



Promotion of Healthy Weight-Control Practices in Young Athletes

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Children and adolescents may participate in sports that favor a particular body type. Some sports, such as gymnastics, dance, and distance running, emphasize a slim or lean physique for aesthetic or performance reasons. Participants in weight-class sports, such as wrestling and martial arts, may attempt weight loss so they can compete at a lower weight class. Other sports, such as football and bodybuilding, highlight a muscular physique; young athletes engaged in these sports may desire to gain weight and muscle mass. This clinical report describes unhealthy methods of weight loss and gain as well as policies and approaches used to curb these practices. The report also reviews healthy strategies for weight loss and weight gain and provides recommendations for pediatricians on how to promote healthy weight control in young athletes.

Young athletes who participate in sports that favor a particular body type may express a desire to lose or gain weight. Athletes who participate in “weight-sensitive” sports, which emphasize a lean, slim physique, often seek to lose weight. In aesthetic sports, such as gymnastics, figure skating, and diving, athletes may believe they will be judged more favorably if they have a lean body build. With other sports, distance running and cycling, for example, participants with a slim physique are perceived to have a greater ability to move the body against gravity if they weigh less. Table 1 lists examples of sports that typically favor a slim/lean build. For weight-class sports, including wrestling and martial arts, athletes often desire to compete at the lowest possible weight in the belief that lighter athletes have an increased strength-to-weight ratio (Table 2).

Football and powerlifting are examples of sports that highlight a muscular physique (Table 3). Children and adolescents who participate in sports that emphasize strength and power often attempt to gain weight and lean muscle mass to improve performance. Participants in bodybuilding may seek to increase muscle mass and definition for aesthetic reasons.

In their attempts to change body weight and composition, some athletes resort to unhealthy weight-control practices.^{1–6} These unhealthy

abstract

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TABLE 1 Sports That Emphasize a Thin/Lean Physique

Dance
Cheerleading
Cross country/distance running
Cross-country skiing
Cycling
Diving
Figure skating
Gymnastics (artistic and rhythmic)
Ski jump
Swimming
Synchronized swimming

TABLE 2 Sports With Weight Classes/Weight Limits

Boxing
Crew
Horse racing—jockeys
Martial arts
Weight-class football
Wrestling

TABLE 3 Sports That Emphasize a Muscular Physique

Baseball
Basketball
Bodybuilding
Football (especially linemen)
Powerlifting
Rugby
Track (eg, shot-put, discus)

weight-control approaches may adversely affect health and, in some cases, can negatively affect performance. Pediatricians should have an awareness of safe and unsafe weight-control practices so they can counsel young athletes and family members appropriately.

The American Academy of Pediatrics (AAP) policy statement “Promotion of Healthy Weight Control in Young Athletes” was published in 1996 and updated in 2005.^{7,8} This clinical report replaces the 2005 statement and includes more recent evidence about the detrimental effects of dehydration and the benefits of gradual weight loss as compared with acute weight loss. Data on the effects of collegiate and high school rule changes are also included.

WEIGHT LOSS

Athletes may attempt to lose weight to enhance performance, to qualify for a particular weight class, or to change their appearance for a sport that emphasizes a lean physique. Weight loss becomes a problem when athletes are inadequately hydrated and/or when nutritional needs are not met. Table 4 lists healthy and unhealthy weight loss methods.

Unhealthy Weight Loss

Some weight loss methods can lead to serious physical and psychological harm. Additionally, certain weight loss practices impair athletic performance and increase injury risk. Weight loss may initially improve athletic performance because of an increase in the strength-to-weight ratio. However, continued use of

inappropriate weight loss methods can result in reduced muscle strength, reduced performance in aerobic activities, decreased mental and cognitive performance, mood changes, depression, compromised immune response, and changes in the cardiovascular, endocrine, gastrointestinal, renal, and thermoregulatory systems.^{1–3,6,9–16}

Weight Loss Attributable to Dehydration

Up to 67% of athletes involved in weight-class sports, such as wrestling, boxing, and weight-class crew, attempt to lose weight acutely with dehydration techniques.⁴ High school and college wrestlers report high rates of fasting, restricting fluid intake, and engaging in practices that increase sweating for acute weight loss.^{17,18} This process, referred to as “weight cutting,” allows competitors to weigh in at the lowest possible weight; most athletes subsequently attempt to regain weight by rehydrating between the weigh-in and competition. The term hypohydration refers to the state of suboptimal hydration, and dehydration describes the transition from a well-hydrated to a hypohydrated state.¹⁹ Examples of dehydration techniques include fluid restriction, spitting, vomiting, steam baths, saunas, using laxatives or diuretics, and wearing nonporous

TABLE 4 Unhealthy and Healthy Weight Loss Methods

Unhealthy Weight Loss	Healthy Weight Loss
Rapid weight loss	Gradual weight loss
Loss of >2 lb/wk	Loss of no more than 1 lb/wk in growing athlete with excess body fat, 2 lb/wk in mature athlete
Muscle mass is lost	Weight lost is excess body fat, not muscle mass
Stimulant use to promote weight loss	Exercise an appropriate amount for the sport
Exercise in excess of what is recommended for sport	Diet is well-balanced and consists of ~6–10 g/kg per d of carbohydrates, 0.85–1.7 g/kg per d of protein, and 1 g/kg per d of fat
Laxative use	Maintain euhydration
Diet pill use	Preferable to lose weight in off-season
Vomiting	Caloric intake meets the energy costs of living, growth, and sport activities
Voluntary dehydration	
Fluid restriction	
Diuretic use	
Spitting	
Enhanced sweat production	
Steam baths, saunas	
Exercise in nonpermeable clothing	

suits to increase sweat production. Using these tactics over the course of several days can lead to progressive dehydration because many athletes fail to fully rehydrate each day.^{20–24} After 2 to 3 days of dehydration, replacement of intracellular fluids takes 48 hours.²⁵

Athletes and coaches in weight-class sports often harbor a belief that weighing in at the lowest possible weight will maximize strength-to-weight ratio and increase an athlete’s competitive advantage.^{4,6} However, inadequate hydration has been shown to decrease athletic performance; aerobic function is impaired more than anaerobic performance.^{26–32} Poor hydration status leads to decreased strength, power, and endurance with high-intensity exercise.^{30,32–34} Dehydration results in increased body temperature and raises susceptibility to heat illness. The effects of hypohydration on thermoregulation is addressed in the AAP policy statement “Climactic Heat Stress and Exercising Children and Adolescents.”²⁰

Dehydrated athletes often experience mental status and cognitive changes (Table 5). Poor hydration status is also associated with impaired performance on the Sports Concussion Assessment Tool, an instrument used to assess mental status and symptoms after concussion.^{35–37} Although most studies on the effects of hydration on performance have included only adult participants, dehydration is also detrimental to aerobic performance and skill-based activities in elite child athletes.^{38,39}

National Sport Governing Bodies Address Rapid Weight Loss Attributable to Dehydration and/or Hypohydration

In 1997, over the course of 33 days, 3 college wrestlers died as a result of attempting drastic weight loss before competition.⁴⁰ In response to

TABLE 5 Mental and Cognitive Changes Attributable to Hypohydration/Dehydration

Decreased psychomotor function
Decreased reaction time
Decreased accuracy
Decreased mental endurance
Decreased alertness
Increased problem-solving time
Increased fatigue
Increased levels of perceived exertion
Temporary learning deficits
Mood swings
Changes in cognitive state

Adapted from Weber AF, Mihalik JP, Register-Mihalik JK, Mays S, Prentice WE, Guskiewicz KM. Dehydration and performance on clinical concussion measures in collegiate wrestlers. *J Athl Train*. 2013;48(2):153–160, Petri NM, Dropulic N, Kardum G. Effects of voluntary fluid intake deprivation on mental and psychomotor performance. *Croat Med J*. 2006;47(6):855–861, and Derave W, De Clercq D, Bouckaert J, Pannier JL. The influence of exercise and dehydration on postural stability. *Ergonomics*. 1998;41(6):782–789.

these deaths, the National Collegiate Athletic Association (NCAA) instituted new rules designed to curb the practice of acute weight loss; the rules were implemented in 1998 and updated in the 2003–2004 and 2013–2014 rule books.⁴¹ The updated NCAA rules banned the use of diuretics, impermeable suits, and saunas for weight loss and decreased the amount of time between weigh-ins and competition. Additionally, the NCAA established a system of setting a minimum weight for competition during the wrestling season by using a calculation that incorporates hydration status (based on urinespecific gravity), weight, and body composition. Before the competition season, athletes submit a urine sample from a witnessed collection for testing. If the urinespecific gravity is 1.020 or less, the athlete is considered well hydrated and can weigh in. Body fat

is measured by using 1 of 3 methods: skin fold caliper measurement by a trained evaluator, hydrostatic (underwater) weighing, or air displacement plethysmography (commonly performed by using a Bod Pod device). Body fat and weight are entered into an online optimal performance calculator and are used to calculate the lowest allowable weight (LAW) by using 2 different methods. The LAW1 formula incorporates the minimum body fat of 5% allowed by the NCAA. The LAW2 accounts for the 1.5% body weight loss per week permitted during the season. The highest of these calculated weights is the lowest weight allowed for competition during the wrestling season.^{41,42} Table 6 provides a list of the variables and the equations used in the calculation of LAW1 and LAW2 for reference.

In the high school wrestling arena, the Wisconsin Interscholastic Athletic Association was the first state high school athletic association to implement a plan to curtail weight cutting among high school wrestlers.⁴³ The National Federation of State High School Associations adopted guidelines that apply to high schools in all states in 2006. High school wrestlers must have a urinespecific gravity of 1.025 or less for their preseason weigh-in. Minimum body fat during the wrestling season is set at 7% for boys and 12% for girls. As with NCAA athletes, high school wrestlers may lose no more than 1.5% of body weight per week. Additionally, there is a 2-lb growth allowance for each weight class per season.

TABLE 6 LAW1 and LAW2 Calculations

Variables	Formulas
bf%	LAW1 = FFW/0.95
wt	LAW2 = wt – (1.5% × #wk × wt)
FW = wt × bf%	
Fat-free weight (FFW) = wt – (wt × bf%)	
No. weeks in season (#wk)	

bf%, body fat percentage; FFW, fat-free weight; FW, fat weight; #wk, number of weeks in season.

High schools are permitted to use bioelectrical impedance analysis as an alternative to skin fold caliper and air displacement options to determine body fat percentage.⁴⁴ Some individual states have adopted stricter policies and require a urinespecific gravity of 1.020 or lower before weigh-ins.^{45,46}

The establishment of minimum competition weight rules has led to a decrease in the practice of rapid weight loss before competition.^{47,48} However, the urinespecific gravity measurements of 1.020 and 1.025 required by the NCAA and National Federation of State High School Associations for weigh-ins, respectively, do not correspond with ideal hydration status. An optimally hydrated athlete should have a urinespecific gravity of ~ 1.010 and a urine osmolality of 300 mOsm/L.⁴⁹ Some athletes may use diuretics to produce dilute urine. Additionally, consuming a large quantity of plain water over a short period of time leads to lower serum osmolality and increased urine output and dilution.^{50,51} This practice may result in a low urinespecific gravity test result in a dehydrated athlete.

There is no agreed-on gold standard for the assessment of body composition. Skinfold measurement is an inexpensive, well-validated method that is commonly used in the high school and collegiate setting to determine body composition. However, skinfold measurement requires trained personnel and may not be as accurate for individuals with obesity.^{28,29,52} In addition, there are racial and ethnic differences in the location of body mass storage and fat deposition that affect skin fold measurements.^{53,54} Hydrostatic (underwater) weight and air displacement plethysmography are simple to perform but require expensive equipment; both methods may underestimate body fat percentage in extremely lean athletes. High schools are allowed to

use bioelectrical impedance analysis to measure body fat percentage; this technique is less accurate than others, and hydration status can affect the results.^{52,55} Dual-energy radiograph absorptiometry (DXA) is accurate, noninvasive, and easy to perform; but DXA scanning involves a small amount of radiation exposure, and athletes over 192 cm (73.5 in) may not fit into standard scanners.⁵² The most precise way to determine body composition is by using several different methods (a multicomponent model), such as skinfold measurements, DXA, and waist circumference measurements.^{27,56} However, the multicomponent method is rarely feasible in the clinical setting. Body composition is most accurately calculated with serial measurements that use the same assessment technique performed by an experienced health care provider, such as an exercise physiologist, athletic trainer, registered dietitian nutritionist (RDN), or sports medicine physician.⁵²

Changing the timing of precompetition weigh-ins to immediately before matches has been proposed as a means of decreasing the incentive to cut weight.⁴ Using a random draw to determine the order in which athletes of different weight classes compete could also spur athletes to avoid purposeful dehydration before sport participation.⁴²

Unhealthy Weight Loss Attributable to Inadequate Energy (Caloric) Availability

Many athletes attempt to lose weight by restricting energy (caloric) intake. Athletes typically need a greater caloric intake than nonathletes.^{9,27,57} The actual energy requirement depends on the athlete's body composition, weight, height, age, stage of growth, and level of fitness, as well as the intensity, frequency, and duration of exercise activity.^{9,57} Athletes need to eat enough to cover the energy costs of daily living,

growth, remodeling bone, building and repairing muscle tissue, and participating in sports.^{9,57,58}

Unhealthy weight loss behaviors occur along a continuum. At one end of the spectrum are individuals with a mild energy imbalance: caloric intake is not sufficient to cover the body's energy requirements. At the other end of the spectrum are athletes engaging in dangerous weight loss practices that carry a high risk of associated morbidity and mortality; this extreme includes children and adolescents with frank eating disorders, such as anorexia nervosa and bulimia nervosa.^{17,59–63} In addition to fasting or restricting calories, risky weight loss practices include vomiting after eating, performing excessive exercise, and the use of diuretic, laxative, or stimulant medications. Persistent weight loss via unhealthy behaviors may result in delayed physical maturation, growth impairment, and the development of eating disorders.^{2,3,11–16}

The "female athlete triad" (triad) is a term that describes the combination of low energy availability, menstrual dysfunction, and low bone mineral density. When first described, the 3 facets of the triad included disordered eating, amenorrhea, and osteoporosis.⁶⁴ The definition was subsequently altered to reflect the spectrum of low energy availability and its consequences in female athletes.^{63,65} Low energy availability refers to an imbalance between caloric intake and energy expenditure. A small body of research supports the concept that male athletes also appear to be susceptible to inadequate energy availability and may experience adverse health consequences as a result.^{66,67}

A survey of female high school athletes revealed that one third had disordered eating; disordered eating was correlated with an increased risk of musculoskeletal injury.⁶⁸

Menstrual irregularities and low bone mineral density, also features of the female athlete triad, have been associated with higher injury risk.⁶⁹ The AAP statement “The Female Athlete Triad” provides an in-depth review of energy deficiency and eating disorders in female athletes.⁷⁰

Although female athletes have the highest rates of eating disorders, male athletes are also at risk. In a study of 677 elite adolescent athletes, female athletes exhibited higher rates of eating disorders than male athletes (14% vs 3.2%), and both groups had a greater risk than their nonathlete peers (5.1% of female controls and 0% of male controls).⁷¹ Male elite athletes in weight-class sports demonstrated higher rates of subclinical and clinical eating disorders than athletes participating in endurance sports or ball game sports, such as handball, soccer, and volleyball (18% for weight-class athletes vs 9% and 5% for endurance and ball game athletes, respectively). In the same study, 42% of female athletes involved in aesthetic sports, such as gymnastics, met the criteria for an eating disorder as compared with 30% of females in weight-class sports and 16% involved in ball game sports.⁷² Male collegiate athletes in weight-control sports have high rates of subclinical eating disorders (16%) and high rates of pathologic weight-control practices, including binge eating, fasting, and strict dieting.⁷³

Screening, Prevention, and Treatment of Unhealthy Weight Loss Attributable to Inadequate Energy Availability

The AAP *Preparticipation Physical Examination* monograph contains a history form for use during preparticipation evaluation. This form is available on the AAP Web site (<https://www.aap.org/en-us/about-the-aap/Committees-Councils-Sections/Council-on-sports-medicine-and-fitness/Pages/PPE.aspx>) and includes questions designed to screen for disordered

eating and menstrual irregularities.^{74,75} Weight, height, and BMI can also be plotted on a growth chart at each office visit, and abnormal trends can be identified. BMI less than the fifth percentile, BMI less than 17.5 in a skeletally mature adolescent, or weight less than 85% of expected body weight would warrant further evaluation for unhealthy weight loss behavior.^{16,63}

Education of athletes, parents, and coaches about unhealthy weight loss behaviors and their negative impact on health and athletic performance is important to prevent adverse health effects. For non-weight-class sports, coaches should promote healthy eating habits and be alert to unhealthy eating habits in their athletes. Coaches of weight-class sports should discourage unhealthy weight-control methods and encourage athletes to compete at a weight that is appropriate for their age, height, physique, and stage of growth and development. Many coaches inappropriately focus on weight instead of performance. In addition, coaches generally do not have an adequate nutritional background to counsel an athlete about weight loss. Coaches' discussions of weight loss with athletes may increase the risk of harmful weight loss practices.^{76,77}

Athletes should focus on optimizing energy availability for maximizing performance and good health. Female athletes with menstrual dysfunction require an evaluation to determine the underlying etiology. If low energy availability is the cause, increasing energy intake will generally lead to resumption of normal menses.^{65,70} If an eating disorder is suspected, referral to a multidisciplinary team of experts in this field, including a physician, RDN, and mental health provider, is appropriate. Referral to an RDN may be of benefit to assist athletes with a well-designed, healthy weight loss program or to provide guidance on increasing caloric

intake, when appropriate. The AAP clinical report, “Identification and Management of Eating Disorders in Children and Adolescents,” discusses the diagnosis and treatment of eating disorders in the pediatric population.¹⁶ Recommendations have also been published on return-to-play criteria in female athletes with disordered eating, menstrual dysfunction, and decreased bone mineral density.^{61,63}

Healthy Weight Loss in the Athlete Classified as Having Overweight or Obesity

The AAP has published clinical reports that outline guidance for the prevention and treatment of obesity for all children and adolescents.^{78,79} These AAP recommendations emphasize adherence to physical activity recommendations, healthy diet, and limits on screen time. For most children and adolescents, the goal of weight management should be to keep BMI below the 85th percentile. Recommendations for weight maintenance and weight loss are based on the degree of obesity.⁷⁸

Excessive body fat may interfere with acclimation to heat and negatively affect speed, endurance, and work efficiency.^{6,9,27} Young athletes who are not classified as having obesity may strive to lose weight or increase lean body mass to improve sports performance. Because weight is not an accurate indicator of body fat, lean muscle mass, or performance, athletes should focus on maintaining lean muscle mass.^{27,57} Skeletally immature athletes should not be encouraged to lose weight to improve athletic performance. An imbalance between energy intake and energy expenditure can result in the loss of lean muscle mass, which can negatively affect performance.^{9,27,57} Changes in weight and body composition should be achieved gradually, by using sensible methods aimed at long-term change. Athletes should avoid cyclic weight fluctuations. Once desired

body composition and weight are achieved, dietary, exercise and lifestyle behaviors should focus on maintenance, with allowances for growth.

Gradual weight loss appears to confer greater performance benefits than rapid weight loss. A study of athletes engaged in strength training demonstrated that weight reduction of 0.7% of body weight per week results in increased lean body mass and strength when compared with rapid weight reduction of 1.4% body weight per week.⁷⁷ It has been recommended that growing athletes with excess body fat lose no more than 1 lb per week, and athletes who are mature can lose up to 2 lb per week.^{27,57}

Adult athletes generally require a minimum of 2000 kcal per day, but this can vary widely depending on sex and level of activity.⁸⁰ Caloric requirements for active children and adolescents differ depending on age and stage of growth; caloric requirements peak in adolescence and early adulthood. Type and intensity of physical activity will also influence caloric needs. The US Department of Agriculture provides an online interactive tool for health care providers to calculate an individual's caloric needs on the basis of sex, age, and activity level (<https://fnic.nal.usda.gov/fnic/interactiveDRI/>).

Approximately 55% to 65% of energy (calories), or 6 to 10 g/kg per day, should be from carbohydrates; 15% to 20%, or 0.85 to 1.7 g/kg per day, should be from protein, and 20% to 35%, or 1 g/kg per day, should be from fat.^{9,27,57} The diet should be well balanced and consist of a variety of foods. Young athletes attempting to lose weight may benefit from the guidance of a RDN with sports nutrition experience.⁸¹

WEIGHT GAIN

Athletes involved in sports such as football, rugby, power lifting,

TABLE 7 Unhealthy and Healthy Methods of Weight Gain

Unhealthy Weight Gain	Healthy Weight Gain
Rapid weight gain	Gradual weight gain
Weight gain resulting in excess body fat	Weight gain as muscle mass
Use of anabolic compounds	Boys gain up to 0.5–1.0 lb/wk
Use of supplements	Girls gain up to 0.25–0.75 lb/wk
“Weight gainers,” which contain an overabundance of calories and/or protein	Gain up to one’s genetic potential
	If maintaining body weight and eating RDA of protein:
	1. Consume 300–500 kcal/d above baseline intake;
	2. Consume extra 14 g of protein/d (or 1.5–1.8 g protein/kg/d);
	3. Strength train; and
	4. Get adequate sleep.

RDA, recommended daily allowance.

and bodybuilding may desire to gain weight and lean muscle mass to improve power and strength or to achieve a muscular physique. Preadolescent and adolescent athletes who want to gain weight may require guidance about appropriate, healthy strategies for achieving their goals. Table 7 lists healthy and unhealthy methods of weight gain.

Unhealthy Weight Gain

Increasing caloric intake in the form of food consumption or use of dietary supplements may lead to excessive fat accumulation rather than the desired increase in lean muscle mass.⁵⁷ Excess body fat can have a negative effect on overall health and athletic performance.²⁷ Often, athletes use over-the-counter dietary supplements to increase lean body mass. Supplement manufacturers are not required to prove safety before bringing their products to the market. Many supplements, even those sold by national retailers, contain unlisted, potentially harmful ingredients.⁸² In 1 analysis, 20% of drug-related liver injuries resulting in hospitalization were associated with use of dietary supplements.⁸³ Young athletes may use illegal and dangerous medications to gain weight and increase muscle mass. Adolescent males who perceive themselves as under- or overweight are nearly 4

times more likely to use anabolic steroids to attempt to change body composition as compared with those who perceive themselves as being at an appropriate weight.⁸⁴ The AAP policy statement “Use of Performance-Enhancing Substances” reviews the risks of supplements and drugs used for weight gain in detail; Table 8 provides a summary of performance-enhancing substances and their effects adapted from this statement.⁸⁵

Healthy Weight Gain

Young athletes in sports in which a muscular physique is valued for aesthetic or performance reasons may seek to gain weight and increase lean body mass through a combination of increased caloric intake and strength training. An athlete's stage of development, genetic factors, type of training, diet, and motivation are all factors that influence weight gain and muscle development.^{57,83,86,87}

Female athletes and prepubertal male athletes typically increase strength with a weight-training program but generally do not have sufficient circulating androgens to increase muscle bulk considerably.⁸⁸ Athletes with a slender body build (ectomorphs) will have more difficulty increasing muscle mass

TABLE 8 Summary of Performance-Enhancing Substances Commonly Used by Athletes With Effects on Performance and Possible Adverse Effects

Substance	Usual Form of Intake	Purported Mechanism of Performance Effect	Data on Performance Effects	Potential Adverse Effects
Creatine	Creatine is found in meat and fish. About 3–5 g/kg uncooked meat or fish. Cooking can degrade some creatine in food. Generally about 1 g/d found in omnivore diet	Delays onset of muscle fatigue during high-intensity training by adenosine triphosphate production in high intensity activities that rely upon phosphocreatine shuttle	Performance benefit in most studies is small and primarily seen in short-duration, maximum-intensity resistance training. ³⁴ No benefit generally shown in aerobic activities or with “on-field” athletic performance	Short-term use at usual doses appears safe in normal adults, but has not been evaluated specifically in the pediatric population. Most concern with impact on kidneys because of nephrotic metabolites (methylamine and formaldehyde), and specific recommendation against use for athletes at risk for kidney dysfunction. ³⁵ May impair performance in endurance activities. Causes water retention.
Anabolic agents	Orally ingested creatine monohydrate supplement Variety of testosterone derivatives. Schedule III drugs. Oral, injectable, buccal, and transdermal forms. Multiple forms often taken in “stacks” in 6- to 12-wk cycles	Enhances net protein synthesis by increasing transcription and decreasing catabolism	Increased strength and lean muscle mass athletic performance	Possible long-term effects on brain remodeling with adolescent AAS exposure. Premature physal closure with decreased final adult height. Acne. Gynecomastia (irreversible). Hair loss/male pattern baldness (irreversible). Hypogonadism. Dependence. Behavior change (hypomania, irritability, aggression). Cardiomyopathy. Increased low-density lipoproteins/decreased high-density lipoproteins. Cholestatic jaundice. liver tumors.
Prohormones	Variety of substances often taken in combination (“stacks”) and in cyclical fashion All except for DHEA are now scheduled drugs as a result of the Anabolic Control Act of 2005 and Designer Anabolic Steroid Act of 2014	Purported to enhance testosterone concentrations after ingestion as well as potential direct anabolic effects	Androstenedione and DHEA: repeated dosages do not appear to increase blood testosterone concentrations or increase muscle size or strength ³⁶	Suppression of endogenous testosterone production, otherwise potentially same for testosterone as listed above. ³⁷ Supplements contaminated with prohormones are a common cause of doping violations in organized sports. ³⁶
Caffeine/other stimulants	Caffeine is ubiquitous in a variety of food and beverages, as well as over-the-counter diet pills and “stay awake” medication Amphetamines often are diverted from prescription use	Currently believed that performance benefit primarily due to central nervous system stimulation and enhanced muscle activation	Most studies with caffeine have examined 3–6 mg/kg, but 1–3 mg/kg has been shown to have performance-enhancing effects, particularly in endurance activity ⁴¹ This includes 4% improvements in strength of knee extensors (note: other muscle groups did not show strength improvements with caffeine); 14% in muscular endurance; and 10%–20% improvements in time to exhaustion studies	Tolerance. Cardiac arrhythmias (premature ventricular contractions) increased blood pressure. Headaches, irritability, sleep disruption, tremor. Gastric irritation. Increased core temperature with exertion, particularly in hot environments. Significant toxicity has been associated with ingestion of multiple energy drinks, leading to almost 1500 emergency department visits in 2011 in the 12- to 17-y age group. ⁴² Increased availability of pure powdered caffeine is of particular concern and is responsible for at least 2 deaths in young people (1 teaspoon is equivalent to 25 cups of coffee) (FDA warning).

TABLE 8 Continued

Substance	Usual Form of Intake	Purported Mechanism of Performance Effect	Data on Performance Effects	Potential Adverse Effects
Protein supplements	Variety of powders/bars/shakes	Provides "building blocks" for muscle and lean tissue growth	No performance benefit if diet provides adequate protein	Contamination. Increased risk of liver disease. ⁸⁵
Amino acids and related compounds	Oral supplements. Individual amino acids or in combination	Arginine and citrulline produce increases in nitric oxide (see below for further discussion). β -alanine and carnosine buffer H+ accumulation (see buffer discussion below). HMB is believed to enhance repair of damaged muscle tissue	HMB: meta-analysis of studies on young adults show untrained athletes with 6.6% gains in strength, but only trivial strength impacts in trained athletes ⁴³ Study on elite adolescent volleyball players anaerobic power: HMB 11% improvement vs 4% with placebo ⁴⁴	Ingestion of single amino acids may result in imbalance of others. Short-term ingestion of HMB appears safe at 6 g/d. ⁴⁵
Human growth hormone/insulin-like growth factor 1 (IGF-1)	Injectable recombinant hGH or IGF-1	hGH acts primarily through IGF-1, resulting in increases in lean mass, decreases in fat mass ⁴⁶	Most recent reviews do not support performance benefit ⁴⁶	Elevated plasma glucose/insulin resistance, sodium retention and edema, myalgia/arthralgia, benign intracranial hypertension, acromegaly, cardiovascular disease, gynecomastia. ⁴⁷
Nitric oxide boosters (arginine, beetroot juice, citrulline)	Oral supplements and high nitrate-containing foods (beets most commonly studied, but also found in lettuce, spinach, radish, celery)	Nitric oxide is a potent vasodilator. Synthesized from arginine via reduction to nitrate. Citrulline is an arginine precursor	Any potential benefit of arginine appears minimal in healthy young athletes who ingest sufficient protein. ³⁷ Results are mixed regarding potential benefit of high nitrate-containing foods on athletic performance. ^{48, 49} Study on junior rowers with 1.7% improvement in rowing time after repeat 500-m efforts ⁵⁰	Supplementation with the amino acid arginine may create imbalance between other amino acids. Inorganic forms of nitrate are associated with carcinogenesis, however, current data does not support restriction of vegetable source of nitrates. ⁴⁹
Buffers	Sodium bicarbonate or sodium citrate. Carnosine and β -alanine	Buffers the metabolic acidosis resulting from high-intensity physical activity. β -alanine is a precursor of carnosine	Data are variable regarding endurance exercise. ⁵¹ Studies in adolescent swimmers with sodium bicarbonate show some swimmers with ~1-s improvement in 200-m efforts. ⁵² Meta-analysis β -alanine with 2.85% median improvement in exercise lasting longer than 60 s. No benefit to exercise of shorter duration. ⁵³	Sodium bicarbonate with significant gastric upset in about 10%. β -alanine with paresthesias at higher doses. ⁵¹

Modified from LaBotz M, Griesemer BA, Council on Sports Medicine and Fitness. AAP Clinical Report: Use of Performance Enhancing Substances. *Pediatrics*. 2016;138(1):e20161500. AAS, anabolic-androgenic steroid; DHEA, dehydroepiandrosterone; hGH, human growth hormone; HMB, hydroxymethyl butyrate; IGF-1, insulin-like growth factor 1; —, not applicable.

than athletes with a solid body build (mesomorphs).^{27,87}

To increase muscle mass, athletes must consume sufficient calories and include adequate proteins, carbohydrates, and fats.^{57,86,87} Weight gain needs to be gradual; gain in excess of 2 lb per week may result in increased body fat.^{27,57,87}

A male athlete could expect to gain 0.5 lb to 1.0 lb of lean mass per week, and a female could expect to gain 0.25 lb to 0.75 lb of lean mass per week. Increased energy intake should always be combined with strength training to induce muscle growth. Children and adolescents who wish to engage in strength training should begin by learning proper technique without resistance. Weight loads should be increased gradually; programs should incorporate 2 to 3 sets of 8 to 15 repetitions with the athlete maintaining proper technique. Although weight-training programs for children and adolescents have health and athletic performance benefits, the AAP recommends that skeletally immature children and adolescents avoid power lifting, bodybuilding, and maximal lifts.⁸⁸ Referral to an RDN may be helpful for athletes attempting to gain weight and increase lean body mass, particularly for those who have not been successful despite a seemingly appropriate strength-training program, adequate rest, and a nutritionally sound diet.

WEIGHT, BMI, AND BODY COMPOSITION MEASUREMENTS

Optimal weight, BMI, and body composition measures for athletic performance have yet to be determined, and sports performance measures may be the best indicator for an athlete's optimal body composition and weight at his or her developmental stage. BMI, defined

as weight in kilograms divided by height in meters squared,² is a commonly applied screening tool used as a measure to assess general health. BMI values between the 5th and 85th percentile for age are considered normal. The Centers for Disease Control and Prevention has published BMI charts that categorize BMIs on the basis of sex and age.⁸⁹ Although BMI is easy to measure in the clinical setting, abnormal values should be interpreted with caution. Approximately one-third of adults classified as having obesity on the basis of BMI measurement have good cardiac and metabolic health on the basis of other variables, such as blood pressure, cholesterol concentrations, and insulin resistance.⁹⁰ BMI is a measure of weight relative to height but reveals nothing about body composition.²⁷ Athletes, particularly those with a muscular build, are especially vulnerable to being misclassified as having obesity on the basis of BMI data because increased lean body mass increases BMI values. An increased torso-to-leg ratio also results in increased BMI. In adolescents, increased weight gain and increased height velocity during puberty may not coincide, resulting in temporary elevation or depression of BMI.⁹¹ In addition, BMI values in adolescents with eating disorders (or underweight adolescents) can result in an underestimation of the degree of malnutrition.⁹²

Although there are normative data for body fat percentage, there are no established recommendations regarding body composition in children and adolescents.⁹³ Body fat percentage varies by age. The average body fat in healthy adolescents without obesity ranges from ~16% to 18% for males and ~25% to 28% for females.^{57,94} The NCAA minimum allowable body fat percentage is 5% for male wrestlers. The minimum body fat percentage recommended by the National Federation of State High School Associations is 7% for

male wrestlers and 12% for female wrestlers. These minimums are well under the fifth percentile for body fat observed in the general adolescent population. Rather than suggesting a specific percentage of body fat for an individual athlete, a range of values that is realistic and appropriate should be recommended.⁹⁴

GUIDANCE FOR THE CLINICIAN

1. Physicians who care for young athletes are encouraged to have an understanding of healthy and unhealthy weight-control methods;
2. Health supervision visits for young athletes generally include history-taking to ascertain diet and physical activity patterns. When discussing diet and exercise, physicians can encourage parents of young athletes to place nutritional needs for growth and development above athletic considerations. Acute weight loss through dehydration and the use of potentially harmful medications and supplements for weight control should be strongly discouraged;
3. Physicians should counsel young athletes who express a desire to gain or lose weight to avoid weight-control methods that may have adverse health effects, such as acute weight loss through dehydration and the use of potentially harmful medications and supplements. Many of these methods may have a negative effect on performance as well;
4. Some states require a specific form for sports preparticipation examinations. For physicians in states without a specific requirement, the *AAP Preparticipation Physical Examination* monograph contains a standardized history-taking form that may be helpful for

screening athletes. This form is also available on the AAP Web site and includes questions designed to screen for disordered eating and menstrual irregularities.⁷⁵ When appropriate, pediatricians should advocate for the use of this form as the preferred tool for the preparticipation evaluation at the state and local level;

5. Physicians are encouraged to engage the services of RDNs familiar with athletes to help with complex weight-control issues, if these providers are available in their communities. Monitoring athletes with weight-control issues every 1 to 3 months can aid the physician in detecting excessive weight loss;
6. There are no established recommendations for body fat percentages in adolescent athletes. Rather than suggesting a specific percentage of body fat for an individual athlete, a range of values that is realistic and appropriate should be recommended;
7. Physicians should counsel young athletes that weight gain or

weight loss regimens should be initiated early enough to permit gradual weight change before a sport season. Slow weight gain, in combination with strength training, will decrease gain of body fat. Slow weight loss in the athlete with excess body fat will decrease loss of muscle mass. A well-balanced diet is recommended for all athletes. Once the desired weight is obtained, the athlete should attempt to maintain a constant weight; and

8. When opportunities for community education arise, pediatricians should collaborate with coaches and certified athletic trainers to encourage healthy eating and exercise habits.

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ABBREVIATIONS

AAP: American Academy of Pediatrics
DXA: dual-energy radiograph absorptiometry
LAW: lowest allowable weight
NCAA: National Collegiate Athletic Association
RDN: registered dietitian nutritionist

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