

SPORTS NUTRITION

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BACKGROUND

The term *youth sports* in American culture has been applied to various athletic programs that provide a systematic sequence of practices and contests for children and youth. In reality, these sports experiences differ greatly in competitive level, length of season, cost to competitors, qualifications of coaches and officials, and skill levels of athletes. It is estimated that at least 38 million children and youth participate in organized sports programs in the US each year.¹ The Surgeon General's Report on Physical Activity and Health² clearly documents the benefits of regular physical activity to health of adults and adolescents. Because sports participation is a major type of activity in which youth are involved, it can be considered a viable method of promoting good health. Sports that are considered "lifetime" activities are especially important in meeting the nation's health objectives.

In 1997, the Centers for Disease Control and Prevention (CDC) published "Guidelines for School and Community Programs to Promote Lifelong Physical Activity Among Young People."³ The guidelines identify the benefits of regular physical activity in adolescence and include the following recommendations:

- Improves strength and endurance.
- Helps build healthy bones and muscles.
- Helps control weight.
- Reduces anxiety and stress.
- Increases self-esteem.
- May improve blood pressure and cholesterol levels.

POTENTIAL CONCERNS

Although the benefits of participating in physical activity greatly outweigh the risks, there are some health issues that must be considered. Athletes, at all levels of competition, often search for a nutritional edge in hopes of improving performance. The vast majority of coaches, estimated to be as high as 90%, have no formal education in nutritional needs of athletes.⁴ Misinformation, as well as heavy marketing by supplement manufacturers, often cause coaches and parents to recommend unhealthy and potentially dangerous nutritional practices. Of major concern for the female athlete are the relationships among unhealthy eating behaviors (disordered eating), amenorrhea (absence of menstruation), and osteoporosis, known as the Female Athlete Triad.^{5,6} Other concerns include inappropriate and often dangerous methods used to control weight in sports where weight class and appearance are important (e.g., wrestling, gymnastics, dancing).

SCREENING AND ASSESSMENT

Assessing Physical Growth

Sports participation places increased energy demands on adolescents. In order to assure that adolescents are growing appropriately it is important to periodically assess their physical growth. Height and weight measurements can be used to indicate nutrition and growth status. The following parameters provide an overall assessment.

Weight and Height for Age

Changes in weight reflect short-term nutrient intake and serve as a general indicator of nutrition status and overall health. Over time, plotting height-for-age on the CDC growth charts⁷ provides an index of previous nutrition and growth. Since a reduction in height velocity is slower to develop in the presence of under-nutrition, it can be used as an index of chronic malnutrition.⁸ Decreasing percentiles is a sign of decreased growth velocity.

Weight/Height and Body Mass Index (BMI)

Assessment of weight in relationship to height, using Centers for Disease Control BMI growth charts,⁷ enables assessment of current nutritional status. BMI is a more sensitive index of appropriate growth than weight-for-age, since appropriateness of body weight is more dependent on body size than age. For optimal performance, BMIs should be between the 10th and 85th percentiles. However, some adolescents have a high BMI because of a large, lean body mass resulting from physical activity, high muscularity, or frame size. An elevated triceps skinfold can differentiate excess body fat from lean body mass in adolescents.

Assessing Nutritional Quality of the Athlete's Diet

Proper nutrition is one factor that can contribute to making sports a positive experience for adolescents. If adolescents are well hydrated and adequately fueled, they will get more out of practice and other daily physical activities than if they are not nutritionally prepared.⁹

A dietary assessment should ensure the following:

- Adequate energy intake to support normal growth and development and physical activity
- Adequate carbohydrate intake to promote glycogen storage
- Adequate protein intake for growth, but not excessive intake that may increase the risk of dehydration or renal stress
- Adequate fluid intake to prevent dehydration and promote optimal endurance
- Adequate, but not excessive fat intake
- Variety of fruits and vegetables to provide adequate vitamin and minerals needed for growth and performance (e.g., iron, B vitamins)
- Variety of calcium and vitamin D sources to promote peak bone mineralization

NUTRITIONAL NEEDS

Many factors may affect a young athletes' food intake, including socioeconomic status, the individual responsible for food purchase and preparation, access to sufficient calories, intentional weight loss and body image disturbance, peer pressure, and health problems.⁸

Energy

Athletes must consume adequate calories for growth and physical activity. Stage of development is a more critical determinant of energy needs than age. Although the exact energy needs of young athletes have not been determined, on average active teenagers may require 1,500-2000 kcal/day more energy than the Recommended Dietary Intake (RDA) (Chapter 4). To meet the nutritional needs for physical activity and health, the training diet should provide about 55% of total energy from carbohydrates, 12-15% from protein, and 25-30% from fat.

Carbohydrates

Carbohydrates (CHO) are the most efficient fuel for athletic performance. Because energy from carbohydrate sources can be released within exercising muscles up to three times faster than energy from fat, carbohydrate is the preferred fuel for working muscles. Carbohydrate is used for immediate energy by being converted to glucose, which is circulated in the blood. However only a limited amount of carbohydrate can be stored as glycogen in the liver and in muscles. Once used, glycogen must be replaced or the athlete will have less energy for endurance.

The body uses carbohydrate mainly to provide energy for muscles to do work. How much and what type of fuel (glycogen or fat) is used depends on how intense the activity and how long the period of exercise.¹⁰ Glucose converted from glycogen in the muscles is used for brief, intense exercise, such as sprinting or jumping, as well as for intermittent sports, such as basketball, football or volleyball. Endurance sports such as long-distance running or cycling use glycogen stores initially and then turn to body fat for energy.¹¹ Exercise must be performed for 30-40 minutes before fatty acids are available for energy. As the intensity of the exercise increases, working muscles have less oxygen available to them, and fat cannot be used as fuel. As the intensity decreases the body is able to use more fat stores for energy and spare the glycogen.¹²

Carbohydrate needs are also based on body weight and level of intensity of activity. Often counting carbohydrates is easier for athletes to understand than percentage of calories from carbohydrate, protein, and fat. Table 1 provides daily ranges for carbohydrate based on weight and level of intensity.

TABLE 1
Daily Ranges for Carbohydrate Based on Weight and Level of Intensity

Intensity of Activity	Carbohydrate (g/kg)
None/light training	3-5 g/kg
Moderate/heavy training	5-8 g/kg
Pre-event (24-48 hours)	8-9 g/kg
Post-event (within 2-3 hours)	1.7 g/kg

In addition to knowing the optimal amount of carbohydrate intake to maintain or build glycogen stores, athletes should also be aware of the optimal timing of the high-carbohydrate meals and snacks.¹¹

Carbohydrate Loading

Carbohydrate loading has been used by many athletes in the belief that it would improve endurance and performance. However, while carbohydrate loading is popular among adolescents, it has not been shown to be effective. True carbohydrate loading has an athlete deplete glycogen stores by eating a low carbohydrate diet and exercising at maximum capacity for about five days before competition. Then two to three days before competition, the athlete stops exercising and eats a very high carbohydrate diet. In theory, this allows the muscles to readily accept carbohydrate and increase the muscle glycogen, but this routine raises many concerns. First, during the low CHO phase the athlete feels fatigued and is at risk for injury. Second, during the high CHO phase the athlete cannot exercise and this often causes anxiety in the athlete. Research has shown that if an athlete does not go through the low CHO phase and only increases the CHO for two to three days before an event, while continuing light training, the athlete will receive the same benefit without the negative aspects.⁶

Pre-event

The goal of the pre-event meal is to prevent the athlete from feeling hungry before or during the workout or competition as well as to maintain optimal blood sugar levels.¹⁰ The athlete is actually performing from glycogen stored in the muscles the 24-48 hours prior to the event. The main dietary goal for the pre-event meal is to provide high carbohydrate foods, especially complex carbohydrates, with moderate amounts of protein and small amounts of fat. The athlete's food preferences should also be considered, particularly since there is wide individual variation with regard to foods that might upset an athlete's stomach. How much food to eat will depend on how much time is available before the event/practice starts. Table 2 shows a sample meal/snack pattern:

Meal/Snack	Timing	Examples
Snack 15-20 g CHO <5% fat	1/2-1 hour before	Pretzels and fluids
Light Meal 30-40 gm CHO 5-15 % fat	2-4 hours before	Turkey sandwich, fruit, fluids
Heavy Meal 50-60 gm CHO 15-25% fat	4-5 hours (may need a snack later)	Baked chicken, potatoes, fruit, bread, lemonade

Post-event

Muscles are most receptive to storing glycogen during the first two to three hours following exhaustive exercise. Eating or drinking carbohydrate immediately after the exercise or competition and then again at two-hour intervals may optimize the replenishment of glycogen in the muscles. This could be accomplished by drinking a high-carbohydrate beverage immediately after the workout and then eating a high carbohydrate meal within the next two hours.^{8,12} Carbohydrate levels can be adjusted to meet the energy needs.

Protein

Protein, in moderation, is an essential part of an adolescent athlete's diet. The function of protein in youth is to build, maintain, and repair muscle and other body tissue; produce hemoglobin; form antibodies; and form enzymes and hormones. Athletes should be instructed that eating more than the

recommended amount of protein does not improve any of these functions and does not make stronger or larger muscles. Protein in excess of total energy needs will be stored as fat, not as muscle. The only way to build muscles is to eat adequate amounts of protein, energy, and other nutrients, and to exercise the muscles through strength training at least every other day.

Protein recommendations for adolescents are 0.9 g protein per kg of body weight per day (g/kg/d). The average teenager usually consumes about 1.3 g/kg/d.

Additional protein requirements for athletes in this age group have not been specifically evaluated. Young athletes may need more protein:⁸

- Athletes who are just beginning a training program should consume 1.0-1.5 g/kg/d and adequate calories to reduce the associated loss with increased protein turnover and nitrogen loss.
- Endurance athletes may need 1.2-1.4 g/kg/d.

Athletes who chronically restrict calories require higher intakes of protein to allow for adequate synthesis and repair of tissue. But it is more important to counsel the athlete to increase calories to spare the protein than to increase protein above 1.5 g/kg/d.

Protein supplements have not been shown to enhance muscle development, strength, or endurance. In addition, supplementation with specific amino acids will not increase muscle mass, decrease body fat, or improve endurance. Many athletes do not realize that excess protein is either burned for energy or converted to fat. Consuming too much protein, whether from food or supplements, can lead to dehydration, weight gain, and increase calcium loss from the body. Consuming a high-protein diet after training does not allow for complete replacement of muscle glycogen and may impair future performance.⁸

Although the above recommendations are for the general pediatric population there are several other factors that affect protein requirements. These include:

- Young athletes may have slightly higher protein needs if they are beyond the stage of sexual maturity when hormone levels are high enough for significant muscle mass to be added. But in all cases protein recommendations should never be greater than 1.5g/kg/d. Until the completion of the growth spurt, male athletes do not have sufficient circulating male hormones to increase the actual number of muscle fibers or to develop large muscles, although strength can be increased at all levels of maturation.
- Although not recommended, a low carbohydrate intake will increase and/or change protein needs, because the body will need additional calories for growth and body functioning. If athletes eat the recommended amount of carbohydrate (50-55% of calories), they should need only the recommended amount of protein for their age and sex.
- Young athletes who follow hard, exhausting training schedules may need to eat protein levels at the high end of the recommendations (1.2-1.4 g/kg/d). This should only be done during the training season.

Protein sources

Athletes who eat most or all of their proteins from plant sources must eat a wide variety of grains and vegetables and have an adequate energy intake. Youth who eat a variety of protein from both plant and animal sources usually get adequate protein.

Fat

Although optimal performance is dependant on adequate muscle glycogen, fat also provides energy for exercise. Fat is an important fuel for light to moderate intensity exercise as well as a valuable metabolic fuel for muscle activity during longer aerobic exercises. Athletes should consume 20-30% of their calories from fat. Athletes who consume a high fat diet (>30% of total calories) typically consume fewer calories from carbohydrate. Severe fat restriction (<15% of total calories) may limit performance by hindering intramuscular triglyceride storage, which provides a significant proportion of energy for all types of exercise.⁸

Fluids and Electrolytes

Fluids play a critical role in maintaining the health and optimal performance of the adolescent athlete.¹³ One of the most important functions of water is to cool the body. As the adolescent exercises, working muscles generate heat, and this raises the temperature of the entire body. Increased body heat makes the body sweat and as the sweat evaporates the body is cooled. If the teen does not replace this sweat by drinking more fluids, the body's water balance will be upset and the body may become overheated. Humid days require even more care. If the air is humid, sweat does not evaporate, the body is not cooled, and overheating can occur.

Young adolescents are at even higher risk for overheating than adolescents who have begun the pubertal process, or adults.¹³ A number of physiologic differences impair children's ability to thermoregulate, particularly when ambient temperatures exceed skin temperature.¹⁴ Young teens have a larger body surface area than adults, so that extreme ambient temperatures have a greater effect on body temperature. They also have lower sweating capacity than adults until puberty begins and sweating increases. Lower sweating capacity means less efficiency at dissipating excess body heat. Young adolescents also have a lower cardiac output, which decreases transfer of internal body heat to the body's surface and have higher heat production during activity and require more time to acclimate to warm temperatures.⁹

The goals of fluid maintenance and rehydration are to prevent dehydration. Signs of dehydration include: dark urine, small volumes of urine, elevated heart rate, headaches, reduced sweating, muscle cramps, chills, clammy skin, and nausea. Table 3 gives general recommended rehydration guidelines. Temperature, humidity, and type of sport may affect these recommendations.

TABLE 3	
Recommendations for Hydration	
Time	Rehydration amounts
1-2 hours before event	10-14 ounces of cool water (50- 72° F) , always lower than the ambient temperature
10-15 minutes before event	10-12 ounces of cool water
During exercise	4-6 ounces cool water every 15-20 minutes
After exercise	2-3 cups (16-24 ounces) of cool fluids for every pound of weight lost

Monitoring hydration status is essential.

- Weigh athletes before and after practice/events and replace fluids lost (16-24 ounces for every pound lost).

- If an athlete has not regained the weight by the next practice or event, he/she should be rested until totally rehydrated. This is especially critical in hot and/or humid weather, when heat illness increases, or when multiple practice sessions or events occur in one day.¹⁴
- Adolescents do not instinctively drink enough fluid to replace body water losses and thirst does not indicate when a athlete needs more fluids because the body's thirst mechanism does not work well during exercise.^{9,14}
- Fluids should be available to athletes at all times.
- Fluid restriction should never be used to reduce weight or meet a certain weight class.

For activities lasting less than 60 minutes water is all that is needed for hydration. But for activities longer than 60 minutes, other beverages such as fluid replacement drinks, may be helpful due to for the carbohydrate and electrolyte contents. Recent studies¹⁵ suggest that the presence of flavoring, sodium, and carbohydrate in a beverage enhances thirst and is effective in reducing or preventing voluntary dehydration. With teens carbohydrate-electrolyte beverages tend to elicit a greater fluid intake in both boys and girls than water alone. Fluids drunk during exercise should provide 6-8% carbohydrate, since carbohydrate levels greater than this (e.g., fruit juice, soda) may cause delayed gastric emptying and may cause stomach cramping.¹⁵ Soft drinks and juices may contain 10-12% carbohydrate and should be diluted 1:1 with water to avoid potential side effects.

Vitamins and Minerals

Nutrients reported most often in less than adequate amounts for the school-aged child include calcium and iron and vitamins A, C, E, and B₆.^{8,12} Iron is important to maintain adequate hemoglobin concentrations as well as total iron stores during growth. In the adolescent, there are increased needs for growth, expansion of red blood cell volume, and addition of lean body mass. Because iron deficiency anemia can lead to poor stamina, performance, and learning ability, prevention should center on regular consumption of adequate sources of iron that are acceptable to the teen. Counseling should center on high iron foods and high vitamin C foods to improve absorption (see Chapter 10).

Intakes of calcium and vitamins A, C and B₆ and folate may be inadequate because adolescents often avoid fruits, vegetables, and dairy products, which are primary sources of these nutrients. Calcium is especially critical in adolescents because the Dietary Reference Intakes (DRI) for calcium increases to 1300 mg/day. Adolescence is when peak bone growth and bone mineralization occurs. On average, an adolescent's calcium intake is one half to two-thirds of the DRI. Inadequate calcium consumption may place athletes at risk for stress fractures and osteoporosis. These complications are most relevant for female adolescents (especially those who have the female athlete triad: disordered eating, menstrual dysfunction and bone mineral disorders).^{5,6} Diet instruction should include recommendations of foods and beverages that are high in calcium.

Dietary Supplements

Adolescents often turn to dietary supplements that promise increased performance. Dietary supplements (ergogenic aids) are usually not needed and in some cases may be dangerous (see Table 4). Although vitamin and mineral supplementation may improve the nutrition status of persons consuming inadequate amounts, no scientific data support the general use of supplements to improve athletic performance. Supplements can give young athletes a false sense of security and any performance improvement will be credited to the supplement, not to the hard work and practice.

TABLE 4
Potential Adverse Effects of Ergogenic Aids in Adolescents

<u>Ergogenic Aid</u>	<u>Adverse Effects</u>
Anabolic steroids	Testicular atrophy, clitoral hypertrophy, menstrual irregularities, gynecomastia (males), hirsutism, hepatocellular toxicity, hepatocellular carcinoma, hypertension, acne, alopecia, lipid abnormalities, premature epiphyseal closure, mood swings
Androstenedione	Decreased testosterone
Beta-2 agonist	Tremor, palpitations, tachycardia, cardiac arrhythmia, anxiety, insomnia, headache, nausea
Creatine	Muscle cramping, muscle strains, dehydration
Human Growth Hormone	Acromegalic syndrome, hypothyroidism
Stimulants (amphetamines, caffeine, ephedrine, sympathomimetic amines)	Restlessness, insomnia, anxiety, tremor, palpitations, tachycardia, cardiac arrhythmia, hypertension, disruptions in thermoregulation

Adapted from: Patrick K, Spear BA, Holt K, and Sofka D. 2001. Bright Futures in Practice: Physical Activity. Arlington, VA: National Center for Education in Maternal and Child Health; 2001.

The unsupervised and indiscriminate use of protein, vitamin, and mineral supplements also raised safety concerns. When the use of these substances replaces a sound nutrition program, health and performance may be compromised. Excessive protein intakes increase the risk of dehydration as well as renal toxicity. Adolescents also need to be cautious of excessive intake of vitamins and minerals. Table 5 identifies some of the potential adverse effects of excessive nutrient intakes.

TABLE 5
Potential Adverse Effects of Excessive Protein, Vitamins and Minerals

<u>Nutrient</u>	<u>Adverse Effect</u>
Amino Acid and protein supplements Excessive amounts (>2 g/kg/day)	Dehydration, gout, gastrointestinal upset, hepatotoxicity, renal toxicity, hypercalciuria, impaired essential amino acid absorption
Vitamin A Excessive amounts (>300% RDA)	Fatigue, irritability, increased intracranial pressure, gastrointestinal upset, hepatocellular toxicity, bone and joint pain, hypercalcemia, skin and nail abnormalities
Niacin Excessive amounts (>300% RDA)	Flushing, purities, gastrointestinal upset, skin abnormalities, glucose intolerance, hyperuricemia, hepatocellular toxicity
Vitamin B₆ Excessive amounts (>300% RDA)	Headache, nausea, sensory neuropathy, hepatocellular toxicity
Vitamin C Excessive amounts (>300% RDA)	Gastrointestinal upset, nephrolithiasis
Vitamin D Excessive amounts (>300% RDA)	Hypercalcemia and associated effects including: weakness, lethargy, anorexia, nausea, vomiting, constipation, polyuria, cardiac arrhythmia
Vitamin E Excessive amounts (>300% RDA)	Gastrointestinal upset, fatigue, weakness, lipid abnormalities, inhibited absorption or action of vitamin K

Adapted from: Patrick K, Spear BA, Holt K, and Sofka D. 2001. Bright Futures in Practice: Physical Activity. Arlington, VA: National Center for Education in Maternal and Child Health; 2001.

Female Athlete Triad

The Female Athlete Triad is the relationship between unhealthy eating behaviors, amenorrhea, and osteoporosis.⁵ Physically active adolescents whose caloric intake is not sufficient to provide the energy needed to participate in physical activity are at risk for weight loss. This can lead to menstrual irregularities, most often amenorrhea, and negative consequences for bone health such as premature bone loss, decreased bone density, and increased risk of stress fractures.¹⁶

Restricted food intake and poor body image can occur among adolescents of both sexes, but those at greatest risk are females who participate in activities that focus on appearance, size, body shape, or weight class (e.g., ballet, gymnastics, figure skating, running, crew). It is important to identify and treat adolescents suffering from the Female Athletic Triad early because bone loss may be only partially reversible. Adolescents who develop symptoms such as excessive weight loss, irregular menstrual periods, or frequent injuries (including stress fractures) should be evaluated by a health care team, which includes a physician, nutritionist, and mental health provider.¹⁷

RESOURCES

Amateur Athletic Union	http://www.aausports.org/
American Alliance for Health, Physical Education, Recreation and Dance	http://www.aahperd.org/
American College of Sports Medicine	http://www.acsm.org/
American Medical Society for Sports Medicine	http://www.amssm.org/
Cooper Institute for Aerobic Research	http://www.cooperinst.org/
National Collegiate Athletics Association (NCAA)	http://www.ncaa.org/
National Recreation and Park Association	http://www.activeparks.org/
President's Council of Physical Fitness and Sports	http://www.fitness.gov/
Gatorade Sports Science Institute	http://www.gssiweb.com/
Bright Futures Website (Bright Futures in Practice: Physical Activity)	http://www.brightfutures.org/

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