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Current Concept Review

Nutritional Recommendations for the Young Athlete

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Abstract

Adolescent athletes require nutrition that meets their demands for performance and energy expenditure, yet over half of the adolescents in the United States receive low-quality nutrition. To support the sport performance and overall health of this group, physicians need evidence-based, practical nutrition recommendations to disseminate to young athletes, their parents, and coaches. This narrative review serves to inform guidance on young athlete nutrition, nutrient timing, hydration, dietary supplementation, and educational interventions.

Key Concepts

- Individualized assessments of energy requirements as well as hydration status are key to optimizing nutritional plans for young athletes.
- Nutritional plans should consider both the content and timing of meals, particularly in the pre- and post-physical activity windows.
- In general, the literature does not support dietary supplement utilization to enhance performance in young athletes.
- Whether via interventional programs or physician counseling, guiding young athletes on the cultivation of sustainable dietary habits is critical for long-term healthy behaviors and resultant optimal performance.

Introduction

Adequate nutrition is essential for the optimal development and sport performance of young athletes. Based upon the National Health and Nutrition Examination Survey (NHANES) results from 1999 to 2016, adolescents with low-quality diets as determined by the American Heart Association primary diet score

decreased from 76.8% (95% CI, 72.9%–80.2%) to 56.1% (95% CI, 51.4%–60.7%; p<0.001).[1] While this trend reflects a broad improvement in youth nutrition over time, over half of children are still not receiving adequate nutrition. Considering the additional dietary demands for not only growth but also athletic performance and recovery in youth athletes, sustainable and healthy nutritional guidance is of utmost importance. As the nutritional profiles for youth athletes differ by age ranging from 5 to 18 years old and pubertal status, recommendations included in this review reflect the key distinctions when appropriate.

To supply enough energy and proper hydration for development, exercise, and performance, well-designed nutritional plans include sufficient intake of macronutrients (protein, carbohydrates, and fat), micronutrients (minerals and vitamins), and fluids. Parents, coaches, and youth athletes deserve evidenced-based education on the current nutritional recommendations for their optimal health and sport participation. While prior reviews have presented the literature about youth athlete nutrition, this review uniquely pairs current scientific evidence with directly applicable measures that physicians and athletes may implement to support optimal performance. Therefore, this narrative review serves to provide guidance on optimum nutrient type, the timing of nutrient consumption, educational interventions available, and optional dietary supplements for growing youth athletes.

Macronutrients

Protein

Assuming total energy requirements are satisfied, youth athletes typically need approximately 1.5 g/kg of daily protein intake (Table 1). This level of protein intake not only supports the young athlete's development and maturation even in times of peak muscular and linear growth but it also covers amino acid oxidation losses during exercise and leads to a net positive protein balance.[2,3] Additionally, the timing of protein consumption contributes to a youth's whole-body protein balance. For example, having protein at breakfast helps shift youth into a positive balance.[4] Likewise, smaller doses of protein (0.22–0.33 g/kg- per meal) at regular 3 or 4-hour intervals allow youth athletes to remain in positive whole-body protein balance for the longest periods.[5] Combining these findings into an optimal daily routine for protein intake, youth athletes should consume approximately 0.3 g/kg five times per day.[2,3,5] Contrary to popular diets that encourage copious protein consumption, higher daily protein intakes, such as above >2.5 g/kg, provide no adaptive benefit.[6]

Carbohydrates

Carbohydrate requirements for youth athletes are contingent upon their training and competition routines.[7,8] Unless youth athletes buffer their expenditure by consuming carbohydrates when recovering from training or competition, these athletes are prone to fatigue quicker than adult athletes due to faster glycogen depletion.[9] When recovering, high-glycemic index carbohydrate drinks may be advantageous since they promote glycogen synthesis while maintaining proper hydration. Optimally, young athletes should consume a 6% carbohydrate drink (i.e., Gatorade, Powerade, or fruit juices) since drinks ≥ 8% carbohydrate (i.e., energy drinks, milkshakes, adding extra sugar to Gatorade) are linked to gastrointestinal discomfort.[10] Drinks containing fructose (i.e., fruit juices) and galactose (i.e., dairy products) replenish glycogen faster than glucose, which is particularly useful when young athletes have short recovery periods between trainings or competitions.[11] Azen et al. found that youth pentathlon athletes have sufficient intakes of protein and lipids, but they did not adequately consume carbohydrates in their diets. Consequently, physicians and coaches should pay special attention to carbohydrate intake and expenditure in young athletes to optimize performance (Table 2).[12]

Fat

Dietary fat intake is necessary for the absorption of fat-soluble vitamins (i.e., Vitamins A, D, E, and K) as well as to supply essential Omega-3 and Omega-6 fatty acids, all of which are necessary for optimal youth athlete performance.[13,14] For example, Vitamin E acts as an

Table 1. Examples of Recommended Protein Intake Per Age Group and Dietary Restrictions

	Breakfast	Lunch	Dinner	Snack
No Restrictions	Pork Sausage (5 g/link) 5-8: 1 link 9-13: 2 links 13-18: 3 links	Turkey Sandwich (2 g/slice) 5-8: 2 slices 9-13: 3 slices 13-18: 3 slices	Chicken Breast (5 g/oz) 5-8: 4 oz. 9-13: 6 oz. 13-18: 8 oz.	Sunflower Seeds (5 g/1 oz) 5-8: 1 oz. 9-13: 2 oz. 13-18: 4 oz.
	Bacon (3 g/strip) 5-8: 1 strip 9-13: 2 strips 13-18: 2 strips	Ham Sandwich (4.5 g/slice) 5-8: 1 slice 9-13: 2 slices 13-18: 2 slices	Baked Cod (6 g/oz) 5-8: 4 oz. 9-13: 6 oz. 13-18: 10 oz.	String Cheese (7 g/stick) 5-8: 1 stick 9-13: 1 stick 13-18: 1 stick
	Skim Milk (8 g/cup) 5-8: 1 cup 9-13: 1.5 cups 13-18: 2 cups	Peanut Butter & Jelly Sandwich (10 g/sandwich) 5-8: ½ sandwich 9-13: 1 sandwich 13-18: 1 sandwich	Turkey Breast (5 g/oz) 5-8: 4 oz. 9-13: 4 oz. 13-18: 8 oz.	Peanuts (8 g/32 nuts) 5-8: 32 nuts 9-13: 48 nuts 13-18: 48 nuts
	Large Egg (6 g/egg) 5-8: 1 egg 9-13: 2 eggs 13-18: 2 eggs	Shrimp (1.5 g/medium shrimp) 5-8: 4 shrimp 9-13: 6 shrimp 13-18: 8 shrimp	Ground Beef (7 g/oz) 5-8: 4 oz. 9-13: 5 oz. 13-18: 6 oz.	Almonds (6 g/23 nuts) 5-8: 23 nuts 9-13: 23 nuts 13-18: 46 nuts
Vegan	Hummus (1.5 g/oz) 5-8: 2 oz. 9-13: 5 oz. 13-18: 6 oz.	Black Beans (15 g/cup) 5-8: 1 cup 9-13: 1.5 cups 13-18: 2 cups	Tofu (2.5 g/oz) 5-8: 4 oz. 9-13: 6 oz. 13-18: 10 oz.	Pumpkin Seeds (7 g/oz) 5-8: 1 oz. 9-13: 1 oz. 13-18: 2 oz.

antioxidant, Vitamin A helps maintain immunological health and vision, and the omega-3 and omega-6 fatty acids are involved in inflammatory pathways. Young athletes should consume natural sources of fat (especially sources containing Omega-3 such as nuts, seeds, and oily fish) over trans-fat (common in processed foods such as pastries, fast food, and margarine) since trans-fats increase cardiovascular risk.[15] As such, it is recommended that adolescents' fat consumption is 20% to 35% of their total energy intake, limiting trans-fat as much as possible (Table 3). Importantly, nutrition labels listing 0 grams of trans fat may be misleading, as less than 0.5 grams/serving of trans-fat are rounded down per the U.S. Food and Drug Administration guidelines.[16,17] Although youth athletes have a higher absolute total energy requirement than non-athlete youth, there is no current evidence that would suggest the relative fat intake requirements of youth athletes is significantly different from non-athlete youth.[18] Importantly, for youth athletes that partake in endurance, weight-making, or aesthetic sports in which fat consumption is typically limited, physicians and coaches should closely monitor the athlete's fat-soluble vitamin and Omega-3 and Omega-6 fatty acid status to prevent deficiencies.[18]

Table 2. Examples of Recommended Carbohydrate Intake Per Age Group and Dietary Restrictions

	Breakfast	Lunch	Dinner	Snack
No Restrictions	Oats (27 g/½ cup) 5-8: ½ cup 9-13: ¾ cup 13-18: 1 cup	Medium Bell Pepper (7 g/pepper) 5-8: 1 pepper 9-13: 1 pepper 13-18: 1.5 peppers	5-inch Sweet Potato (26 g/potato) 5-8: 1 potato 9-13: 1 potato 13-18: 1 potato	Mini Pretzels (23 g/19 pretzels) 5-8: 38 pretzels 9-13: 38 pretzels 13-18: 57 pretzels
	Medium Banana (27 g/banana) 5-8: 1 banana 9-13: 1 banana 13-18: 1 banana	Broccoli (6 g/1 cup) 5-8: 1.5 cups 9-13: 2 cups 13-18: 2 cups	Quinoa (42 g/1 cup) 5-8: 1 cup 9-13: 1 cup 13-18: 1.5 cups	Blueberries (21 g/1 cup) 5-8: 1 cup 9-13: 1.5 cups 13-18: 1.5 cups
	Whole-Grain Cereal (27 g/1 cup) 5-8: 1 cup 9-13: 1.5 cups 13-18: 2 cups	Strawberries (11 g/1 cup) 5-8: 1 cup 9-13: 1 cup 13-18: 2 cups	Brown Rice (44 g/1 cup) 5-8: 1 cup 9-13: 1.5 cups 13-18: 1.5 cups	Medium Potato (32 g/potato) 5-8: 1 potato 9-13: 1 potato 13-18: 1 potato
Gluten Free	Gluten-Free Bread (12 g/slice) 5-8: 2 slices 9-13: 4 slices 13-18: 4 slices	Baby Cut Carrots (8 g/3 oz) 5-8: 1 cup 9-13: 1.5 cups 13-18: 2 cups	Cherry Tomatoes (6 g/1 cup) 5-8: 1.5 cups 9-13: 1.5 cups 13-18: 3 cups	Sun-Dried Raisins (33 g/¼ cup) 5-8: ¼ cup 9-13: ½ cup 13-18: ½ cup
Vegan	Apple (20 g/apple) 5-8: 1 apple 9-13: 1 apple 13-18: 1 apple	Mashed Cooked Pumpkin (20 g/1 cup) 5-8: 1.5 cup 9-13: 1.75 cups 13-18: 2 cups	Green Peas (21 g/1 cup) 5-8: 1 cup 9-13: 1.5 cups 13-18: 2 cups	Pasta Noodles (40 g/1 cup) 5-8: 1 cup 9-13: 1.5 cups 13-18: 1.5 cups

Micronutrients

Micronutrients such as vitamins and minerals are typically obtained through the diet and are required for healthy development and homeostasis, particularly in youth.[19] When deficient in one or more micronutrients, youth athletes may incur a loss of athletic performance, so prevention of micronutrient deficiencies is a top priority in optimizing their nutrition.[20] Deficiencies can be quite common: in a 3-year study of 60 sprint youth athletes, Aerenhouts et al. found that females had low iron intakes, and both genders had deficient calcium, Vitamin E, and Vitamin B2 intakes. Of note, youth athletes who take dietary supplements already have a sufficient intake of these micronutrients in their diet, but athletes who do not use supplements are more likely to be micronutrient deficient in their diet.[21] While most research has investigated iron, calcium, and Vitamin D status in youth athletes, Ercan et al. analyzed pre-participation exams and found that 7% of athletes had severe Vitamin B12 deficiency and 4% had severe folic acid deficiency, although anemia due to these was not detected.[20] Therefore, particular attention must be

Table 3. Examples of Recommended Fat Intake Per Age Group and Dietary Restrictions

	Breakfast	Lunch	Dinner	Snack
No Restrictions	Scrambled Eggs (7.5 g/egg) 5-8: 1 egg 9-13: 2 eggs 13-18: 2 eggs	Walnuts (19 g/7 walnuts) 5-8: 2 walnuts 9-13: 3 walnuts 13-18: 5 walnuts	Ground Beef (85% lean) (4.2 g/oz) 5-8: 4 oz 9-13: 5 oz 13-18: 6 oz	String Cheese (6 g/stick) 5-8: 1 stick 9-13: 1 stick 13-18: 1 stick
	Butter (12 g/tbsp) 5-8: 1 tbsp 9-13: 1 tbsp 13-18: 1.5 tbsp	Peanut Butter (8 g/tbsp) 5-8: 1 tbsp 9-13: 1 tbsp 13-18: 1.5 tbsp	Cheeseburger with Cheddar Cheese (15 g/sandwich) 5-8: 1 sandwich 9-13: 1 sandwich 13-18: 1 sandwich	Dark Chocolate (12 g/50 g bar) 5-8: none 9-13: 1 bar 13-18: 1 bar
	Milk (5 g/1 cup) 5-8: 1 cup 9-13: 1.5 cups 13-18: 2 cups	Almond Butter (10 g/tbsp) 5-8: 1 tbsp 9-13: 1.5 tbsp 13-18: 2 tbsp	Salmon (1.7 g/oz) 5-8: 4 oz 9-13: 6 oz 13-18: 8 oz	Sunflower Seeds (15 g/¼ cup) 5-8: ¼ cup 9-13: ¼ cup 13-18: ¼ cup
	Pancake with Butter and Syrup (7 g/pancake) 5-8: 1 pancake 9-13: 2 pancakes 13-18: 2 pancakes	Cashews (13 g/¼ cup) 5-8: ¼ cup 9-13: ½ cup 13-18: ½ cup	Baked Trout (2 g/oz) 5-8: 4 oz 9-13: 5 oz 13-18: 6 oz	Pistachio Nuts (13 g/50 kernels) 5-8: 25 kernels 9-13: 25 kernels 13-18: 35 kernels
Vegan	Hummus (1.3 g/tbsp) 5-8: 2 tbsp 9-13: 3 tbsp 13-18: 4 tbsp	Avocado (12 g/½ avocado) 5-8: ½ avocado 9-13: ¾ avocado 13-18: 1 avocado	Chickpeas (2 g/½ cup) 5-8: 1 cup 9-13: 2 cups 13-18: 2.5 cups	Soy Milk (5 g/1 cup) 5-8: 1.5 cups 9-13: 2 cups 13-18: 2 cups

directed towards youth athletes with poorer diets to make them micronutrient replete.

Iron

Iron is an essential mineral involved in several pathways central to athletic activity, such as oxygen transportation and oxidative phosphorylation, yet the amount of iron absorbed in the diet ranges between 5-35% depending on the food source and type of iron it contains (Table 4).[22] Studies on the prevalence of iron deficiency in young athletes vary considerably from 4.5% of males and 27.3% of females to 51% and 68%, respectively.[20,23] The higher prevalence of iron deficiency in females may be mediated by their loss of blood during menstrual cycle.[24] Furthermore, the discrepancies in the reported prevalence of iron deficiency among youth athletes may be explained by the lack of cut-off value standardization and sole consideration of ferritin levels as a marker for an adolescent's iron status.[25] Likewise, ferritin levels in athletes are typically lower than non-athletes, and the ferritin levels may fluctuate depending on the athlete's level of stress, injury, or infection.[26] Although iron supplementation for primary prevention of iron deficiency is generally not recommended in adolescents,

Table 4. Examples of Iron-Rich Foods

Food	Serving Size	Amount of Iron (mg)
Enriched White Bread	1 slice	0.7
Fortified Oat Cereals	1 cup	9.0
Eggs	1 egg	0.9
Mussels	3 oz	5.7
Beef	3 oz	2.5
Turkey Leg	3 oz	2.0
Broccoli	1 cup	0.7
Cooked Spinach	1 cup	6.4
String Beans	1 cup	1.2
Sesame Seeds	½ oz	2.1
Cashews	1 oz	1.9

Adapted from the 2020-2025 United States Dietary Guidelines.[2]

those at high risk should be monitored yearly, such as adolescents with a chronic disease, menstrual blood loss >80 mL/month, obesity, frequent use of medicines or foods that reduce iron absorption (i.e., excessive phylate, phosphate, or tannin intake as well as antacids, aspirin, and non-steroidal anti-inflammatory drug usage).[27,28] Menstrual blood flow can be estimated by gauging the saturation of female hygiene products as a fully saturated light tampon holds up to 3 mL of fluid while a typical daytime fully soaked pad holds around 5 mL and a fully soaked overnight pad holds between 10–15 mL.[29,30] Additionally, adequate Vitamin C intake promotes increased iron absorption.[27] To treat iron deficiency effectively and inexpensively, athletes may be administered oral iron salts such as ferrous sulfate, fumarate, and gluconate until iron is replete, not taken with meals to permit maximal absorption.

Calcium and Vitamin D

Vitamin D helps absorb dietary calcium, in which this calcium is primarily utilized in the growth and maintenance of bone mineral density and the immune system.[31,32] Calcium requirements are highest during the pubertal growth spurt of adolescents, in which the rate of skeletal calcium accretion is approximately 300 mg/day.[33] The recommended dietary allowance per the National Institute of Health for calcium is 1000 mg/day for adolescents aged 4-8 and 1300 mg/day for those aged 9–18 (Table 5).[32] Currently, no specific guidelines for the recommended daily allowance

Table 5. Examples of Calcium and Vitamin D Rich Foods

Food	Serving Size	Amount of Calcium (mg)	Amount of Vitamin D (IU)
Swiss Cheese	1 cup diced	1175	Not a significant source
Cheddar Cheese	1 cup diced	937	Not a significant source
Spinach	1 cup	245	Not a significant source
Orange Juice	1 cup	349	100
Milk (1% Fat)	1 cup	305	117
Almond Milk	1 cup	442	107
Plain Yogurt (low fat)	8 oz	488	116
Plain Yogurt (non-fat)	8 oz	448	116
Salmon	3 oz	410	380-570
Trout	3 oz	180	645
Tofu	2 oz	434	Not a significant source

Adapted from the 2020-2025 United States Dietary Guidelines.[2]

of calcium for youth athletes exist, so utilizing the population reference standards is advisable until further investigation of youth athletes is conducted.[25]

Likewise, the National Institute of Health recommends 15 mcg of Vitamin D for adolescents and adults between 1 and 70 years old, in which fatty fish (i.e., salmon, trout, tuna, and mackerel) and fish liver oils are the best sources.[32,34] While most Vitamin D is acquired through dietary intake, exposure to sunlight contributes to the synthesis of Vitamin D but is highly dependent on skin pigmentation, usage of protective sunscreens, style of clothing, cloud coverage, pollution, time of day, season, and distance from the equator.[35] Constantini et al. determined that 80% of young athletes who train and compete indoors or during the winter were deficient in Vitamin D, compared to 48% of their outdoor peers.[31] Additionally, female athletes have been shown to be at higher risk for Vitamin D deficiency.[20] Notably, low iron levels increased the rate of Vitamin D deficiency in youth athletes, illustrating that some micronutrient deficiencies are interdependent.[31] Thus, youth athletes who present with signs of Vitamin D deficiency such as bone pain, muscle weakness, and joint deformities should be screened via measuring serum 25-hydroxyvitamin D levels and treated accordingly (i.e., diet and lifestyle modifications as well as possible oral substitution of cholecalciferol) to optimize their athletic performance.[36,37]

Fluid Intake

Hydration Status

Maintaining adequate hydration status in youth athletes is imperative for optimal sport performance, as water losses ≥ 2% of total body weight detrimentally hinder their abilities.[8-16,21] When engaging in sport activity in the heat, young athletes may become severely fluid deficient, potentially losing >4% body weight due to sweating.[38] Fluid deficiency is common, with one study finding 20–44% of athletes are underhydrated even at the beginning of their training sessions.[39] To combat dehydration, fluids should be readily available for consumption before, during, and after activity sessions, and contrary to the routines of many youth athletes, activity sessions need to be separated further to maintain their normal level of hydration.[40-43] Moreover, drinking fluids ad libitum during practices is insufficient to prevent further dehydration.[41] Therefore, coaches should encourage regular fluid consumption to prevent further dehydration of their athletes as well as to maintain adequate hydration for optimal performance. Although dependent upon the intensity and duration of exercise, adolescents should drink 8–20 ounces of fluids 1 hour before performing depending on prior hydration status, 5 ounces every 15 minutes during, and 20 ounces of fluids per pound of water lost through sweat when recovering.[44]

Dietary Supplements

Prevalence of Supplement Usage Among Youth Athletes

A 2012 survey of 9,417 American adolescent athletes had a self-report usage rate of supplements of 34.1%.[45] Additionally, another sample of youths across several sports found that 49.8% and 8.4% of adolescent males use protein powder and creatine supplements, respectively.[46] Furthermore, there is a positive relationship between age and usage of protein supplements.[47] Coaches frequently are the initiators and primary source of information regarding these supplements for athletes, with most athletes never receiving counseling from sport dieticians or other healthcare professionals.[12,47,48]

Recommendations on Supplement Utilization

Generally, it is not recommended for youth athletes to consume dietary supplements for performance enhancement unless they have a clinical need as determined by physicians or sport dieticians.[25] The utilization of supplements in young athletes "over-emphasizes their ability to manipulate performance (i.e., typically 2–5% improvement)."[49] Similarly, most dietary supplements have not been studied in a pediatric population due to ethical concerns, so the long-term safety profile of consumption is largely unknown.[49] Protein supplements such as protein shakes are not recommended since adolescents commonly consume enough protein daily to surpass their requirements.[18]

Conversely, Jagim et al. in a literature review concluded that creatine supplementation in youth athletes improved sport performance without adverse events.[50] As many youth athletes consume dietary supplements, many of which are not fully understood in the pediatric population, there is a significant need for healthcare professionals to actively inquire about young athletes' dietary supplements and provide judicious counseling on dietary supplement usage.

Energy Requirements

Metrics to Quantify Energy Needs

Generally, adolescent females require around 1,800 to 2,400 kilocalories (kcal) per day, whereas adolescent males require approximately 2,000 to 3,200 kcal/day.[17] To optimize macronutrient nutrition for youth athletes, not only maturation and growth need to be considered but also energy expenditure during training, sport-specific training, competition, and recovery.[18]

Individualized appropriate nutrition should, at the minimum, cover baseline caloric needs (i.e., resting metabolic rate, RMR), calories burned through their sport-specific training regimen(s) and other daily activity (i.e., energy expenditure, EE), and calories utilized to process food (i.e., thermic effect of food, TEF). Considering the regular flux of these variables throughout the course of a young athlete's development and day-to-day life, it would be not only impractical but extremely difficult to determine the exact caloric needs in this population. Thus, energy availability (EA) (i.e., the amount of energy available to sustain physiologic function), may be a suitable proxy for caloric requirements.[51,52] Based on EAs in adult athletes,[51] an EA of ≥45 (kcal·kg) / (FFM·day) is hypothesized to be the minimum energy requirement for young athletes, though this is yet to be verified in studies (Tables 6 and 7).[18]

Table 6. Estimated Energy Requirements for Youth Athletes Stratified by Age and Weight

Age (years)	Weight (kg)	Estimated Energy Requirement (Kcal/day)
6-8*	15	900-975
	20	1200-1300
	25	1500-1625
9+	30	1350
	35	1575
	40	1800
	45	2025
	50	2250
	55	2475
	60	2700

**Children 6-8 years old are noted to have higher daily energy requirements approximately 60-65 Kcal/kg/day.*[53]

Consequences of Low Energy Availability

Relative Energy Deficiency in Sport (RED-S) is a condition defined as a syndrome of impaired physiologic function caused by low energy availability (LEA). The affected physiologic functions include, but are not limited to, metabolism, reproductive function, bone, immune, and cardiovascular health.[54] This framework is an expansion on the "Female Athlete Triad" concept which characterizes the relationship between LEA, menstrual dysfunction, and low bone mineral density.[55] Features of this syndrome may manifest in increased injury risk, decreased muscle strength, decreased endurance, decreased training response, depression, irritability, decreased concentration, decreased coordination, and impaired judgment.

Addressing RED-S

Due to its multifactorial nature, preventing and treating RED-S in youth athletes dictates an interdisciplinary team approach, including sport medicine physicians and surgeons, dietitians, psychologists, and coaches.[54] Screening using the Relative Energy Deficiency in Sport Clinical Assessment Tool (RED-S CAT), referral, and education are integral components to prevent RED-S (Figure 1).[56] Athletes at higher risk of developing RED-S includes females and those who compete in endurance sports (i.e., long-distance running), aesthetic sports (i.e., gymnastics, cheerleading, diving), antigravitational

Table 7. Recommended Macronutrient and Hydration Schedule Per Age Group

	5-8 years old	9-13 years old	13-18 years old
Breakfast (7:30 AM)	Protein: 7 g Carbohydrate: 20 g Fat: 5 g Hydration: 1 cup	Protein: 11 g Carbohydrate: 20 g Fat: 10 g Hydration: 1.5 cups	Protein: 16 g Carbohydrate: 20 g Fat: 10 g Hydration: 2 cups
Morning Snack (10:00 AM)	Protein: 0 g Carbohydrate: 10 g Fat: 5 g Hydration: ½ cup	Protein: 0 g Carbohydrate: 10 g Fat: 0 g Hydration: 1 cup	Protein: 0 g Carbohydrate: 15 g Fat: 5 g Hydration: 1.5 cups
Lunch (12:30 PM)	Protein: 7 g Carbohydrate: 20 g Fat: 10 g Hydration: 1 cup	Protein: 11 g Carbohydrate: 20 g Fat: 15 g Hydration: 2 cups	Protein: 16 g Carbohydrate: 25 g Fat: 15 g Hydration: 2 cups
Afternoon Pre-Sport Snack (2:30 PM)	Protein: 7 g Carbohydrate: 10 g Fat: 5 g Hydration: 1.5 cups	Protein: 11 g Carbohydrate: 15 g Fat: 10 g Hydration: 1.5 cups	Protein: 16 g Carbohydrate: 20 g Fat: 10 g Hydration: 2 cups
Sport Activity (3:00-5:30 PM)	Hydration: 5 oz/15 minutes activity	Hydration: 5 oz/15 minutes activity	Hydration: 5 oz /15 minutes activity
Post-Sport Recovery (5:30-6:30 PM)	Protein: 0 g Carbohydrate: 10 g Fat: 0 g Hydration: 20 oz /pound lost	Protein: 0 g Carbohydrate: 15 g Fat: 0 g Hydration: 20 oz/pound lost	Protein: 0 g Carbohydrate: 20 g Fat: 0 g Hydration: 20 oz/pound lost
Dinner (7:30 PM)	Protein: 14 g Carbohydrate: 40 g Fat: 10 g Hydration: 1 cup	Protein: 22 g Carbohydrate: 50 g Fat: 15 g Hydration: 2 cups	Protein: 32 g Carbohydrate: 50 g Fat: 15 g Hydration: 2.5 cups

sports (i.e., indoor rock climbing), and sports with weight classifications (i.e., karate or wrestling). Preemptive education about RED-S should aim to reduce the perceived importance of body weight, rule modifications that bar group weigh-ins, treat each athlete individually, and support healthy weight management practices. Along with treating any specific issues that arise secondary to RED-S, one treatment approach to rectify insufficient energy availability is to create a plan to increase current energy intake by ~300–600 kcal/day, with meals spread around sport activities.[54]

Nutrition Education Interventions

Through programs or counseling, guiding youth athletes on building sustainable nutritional habits is imperative for long-term adherence and optimization of their athletic abilities. They should be advised to consistently eat breakfast to foster a better overall nutritional profile, especially with increased consumption of protein, carbohydrates, iron, and calcium.[57,58] The nutritional content of breakfast is recommended to be rich in fiber, whole grains, fruit, and dairy.[58] Likewise, youth athletes should be counseled to eat a meal or

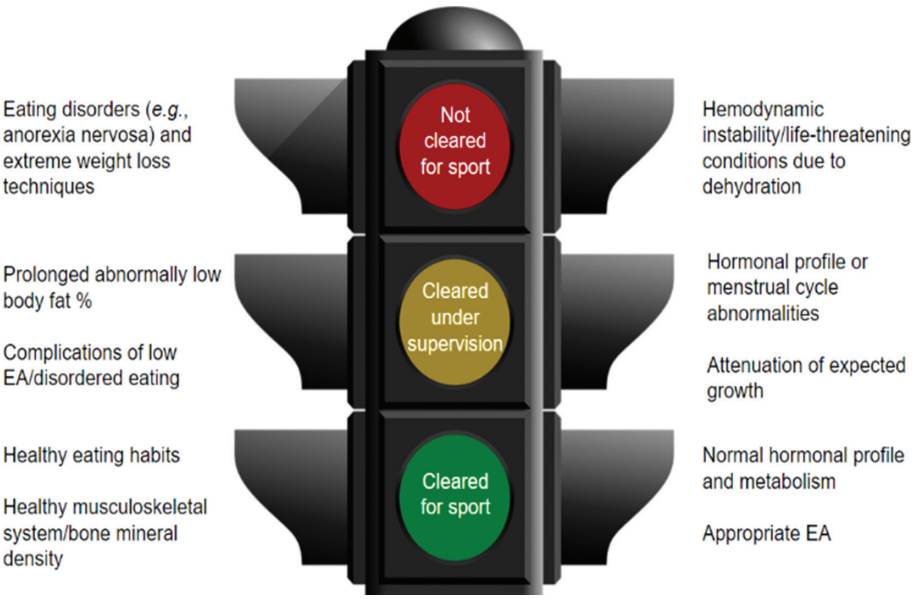

Figure 1. *RED-S Risk Assessment Model, adapted from Mountjoy et al. (2014).*[56]

snack before and after engaging in physical activity to promote increased performance and faster recovery, respectively.[25] However, there are mixed results for the efficacy of interventional nutrition education programs among youth athletes. Generally, programs that provided educational content in shorter periods of time (i.e., 1-day workshops or 6-week programs vs. year-long programs) have yielded superior outcomes in increasing knowledge about nutrition, lowering BMI, and improving diet adherence.[59-61] In particular,

Table 8. Most Frequently Utilized Motivational Interviewing Components

Motivational Interviewing Component	Example
Collaboration	Together, we can generate a plan that will work for you.
Evocation	Why might you want to improve your nutritional habits?
Patient-Centered	Is there anything you are worried or concerned about?
Autonomy	To what degree do you feel you are in control of your nutrition?
Express Empathy	You seem nervous. How can I help?
Reflection	What I heard you say is…
Open-Ended Questions	What habits would you like to change?
Affirmation	Your plan sounds challenging, but I am confident you can succeed by staying focused.
Permission	Are you comfortable talking about your weight?
Decisional Balance Exercises	Let us think of the positives and negatives for changing your diet.
Values Clarification	Is your current exercise plan and nutrition consistent with your values?

Adapted From Borrelli et al. (2015).[62]

engaging both the young athlete and their parents as well as utilizing pre-existing modes of communication such as posting nutritional content on social media have been found to be effective.[59,61] Additionally, interventions should incorporate motivational interviewing to cultivate intrinsic motivation in young athletes to build healthy nutritional habits, since motivational interviewing is associated with improved pediatric health behaviors and outcomes (Table 8).[62]

Summary

As over half of adolescents receive inadequate nutrition, providing practical guidance to foster healthy and sustainable nutritional habits is critical to optimize the health and sport performance of young athletes. Herein, this narrative summarizes current concepts on the nutritional optimization of the young athlete, and we subsequently provide evidence-based recommendations for macronutrient, micronutrient, and fluid intake in this group. Furthermore, guidance and resources on dietary supplement usage is provided, and certain stakeholder education programs for nutrition counseling were found to be effective.

Additional Links

- Raising the Young Athlete: Training and Injury Prevention Strategies, *JPOSNA*® Vol. 4 No. 2: May 2022.
- Pitfalls of Pediatric and Adolescent Sports Specialization,| *JPOSNA*® Vol. 3 No. 2: May 2021.
- Sleep Optimization in the Young Athlete,| *JPOSNA*®, Vol. 3 No. 3: August 2021.

Disclaimer

The authors have no conflicts of interest to report.

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