Colorado State University
Extension

Nutrition for Athletes

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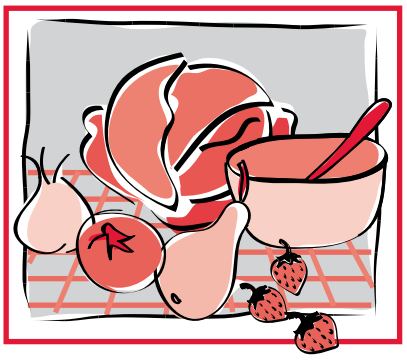
Fact Sheet No.

Food and Nutrition Series|Health



by J. Clifford and K. Maloney (7/15)

Becoming an elite athlete requires good genes, good training and conditioning, and a sensible diet. Optimal nutrition is essential for peak performance. Nutritional misinformation can do as much harm to the ambitious athlete as good nutrition can help. An individual involved in a general fitness regimen (ex. 30-40 min/day, on most days of the week) can meet their nutritional needs by adhering to a balanced diet. However, athletes involved in moderate or high frequency training program will need to increase their intake to meet nutritional requirements.

Carbohydrates

Carbohydrates are an important fuel source. In the early stages of moderate exercise, carbohydrates provide 40 to 50 percent of the energy requirement. As work intensity increases, carbohydrate utilization increases. Carbohydrates yield more energy per unit of oxygen consumed than fats. Because oxygen often is the limiting factor in long duration and high intensity events, it is beneficial for the athlete to use the energy source requiring the least amount of oxygen per kilocalorie produced. Depending on the intensity, duration, and frequency of exercise, in general athletes should consume between 6-10 grams of carbohydrates per kilogram of body weight per day. (A kilogram equals 2.2 pounds.) Carbohydrate requirements are also affected by the athlete's sex and body mass, as well as total daily energy expenditures and environmental conditions.

Complex carbohydrates come from foods such as potatoes, beans, vegetables, whole grain pasta, cereals and other grain products. Simple carbohydrates are found in foods such as fruits, milk, honey and sugar. During digestion, the body breaks down carbohydrates to glucose, which is then utilized for energy or converted to glycogen and stored in the muscles and liver to fulfill later energy needs.

During exercise, stored glycogen is converted back to glucose and used for energy. The body can only store a finite amount of carbohydrates as glycogen. The ability to sustain prolonged vigorous exercise is directly related to initial levels of muscle glycogen. For events lasting less than two hours, the glycogen stores in muscles are typically sufficient to supply the needed energy. Extra carbohydrates will not help any more than adding gas to a half-full tank will make the car go faster.

For events that require heavy work for more than two hours, a high-carbohydrate diet eaten for two to three days before the event allows glycogen storage spaces to be filled. Endurance athletes, such as long distance runners, cyclists, swimmers, and cross-country skiers, report benefits from a pre-competition diet, in which 70 percent of the calories comes from carbohydrates.

Research has demonstrated that endurance athletes on a high-carbohydrate diet can exercise longer than athletes eating a low-carbohydrate, high-fat diet. However, constantly eating a high-carbohydrate diet is not advised. This conditions the body to use only carbohydrates for fuel and not the fatty acids derived from fats.

For continuous activities of three to four hours, it is important that glycogen stores in the muscles and liver are at a maximum. Additionally, taking carbohydrates during the event in the form of carbohydrate solutions, such as electrolyte drinks can be beneficial. The current recommendation is a 6 to 8 percent glucose solution.

A homemade electrolyte drink with 7.6% glucose and reasonable sodium amounts can be easily made. Add 6

Quick Facts

- Athletes achieve peak performance by training and eating a balanced diet including a variety of foods.
- Carbohydrates and fat provide fuel for the body.
- The use of fat as a fuel source depends on the intensity and duration of the exercise, as well as the condition of the athlete.
- Exercise may increase the athlete's need for protein.
- Water is a critical nutrient for athletes. Dehydration can cause muscle cramping and fatigue, and increases the risk for heat stroke.

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tablespoons sugar and 1/3 teaspoon salt to each quart of water. Dissolve sugar and cool. The salt translates into a sodium concentration of 650 mg/liter.

Sports drinks can be used to supply sodium and glucose if the athlete tolerates them, but other electrolytes are not essential until after the event. Athletes should experiment during training to find if electrolyte beverages are right for them.

Eating sugar or honey just before an event does not provide any extra energy for the event. It takes approximately 30 minutes for the sugar to enter the blood stream. This practice may also lead to dehydration. Water is needed to absorb the sugar into the cells. Furthermore, sugar eaten before an event may hinder performance because it triggers a surge of insulin. The insulin causes a sharp drop in blood sugar level after about 30 minutes. Competing when the blood sugar level is low leads to fatigue, nausea and dehydration.

A diet in which 70 % of calories come from carbohydrates, eaten for three days prior to the event, is sometimes helpful for endurance athletes. (See Table 1 for a sample menu.) However, water retention often is associated with carbohydrate loading, or the practice of eating large amounts of carbohydrates. This may cause stiffness in the muscles and sluggishness early in the event. Sticking to a three-day regimen minimizes this effect.

Table 1: Sample menu of a high carbohydrate diet.

Food item	Calories	Grams carbohydrate
Breakfast		
8 ounces orange juice	134	33
1 cup blueberries	83	21
1 medium banana	105	27
8 ounces low-fat vanilla yogurt	240	41
2/3 cup LEP Cranberry Pecan Granola	443	58
Lunch		
2 cups (cooked) whole wheat pasta	347	74
4 ounces skinless chicken breast	187	0
½ cup marinara sauce	80	10
2 ounces sautéed onions	33	6
½ cup sautéed mushrooms	14	2
2 ounces sautéed zucchini	33	3
1 tablespoon parmesan cheese	21	0
1 whole wheat dinner roll	76	15
8 ounces grape juice	150	37
Dinner		
3 ounces grilled cod	89	0
1 baked yam	174	41
1 cup (cooked) brown rice	216	45
1 cup spinach	7	1
½ cup carrot	25	6
½ cup croutons	31	6
5 cherry tomatoes	15	3
8 ounces non-fat milk	83	12
8 ounces apple juice	114	28
Snack		
4 ounces of raisin	339	90
10 whole wheat crackers	171	28
½ LEP Balsamic Grilled Peach	112	19
TOTAL	**3323**	**606**
	(73% of total calories)	

Fats

Fat is also a significant contributor to energy needs. It supplies 9 kcal/g of fat, making it the most energy dense macronutrient. During ultra-endurance events, lasting 6-10 hours, fat can contribute 60-70% of energy requirements.

Using fat as fuel depends on the event's duration and the athlete's condition. As duration increases and/or intensity decreases, the utilization of fat as an energy source increases. For moderate exercise, about half of the total energy expenditure is derived from free fatty acid metabolism. If the event lasts more than an hour, the body may use mostly fats for energy. Furthermore, trained athletes use fat for energy more quickly than untrained athletes.

Fat consumption should be a minimum of 20 percent of total energy intake to preserve athletic performance. Maintaining adequate fat intake is crucial to meeting nutritional needs of essential fatty acids and fat-soluble vitamins, vitamins A, D, E and K. Athletes who are under pressure to achieve or maintain a low body weight are susceptible to using fat restriction and should be told that this may hinder their performance. While adequate fat intake is necessary, claims that suggest a high-fat low-carbohydrate diet enhances athletic performance have not been supported by research.

Protein

When compared to fat and carbohydrates, protein contributes minimally to energy needs for the body. Dietary protein is digested into amino acids, which are used as the building blocks for the different tissues, enzymes, and hormones that the body needs to function. It is important for muscle building and repair that occurs after exercise.

Exercise may increase an athlete's need for protein, depending on the type and frequency of exercise. The current Recommended Daily Allowance (RDA) for protein is 0.8 grams per kilogram per day. However, the Academy for Nutrition and Dietetics and the American College of Sports Medicine recommend that endurance athletes eat between 1.2-1.4 grams of protein per kg of body weight per day and resistance and strength-trained athletes eat as much as 1.2-1.7 grams protein per kg of body weight.

Eating protein after an athletic event has been shown to support muscle protein synthesis. However, eating protein in excess of nutritional needs has not been shown to further increase muscle building. Extra protein is broken down for energy or is stored as fat.

A varied diet should provide more than enough protein as caloric intake increases. However, vegetarian athletes should work with a dietitian to make sure their protein intake is sufficient. Excess protein can deprive the athlete of more efficient fuel sources and can lead to dehydration. High-protein diets increase the water requirement necessary to eliminate the nitrogen through the urine. Also, an increase in metabolic rate can occur and, therefore, increased oxygen consumption.

Protein and amino acid supplements are unnecessary and not recommended. Some athletes turn to protein/amino-acid supplementation in the form of powders or pills to fulfill protein requirements. However, this is typically excessive, because proteins needs are easily met in an American diet. Eating whole foods instead of supplements is generally the best practice. Any athlete consuming supplements in replacement of meals should consult with their doctor or a registered dietitian before continuing.

Water

Water is an important nutrient for the athlete. Water loss during an athletic event varies between individuals. Sweat loss can be tracked by measuring weight immediately before and after exercise.

To avoid dehydration, an athlete should drink 5 to 7 mL per kilogram of body mass approximately four hours before an event. Throughout the event, they should drink chilled water or electrolyte drinks, consuming enough to match sweat losses. Chilled fluids are absorbed faster and help lower body temperature.

After exercise, 16-24 oz of water should be for every pound that was lost during the athletic event. By routinely tracking pre- and post- exercise weight changes, sweat rates can be estimated, allowing for more efficient hydration during athletic events. An individual should never gain weight during exercise; this is a sign of excessive hydration, which can lead to electrolyte imbalances, and potentially hyponatremia.

It is important to account for environmental concerns when considering water consumption. Sweat rates may increase dramatically in hot and humid weather, and it is increasingly important for an athlete to stay hydrated in these conditions. Competing at high altitudes also increases water needs.

Athletes consuming sport drinks or energy drinks should be aware of caffeine levels. Limited amounts of caffeine have been shown to enhance athletic performance. However, insomnia, restlessness and ringing of the ears can occur with caffeine consumption. Furthermore, caffeine acts as a diuretic and may cause the need to urinate during competition.

Vitamins

Maintaining adequate levels of vitamins and minerals is important for bodily function, and therefore, athletic performance. As the activity level of an athlete increases, the need for different vitamins and minerals may increase as well. However, this need can be easily met by eating a balanced diet including a variety of foods. There is no evidence that taking more vitamins than is obtained by eating a variety of foods will improve performance.

B vitamins, including thiamin, riboflavin and niacin, are essential for producing energy from the fuel sources in the diet. Carbohydrate and protein foods are excellent sources of these vitamins. B vitamins are water soluble vitamins, which means that are not stored in the body, so toxicity is not an issue. Some female athletes may lack riboflavin, so it is important to ensure adequate consumption of riboflavin-rich foods, like milk. Milk products not only increase the riboflavin level but also provide protein and calcium.

Vitamin D has many functions in the body, and is crucial for calcium absorption. Athletes who train indoors for prolonged periods of time should insure that they consuming adequate amounts of vitamin D through diet.

Exercise increases the oxidative stress on the body, increasing the need for vitamins C and E, which have an antioxidant effect. Vitamin E is a fat soluble vitamin, found in fats in the diet such as nuts, seeds, and vegetable oils. When an individual consumes excess fat-soluble vitamins (A, D, E and K), they are stored in fat throughout the body. Because they are stored, excessive amounts of fat-soluble vitamins may have toxic effects.

Minerals

Minerals play an important role in athletic function. Heavy exercise affects the body's supply of sodium, potassium, iron and calcium. Sodium is lost through the course of an athletic event through sweat, so it may be necessary to replace sodium in addition to water during an event. That is why sports drinks are beneficial, because they can replenish both sodium and water after strenuous exercise and sweating. Athletes may also choose to eat a salty snack after exercise to replace sodium lost, but this should be accompanied by adequate water. Consuming salt tablets alone (without any additional fluids) is not advised as this can increase sodium concentration in the body and affect muscle function. Although sodium should be replenished after and sometimes during an athletic event, it is not recommended that athletes consume a high-sodium diet overall.

Potassium levels can decline during exercise, similar to sodium, though losses are not as significant. Eating potassium-rich foods such as oranges, bananas and potatoes throughout training and after competition supplies necessary potassium.

Iron carries oxygen via blood to all cells in the body. Needs for this mineral are especially high in endurance athletes. Female athletes and athletes between 13 and 19 years old may have inadequate supplies of iron due to menstruation and strenuous exercise. Female athletes who train heavily have a high incidence of amenorrhea, the absence of regular, monthly periods, and thus conserve iron stores. Choosing foods high in iron such as red meat, lentils, dark leafy greens, and fortified cereals can help prevent iron deficiencies, but taking an iron supplement may be advised. It is best to consult a physician before starting iron supplements.

Calcium is important in bone health and muscle function. Athletes should have an adequate supply of calcium to prevent bone loss. Inadequate calcium levels may lead to osteoporosis later in life. Female athletes are more likely to have inadequate calcium consumption. Low-fat dairy products are a good source of calcium.

Restricting calories during periods of high activity can lead to vitamin and mineral deficiencies.

This negatively impacts athletic performance, and has adverse repercussions for general health and wellbeing. Athletes who are wishing to lose weight should do so during the off-season.

The Pre-Game Meal

Eating before competition can increase performance when compared to exercising in fasted state. A pre-game meal three to four hours before the event allows for optimal digestion and energy supply. Most authorities recommend small pre-game meals that provide 500 to 1,000 calories. This meal should be sufficient but not excessive, so as to prevent both hunger and undigested food.

The meal should be high in starch, which breaks down more easily than protein and fats. The starch should be in the form of complex carbohydrates (breads, cold cereal, pasta, fruits and vegetables). They are digested at a rate that provides consistent energy to the body and are emptied from the stomach in two to three hours.

High-sugar foods lead to a rapid rise in blood sugar, followed by a decline in blood sugar and less energy. In addition, concentrated sweets can draw fluid into the gastrointestinal tract and contribute to dehydration, cramping, nausea and diarrhea. Don't consume any carbohydrates one and a half to two hours before an event. This may lead to premature exhaustion of glycogen stores in endurance events.

Pregame meals should be low in fat. Fat takes longer to digest, as does fiber- and lactose-containing meals.

Take in adequate fluids during this pre-game time. Carefully consider caffeine consumption (cola, coffee, tea), as it may lead to dehydration by increasing urine production.

It is important to eat familiar foods before an event, so it is known that they can be tolerated before exercise.

Smaller meals should be consumed if less time remains before an event. If a competition is less than two hours away, athletes may benefit from consuming a liquid pre-game meal to avoid gastrointestinal distress. A liquid meal will move out of the stomach by the time a meet or match begins. Remember to include water with this meal.

The Post-Game Meal

Regardless of age, gender or sport, the post-game competition meal recommendations are the same. Following a training session or competition, a small meal eaten within thirty minutes is very beneficial. The meal should be mixed, meaning it contains carbohydrate, protein, and fat. Protein synthesis is greatest during the window of time immediately following a workout and carbohydrates will help replete diminished glycogen stores. However, consume food within the 30 minute window may be difficult for athletes—they often experience nausea or lack of hunger. Options to address this difficulty include:

- Consuming a drink that contains carbohydrates and protein. There are several liquid smoothies and beverages on the market that provide high protein and carbohydrates for replenishment. One classic is chocolate milk.
- If that is difficult, fruit, bread, crackers, or popsicles would all be better than not consuming any food.

Athletes should be wary of ergogenic aids, which claim to enhance athletic performance. Many of these claims are unsubstantiated, and some aids may be dangerous or hinder performance.

It is crucial to maintain nutritious eating not only for athletic events, but all the time. A pre-game meal or special diet for several days prior to competition cannot make up for inadequate nutrition in previous months or years.

Lifelong nutrition habits must be emphasized. Combining good eating practices with a good training and conditioning program will allow any athlete to maximize their performance.

Additional Resources

- Colorado State University Extension, www.ext.colostate.edu
- Visit the American Dietetic Association's website at www.eatright.org for reliable nutrition information or to find a registered dietician.
- Visit the American College of Sports Medicine's website at www.acsm.org for a variety of information and brochures.
- The Sports Cardiovascular and Wellness Nutrition group has information for athletes and professionals at their website http://www.scandpg.org.
- View information gathered for U.S. Olympic athletes at www.teamusa.org.
- Read Sports Nutrition Guidebook (5th ed.), by Nancy Clark, Human Kinetics, 2013.

Table 2: Two pre-event meal plans.

Pre-Event Meal Plan I, 2-3 hours prior (approximately 500 calories)	
Lean meat or protein equivalent	2 ounces
Fruit	1 serving (1/2 cup)
Bread or easily digestible carbohydrate	2 servings
Pre-Event Meal Plan II, 3 1/2 - 4 hours prior (approximately 900 calories)	
Cooked lean meat or protein equivalent	2 ounces
Fruit	1 serving (1/2 cup)
Pasta or baked potato	1 cup or 1 medium
Bread or carbohydrate substitute	2 servings
Low-fiber vegetable	1 serving (1/2 cup)
Fat spread	1 teaspoon
Dessert: Angel food cake or plain cookies	1 piece or 2 cookies

References

American Dietetic Association. (2009). Position of the American Dietetic Association, Dietitians of Canada, and the American College of Sports Medicine: Nutrition and Athletic Performance. Journal of the American Dietetic Association, 109 (3), 509-527. http://doi.org/10.1016/j.jada.2009.01.005

Grana, W. A. (1989). Advances in Sports Medicine and Fitness (Vol 2). Chicago, IL: Year Book Medical Publishers

Mahan, L. K., Raymond, J. L., & Escott-Stump, S. (2011). Krause's Food & the Nutrition Care Process (13th ed.). St. Louis, MO: Saunders.

Ormsbee, M. J., Bach, C. W., & Baur, D. A. (2014). Pre-Exercise Nutrition: The Role of Macronutrients, Modified Starches and Supplements on Metabolism and Endurance Performance. Nutrients, 6 (5), 1782-1808. http://dx.doi.org/10.3390/nu6051782

Phillips, S. M. & Van Loon, L. J. C. (2011). Dietary Protein for Athletes: From Requirements to Optimum Adaptation. Journal of Sports Sciences, 29 (S1), S29-S38. http://dx.doi.org/10.1080/02640414.2011.619204

Ratzin Jackson, C. G. (Ed.). (1995). Nutrition for the Recreational Athlete. Boca Raton, FL: CRC Press.

Raymond, J. L., & Escott-Stump, S. (2008). Krause's Food and Nutrition Therapy (12th ed.). St. Louis, MO: Elsevier Health Sciences.

Sawka, M. N., Burke, L. M., Eichner, E. R., Maughan, R. J., Montain, S. J., & Stachenfeld, N. S. (2007). American College of Sports Medicine Position Stand: Exercise and Fluid Replacement. Journal of the American College of Sports Medicine, 39 (2), 377-390. http://dx.doiorg/10.1249/mss.0b013e31802ca597

Williams, M. H. (1995). Nutrition for Fitness & Sport (4th ed.). Madison, WI: Brown & Benchmark Publishers.