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Review Article

Nutrition Strategies for Young Athletes: Myths and Realities-A Review

Dan Benardot[1,2*]

[1]*Teaching Professor, Center for the Study of Human Health, Emory University, Atlanta, GA*

[2]*Professor Emeritus, Nutrition, Georgia State University, Atlanta, GA*

Abstract

Young athletes are in a period of accelerated growth that requires satisfying the combined nutritional demands of sport, growth, and development. These nutritional needs can only be satisfied with science-based planning that is free of common nutritional myths. Studies demonstrate the importance of providing energy and nutrients in a way that optimally satisfies tissue requirements in real time. However, there is little consideration of the dynamic relationship between energy/nutrient intake and cellular needs. There is also a tendency to wrongly emphasize some energy and nutrient sources as more critical for both performance and health. These failures diminish the potential benefits of physical activity and may negatively influence health. Protein tends to be overemphasized and there is also a common misunderstanding for how to best consume protein to achieve the desired anabolic benefits. There is also a common misbelief that supplements may optimally satisfy tissue nutrient requirements, but the relatively large doses of individual nutrients that most supplements deliver may serve to diminish the desired benefits. Of particular concern is that misunderstandings about nutrition tend to establish eating habits in youth that elevate obesity risk and associated cardiometabolic disorders later in life. Improving the understanding of what, how much, and when to eat will result in a profound beneficial impact on health outcomes for young athletes that are likely to result in beneficial health outcomes into adulthood. This paper reviews prevalent nutritional myths and nutrition strategies that can help satisfy the energy and nutrient needs of young athletes.

Keywords: Body composition; Nutrition for youth; Real time energy balance; Relative energy deficiency in sport; Supplementation

***Corresponding author:** Dan Benardot, Teaching Professor, Center for the Study of Human Health, Emory University, Atlanta, GA, Tel: +1 404-727-0741; E-mail: dan.benardot@emory.edu

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Introduction

This paper identifies common nutritional myths that are followed by young athletes, and strategies for establishing a better dynamic relationship between energy/nutrient needs and provision in young athletes. The review also points out the common nutritional failures for both athletes and the general public, including a failure to provide energy and nutrients in a way that allows for optimal tissue utilization, and a tendency to excessively emphasize some fuels as more critically important for both performance and health than others. Protein tends to be emphasized over carbohydrates, but few groups have an appropriate understanding of how much should be consumed, and how to best consume it to achieve the optimal anabolic benefit. Importantly, the well-established problems associated with achieving an optimal nutritional state in athletes mirror the common nutritional problems observed in non-athletes. Of particular concern is that the many nutritional misunderstandings about nutrition tend to elevate obesity risk, skeletal fracture risk, and cardiometabolic disorders. This is largely due to a failure to consume foods/beverages in a way that dynamically satisfies tissue requirements for energy and nutrients, even if the total daily intake of energy and nutrients appears to be adequate.

The strategies for optimizing health have nearly always included the importance of physical activity and nutrition. Even in ancient times, Hippocrates emphasized the importance of nutrition to optimize performance in the ancient Olympic Games [1]. However, advice to athletes has often been myth-based rather than science-based, with the myths also often originating in ancient times. As an example, the advice Hippocrates gave for improving sore muscles was to 'get drunk once or twice', and for achieving weight loss to 'eat more meat' [2]. We now know, however, that neither of these strategies are likely to produce the desired outcomes. These issues point out the many challenges for adults who work with youth sports, with success more likely when there is an emphasis on balancing physical fitness with psychological health and focusing on lessons that can be practiced for a lifetime [3]. It is also important to consider that adolescents involved in weight-related and power sports have been found to have better eating patterns than non-sport involved adolescents. However, there are still nutritional weaknesses in this group requiring improvement in calcium and other micronutrient intakes, total energy intake, energy-substrate distribution, and energy intake timing [4,5].

There are many potential contributors to the nutrition problems commonly observed in athletes, including [6]:

- Poor information on what foods contribute what nutrients, coupled with inadequate cooking skills
- An outdated knowledge of how best to satisfy the added nutritional needs of physically active people
- Inadequate access to professionals, such as Registered Dietitians, who can provide needed nutrition information
- Financial limitations that may negatively influence the type and frequency of foods/beverages consumed

- Lifestyle limitations of parents/guardians that may limit provision of appropriate foods and beverages
- Encouraging young athletes to follow eating patterns, such as popular but unproven 'making weight' strategies that could compromise both health and performance
- Using the eating patterns of elite athletes as role models, which are not likely to satisfy the nutritional needs of physically active young and growing individuals
- Living in an environment that does not have adequate availability of good food choices
- Excessive reliance on nutritional supplements and sports foods that have no scientific basis for optimally satisfying the nutritional needs of the young athlete
- Being involved in activities, such as sports that encourage small body profiles, may inhibit appropriate nutrient/energy intake. There is a particular concern that the frequently offered advice to 'Eat less and exercise more' in young athletes is likely to cause both short-term and long-term problems

Weight Issues

One of the major failures observed in both athletes and non-athletes is the use of body mass (i.e., weight) as a primary indicator of well-being. Doing so fails to discriminate between the status of lean mass vs. fat mass, or to determine how these mass components change as a result of altered physical activity and/or nutrient/energy intake. In addition, the terminology used for labeling individuals as 'obese' or 'overweight' via the weight:height index (BMI), can be misleading as the term 'obese' refers to having too much body fat. However, neither 'weight' nor 'BMI' make a direct determination of body fatness [7]. Even in recommendations made by scientific organizations, the use of 'body weight' is often inappropriate. As an example, a recommendation for young athletes states that "Serial measurements of body weight are particularly important for ensuring the adequacy of caloric intake and early identification of pathologic eating behaviors" [8]. In addition, while many of the dietary recommendations are derived from adult scientific literature, it is important to use age-specific research to better understand what constitutes an optimal dietary intake for the young athlete [9].

Athletes are encouraged to increase musculature and lower body fat to enhance their strength:weight ratio, and the resulting elevated musculature per unit height may often inappropriately place them in an 'obese' category using 'BMI' [10]. It is important to consider that BMI was originally intended for assessing population obesity prevalence, but not intended for individual diagnosis of obesity [7,11]. BMI has high specificity but low sensitivity to detect excess adiposity (Figure 1).

Figure 1: Volume difference between 5 lb. of fat and 5 lb. of muscle.

From a nutritional standpoint, it is important that we stop encouraging eating patterns that lower metabolic mass and stop encouraging eating patterns that increase fat mass.

In non-athlete children, the low sensitivity of BMI in detecting excess body fatness fails to identify over 25% of children who are obese (i.e., have high body fat) because of their normal weight:height ratio [12]. It is possible, therefore, that a relatively muscular athletic individual may have more weight:height than non-athletes, but with a relatively low body fat level. This individual may have a false positive BMI by satisfying the criteria for 'overweight' or 'obese', but the low body fat level would suggest that they are definitely not obese [10]. Alternatively, it is also possible that someone on a low caloric intake may reduce their lean body mass while sustaining or increasing body fat mass and appears to be 'thin' but would have a false negative BMI for obesity. Therefore, a young athlete who focuses on body weight and who is increasing more lean mass may consider this positive change as a negative outcome that leads to a calorically restrictive diet. It is important to consider that there is a difference between 'thin' and 'lean'.

There is also a common belief that only consuming excess food will make you fat, but data clearly indicate that individuals who diet (i.e., consume a lower caloric intake than they are accustomed to) to lose weight become more fat because of the excess catabolism of fat-free mass [13]. In addition, once adaptive thermogenesis occurs several months following the 'diet', there is a faster rate of fat recovery relative to fat-free mass recovery, resulting in the same 'weight' the individual had prior to the 'diet', but a weight that is constituted of relatively more fat mass and lower lean mass [14]. This weight rebound is associated with greater risk of weight cycling that is associated with both cardiovascular and renal diseases [15]. Athletes in subjectively scored appearance sports (i.e., diving, gymnastics, figure skating, etc.) tend to be weight conscious, and are predisposed to 'dieting' if they are told they need to lose 'weight' [16,17]. This inevitable weight cycling may predispose young athletes to increased risk for eating disorders and low bone mineral density that places them at high fracture risk [18,19]. The common recommendation to eat less and exercise more may make matters worse for whoever follows this strategy for achieving the desired 'weight' without considering what constitutes weight [11]. Indeed, systematic reviews assessing whether participation in youth sports prevent pediatric obesity are not clear and require a better understanding of whether nutrition/eating patterns sustain energy balance and nutrient intake in a way that optimizes health and body composition [20-22].

Energy Cost of Exercise Issues

One of the difficulties for determining how much food (i.e., how many calories) an individual should consume is difficult to determine because the more chronic the exercise the more individuals find a way to burn less energy to do the exercise [23-26]. This improved energy efficiency is likely a genetic survival mechanism that treats energy/food as precious. Chronic training results in greater cellular mitochondrial content and function, improves oxygen delivery, and results in greater exercise efficiency that is associated with lower energy utilization when doing the same work [25]. As a result, estimating the energy expenditure associated with physical activity may be difficult to assess and increases the risk that the determined value is inaccurate. For instance, athletes exercising on a treadmill or exercise bicycle may enter their age, gender, height and weight, and the equipment calculates the caloric expenditure of the performed exercise. However, a well-conditioned athlete who is accustomed to this activity is likely to burn fewer calories doing this activity than a less well-conditioned athlete. Similar errors may occur when predicting energy expenditure via mass x distance [23-25]. The equipment provided results may misguide the athlete as to how much energy should be consumed to satisfy physiological needs.

Misperception of 'Perfect Food' Issues

It is common for both athletes and non-athletes to think of certain foods as 'perfect', resulting in their overconsumption and a failure to satisfy micronutrient needs. The excessive emphasis on a single food inevitably results in the inadequate consumption of other foods and associated nutrients, with malnutrition as the inevitable outcome [27]. Consider, for instance, that it is common for people to eat the same breakfast virtually every morning. This has two problems associated with it, including a failure to expose tissues with all the nutrients they require and failing to avoid excess tissue exposure to a potentially toxic substance contained in the regularly consumed foods [28]. One strategy for assuring better nutrient exposure is to vary the colors of foods consumed, as each different color is associated with different nutrients/phytonutrients [29]. The following food colors are associated with nutrients/phytonutrients that are uniquely related to the color, and are each important for sustaining cellular integrity and human health [30]:

- Red Foods: Lycopene and Vitamin E
- Green Foods: Glucosinolates and Folic acid
- Green/Yellow Foods: Lutein and Zeaxanthin
- Orange Foods: Alpha and Beta-Carotene
- Orange/Yellow Foods: Vitamin C and Flavonoids
- Red/Purple Foods: Anthocyanins and Ellagic Acid
- White/Green Foods: Allyl Sulfides

Put simply, young athletes who monotonously consume foods with predominantly one color are likely to be predisposed to malnutrition. Young athletes should have as a goal a regular consumption of foods with different colors to help assure tissues are exposed to all the nutrients/phytonutrients they require to sustain health.

Sugar Intake and Food Patterns Associated with Hyperinsulinemia Issues

Physical activity results in a rapid lowering of blood sugar and a loss of sweat associated water and electrolytes, and sports beverages are designed to replace what is lost: sugar, water, and electrolytes. Many athletes are resistant, however, to consuming sports beverages because they contain sugar and are fearful that the sugar will elevate their body fat level. Good sports beverages, which contain approximately 6-7% carbohydrate and 100 to 200 mg Na/cup, are designed to help sustain blood sugar and blood volume by providing electrolytes and water. This helps to sustain the sweat rate and stroke volume, both of which are critical for sustaining the athletic endeavor. Sustaining blood sugar also helps to assure normal neurological function, as blood sugar is the primary fuel for the brain. Athletes should understand that sugar-containing sports beverages, which typically have a sugar concentration that is half of that found in orange juice, are intended to be consumed in small amounts with frequency during physical activity to sustain blood volume, blood sugar, liver glycogen, and muscle glycogen, all of which are essential for high level athletic performance [31,32].

Waiting to drink invariably results in thirst, which commonly results in a large volume of sports beverage consumed at once and potentially resulting in hyperinsulinemia that results in excess fat manufacture and elevated body fatness [33]. However, other factors associated with hyperinsulinemia should also be considered. For instance, delayed meals associated with low blood sugar, large meals, and meals with refined foods may all contribute to a hyperinsulinemic state associated with high fat manufacture [33-37]. Clearly, sugar consumption is not the only problem. Infrequent eating is associated with large bolus meals that result in higher fat storage, even if the total caloric intake is the same as someone who eats more frequently, because the higher bolus meals are associated with an elevated insulin response [37,38]. Also, the appetite stimulating hormone ghrelin is only turned off with a normoinsulinemic response to eating, so a hyperinsulinemic response to eating results in sustained appetite and excessive eating [39,40]. In addition, insulin is also elevated exponentially to the caloric load of the meal, so allowing low blood sugar to occur inevitably results in fat elevating hyperinsulinemia [39,40].

Nutrient Supplement Issues

Nutrient supplements are common in both athlete and non-athlete populations. Studies now clearly indicate that both athletes and the general public would do better with a lower reliance on supplements and higher reliance on good foods to obtain needed nutrients. A clear problem is that young athletes believe that supplements are necessary to optimize the benefits achieved from training [41]. This belief is problematic, as it is becoming increasingly clear that many nutrient supplements have a nutrient content that far exceeds tissue capability to absorb it, with repeating daily intakes resulting in decreased tissue uptake with an elevated potential for inducing an inflammatory effect. The nutrient supplement issues have become sufficiently clear that organizing groups have positions clearly stating that the nutrition needs of adolescent athletes should be met by foods first rather than excessively relying on supplements [42,43].

A number of studies have documented the problems associated with regular supplement use, especially when taken without supervision of a medical professional to address a biologically established nutrient deficiency. As an example, concerns have been raised that an excessively high folic acid supplementation may accelerate the progression of preneoplastic lesions, increasing the risk of colorectal and other forms of cancer, including prostate cancer [44-48].

A study assessing older women (N=38,772) found that several commonly used dietary vitamin and mineral supplements, including multivitamins, vitamin B6, folic acid, iron, magnesium, zinc, copper, and calcium were, with the exception of calcium, associated with increased mortality risk [49]. In this study it was noted that, in 1986, 66% of the assessed women took supplements, while in 2004 supplement intake increased to 85%. It has also been found that, after an average of 4 years of supplementation, the combination of beta-carotene and vitamin A had no benefit and may have had an adverse effect on the incidence of lung cancer and on the risk of death from lung cancer [50]. In an attempt to lower respiratory tract infections in elderly nursing homes vitamin E was provided to residents. However, this supplemented vitamin E was found to have no significant beneficial effect [51]. Poorly nourished athletes place themselves at increased disease risk because of a compromised immune system, and often take supplements that are intended to boost the immune system. However, there is no convincing evidence that immune-boosting supplements, including high doses of antioxidant vitamins and zinc, prevent exercise-induced immune impairment [52].

A study assessing the impact of vitamin E supplements in athletes who competed in the Kona triathlon randomly assigned athletes to a group taking 800 IU daily or a group taking a non-nutritive placebo daily for 2 months prior to the triathlon. It was found that the group taking the vitamin E had greater lipid peroxidation and more inflammation after completing the triathlon [53].

One of the most commonly taken substances taken to achieve an ergogenic benefit is creatine monohydrate. A study assessing elite young soccer players found that low-dose, short-term oral creatine supplementation positively influences muscular power [54]. However, this study had no assessment of energy balance and energy substrate intake to determine if the study subjects consumed sufficient energy to enable cell manufacture of creatine. A study of male collegiate athletes, who were randomly assigned to a creatine monohydrate group, 2 different carbohydrate groups (100 kcal and 250 kcal), and a non-caloric placebo group found the following in a 10 jump-height test following 6 days of supplementation [55]:

- Jump 1 to 6: No difference between groups
- Jump 7: 250 kcal supplement group performed significantly better than all other groups
- Jump 8 & 9: 250 kcal and creatine supplement groups performed better than other groups
- Jump 10: All supplements (100 kcal, 250 kcal, Creatine) performed better than the non-caloric/non creatine placebo
- In no case did the creatine monohydrate supplement group outperform the 250 kcal from carbohydrate group
- Creatine monohydrate group gained 1.5 kg after 6 days; 250 kcal group gained 0.0kg after 6 days (Creatine storage is associated with water storage)

A logical explanation for these findings is that if you provide sufficient energy and protein in meals, body cells can synthesize the required secondary proteins, including creatine. Give the body enough protein but not sufficient energy, and the protein will be used to satisfy the individual's energy requirement, with a failure to synthesize needed secondary proteins.

The highest biological value protein a human can consume is whey protein, in large part because the amino acid leucine, which functions as a muscle protein synthesis (MPS) stimulator, is slightly elevated in whey. However, it has been found that > 500mg of leucine/kg/d may increase adverse events and inhibit MPS. Because many athletes are aware of the high biological value of whey protein, they often over-consume whey protein and achieve the opposite of the desired effect [56].

It is important for athletes to understand that far too many supplements that target athletes via advertisements contain banned substances not listed on the label [57-59]. These supplements may result in a misattribution of benefit, as the athletes believe that the 'vitamin' supplement they are taking is responsible for helping them enlarge their muscle mass, but it is more likely to be the banned anabolic steroid not listed on the label that is achieving this benefit. All of these findings suggest that nutrient/energy intake must be provided in a way that does not exceed the cellular capacity to deal with what is provided, and that sustaining energy balance is an important feature in achieving desired outcomes. Ideally, the goal should be to never overfill the cellular tank, and never let it go to empty through a well-timed intake of a wide variety of foods that expose tissue to an array of needed nutrients. These findings also suggest that, unless there is a known biologically assessed nutrient deficiency, taking a pharmacological approach to nutrition is not better than eating good foods.

Within-Day Energy Balance Issues

It is important to consider the problems associated with the traditional strategy for determining energy balance, often referred to as 'Energy-In vs. Energy-Out' and determined over a 24-hour period. This traditional view of energy balance suggests that if, over a 24-hour period, 3,000 kcals are consumed, and 3,000 kcal are expended the person is in perfect energy balance and 'weight' will stay the same (Figure 2).

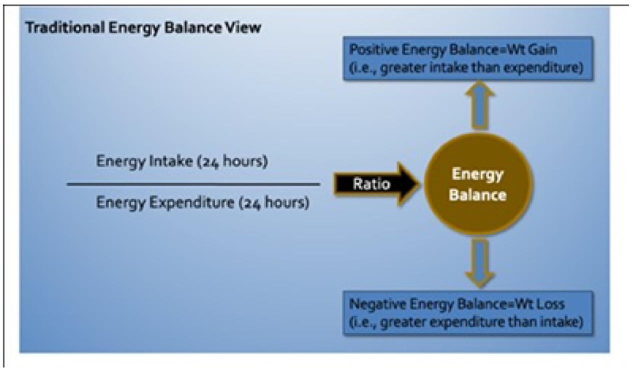

Figure 2: Traditional macroeconomic view of energy balance.

The assumption is that if daily energy intake is equivalent to daily energy expenditure, then weight will be the same. However, this system fails to accept the reality that the body works in real time.

However, because energy balance occurs in real time (i.e., the pancreas doesn't wait until the end of the day to determine how much insulin to produce), this traditional view of energy balance fails to provide essential information. Studies clearly demonstrate that decreased meal frequency resulting in energy balance deficits that exceed -300 to -400 kcal of energy balance, even when 24-hour energy balance is achieved, is associated with endocrine changes that could negatively alter body composition, bone mineral density, athletic performance, and health [38,60-62]. Athletes, because of their elevated energy expenditure during physical activity, can more easily achieve a severe negative energy balanced state, with negative consequences, than non-athletes. However, studies of non-athletes also clearly demonstrate that meal-skipping, which results in a severe negative energy balance, is also associated with higher body fat and more cardiometabolic risk factors [11,15] (Figure 3).

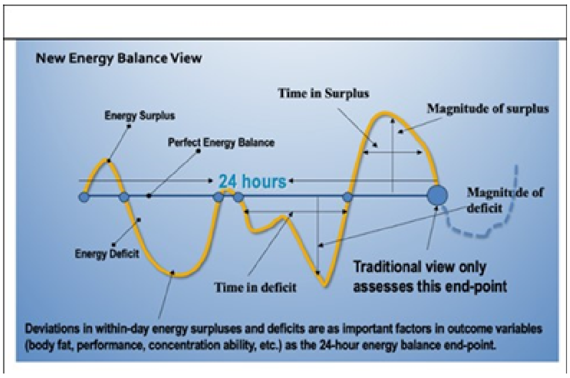

Figure 3: New microeconomic view of energy balance.

The magnitude of deviations, both energy balance surpluses and deficits, impact multiple health and performance outcomes.

A recent consensus statement by the International Olympic Committee has established a term for this condition, which is referred to as 'Relative Energy Deficiency in Sport (RED-S)', and has determined that this condition (i.e., not having sufficient energy to do the physical task required), results in higher disease risks and multiple negative performance outcomes [18,63]. A study of elite athletes found that the athletes with the most severe energy balance deficits during the day, had the highest body fat levels [38]. A study of female athletes assessed athletes who consumed sufficient daily energy, but had different eating strategies, some of which resulted in more severe energy balance deficits. In the female athletes with energy balance deficits that exceeded 300 kcal, it was found that they experienced higher cortisol and lower estrogen levels [61]. A similar study on male athletes found that those with more severe energy balance deficits had a higher cortisol:testosterone ratio [62]. Studies have also demonstrated that the state of energy balance, in real time, can influence how nutrients are used and can also influence hormones that are produced. Poor energy balance may result in excess serotonin that results in central nervous system fatigue [64]. Good energy balance and appropriate distribution of protein has a much better anabolic outcome than consuming the same amount of protein that is poorly distributed or consumed when in a negative energy balanced state [65]. It is important to consider that both nutrient and energy balance must be considered in real time, with both intakes that are excessive or inadequate in real time causing problems that can negatively impact body composition and health. Poor within-day energy balance may also negatively influence leptin and ghrelin, which are important factors in sustaining a desired weight and body composition. Leptin, which is produced predominantly by adipose tissue, impacts the hypothalamus in a way that lowers food intake, elevates energy expenditure, increases fat catabolism, lowers plasma glucose, and lowers body fat weight. Ghrelin, the appetite stimulating hormone, has the opposite effect by increasing food intake, lowering energy expenditure, lowering fat catabolism, increasing plasma glucose and increasing body fat weight. These two hormones have a clear impact aimed at sustaining a healthy body composition and weight. However, poor within-day energy balance can negatively impact the desired impact of leptin and ghrelin. It has been found that decreased meal frequency is correlated with greater daily energy consumption, possibly resulting from an up-regulation of appetite and/or a tendency toward elevated fat intake [66-68]. The elevated energy intake in not matched with higher activity, resulting in higher body fat levels [69,70]. In addition, insulin release typically suppresses ghrelin, which suppresses appetite, but an eating pattern that results in low blood sugar is likely to result in hyperinsulinemia, which fails to suppress ghrelin [39,40].

A new model for energy balance should assess the degree to which athletes spend time above or below + or – 300 to 400 kcal of energy balance [71] (Figure 4).

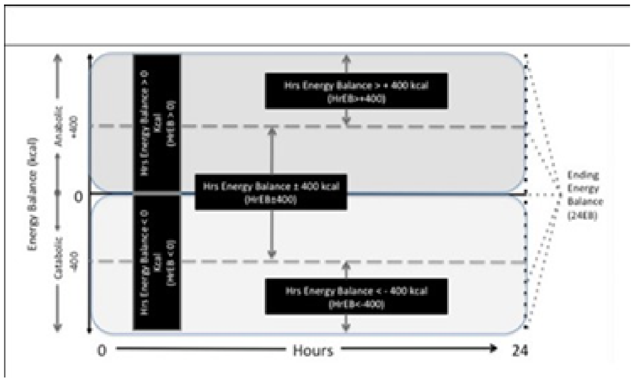

Figure 4: A new model for energy balance.

The goal is to sustain an energy balance that does not exceed +or-400 kcal throughout the day. Achieving an energy balance exceeding this range is associated with performance and health problems.

It is also important to consider that there are significant metabolic adaptations that occur as a result of poor fuel delivery. Muscle catabolism occurs with inadequate fuel as a logical adaptation to the poor fuel delivery as a result of elevated cortisol [72,73]. In addition, infrequent eating is associated with large bolus meal intake that is associated with higher fat storage, even if the total daily caloric intake is the same as smaller more frequent meals, as insulin is produced exponentially to the caloric value of the meal consumed [37,38]. The focus should be on dynamically linking food intake with energy/nutrient requirements. In addition, the nutrition goals of pre-, during-, and post-exercise should be planned (Table 1).

The issue of having a strategy for adequate energy/nutrient intake in young athletes has been found to be a real issue. A study of youth soccer plays found inadequate total energy intake, inadequate carbohydrate intake, post-loaded protein intake (i.e., consumed at the end of the day when in a severe energy balance deficit), with the recommendation that young athletes should focus on total daily macronutrient intake coupled with optimal daily food intake distribution patterns [74].

Summary

The goal of optimizing nutrient and energy intake in young athletes requires planning and cooperation with the environment in which young athletes are training. Having readily available foods and drinks that are appropriate for the athletes is critical to optimizing performance and reducing health risks. The International Olympic Committee consensus statement on Relative Energy Deficiency in Sport (RED-S) makes clear the performance and health problems that occur with a failure to sustain a reasonable energy balance state throughout

Timing	Goals	Food Examples
Pre- Exercise Meal	Familiar foods high in carbohydrates, moderate in protein, low in fat with ample amounts of water. Avoid high fiber foods/raw vegetables.	• Baked (not fried!) chicken breasts without skin • Broiled lean steak with no visible fat and no sauce • Baked or grilled (not fried!) fish • Mashed potatoes (easy on the butter!) • Baked sweet or white potato, no skin (easy on butter and sour cream!) • Rice, grits, bread, and/or pasta • Cooked vegetables (no raw vegetables/salads)
~2-4 Hours Pre-Exercise	Sustain blood sugar and muscle glycogen through occasional solid snacks high in carbs, and low in protein, low in fat.	• Very small serving (1 to 2 oz max) of lean deli cut meats (lean turkey, lean roast beef, etc. • Bagel, toast, or plain saltine crackers • Banana, grapes, apple, orange • Avoid all beans, and vegetables • Start sipping on sports beverage (limit to 1 to 2 mouthfuls every 15 minutes)
~1 Hour Pre-Exercise	Assure blood sugar is normal in advance of practice. Limit intake of solid foods to help assure empty stomach prior to exercise. Enhance gastric emptying by consuming ½ to 1 liter of water in a short period of time.	• Lowfat plain yogurt if tolerated, and no closer than 30 minutes before practice. • Very small amounts of plain white bread, pretzels, and saltine crackers, but not closer than 30 minutes before practice • Banana, but not closer than 30 minutes before practice • ½ to 1 liter of water with any solid foods that are consumed • Continue sipping on sports beverage (limit to 1 to 2 mouthfuls every 15 minutes
During Exercise	Do not wait for the sensation of 'thirst' as a marker of when to drink. The goal is to sustain blood volume and blood sugar 'normalcy' rather than recover from an abnormally low blood volume and blood sugar through regular, frequent consumption of sports beverage.	• Consume sports beverage at every available opportunity during practice • Avoid single high-volume consumption of sports beverage by avoiding 'thirst'
Post-Exercise	Recover blood sugar, blood volume, muscle glycogen, and muscle soreness. Weight lost during practice should be recovered through consumption of 16 oz of fluid for every pound lost, plus additional fluid to sustain current needs.	• Chocolate milk (if tolerated) • 100 kcal (25 gm) whey protein isolate added to 32 oz of sports beverage and consumed soon after practice ends • Continue eating foods frequently, with a focus on high carbohydrate, moderate protein, and low-fat foods

Table 1: General, Pre-Practice, During-Practice, and Post-Practice Nutrition Goals and Examples.

Sports beverage should be constituted of a 6 to 7% carbohydrate solution with 100 to 200 mg sodium/cup. Higher sodium is desired for longer duration activities to help sustain blood volume and associated heart stroke volume. The carbohydrate should, ideally, consist of mixed mono- and disaccharides with no high-fructose corn syrup.

the day [14-18]. It is also clear that RED-S is most likely to occur in athletes who are restricting intake while trying to lose 'weight', when the focus of these athletes should be to have a nutritional and exercise strategy that will help them achieve a desirable body composition.

Supplement intake in young athletes is a concern, particularly when it is arbitrary and not prescribed by a medical professional. These supplements have multiple problems, including creating cellular dysfunction and creating a belief system that the athlete's nutritional needs are being met regardless of the quality of the diet. It should be made clear to young athletes that supplements are not a substitute for consuming the right foods and drinks in a way that dynamically satisfies the combined needs of growth, development, and physical activity.

While protein intake is often seen as critically important to achieving a desired musculature, few athletes understand how to best consume protein to achieve the desired outcomes. It is also important to consider that inadequate carbohydrate intake, especially when coupled with a poor hydration state, is associated with overtraining syndrome that could elevate injury risk [75].

Having good quality carbohydrate, fluids, and protein available post-exercise helps to decrease overtraining and aids in tissue recovery from stress and exercise [32]. It is important to consider that the optimal nutritional strategy is to sustain normalcy, rather than attempt to recover from abnormalcy. This recovery strategy often leads to large meal consumption following exercise that is not ideal for optimizing the training effect while attempting to minimize fat storage to optimize the strength:weight ratio [65]. Important points to consider when working with young athletes include:

- Sustaining a desired within-day energy balance of approximately ± 300 to 400 kcal is important for avoiding health and performance problems
- Tracking changes in body composition are more useful for determining dietary adequacy than weight and 'BMI'
- Dietary supplements may cause more problems than they resolve and should only be used under medical supervision to address an assessed nutrient deficiency
- Having a supportive environment that has easily available foods and beverages to consume before, during, and after training/competition is an important factor in achieving a desired nutritional status
- Athletes working in different environments (i.e., indoors vs. outdoors), in different growth phases (i.e., adolescent growth phase vs. pre-adolescence), and of different genders have different nutritional requirements that should be addressed
- The focus on 'perfect foods' may limit the intake of a wide variety of foods that are needed to expose tissues to all nutrients/phytonutrients

Conclusion

Young athletes must satisfy the combined nutrient/energy needs of growth, development, and physical activity. These needs can only be satisfied with an eating pattern that avoids long periods without food availability, and availability of the right foods/beverages before, during, and after physical activity. Athletes who are focused on achieving a lower weight are likely to be predisposed to a restricted eating pattern that compromises bone mass, negatively influences hormones, and exercise recovery. It is important to focus on muscle and bone mass development, and the message given to athletes who seek a change in body composition should be one that encourages the athlete to do the right things. For instance, young athletes who are told that their body fat % is too high are likely to be predisposed to restrictive eating. However, the same athlete who is told that lean mass % (i.e., the inverse of body fat %) is too low and is provided a logical strategy for making improvements in musculature is more likely to follow an appropriate nutritional plan. Encouraging young athletes to eat a wide variety of foods to satisfy nutritional needs is a far better strategy, with fewer associated problems, than an excessive reliance of nutrient supplements. It is critical that youth sport environments understand the importance of avoiding RED-S by having easily available foods and beverages for the young athletes. Having good foods provided at the right times is critical to both the health and performance outcomes of young athletes and their future health and wellbeing.

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