Chapter 2
Sports Nutrition

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Introduction

There are a many articles written about the female athlete triad including studies on bone health, hormone regulation, eating disorders, and excessive exercise. These studies consistently conclude that eating a balanced diet appropriate for the level of physical activity can resolve the problem, in other words fixing the "energy availability" component of the triangle. Proper nutrition may not add years back to bone age or health for an adolescent girl or make up for months or years of amenorrhea, but with sufficient energy intake, periods should resume, hormones should come back into balance, and bones should begin to strengthen. Undoubtedly, sports nutrition is an essential component of the prevention of, the prescription for management of, and the continued care for treatment of the female athlete triad.

The macronutrients protein, carbohydrate, and fat make up any healthy diet. A sports diet needs appropriate quantities of each component: carbohydrate to fuel the body, protein to rebuild, and fat to absorb nutrients and prevent disease. Someone who eats a healthy, balanced diet should not need to make major dietary changes to have a healthy, balanced, "sports diet." As the position paper of the Academy of Nutrition and Dietetics, Dietitians of Canada, and American College of Sports

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Medicine states, "the fundamental differences between an athlete's diet and that of the general population are that athletes require additional fluid to cover sweat losses and additional energy to fuel physical activity" [1].

Micronutrients are also extremely important for an athlete. Specifically for active women, iron, calcium, and vitamin D must be provided in appropriate quantities to prevent injury and other negative outcomes associated with sport such as fatigue and stress fracture. While this chapter focuses on sports nutrition including what to eat pre-, during, and post-workout, it is important to emphasize that a healthy, varied, balanced diet will provide these important nutrients and does not need to change substantially or include expensive supplements in its makeup to become a "sports diet." However, there are certain percentages of nutrients, timing tips, and other tools that individuals can use to modify their diet to improve athletic performance. Whether modifying an athlete's diet is needed to address a problem such as the female athlete triad or if it is the focus of a performance improvement plan, ensuring that enough energy is consumed consistently is essential.

As the other chapters of this book have shown, an energy deficit, whether inadvertent or intentional, can cause serious harm. Despite the popular belief that athletes can eat whatever they want because they burn many calories through training, the foods they eat must be varied enough to ensure that correct amounts of vital nutrients are being consumed. One might think that after a vigorous bout of exercise, an athlete would be especially hungry, so that if she does not adequately refuel, then it must be intentional (i.e., for weight loss or due to body image issues). However, recent studies of appetite-related hormones in female athletes have shown that exercising can raise the levels of peptide YY and ghrelin, resulting in a suppressed appetite rather than an appropriate level of hunger necessary to fuel the body [2]. Sometimes athletes need a reminder that they must refuel, whether their body is sending them the correct signals to do so or not.

Dietary Assessment

Assessing an athlete's diet requires asking numerous questions. A 24-hour food recall is generally a good place to start. However, the past 24-hour intake may not adequately capture the typical intake of an athlete whose diet varies substantially from day to day because of training demands. When assessing an athlete, it is better to be more specific and ask for a dietary recall for a practice day, game day, and rest day, for example. Some athletes will fuel appropriately during training, but get an upset stomach prior to competition and will eat or drink very little out of fear that needing to use the bathroom during competition will affect their performance. Others may eat adequately on days when they exercise, but skimp on days that they know that they will not be "burning it off" at the gym. In assessing an athlete's diet, a clinician can begin to see trends: Do they avoid meat or grains? Are they getting enough dietary fat? Are they restricting calories or overloading on protein? In addition to food and beverages, it is also important to ask about any vitamins, supplements, or other ergogenic aids such as caffeine that they may be taking.

In addition to diet, it is important to ask about hours and intensity of activity each day. As you will see, that is one factor in assessing caloric needs. However, another important reason for asking is because not all women who exercise consider themselves "athletes" or think that they would fit the category of needing a sports diet. Lack of recognition of intensity of exercise could prevent someone from getting the extra nutrients that they need.

It is beneficial to conduct an anthropometric assessment of athletes and, depending on the athletes and their needs, to measure body composition in the assessment. The standard assessment is the body mass index (BMI) which is a measurement of a person's height in relation to her weight (kg/m^2). Although BMI only takes into account height and weight, there is a good correlation between BMI and % body fat among adults [3]. Because the BMI is an indirect measure, which cannot discriminate between lean mass, fat mass, and bone, it may be less accurate for use among athletes with higher muscle mass and lower body fat percentage than the general population [4]. However, BMI assessment is a useful tool when included as part of a complete assessment of an athlete's health, especially for those who are underweight or at risk for an eating disorder. As an example, an individual's BMI or the trend in her BMI, especially during adolescence, may be more revealing than her report of amount of activity and quantities of food consumed.

If more detailed information about an athlete's body composition is desired, body fat percentage can be estimated by using calipers to measure the thickness of subcutaneous fat in multiple places on the body including the abdominal area, the subscapular region, arms, buttocks, and thighs. Alternatively, a more accurate and precise method of measuring body composition is by dual X-ray absorptiometry (DXA), which makes it possible to determine the amount of total and regional fat and lean tissue including the fat and lean mass indices normalized to height squared. Alternatively, bioelectrical impedance analysis or air displacement plethysmography (Bod Pod®) can be used, although each requires equipment that is not commonly available. Once the data have been gathered, it is important to know what goals an athlete has. Is she looking to gain muscle, lose fat, or reach a specific weight in order to compete at a certain weight class? Is she attempting to reach an unrealistic body fat percentage? The goal will help to guide the nutritional counseling, ensuring that whatever the athlete's goals, she is attempting to reach them in a safe and healthy way.

Energy Requirements

Energy requirements for athletes vary substantially from sport to sport. Athletes in certain sports such as wrestling, boxing, or rowing may need to maintain a specific weight in order to compete; others may strive for a certain body ideal for sports like dance or gymnastics. Still others such as distance runners, cyclists, or swimmers may be burning so many calories in their training that they find themselves in negative energy balance without even realizing it.

The easiest method for determining an athlete's total daily energy needs is to use the Harris Benedict Equation (see below) because all that must be known is the athlete's weight, height, and age.

Harris Benedict Equation

$$\text{Females}: \text{Resting metabolic rate}\left(\text{RMR}\right) = 665.0955 + 9.5634 \times \text{Weight in kg} + 1.8495 \times \text{Height in cm} - 4.6756 \times \text{Age in years}$$

Direct estimates of energy requirements, such as indirect calorimetry, require the use of costly equipment and other methods of calculating energy requirements require knowledge of an athlete's lean body mass (determined through the methods described above). For example, RMR can be estimated using the Cunningham Equation (below), although fat-free mass must be known in order to calculate.

Cunningham Equation

$$\text{Females}: \text{Resting metabolic rate}\left(\text{RMR}\right) = 370 + 21.6 \times \text{Free} - \text{Fat Mass}$$

The RMR, found using either method described above, indicates the amount of calories burned at rest; multiply this by an activity factor of 1.8–2.3 depending on activity level to account for calories burned above and beyond the RMR. An activity level of 1.8 would equate to someone who exercises around an hour each day whereas 2.3 would be someone who is exercising for several hours each day [4].

Macronutrients

Carbohydrate

Carbohydrates should be the foundation of any healthy meal plan, especially that of an athlete. An athlete should consume from 6 to 10 g/kg/day of carbohydrate, depending on activity level and type of activity [1]. For someone exercising 1 h/day, the lower end of this range would suffice, but athletes exercising intensely, possibly even more than once a day, should aim for the higher end of the range. Intake of carbohydrates should be spread fairly evenly throughout the day rather than included only in one big meal, for example, at dinner [4].

Carbohydrates are found in different places in the body: stored in the muscles as glycogen, stored in the liver as glycogen, and circulating in the blood as glucose [4]. Athletes need to consume enough carbohydrate so that their glycogen stores are

maximized and ready when they begin exercise. The body uses carbohydrates to fuel exercise; half of the energy for moderate-intensity exercise comes from muscle glycogen and blood glucose and two thirds of the energy for high-intensity exercise does [4]. Athletes need to replace these stores during exercise lasting longer than 1 h in duration with food and/or drink that contain carbohydrates in order to have continued fuel. It is important to note that no amount of eating or drinking during exercise can make up for beginning with depleted stores [5].

Adequate carbohydrate intake is not only important for endurance athletes such as runners or cyclists who might generally hear advice about *carbo loading*. Athletes on team sports or those who compete in shorter distance activities will also need stored energy for practices and will need adequate fuel available for the short bursts of energy necessary during competition. Officially, *carbo loading* is more than just eating a pasta dinner the night before a race or athletic event, although some athletes may still do this as a last ditch effort to top off glycogen stores. As stated previously, anyone participating in athletics should make sure to get enough carbohydrates in their diet on a consistent basis. The theory behind *carbo loading* is that athletes can maximize their glycogen stores by eating the low end of the recommended amount of carbohydrate starting 6 days prior to the competition or event. They continue with this for 3 days at which point they increase to the high end of the recommended amount of carbohydrate for the final 3 days leading up to the competition [5].

There are negative consequences associated with inadequate muscle glycogen stores, as well as inadequate liver glycogen stores. When muscle glycogen is too low and not repleted, athletes may "hit the wall" and find that they can no longer continue at the same level of performance as they could previously. This tends to happen more during endurance activities such as a long-distance running event or cross-country ski race. Liver glycogen and blood sugar provide fuel for the brain; when there is not enough an athlete may lose motivation to continue performing or become disoriented despite the availability of the muscle stores to continue—sometimes this is referred to as "bonking" [6]. This is why it is important not only to eat carbohydrates consistently on a daily basis (and possibly also *carbo load* leading up to an event), but also to eat a source of carbohydrate in the hours immediately prior to the event.

There are many food and beverage sources of carbohydrate from one or more of the following categories: fruit, vegetables, grains, dairy, beans, nuts, and sugar. Some of these carbohydrate sources are healthier than others. Accordingly, the U.S. government's MyPlate recommendations suggest that half of all grains consumed should be whole grains such as whole wheat, whole wheat pasta, brown rice, quinoa, oats, bulgur, barley, and amaranth in order to help prevent heart disease and ensure adequate fiber intake. In addition, not all carbohydrates perform the same once they have been eaten. The speed and amount which a certain food raises a person's blood sugar is referred to as the glycemic index (GI). A low GI food will slowly raise blood sugar and slowly bring it back down. A high GI food will spike blood sugar quickly and can bring it down fast as well. The blood sugar response to a particular food depends on the makeup of the food as well as what it is eaten in concert with. Generally speaking, a low GI food such as a banana or

glass of milk might better serve an athlete prior to exercise whereas a high glycemic index food like gummy bears or juice might better serve an athlete during or immediately after exercise [6].

Protein

The RDA for protein intake for a healthy adult is 0.8 g/kg/day and the "Acceptable Macronutrient Distribution Range" is 10–35 % of daily calories provided by protein. For endurance athletes, that amount can increase to 1.2–1.4 g/kg/day and the amount can go even higher for strength training athletes, up to 1.7 g/kg/day. Some athletes may think that they need to take in excess amounts of protein in order to build muscle. However, it is a combination of total energy intake with sufficient protein and resistance exercise that build muscle, not excessive protein intake. Athletes interested in building muscle must eat appropriate amounts of "protein-sparing" carbohydrate in order for the essential amino acids to remain free to build muscle [1]. There is also the opposite risk of having too little protein which can cause the breakdown of muscle, a side effect any athlete will want to avoid [5].

While it is entirely possible for an athlete to meet her protein requirements by eating a varied diet that includes protein sources such as meat, fish, poultry, tofu, beans, legumes, nuts, and dairy, some turn to protein powders or bars. An athlete can find protein powder in all sorts of varieties: from standard whey or soy protein to egg white and beef protein to vegan pea, hemp, and rice protein (notice that all of these protein powders originate from food sources). If she finds it convenient and cost effective to consume protein in powder form, it is not necessarily detrimental (although a thorough review of other ingredients is important) but it is not necessary either. Regardless of the source or form, protein still contains 4 cal/g. An athlete should be aware of not just the grams of protein she is consuming, but also the potential for extra calories in an extremely high-protein diet. Also, many protein powders are flavored with artificial sweeteners in order to reduce the calories in the powder but keep the taste acceptable. Athletes who might be sensitive to artificial sweeteners, such as those with irritable bowel syndrome, should be sure to read label and ingredient list on protein powders carefully.

When a person consumes excessive amounts of protein, she risks becoming dehydrated due to the increased urine that is created as the body disposes of the excess ammonia derived from amino acids. This is called nitrogenous waste and is created by the liver once the kidney has worked to filter out the excess nitrogen [5].

Fat

The percentage of fat in an athlete's daily diet should be between 20 and 35 %. Less than this amount may have an adverse affect on performance and can hinder a person's ability to absorb fat-soluble vitamins (A, D, E, and K). Eating a diet higher in fat than 35 %, however, does not appear to be beneficial to athletes [1, 4].

Athletes who need to consume large amounts of calories each day to avoid an energy deficit should utilize fat source not just for its health benefits but also due to its energy density. Fat contains 9 cal/g as opposed to carbohydrates and protein both of which contain 4 cal/g. However, emphasis should be placed on unsaturated fats which are derived from plant sources such as avocado and nuts rather than saturated fats which are derived from animal sources such as butter and cream.

For low-intensity exercise (and when a body is at rest), fat stored in the body is used as a source of fuel. As exercise intensity increases, the body more efficiently uses carbohydrate more so than fat as the fuel source [5]. Some athletes may ask about using medium chain triglycerides (MCTs) as an alternative energy source to carbohydrates. MCT oil is marketed to athletes as a way to boost energy and maximize performance, although research studies have found little benefit related to its use. Instead, MCT has actually been shown to cause gastrointestinal distress and elevated blood lipid levels [4]. Another type of fat advertised to athletes is branch-chain amino acids (BCAAs) made up of leucine, isoleucine, and valine. These have also shown no improvement in performance, though they may have a benefit related to immune function [4].

Pre-, During, and Post-workout Fueling

Pre-workout

Athletes will perform better if they are adequately fueled prior to performance [1]. What a person eats prior to practice or competition will depend partly on how much time is available. Having a meal 3–4 h prior to activity and a small snack 1 h before can give the body time to digest but remain fueled, which is realistic for activities that occur later on in the day. If an athlete will be practicing or competing in the early morning, she may not have enough time to eat anything substantial between waking up and exercising. In this case, a small meal prior to bed the night before might be the best way to ensure that her body is ready for activity upon waking [6]. Ideally, she will wake up at least an hour before activity so that she can eat a small meal and digest before beginning exercise.

While many have sought the "perfect" pre-race meal, it will likely differ from individual to individual based on foods that they best tolerate. The meal or snack should be consumed with enough time to digest it, should leave the athlete feeling satiated, should be low in fat and fiber so as not to cause an upset stomach, should be high in carbohydrate to give energy, and should be moderate in protein [1]. This combination may sound overly specific and possibly even unattainable, but there are easy ways to achieve this. For example, a piece of white bread with a small amount of peanut butter or an English muffin with a slice of cheese and an egg white would meet these requirements, as would some trail mix and a glass of orange juice. The pre-race or pre-workout meal does not need to come in a package and does not need to be sold for that specific purpose; often the normal foods that one eats, perhaps with slight modifications to portion size and makeup, can be just the right pre-workout meal or snack.

Here are some other suggestions for healthy pre-race meals or snacks (portions depend on timing and intensity of workout, and on the individual athlete):

- Peanut butter and banana in a whole wheat wrap
- Turkey sandwich with a glass of orange juice
- Bagel with cream cheese
- Energy bar with an apple
- Pita chips or pretzels with hummus
- Baked potato with cottage cheese and broccoli

During Workout

Consuming carbohydrates during exercise, mainly in the form of glucose, can enhance performance when exercise will last longer than 60 min [1]. It is important that whatever is ingested during activity has been tested by the athlete prior to competition and is known to be well tolerated. Popular products such as gels and chews can provide the necessary fuel and will be quickly digested and absorbed by the body. If exercise will last longer than 60 min, ingesting carbohydrates at the rate of 0.7 g/kg body weight per hour can extend performance [1]. For a 130-lb athlete, this would equal around 41 g of carbohydrate per hour or the equivalent of two energy gels. A small banana and 12 oz of Gatorade would also provide enough carbohydrates for that athlete.

Post-workout

After exercise, it is necessary to restore depleted glycogen stores with carbohydrates as well as rebuild broken-down muscle with protein. There have been a few different reported "ideal" ratios of carbohydrates to protein for post-workout such as 3–1 or 4–1. These ratios may surprise athletes who think that they need to focus primarily on protein for recovery [6]. Chocolate milk is a favorite recovery beverage among many endurance athletes due to the combination of carbohydrate and protein, not to mention the electrolytes that are found naturally in milk such as sodium and potassium [6]. Despite the fact that this simple beverage or other whole foods can provide all of the carbohydrates and protein necessary for a post-workout snack, many athletes believe that they need to consume excess amounts of protein and are prone to believe marketing campaigns and internet postings leading them to recovery shakes, protein powders, and other products that may contain unnecessary nutrients, untested supplements, and chemicals that could harm the body in the long run.

Refueling within 30 min of a workout can restore glycogen faster, but depending on the length and intensity of the workout, it may not be necessary to worry about the timing as long as a meal with carbohydrates and protein will be consumed within

2 h. With the increased amount of carbohydrates that an athlete should consume, a post-workout snack should be eaten if a meal is not imminent [1].

Micronutrients

Iron

Women need more iron than men to begin with due to the blood loss that occurs during menstruation and are at higher risk for iron deficiency anemia. The Dietary Reference Intakes (DRIs) put out by the Institute of Medicine recommend that females ages 9–13 consume 8 mg of iron per day. Those ages 14–18 should consume 15 mg/day and from 19 to 50 should consume 18 mg/day. Over age 50, the recommendation decreases back down to 8 mg/day [7]. However, endurance athletes need as much as 70 % more iron than their non-athletic counterparts [1]. Iron deficiency anemia can be especially detrimental for athletes who could suffer performance setbacks due to the symptoms of anemia such as fatigue and decreased motivation.

Vegetarians and vegans should pay especially close attention to their iron intake (see "Special Populations" section below). Women who may not identify as vegetarian, but who may avoid red meat due to the perception that it is unhealthy, are also a population at risk of inadequate iron intake. While avoiding red meat can be a healthy dietary choice, it can also be included as part of a healthy, balanced diet by choosing lean cuts, trimming any excess fat, and limiting consumption to two to three times per week. It is possible that while not technically a vegetarian, she may not be consuming much meat but also not meeting her iron needs via plant-based sources. Iron supplements are an option but can have negative side effects such as gastrointestinal distress. If possible, encourage athletes to analyze how much iron is in their diet and to increase the amount, whether plant based or animal based.

Vitamin C plays a supporting role in iron absorption. As such, athletes should have a source of vitamin C each time they are consuming an iron-containing food. This could be a glass of orange juice alongside iron-fortified cereal, green peppers sautéed with chicken, or tomatoes added to bean chili. See Table 2.1 for good dietary sources of iron. Remember that animal-based sources of iron are absorbed far better than plant-based sources. Although animal-based sources might not contain as much iron as those products that have been fortified with iron, the body will be able to use the iron more effectively if it comes from the animal-based source.

Calcium

Calcium intake is extremely important for athletes, especially females who might have less than adequate overall intake. The DRIs indicate that the recommended amount of calcium for girls ages 9–13 is 1,300 mg/day; for ages 19–50 it decreases to 1,000 mg/day and back up to 1,200 mg/day for women over 50 [7].

Table 2.1 Dietary sources of iron

	Serving size	Amount of iron (mg)
Animal based (better absorbed)		
Beef, chuck	3 oz	2.8
Pork	3 oz	1.3
Chicken, dark meat	3 oz	1.4
Plant based (not as easily absorbed)		
Soybeans	1/2 cup	15
Kidney beans, raw	1/2 cup	8
Black beans, raw	1/2 cup	8
Lentils, raw	1/2 cup	7
Post grape nuts (fortified)	1/2 cup	22
Quaker oatmeal squares (fortified)	1 cup	18
General Mill's total (fortified)	3/4 cup	18
Kellogg's all-bran complete (fortified)	3/4 cup	18

Based on data from USDA Nutrient Database for Standard Reference. Release 26, Software v.1.3.1 accessed 1/22/2014

There are 300 mg of calcium in one cup (8 oz) of milk which is one serving of dairy. Accordingly, the government recommends three servings of dairy or other calcium-rich foods per day. It is ideal to consume calcium in the diet; however, some women may need to take a calcium supplement to meet these DRIs. While it is important for athletes to get enough calcium, they do not have increased needs from those of non-athletes [4].

Recently Greek yogurt has become a popular dairy food, especially among athletes looking for the extra protein it provides. Women should be reminded, however, that Greek yogurt does not contain as much calcium as its non-Greek counterparts so if they are using it as a replacement for their dairy source, they should make sure to consume other additional sources. See Table 2.2 for select dietary sources of calcium.

Vitamin D

Vitamin D is important for the bones because it helps the body absorb calcium and higher intakes are linked with lower risk of stress fractures among youth [8]. It can be challenging to find dietary sources of vitamin D because it does not occur naturally in many forms except for some fish and mushrooms grown under special UV lights (see Table 2.3). However, many foods have vitamin D added to them. Any milk that is labeled as "fortified" is required to contain vitamin D. Other products such as enriched grains and cereals, yogurt, cheese, margarine, and juice have the option of adding vitamin D but are limited by the amount that they can

Table 2.2 Dietary sources of calcium

Food source	Serving size	Amount of calcium (mg)
Milk	8 oz	300
Cheese, provolone	1 oz	214
Cheese, mozzarella	1 oz	207
Cheese, cheddar	1 oz	204
Yogurt, non-Greek	6 oz	291
Yogurt, Greek	6 oz	187
Canned sardines with bone	3 oz	325
Soybeans, raw	3 oz	167
Tofu (with calcium sulfate)	3 oz	581
Soymilk (fortified)	8 oz	299
Rhubarb, cooked	1 cup	348
Almonds	1 oz	76
Orange juice (fortified)	8 oz	349
Broccoli	1 cup	43
Kale	1 cup	100

Based on data from USDA Nutrient Database for Standard Reference. Release 26, Software v.1.3.1 accessed 1/22/2014

Table 2.3 Dietary sources of vitamin D

Food source	Serving size	Amount of vitamin D
Fish oil (cod liver)	1 tbsp	1,360 IU
Mushrooms, portabella (with UV light)	1 cup	634 IU
Canned salmon	3 oz	493 IU
Milk (fortified)	8 oz	124 IU

Based on data from USDA Nutrient Database for Standard Reference. Release 26, Software v.1.3.1 accessed 1/22/2014

include and are not required by law to include it. If an athlete is worried about the amount of vitamin D that she is consuming or about a potential deficiency, it is best to read labels on specific foods rather than make assumptions. For example, one might think that because they get enough calcium from yogurt and cheese that they do not need to also drink milk. However, most cheeses and yogurts (especially Greek yogurt) are not fortified with vitamin D nor are they made from vitamin D-fortified milk [9]. Sunlight is the best source of vitamin D for the body so in the winter months (or if using sunscreen during the summer months), it is important to get enough from food sources or take a supplement if deemed medically necessary. For vitamin D the DRIs recommend women under the age of 70 consume 600 IU/day and over the age of 70, 800 IU/day [7]. See Table 2.3 for select dietary sources of vitamin D.

Supplements and Ergogenic Aids

Athletes should be counseled not to take any supplements or ergogenic aids without first checking with a medical provider, coach, or athletic trainer to ensure that it is a safe substance, that it is medically necessary for them to take, and that it is not a banned substance in their particular class of sport. For example, something as simple sounding as a vitamin enhanced with caffeine could have levels that are not allowed by the NCAA.

Sales of vitamins, supplements, and ergogenic aids are extremely high because these products make appealing promises to athletes: with one little pill you can improve performance, sleep better, have more focus, lose weight, etc. Like most promises such as these, they are too good to be true. Supplements are not regulated like food or medication are by the FDA, so sometimes ingredients are not all listed or the amounts of some ingredients might not be listed or may be inaccurate. Supplement companies are not required to verify the composition of their products before they go on sale to the public; only after they've been on the market and found to be unsafe are companies held accountable for this [4]. Athletes should be cautioned that taking a supplement could result in a positive urine test for a banned substance even if that ingredient is not listed. The best way for an athlete to avoid this unintended consequence is for that athlete to rely on real food and beverages rather than depending on a supplement to maximize performance. If athletes are taking supplements, it is important that they disclose all of them to their medical provider so that the potential for drug interactions can be reviewed.

While not recommended, not all supplements are bad and some, such as caffeine, have even been shown to improve performance in some studies [6]. Because many athletes take supplements regardless of whether or not there is scientific evidence to support their use, it is important not to approach the subject as a black or white issue. Explore why they are taking certain supplements and help them decide whether or not they are safe for continued use [4].

Hydration

For best performance, an athlete should begin exercising fully hydrated. That means being conscious of hydration status at all times, not just during a workout or when thirsty. Some people may complain that they do not like the taste of water, or cannot seem to remember to drink throughout the day. If possible, find ways to work around these barriers such as suggesting that they add lemon slices to water or eat fluid-packed snacks such as watermelon and cucumber. An athlete should consume 2–3 mL/lb of body weight of water 4 h before exercise in order to be fully hydrated and ready to perform [1]. For a 130-lb athlete that is a little over a cup of fluid. It was previously thought that caffeinated beverages would dehydrate rather than hydrate a person, but that has since been disproven [5]. However, an athlete should

consider whether or not caffeine is a banned substance in her organization before consuming caffeine prior to performance.

Even athletes who begin their workout hydrated can lose large amounts of water during exercise. The best way to find out just how much fluid a person is sweating out is to perform a sweat rate test. This can be done at home by taking weight pre-exercise and post-exercise using the equation below [5].

Sweat Rate Equation

$$\begin{aligned}&\left(\text{Pre-exercise weight in pounds} - \text{Post-exercise weight in pounds}\right)\\&\times 2.2\left(\text{kg}/\text{lb}\right)\times 1{,}000\left(\text{g}/\text{kg}\right) = \text{mL of fluid lost during exercise} / 29.5\left(\text{mL}/\text{oz}\right)\\&= \text{oz of fluid lost during span of exercise}\end{aligned}$$

This number might change depending on heat and the timing of exercise. As such, athletes should drink when thirsty and be mindful that urine is coming out light yellow to ensure adequate hydration status. Dehydration occurs when more than 2 % of body weight is lost without replacement and can cause detrimental effects such as muscle cramps [5].

During activity, electrolyte status must be considered in addition to hydration status. It can be helpful to consume a sport drink such as Gatorade that contains both carbohydrates and electrolytes when exercising for more than an hour. The sports drink should ideally contain 6–8 % carbohydrate [1].

After exercise is complete, it is important for an athlete to continue hydrating, both to make up for any fluids lost and not replaced during exercise and to remain properly hydrated for the next round of exercise. If dehydrated, rehydration post-exercise can be done by consuming 16–24 oz of fluid per pound of body weight lost during exercise, as determined by the sweat rate test [1].

Special Populations

Vegetarian and Vegan Athletes

Since many athletes are health conscious, they may be following a vegetarian or vegan diet due to the evidence that a primarily plant-based diet can prevent a host of chronic diseases. Or, they might avoid consuming animal products for ethical reasons. Whatever the origin, the vegetarian or vegan athlete needs to pay specific attention to several nutrients and ensure that adequate portions are consumed. First is protein; it is not sufficient to simply cut out meat without replacing it with a different source of protein. Good vegetarian protein sources include beans, lentils, tofu, eggs, nuts, seeds, and dairy. The next nutrient a vegetarian athlete should pay

special attention to is iron (see previous section for tips on consuming adequate iron). This is especially important because plant-based sources of iron (non-heme iron) are not absorbed by the body as well as animal sources (heme iron) are. Good vegetarian sources of iron include beans, lentils, leafy green vegetables, and enriched products such as cereal and bread.

Vegans who do not consume dairy need to make sure that they have an alternate source of calcium and vitamin D in their diet such as soy milk, cheese, or yogurt, tofu, leafy green vegetables, or fortified products such as orange juice or almond milk. Finally, a vegetarian athlete needs to be aware of her B12 consumption. Many vegetarian and vegan foods are fortified with B12, but if an athlete is not eating enough of these foods, she may require a B12 supplement.

Gluten-Free Athletes

About 1 % of Americans have celiac disease for which the treatment is to follow a diet free from gluten. A higher percent of people avoid gluten due to a sensitivity, a misconception that gluten or grain is "bad" for them, or a misconception that avoiding gluten can lead to weight loss. Whatever the reason for not eating gluten, an athlete can still eat a healthy, balanced diet that will provide enough carbohydrates for sustained energy. However, she will have to put effort into ensuring that she is getting enough carbohydrates in her diet and, for those with celiac disease, that the sources of carbohydrate have not been contaminated with gluten [6]. Carbohydrates are not only important in an athlete's diet for the purpose of providing sustained energy for exercise but also the preferred fuel of the brain. Needlessly cutting gluten from a person's diet can result in low carbohydrate intake, low iron or fiber intake (due to lack of iron-fortified grain products), and high cholesterol from increased animal product intake.

Foods that are high in carbohydrate but do not contain gluten include potatoes (white and sweet), corn, quinoa, rice (white, brown, wild), millet, amaranth, chickpeas, certified gluten-free oats, rice pasta, corn pasta, and gluten-free baked goods made from ingredients such as almond flour, rice flour, and potato flour.

Pregnant Athletes

Any athlete who is pregnant should consult a medical provider to make sure that the exercise plan that she has is safe and does not have the potential to cause harm to the mother or the fetus. The energy requirements listed previously in this chapter can be used for a pregnant athlete using the appropriate activity factor. For the first trimester this estimate of energy needs should suffice (i.e., no additional calories are necessary). For the second trimester an additional 340 cal/day is

suggested and for the third trimester an additional 452 cal/day [4]. Pregnant women should be counseled on eating recommended amounts of macro- and micronutrients, with a special emphasis on iron due to the increased blood supply, and folic acid due to the potential for birth defects associated with deficiency. Iron sources are listed in a previous section of this chapter. Sources of folic acid include dark green leafy vegetables, beans, lentils, and enriched grain products such as cereal, bread, pasta, and rice.

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