated in comparison with hydrostatic weighing because of its lower standard error of the estimate. Similar to hydrostatic weighing, air displacement plethysmography is a newer densitometric method that measures mass and volume to calculate body density.[61]

Multicompartment models, in which FFM is divided into 2 or more components, have been validated with hydrostatic weighing methods in athletes.[59–65] Some authors[66–68] suggested that these multicompartment models may be more appropriate for the athletic population; however, these findings are not widely accepted. Two-compartment models demonstrated a significant overestimation for air displacement plethysmography in collegiate football players[69] but close agreement between hydrostatic weighing and air displacement plethysmography in collegiate wrestlers.[70]

Some concerns have been raised about selecting the appropriate conversion formula when using the 2-C model to assess body composition in active people. The Schutte equation[71] is commonly used to estimate fat and FFM from body density in black males, but with multicompartment models, recent researchers[72–74] found that using race-specific equations to estimate percentage of fat from bone density was inappropriate. For adolescent and high school athletes, the adult conversion formulas of Siri[75] and Brozek et al[76] are generally accepted.

Dual-energy x-ray absorptiometry (DXA) has been reported[63,64] to slightly underestimate body fat in some athletic populations when compared with multicompartment models. Other authors[54,56] have noted strong agreement between DXA and multicompartment models in various athletic groups. Athletes generally have greater bone mineral content, bone mineral density, and FFM and a lower percentage of body fat than nonathletes.[77] Considering that DXA also measures bone mineral composition and density, it may be preferable to either hydrostatic or air displacement plethysmography 2-C models as a reference method for assessing body composition in athletes and active people.[78]

Clinical Methods Used to Assess Body Composition

Skinfold thickness, which has been validated with hydrostatic weighing, is the most frequently used and easily accessible clinical method to estimate body composition. Although skinfold measures are easy to obtain, the importance of developing a skillful measuring technique cannot be overstated. Standardized skinfold sites and measurement techniques are described in the *Anthropometric Standardization Reference Manual*.[79] An extensive number of prediction equations are available for estimating bone density from skinfold measures in different athletic populations (Durnin and Womersley, Katch and McArdle, Jackson-Pollock), but selected equations have been recognized for broad applicability to both male and female athletic populations. In addition to these equations, the generalized Lohman equation[80] is recommended for both high school and collegiate wrestlers.[78] Based on the referenced validity studies, ready availability of equipment, and ease of use, skinfold prediction is highly recommended as a body composition assessment technique for athletes and active clients.

The accuracy of bioelectric impedance analysis (BIA), another method used to assess body composition, is highly dependent on testing under controlled conditions. Skin temperature, strenuous exercise, dehydration, and glycogen depletion significantly affect impedance values.[81,82] Population-specific and generalized BIA equations, developed for the average population, do not accurately estimate the FFM of athletic men and women.[83–86] Some researchers[65,87,88] reported that the skinfold method is a better predictor of body fat percentage in athletes than the BIA method, which is a more effective tool for obtaining group data on athletes than for detecting small changes in individual athletes' body fat.[89]

Another body fat measuring technique, near-infrared interactance (NIR), provides optical density values for estimating body fat. The manufacturer's prediction equation systematically underestimated body fat in both active men and collegiate football players.[83,90,91] Limited research is available on the validity of NIR among female athletes in various sports. A few authors[92,93] used optical density values to develop prediction equations in athletic populations. The NIR prediction equations were slightly better than the skinfold method in estimating body composition and minimal wrestling weight in high school–aged wrestlers.[94]

Fat and FFM should be assessed by an AT or other trained body-composition assessor using one of the validated methods available (eg, hydrostatic weighing, air displacement plethysmography, skinfold measures). All manual measurement techniques (eg, skinfold calipers) should follow standardized protocols and be performed at least 3 times by the same assessor to ensure reliability.[79] The body size needs of the activity and the typical body composition of the participants in that activity should be considered, as well as the minimum body composition standards when available.

Body Composition and Hydration Assessment

Body composition and weight assessments should always be conducted on hydrated people. Criterion (ie, total body water and plasma markers) and field methods (ie, acute body mass change, urine and saliva markers, bioelectric impedance) can be used to assess hydration status. The gold standard for determining hydration status is measurement of total body water. Repeated measurements of water content before and after rapid weight reduction reflect the absolute change in fluid content. The FFM of adult bodies contains approximately 72% water,[94] a value slightly less than in children (75%) and adolescents (73%).[94,95]

Plasma markers, or a comparison of blood indices of hydration status with laboratory standards, also may be used to determine hydration status. Plasma osmolality of the blood, sodium content, and hemoglobin and hematocrit levels are typically elevated when the plasma volume is reduced because of dehydration. The plasma osmolality of a hydrated person ranges between 260 and 280 mOsm/kg. A plasma osmolality above 290 mOsm/kg indicates dehydration.[96] Hemoglobin and hematocrit levels can also be used to assess relative changes in plasma volume based on loss of fluid from the vascular space. However, this technique has many limitations and does not always reflect changes in hydration.[97,98]

The acute body-mass change field method is one of the simplest ways to assess changes in hydration. Assessing body weight before and after a period of exercise or heat exposure can provide data reflecting hydration. Immediate weight loss after exercise results from dehydration and should be addressed using the guidelines described in the NATA position statement on hydration.[99] Using weight-tracking charts to evaluate these changes during exercise can help to determine the hydration status of an active person.

Urine markers are another noninvasive method to determine the hydration status of the blood.[100–104] When the body has a fluid deficit, urine production decreases, and the urine becomes more concentrated. The total volume of urine produced during a specified period is lower than expected (normal is approximately 100 mL/h).[96] Simultaneously, urine specific gravity, osmolality, and conductivity increase due to a greater number of solids in the urine and the conservation of body fluid. Urine color also may serve as a gross predictor of hydration state.[102]

Urine specific gravity and osmolality respond to acute changes in hydration status. However, changes in these markers may be delayed or insensitive to low levels of acute dehydration (1% to 3% of body weight).[100] In addition, these markers may be no more effective in detecting dehydration than assessing urine protein content via the dipstick method.[105] Ease of collection and measurement, at least for urine specific gravity and color, make the dipstick method practical for self-assessment of hydration status in most settings.[99]

Similar to those of urine, characteristics of saliva change as the hydration level changes.[106] Because the salivary glands produce saliva using plasma, a decrease in plasma volume due to dehydration affects the concentration of substances found in saliva. Although a saliva sample is easy to obtain, the analysis for osmolality and total protein content requires instrumentation beyond the scope of most practice settings. Saliva flow rate is collected with a dental swab but requires an analytical balance for precise measurement of the change in swab weight after saliva collection.

Recently, BIA and bioelectric impedance spectroscopy have been proposed[104,107] for measuring total body water and the compartments within the total body water, respectively. These methods provide reasonable measurements of body composition and total body water for groups of individuals, but whether they can track changes in hydration status and an individual's hydration level is unknown. Several investigators[108,109] found that bioelectric impedance analysis and bioelectric impedance spectroscopy failed to accurately predict reductions in total body water after rapid dehydration. Some of this inaccuracy may result from other factors (eg, increased core temperature and skin blood flow) that may influence the reactance and resistance measurements on which these techniques rely.

To ensure adequate hydration, an average adult's water intake should be 3.7 L/d for men and 2.7 L/d for women.

Athletes, active clients, and those who are exposed to hot environments need higher intakes of total water.[110] To maintain adequate hydration, a person should drink 200 to 300 mL of fluid every 10 to 20 minutes during exercise. Pre-exercise and postexercise fluid intake should be consistent with the recommendations provided in the NATA position statement on fluid replacement.[99]

As noted previously, body weight and body composition should be assessed with the person in a hydrated state. Those who fail to meet the minimum hydration levels (urine specific gravity of less than 1.020 or urine color less than or equal to 4)[111] should not be assessed until hydration standards are met and no sooner than 24 hours after the first hydration status failure.

Body Composition and Determining Body Weight

No single source offers normative body composition data for athletes. Therefore, ATs and other health care personnel involved in body composition assessment should become familiar with data sources specific to their athlete or client populations. They should take into consideration the safe ranges and the body composition needs of the sport and then individualize weight and body composition goals.

The lowest safe weight should be calculated at no lower than the weight determined by the low-reference body fat composition delineated by sex and age. The *lowest safe weight* can be defined operationally as the lowest weight, sanctioned by the governing body, at which a competitor may compete. When no standard exists, participants should be required to remain above a certain minimum body fat. Highest safe weight should be calculated using a value no higher than the highest end of the range considered satisfactory for health: 10% to 22% body fat in males and 20% to 32% in females (Table 2).[13]

The AT should work closely with the team physician or medical supervisor to develop a plan for the collection and management of body composition data and related information.[112] This information should be restricted to those who need it to provide care for the athlete or client. The AT should fully disclose to the athlete or client who will have access to personal body composition information.[113] If the body composition or other nutritional and weight management findings indicate a potentially harmful or high-risk behavior, the AT is responsible for informing the athlete or client of the risk[113] and the team physician or medical supervisor of the medical concern.[114]

Body composition measurements to determine goal weights should be assessed twice annually,[115] with no less than 2 to 3 months between measurements[50] for most people. These regular measurements will allow ATs and other health professionals to alter weight goals based on decreases in body fat and increases in lean muscle mass. Caution should always be taken to ensure that an athlete's or client's body composition never falls below the lowest or rises above the highest safe weight or body fat level. To track an athlete's or client's progress toward a weight or body composition goal, private weight and body composition assessments should be scheduled at more frequent intervals to guide and refine progress and to establish reinforcement and reassessment periods.

Measurement intervals should be identified in consultation with the physician and other members of the health care team involved in the athlete's or client's care. This team should include an AT, licensed mental health care provider, physician, and registered dietitian.[116] If weight control practices are a concern, collaboration and education should occur early and frequently in the process.

Monitoring Body Weight

During preseason activities that involve equipment that could increase sweat loss or prevent adequate cooling in warmer and more humid climates, body weight should be reassessed at least daily because of the increased risk of dehydration and heat-related illness. Daily weigh-ins, before and after exercise, can help identify excessive weight loss due to dehydration.

Active clients and athletes in weight classification sports should not gain or lose excessive amounts of body weight at any point in their training cycles. Athletes and clients should attempt to maintain levels that are close to their weight and body composition goal when not competing and maintain their goal weight and body composition during competition. Excessive fluctuations in body weight or body composition (or both) can negatively affect the body, including but not limited to changes in metabolic activity, fluctuations in blood glucose levels, and muscle wasting.[14] Athletes in weight classification sports should have individual monitoring plans, such as assessments at least once per month in the off-season and at regular intervals, not to exceed once per week, to monitor for weight fluctuations.[115]

Body Composition and Dietary Intake

Caloric and nutrient intake should be based on lean body mass, desired body composition, goal weight, and sport or activity requirements. Intake that is too high or too low to support the desired lean body mass will negatively affect metabolic function and body composition. Metabolic function is more efficient in those with greater amounts of lean body mass. Metabolic function and oxygen utilization can be measured or estimated with predictive equations that take into consideration body size, fat mass, FFM, age, sex, and the expenditure of energy for activity.[12,117] The Harris-Benedict[14] and Mifflin-St. Jeor[15] estimation formulas, which account for height, weight, age, and sex to determine the BMR, are commonly recommended methods for indirectly estimating total caloric need; however, other methods are also appropriate. One drawback to the use of estimation formulas is that muscular tissue uses more energy than does nonmuscular tissue. Therefore, estimation formulas may underestimate the daily caloric needs of athletes or clients who are very muscular (Table 4).

A healthy diet or meal plan should provide adequate calories to achieve body weight goals, supply essential nutrients, and maintain hydration. To ensure effective performance, energy intake must come from an appropriate balance of the 3 essential energy-producing nutrients (ie, protein, carbohydrates, and fats). In addition, appropriate intake of non–energy-producing essential nutrients (eg, vitamins, minerals, water) is needed to facilitate energy creation and maintain other body processes.[8] Carbohydrates should provide 55% to 70% of the total caloric need of athletes and active people and may be as high as 12 g or more per kilogram of body weight.[5,10,16] Muscle glycogen (stored glucose) and blood glucose, derived from carbohydrates, are the primary energy substrates for working muscle.[17,18,118] Therefore, the more aerobic the activity, the greater the carbohydrate need (Tables 6, 7).

To determine needed protein intake, it is important to identify the type of exercise and the intensity level of that exercise.[5,10,17,18] Protein assists with many bodily functions, but most athletes and clients are interested in building and repairing muscle contractile and connective tissue. Protein provides 8% to 10% of the body's total energy needs. In events lasting longer than 60 to 70 minutes, amino acid oxidation increases, thereby increasing the use of protein to support the greater energy demands. Strength athletes and those whose goals are to build FFM need the most protein in the diet. For those who are not interested in developing a great deal of FFM but want to meet the needs of an aerobic activity, more moderate amounts of protein are desirable. Protein intake in excess of the body's physical requirements increases hydration needs, overburdens the liver and kidneys, and interferes with calcium absorption; in addition, excess protein can be broken down and used as components of other molecules, including stored fat (Table 6).[14]

Finally, dietary fats are essential to a healthy diet because they provide energy, assist in the transport and use of fat-soluble vitamins, and protect the essential elements of cells.[12] Fat metabolism provides a portion of the energy needed for low- to moderate-intensity exercise, and the use of fat for energy metabolism increases as aerobic metabolism increases. Fats can be used to spare both readily available glucose and stored muscle glycogen. Although the average intake of fat in athletes is approximately 30% of total caloric intake,[10,14] the commonly held consensus is that 20% to 25% of total caloric intake should come from fats.[12] To maximize performance, athletes should take in no less than 15% of total caloric intake from dietary fats.[12,17] Fat intake should minimize partially hydrogenated, unsaturated (trans) fats and saturated fats[17]; total fat intake should be equally divided among polyunsaturated, monounsaturated, and trans or saturated fats.

Maintaining Body Composition and Weight with Diet and Exercise

Diet. Management of body composition should include both diet and exercise. To maintain good health and stave off disease, a regular exercise program should be combined with a dietary plan. The dietary plan should be developed to address the athlete's or client's specific body composition, body weight, and activity goals. Individual body composition and dietary needs should be discussed privately with appropriately trained nutrition and weight management experts. Athletic trainers and other health professionals, such as registered dietitians, should provide nutritional information to athletes and clients. A Board-Certified Sports Dietitian (CSSD) is a registered dietitian who has earned the premier professional sports nutrition credential from the American Dietetic Association. Coaches, peers, and family members should not provide information on diet, body composition, weight, or weight management practices and should refrain from making comments on or participating in the monitoring of body composition and weight.[50]

Total caloric intake should be determined by calculating BMR and the energy needs for activity. Many methods are available to determine total caloric need, including assessments of metabolic function and oxygen utilization, but equations that estimate metabolic function are more plausible options for clinicians. These metabolic estimation equations take into consideration body size, fat mass and FFM, age, sex, and the expenditure of energy for activity.[12,117] One drawback to the use of estimation formulas is that muscular tissue uses more energy than does nonmuscular tissue; therefore, estimation formulas that are not adjusted for lean muscle mass may underestimate the daily caloric needs for athletes or clients who are very muscular.

Caloric intake should be based on the body weight goal. A person should consume a total number of calories based on body composition and weight goals. Caloric intake that is too high or too low to support the desired lean body mass will negatively affect metabolic function and body composition. Metabolic function is more efficient in those with greater amounts of lean body mass. When BMR is calculated based on the body composition and weight goals, this formula provides an important estimate of the energy needed to meet activity requirements.

A safe and healthy dietary plan that supplies sufficient energy and nutrients should be maintained throughout the year. A healthy diet or meal plan provides adequate calories to achieve body weight goals, supply essential nutrients, and maintain hydration. The U.S. Department of Agriculture's Food Pyramid Guide is one method that can be used to ensure adequate nutrient intake. Athletes and clients should identify the appropriate Food Guide Pyramid (www.mypyramid.gov)[119] that describes food groups and the recommended number of daily servings per group adults and children need to consume for essential nutrients. The AT or other trained health care professional can also use the appropriate Food Guide Pyramid to calculate the recommended caloric intake level based on the individual's goal weight. The guidelines at www.mypyramid.gov are consistent with recommendations by organizations such as the American Heart Association and the American Cancer Society to control diabetes, heart disease, cancer, and other chronic and debilitating diseases.[120] Even though this method may underestimate the protein and carbohydrate needs of athletes or clients, it can be used to correctly guide a person's eating needs for vitamin and mineral intake and overall caloric intake.

The metabolic qualities of the activity should be used to calculate the need for each energy-producing nutrient in the diet. To determine specific dietary needs and adjustments, an analysis of the metabolic characteristics (eg, anaerobic or aerobic) with consideration for the performance, body composition, weight, and personal goals of the athlete or client (eg, build muscle mass, lose fat) must be performed.

Ergogenic and dietary aids should be ingested with caution and under the advice of those knowledgeable about the requirements of sports and other governing organizations. The NCAA, U.S. Olympic Committee, and International Olympic Committee regulate supplements approved for use by athletes. By-law 16.52 g of the NCAA states that an institution may provide only non–muscle-building nutritional supplements to a student-athlete at any time for the purpose of providing additional calories and electrolytes, as long as the supplements do not contain any substances banned by the NCAA.[19] Athletes and clients should be educated against taking any dietary or other nutritional supplements without first checking with the AT or another health care provider who is familiar with the competitive regulations.

Exercise. The exercise program should not only train the person for his or her activity but should also help the person maintain overall physical fitness and wellness. Body weight and composition may be maintained by pursuing an exercise regimen that matches a person's needs. The American College of Sports Medicine recommends 30 minutes of exercise, 5 days per week to remain healthy[7]; however, if the goals are to facilitate weight and body fat loss, a safe and appropriate aerobic exercise program will facilitate that loss. To maximize the metabolism of excess fat, one must participate in continuous, rhythmic aerobic exercise for a minimum of 30 minutes per exercise bout but no longer than 60 to 90 minutes, for at least 150 minutes per week.[118,119,121] Although interval exercise for 30 minutes burns the same number of calories, the metabolism of fat is less. If the person is unfit or has not exercised at this level previously, a graded-progression approach should be used to achieve the exercise goals.[14] Target heart rate for this aerobic activity must be above 50% $\dot{V}O_2max$ to initiate lipolysis, with the most efficient fat metabolism occurring between 60% and 70% $\dot{V}O_2max$ (approximately 55% to 69% of maximum heart rate).[5,118] Caution should be used in those with orthopaedic or other health conditions that may warrant changes in exercise protocols. Non–weight-bearing or limited–weight-bearing aerobic exercises are recommended for those with orthopaedic conditions.

Body composition adjustments should be gradual, with no excessive restrictions or unsafe behaviors or products. On average, weight loss goals should be approximately 1 to 2 lb (0.5 to 0.9 kg) per week but should not exceed 1.5% of body weight loss per week.[1,122] A higher rate of weight loss indicates dehydration or other restrictive or unsafe behaviors that will negatively affect performance and health. One pound (0.5 kg) of fat is equal to 3500 kilocalories of energy; therefore, increases or decreases in calories to the level needed to maintain ideal lean mass will help to achieve body fat goals. Few authors have studied plans for weight gain goals in active people, but a process similar to that for weight loss may be used. The AT should work closely with the other members of the health care team to assist in this determination.

Combining weight management and body composition goals with physical conditioning periodization goals will assist athletes and clients in reaching weight goals. Periodization involves manipulating training intensity and volume to yield specific performance outcomes. The best time for adjustments in weight and body composition is during the preparatory period, which occurs outside competition.[115] The main emphasis of the competitive period should be on performing the sport or activity with the body nearing its highest level of physical fitness. During the competitive period, less time is available for physical conditioning and more time is spent on strength, power, and increased training intensity specifically related to sport performance. During the different phases of the preparatory period, physical conditioning goals can be used to achieve body composition goals. During the hypertrophy or endurance phase, the emphasis is on developing lean body mass, aerobic capacity, and muscular endurance, which can provide a physiologic environment to assist in decreasing body fat. During the basic strength and strength-power phases, the emphasis is on developing strength and speed and involves increasing levels of anaerobic activity.[123] An AT or other trained health care professional should be consulted for assistance in manipulating these phases of the periodization plan to meet training goals.

Education on safe dietary and weight management practices should be conducted on a regular and planned basis. The AT and other health care professionals should be involved in educating athletes or clients and monitoring their diets. The initial team meeting or client interview is an opportune time to communicate information on healthy eating habits and the effect of proper nutrition and hydration on performance.

Common Unsafe Weight Management Practices

Athletes and active people regularly seek methods to maximize performance, and many of the common methods involve managing diet, weight, or body composition (or a combination of these). Although many safe methods exist to achieve goal weight or the lowest safe weight, unsafe practices involve self-deprivation techniques that lead to dehydration, self-starvation, and disordered eating. In field studies and experimental research on weight-class athletes, the most common unsafe methods are a mixture of dehydration and other methods, including food restriction or improper dieting to reduce body fat. Therefore, the results of studies examining the physiologic and performance effects of rapid weight reduction may not reflect only dehydration. Studies selected for this summary are those that focused primarily on dehydration techniques and involved short-term, rapid weight reduction.

Dehydration and Weight Management

Since the late 1930s and as recently as 2003, authors[124,125] have reported that athletes used voluntary dehydration as a method of rapid weight loss to reach a lower body weight for competition. Several rapid weight loss methods involve rapid fluid loss; these methods use active, passive, diet-induced, pharmacologic-induced, and blood reinfusion techniques to achieve a desired weight. The active method involves increasing metabolic rate through exercise to increase the rate of heat production in active skeletal muscle.[126] At least 1 L of fluid may be lost through sweat evaporation during exercise[127] when an active person abstains from drinking fluid during activity. To ensure continued sweating, exercise is often combined with excessive clothing, which diminishes the evaporative effects of sweating and increases insulation and core temperature.[128,129] At one time, dehydration was a common method used by wrestlers,[130–132] but a survey[127] indicated that this method has become less popular because of changes in the weigh-in procedures (ie, assessments of hydration status) of sport governing bodies. These active methods may be enhanced by combining the active technique with environmental changes that increase the passive sweat rate, resulting in higher levels of dehydration, or the training facility may be artificially heated to ensure a higher passive sweat rate with less physical effort.[130–134] Recent changes in sport guidelines appear to have reduced the extent to which collegiate wrestlers use passive dehydration.[125]

Athletes who use passive dehydration methods also may restrict food intake for weight loss or may purposefully consume foods that promote diuresis for fluid loss. A combined high-protein, low-carbohydrate diet may promote dehydration through several mechanisms. Meals high in protein and devoid of carbohydrate may modestly stimulate urine production. As the body is deprived of carbohydrates, fat oxidation is increased, promoting additional fluid loss in the urine. With a high protein intake, the person may further induce diuresis from the increased nitrogen metabolism and urea excreted via the kidneys.[14]

Some researchers[135] suggested that total body water is elevated with the consumption of a high-carbohydrate diet, forcing muscle glycogen to be stored along with water, which can increase body weight. As dietary carbohydrate intake is restricted, glycogen resynthesis may be limited, thereby avoiding the increase in body weight caused by water storage.[135] However, this dietary strategy does not provide optimal energy stores for a competitive athlete,[136,137] and performance may suffer.[98,138,139]

Ingesting medications that stimulate urine production (eg, diuretics) may have a greater influence on body weight than does altering the diet. Diuretics appropriately prescribed for hypertensive therapy or to reduce edema have been misused by athletes seeking rapid weight loss for competition. Fortunately, the misapplication of pharmacologic agents was uncommon in weight-class athletes who were surveyed[23,132]; however, this practice has not been fully eradicated.

Finally, one report[140] and other anecdotal stories from athletes indicate that some athletes at international competitions have had blood removed intravenously before the required weigh-in. The blood is then reinfused after the athlete "makes weight" for competition. Other than the lone report, no formal information is available about this method or the extent to which it has been practiced or is currently used.

Effects of Dehydration on Performance

Dehydration results in suboptimal performance when the dehydration is ≥1% in children and ≥2% in adults.[140,141] In children, 1% dehydration causes a reduction in aerobic performance[142] and an increase in core temperature.[143] In adults, 2% to 3% dehydration causes decreased reflex activity, maximum oxygen consumption, physical work capacity, muscle strength, and muscle endurance and impairs temperature regulation.[144,145] At 4% to 6% dehydration, further deterioration occurs in maximum oxygen consumption, physical work capacity, muscle strength, and endurance time; temperature regulation is severely impaired.[111] These physiologic effects of dehydration are discussed in depth in 2 NATA position statements[99,111] and will not be discussed further here.

Most athletes who participate in weight-class sports need short-duration, high-intensity efforts that demand rates of energy production at or above the peak oxygen uptake. For single efforts, whether performance is affected by dehydration before performance is unclear. Dehydration does not appear to reduce phosphagen energy stores (adenosine triphosphate, creatine phosphate),[137] although some of the weight reduction found in this study occurred with diet manipulation and not dehydration alone. People involved in activities that use weight manipulation to improve performance appear to be more profoundly affected by hydration status. Efforts that are sustained at intensities below peak oxygen uptake are notably affected by prior dehydration. Dehydration induced with the use of pharmacologic diuretics increases frequency of muscle twitches, a potential risk factor for muscle cramps, more so than does exercise- or sauna-induced dehydration.[132]

Dietary Caloric Restriction and Weight Management

Dietary restriction is another common method used to maintain weight. Very low-calorie diets affect the cardiovascular system and can produce myofibrillar damage, orthostatic hypotension, bradycardia, low QRS voltage, QT-interval prolongation, ventricular arrhythmias, and sudden cardiac death.[146–149] Sudden death may be caused by the ventricular arrhythmias or hypokalemia associated with caloric restriction.[14] Very low-calorie diets can also result in a marked blunting of the normal heart rate increase and blood pressure response to exercise.[149] In addition to these physiologic changes, dietary restrictions cause deficits in recall, understanding visuospatial information,[150] working-memory capacity, recall on the phonologic loop task, and simple reaction time.[151] They also affect planning time.[152]

Low-calorie diets also affect the endocrine system. Levels of growth hormone and insulin-like growth factor (IGF) binding protein 2 are increased. The growth hormone response to growth hormone–releasing hormone is increased; however, levels of IGF I and IGF binding protein 3 are decreased.[153–155] The decrease in IGF I, an anabolic factor, limits growth and muscle development.[153] With improved nutrition, growth "catchup" occurs but is inadequate; children, in particular, will never achieve their potential genetic height.[156,157] Also, lower levels of IGF I are associated with poor muscle development, and thus potential maximum strength is never realized.[153] Lower levels of IGF I are associated with lower bone mineral densities.[153] Urinary excretion of cross-links, a marker of bone absorption, is increased, and serum osteocalcin, a marker for bone formation, is lower than normal in patients with low BMIs.[154] These findings indicate that more bone is being absorbed and less bone is being produced than normal, potentially leading to osteoporosis[154] and stress fractures.

Changes in thyroid function also occur as a result of low-calorie diets. Total thyroxine (T_4) and triiodothyronine (free T_3) decrease and reverse triiodothyronine (rT_3) increases.[155] The response of thyroid-stimulating hormone (TSH) to thyrotropin-releasing hormone (TRH) is diminished,[155] and the BMR is lowered. The adrenal glands produce an increased amount of free cortisol, and serum cortisol levels are elevated, without associated changes in adrenocorticotropic hormone.[155] Gonadotropin-releasing hormone (GnRH) from the hypothalamus is reduced,[158] leading to decreased levels of luteinizing hormone (LH) and follicle-stimulating hormone (FSH) from the anterior pituitary.[159] Estrogen production is low, contributing significantly to osteoporosis[159] and menstrual dysfunction.[15]

Dietary restrictions affect the immune system by significantly impairing cell-mediated immunity, phagocyte function, the complement system, secretory immunoglobulin A levels, cytokinase production,[160–163] haptoglobin production, orosomucoid production,[164] T-lymphocyte response, and production of Th_2 cytokine; Th_1 cytokinase production increases.[162] These immunologic abnormalities may lead to an increased number of infections during the period of inadequate dietary intake.[165]

Eating Disorders, Disordered Eating, and Weight Management

Disordered eating behaviors have been identified in both male and female athletes.[131,166] A total of 10% to 15% of boys who participate in weight-sensitive sports practice unhealthy weight loss behaviors.[131,166] Eleven percent of wrestlers have been found to have eating disorders or disordered eating,[166] and up to 45% of wrestlers were at risk of developing an eating disorder.[129,167,168] Several studies[169–171] revealed a high prevalence of eating disorders in female athletes involved in weight-sensitive sports. Sixty percent of average-weight girls and 18% of underweight girls involved in swimming were attempting to lose weight.[172] Thus, both males and females may develop dysmorphia, disordered eating, and eating disorders as a consequence of their efforts to lose weight for their activities. The female athlete triad is a relationship among disordered eating, altered menstrual function, and abnormal bone mineralization.[160,173,174] Amenorrhea occurs as a result of decreased pulsatile release of GnRH from the hypothalamus,[157] which leads to fewer LH and FSH pulses from the anterior pituitary.[175] Osteoporosis can result from decreased estrogen or IGF I[153,154] and from excess cortisol production.[155]

Athletes competing in aesthetic sports had the highest indicators of eating disorders.[176] Those who participated in weight-matched sports also showed higher levels of disordered eating than did athletes in non–weight-restricted sports.[175–177] Athletes whose bodies differ from the "ideal" physique of the sport may also be at higher risk for developing disordered eating.[20] Some experts have surmised that the demands of the athletic subculture may involve inherent risk for the development of unhealthy weight control behaviors. Subclinical eating disorders in athletes have been associated with dieting to enhance appearance or improve health or dieting because someone (eg, coach, peer) recommended it.[45]

The spectrum of disordered eating behaviors ranges from the very benign and mild to the very severe.[50] In athletes, disordered eating may affect up to 62% of the population and is reportedly highest in weight-class events, such as boxing and wrestling, and aesthetic activities, such as dance and gymnastics, in which low body weight and leanness are emphasized.[178,179]

Disordered eating in the mild and earliest stages may start simply as a dietary plan to achieve a better aesthetic appearance or better performance. A common "diet" involves caloric restrictions, but when these restrictions are taken to the extreme, there is reason for concern. Often, athletes seek weight loss or dieting advice from friends or teammates or simply follow the suggestions of others without fully understanding the importance of maintaining an adequate energy balance. Other times, athletes may adhere to the recommendations made by coaches without understanding the nutritional requirements of the sport.[50] The health care team should be in place to help athletes and active clients address disordered eating behaviors and to assist in providing accurate and appropriate advice. The topics of disordered eating, eating disorders, and dysmorphia are addressed more comprehensively in the NATA position statement on disordered eating.[50]

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