Nutrition and Athletic Performance

Kevin R Stone, MD, Wendy S. Adelson, MS

Food, vitamins, minerals, and water provide fuel for performance. This article summarizes our thoughts on the importance of nutrition for sports performance and health, for athletes, for people recovering from injury and surgery, and for the general population. Information provided comes from our personal experience in treating athletes for the past 20+ years at The Stone Clinic in San Francisco as well as from specific information obtained from peer-reviewed publications.

Nutrition Trends

Many dietary recommendations and nutrition trends are based on hype or dubious scientific studies. This is partially because the largest, long-term studies on nutrition and health are based on questionnaires that request participants to record the foods they consumed over the previous three months or so. This is the case in the highly referenced Framingham Heart Study and Nurses' Health Study. Research shows that food diaries are subject to problems of recall and seasonality, and are therefore unreliable[1]. Consequently, conclusions based on such methods are often unreliable. For instance, the notion that a high fat diet leads to cardiovascular disease came out of the Nurses' Health Study. Current information from the Departments of Nutrition and Epidemiology, Harvard School of Public Health, suggests that the initial diet-heart hypothesis that relates fat intake to cardiovascular disease is overly simplistic, and that evaluating the type of fat and the quantity and quality of carbohydrates is important in cardiovascular disease prevetion[2]. There is a lot of contradictory information out there, so readers beware!

Nutrition for Health and Performance

Food intake affects performance. Food intake affects weight. Food intake affects sense of well-being, energy level, recovery time, etc. Food provides energy in the forms of carbohydrates, protein, and fat. Carbohydrates and proteins provide four calories per gram; fat provides nine calories per gram. The relative contribution of calories from carbohydrates/protein/fat for producing energy depends on many factors such as exercise intensity and duration, diet on the days leading up to exercise, and fitness status. Carbohydrates are stored in the body as glycogen in the muscle and liver; protein is stored in muscle and other body proteins; and fat is stored as triglycerides in adipose tissue.

Converting stored body fat into energy takes a great deal of oxygen, so exercise intensity must decrease for this process to occur. During low-intensity exercise, such as walking and level-ground bicycling, most of the energy comes from fat and activities can be sustained for a long time. During moderate-intensity exercise, such as easy jogging, bicycling at an incline and swimming, energy comes from a mix of carbohydrates and

fats. During high-intensity exercise, such as in maximum-intensity interval training and heavy weight lifting, most of the energy comes from carbohydrates [3]. Proteins and amino acids play a minimal role providing energy during exercise, but are necessary for maintenance of lean muscle mass. Eating a small meal containing high-quality carbohydrates, protein, and fat within the first hour after exercise provides the necessary building blocks for replenishing muscle glycogen and the amino acids necessary for building and for the repair of muscle tissue[3].

Recommended calorie intake per day correlates with the type of and amount of exercise a person performs each day. Most people would benefit from exercising more. Tailoring caloric intake based on physical activity and desired weight gain, loss, or maintenance is superior to basing intake on age, gender, or weight. If weight maintenance is the goal, caloric expenditure, independent of training type, must be taken into account. It is a common misconception that a large post-workout meal is necessary after resistance training sessions; this is not the case if weight loss or maintenance is the goal.

A balanced diet generally consists of 55% - 65% of calories from carbohydrates, 10% - 15% from proteins, and less than 30% from fats[3]. Many components play into daily-required caloric intake. The USDA reports 20% to 50% of your daily caloric needs are determined by physical activity. The remaining 50% to 80% of calories consumed are burned through basic body functions such as breathing, circulating blood, and keeping cells functioning. The more physical activity you engage in, the more calories you burn, and the more calories you require to maintain body weight. Adequate nutrition maximizes training effects and helps to maintain health.

Carbohydrates are stored in the body in the form of glycogen in the muscles and the liver. During exercise, glycogen breaks down into glucose and is used for energy. Stored glycogen is depleted during high-intensity exercise, during repeated near-maximal bouts of effort, and during prolonged endurance exercise. When the glycogen stores are depleted, blood glucose levels begin to fall and athletes begin to experience fatigue, lack of coordination, light-headedness, and lack of concentration. This experience is commonly known as "hitting the wall" or "bonking." It is important to replenish carbohydrates during prolonged, intense exercise to maintain blood glucose levels for the brain and working muscles. To maintain muscle glycogen stores, at least 50% of energy must come from carbohydrates. Recommended carbohydrate intake ranges from 6 - 10 g/kg of body weight per day, depending on daily energy expenditure and the type of sport performed. The Center for Disease Control recommends eating healthy carbohydrates that provide dietary fiber and whole grains as well as those without added sugars. Such healthy carbohydrate items include fruits, vegetables, and whole grain foods. Foods with added sugar are often high in calories and low in nutrients; this does not help fuel your body for optimal performance and health.

Protein requirements depend upon factors including body weight, body composition, type and intensity of physical activity, adequacy of energy and carbohydrate intake, and

illness or injury. Research indicates that protein needs for athletes are greater than the recommended daily allowance of 0.8 grams per kilogram of body weight for sedentary people. The current recommended level of protein intake is estimated to be sufficient to meet the need of nearly all (97.5%) healthy men and women age 19 years and older. This amount of protein intake may be appropriate for non-exercising individuals, but it is likely not enough to make up for the oxidation of protein/amino acids during exercise (approximately 1–5% of the total energy cost of exercise). It is the position of the International Society of Sports Nutrition that exercising individuals need approximately 1.4 to 2.0 grams of protein per kilogram of bodyweight per day, with endurance exercise athletes at the lower end of this range, intermittent activity athletes in the middle of this range, and strength/power exercise athletes at the upper end of this range[4]. Meat, poultry and fish contain about 7 grams of protein per ounce; 3 ounces of meat is about the size of a deck of cards. One large egg contains 7 grams of protein, one cup of milk contains 8 grams of protein. Protein requirements can be met by diet alone in most cases without the use of protein or amino acid supplements. When supplements are required, milk-derived casein, egg white powder, and soy protein isolate are classified as high quality protein sources[4]. Research does not support protein intake in excess of 2.0 grams per kilogram body weight. Excess protein intake is associated with dehydration, and may be related to excessive urinary calcium losses and inadequate carbohydrate intake. Athletes restricting caloric intake in order to achieve low body weight may be at risk for inadequate protein intake. Inadequate protein intake increases an athlete's risk for injury and chronic fatigue.

Fat is important in the diets of athletes, especially those engaging in exercise lasting over 90 minutes. Dietary fat also helps to absorb fat-soluble vitamins (A, D, E and K) and stored fat helps protect internal organs from trauma. The Center for Disease Control and Prevention recommends eating unsaturated fats from sources such as nuts, vegetable oils, and fish. Partially-hydrogenated oils, which are used to keep food fresh longer while on grocery shelves, contain *trans* fats. Trans fats have been shown to negatively affect cholesterol and increase the risk for heart disease. Trans fats are commonly found in commercially baked goods such as cookies, crackers, fast food, and many frozen food items such as dessert pies, pot pies, waffles, and pizzas.

The National Academy of Sciences makes the following daily calorie recommendations:

- 1,600 calories is about right for many sedentary women and some older adults
- 2,200 calories is about right for most children, teenage girls, active women, and many sedentary men (Women who are pregnant or breastfeeding may require more)
- 2,800 calories is about right for teenage boys, many active men, and some very active women

Weight loss and inadequate nutrition intake in women, especially growing girls, is associated with changes in pituitary gonadotropins (LH and FSH), which change ovarian secretions and can lead to amenorrhea. Amenorrhea is directly associated with loss of

bone mass and an increased rate of stress fractures. Calorie restriction can lead to inadequate glycogen stores. For instance, in active individuals, lowering the diet to 2,000 kcal per day in a diet of 60% carbohydrates fails to provide optimal carbohydrate stores (4 - 5 g/kg in a 60 kg athlete).

Contradictory information exists as to whether or not increasing protein intake in body builders to 1.6 g/kg body weight per day is beneficial to build and maintain lean body mass. The same is true for adding additional branched chain amino acids (BCAA)[5].

Athletes require a high strength-to-weight ratio to achieve optimal performance. Since body fat adds weight but not strength, low body fat percentages are often emphasized in sports. However, esthetic considerations (dance, ballet) and weight restrictions (wrestling, lightweight rowing) may dictate unhealthy, often unrealistic body types. Food intake must be customized to meet these non-physiological requirements and supplements are usually required to maintain health. Body fat percentages are often genetically controlled; people with body fat percentages at the extreme ends of the spectrum may have a more difficult time altering their body composition. The minimum healthy body fat percentage for males is 5% and for females, it is 12%[6]. However, optimal body fat percentages range widely for different sports. Unfortunately, even the best body fat measuring devices have a 3% to 6% error range making them unreliable for most applications[5].

Importance of Hydration

Dehydration has negative effects on exercise performance. Many people are chronically dehydrated due to water loss through breathing during the night and drinking coffee and other caffeinated beverages throughout the day while not drinking enough water. All muscles and cells, especially brain cells, work better when hydrated. During heavy exercise in the heat, athletes can easily lose several liters of water per hour in the form of sweat. Starting out fully hydrated and trying to maintain neutral fluid balance is the key to successful performance. Thirst is not always an adequate sign of dehydration and therefore, water should be consumed even when one does not feel thirsty. Most athletes lose water and sodium faster than they can replace them during exercise. Current recommendations are 15 - 350 ml of water per 20 minutes of exercise[5] but clearly these recommendations vary depending on event, heat, etc. Events lasting longer than one hour require replacement drinks with 4% - 8% carbohydrate and 0.5 g/L of sodium. Sodium in the post-exercise fluid reduces diuresis, maintains plasma osmolality, and increases the desire to drink. Most commercial sport drinks do not contain enough sodium for post-exercise fluid replenishment.

Supplementation for Health and Performance

Vitamin and mineral supplements are extremely helpful in maintaining health because many are hard to consume in adequate amounts with common Western diets. Almost

all women are deficient in calcium and Vitamin D, and they start rapidly losing bone mineral density after age 30.

Calcium, iron, and zinc with vitamin D build bone. Only sunlight naturally converts enough of the inactive vitamin D to the active form. A minimum of 30 minutes per day of nearly total body exposure is required. Recommended supplementation levels of vitamin D have been far too low (most vitamin pills have 400 IU) and nearly 2,000 IU of supplementation per day are needed[7]. Sufficient daily calcium is difficult to obtain as most adults do not consume enough dairy. 1500 mg of supplemental calcium per day is recommended with vitamin D.

During exercise, B-complex vitamins are involved in energy production, and Folate and vitamin B-12 are required for the production of red blood cells, protein synthesis, and tissue repair[8]. Vitamins A, E, and C, beta carotene, and selenium protect against oxidative damage[9]. Glucosamine supplementation is helpful for cartilage health, which promotes physical activity over one's lifetime. There are contradictory studies in regards to vitamin supplementation and athletic performance; however, intuition would lead to the conclusion that adding them to the athlete's diet makes sense.

Iron deficiency is the leading cause of anemia in the United States and is the most common nutritional deficiency[10]. Iron deficiency in women is found in 10% of the population. Since it leads to anemia, there are direct performance affects on athletes. Testing annually is helpful as most women do not know their iron levels[5].

Zinc plays a role in building and the repair of muscle as well as energy production. Often diets low in animal products will be deficient in zinc. Exercise is a stressor that can decrease zinc levels, and thus athletes are at risk for being defficient[11]. Oysters, red meat, and poultry provide the majority of zinc in the American diet. Other good food sources include beans, nuts, some seafood, whole grains, fortified breakfast cereals, and dairy products.

Vegetarian diets are usually poor in iron, vitamins, and protein. Plant-derived proteins are not as well digested as animal proteins[12]. The low bioavailability of iron from plants increases the risk of anemia. Combined with the low intake of Vitamin B_{12}, D, riboflavin, calcium, and zinc[5], vegetarian diets do not make the ideal sports performance choice.

The Bottom Line

Whether you are a competitive athlete, a weekend warrior, or a dedicated daily exerciser, the cornerstone to improved performance is a diet that fuels performance. The more trained you become, the better your body gets at "telling" you what you need.

A good rule for the general population, as suggested in the recent novel "In Defense of Food: An Eater's Manifesto"[13]: ***Eat food. Not too much. Mostly plants.***

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