



The Role of Beef in Physical Activity

BEEF FACTS Human Nutrition Research

It is important for athletes to consume a healthy balanced diet providing sufficient calories and nutrients to meet energy and nutrient needs to ensure optimal performance during exercise. Not surprisingly, physical activity creates higher energy demands and subsequently higher macronutrient (carbohydrate, fat and protein) requirements. A healthy diet for athletic performance includes a mix of macronutrients: where carbohydrate and fat are the primary fuels for exercise activity, and protein is necessary for building and maintaining muscle. Energy requirements vary athlete to athlete, depending on energy expenditure, total body weight, duration and intensity of exercise event.

Carbohydrate and Fat Provide Energy

During exercise, carbohydrates and fat work together to provide energy for the athlete. Carbohydrate is stored in the body in the form of glycogen and glucose. During aerobic exercise, the glycogen in the muscles are broken down and fed into a glycolytic pathway to produce adenosine triphosphate (ATP), the “energy currency” utilized by all cells in the human body (1). Fatigue occurs when muscle glycogen stores are low and no longer able to contribute to the production of ATP (2). Fat is stored as triglycerides in adipose tissue and intramuscular triglyceride stores. Although fat is easy to store in the body, the capability of the body to transport and burn fat for energy is limited. During low intensity exercise, the body burns fat at a higher rate than carbohydrates. Increasing dietary fat intake without compromising carbohydrate intake improved endurance performance in female runners who ran at least 35 miles per week (3). As exercise intensity increases, the contribution of fat as fuel decreases while carbohydrate as fuel increases. Adequate dietary intake of both carbohydrate and fat intake are essential as glycogen and fat stores are important for longer duration exercise and depletion of either would result in fatigue (4).

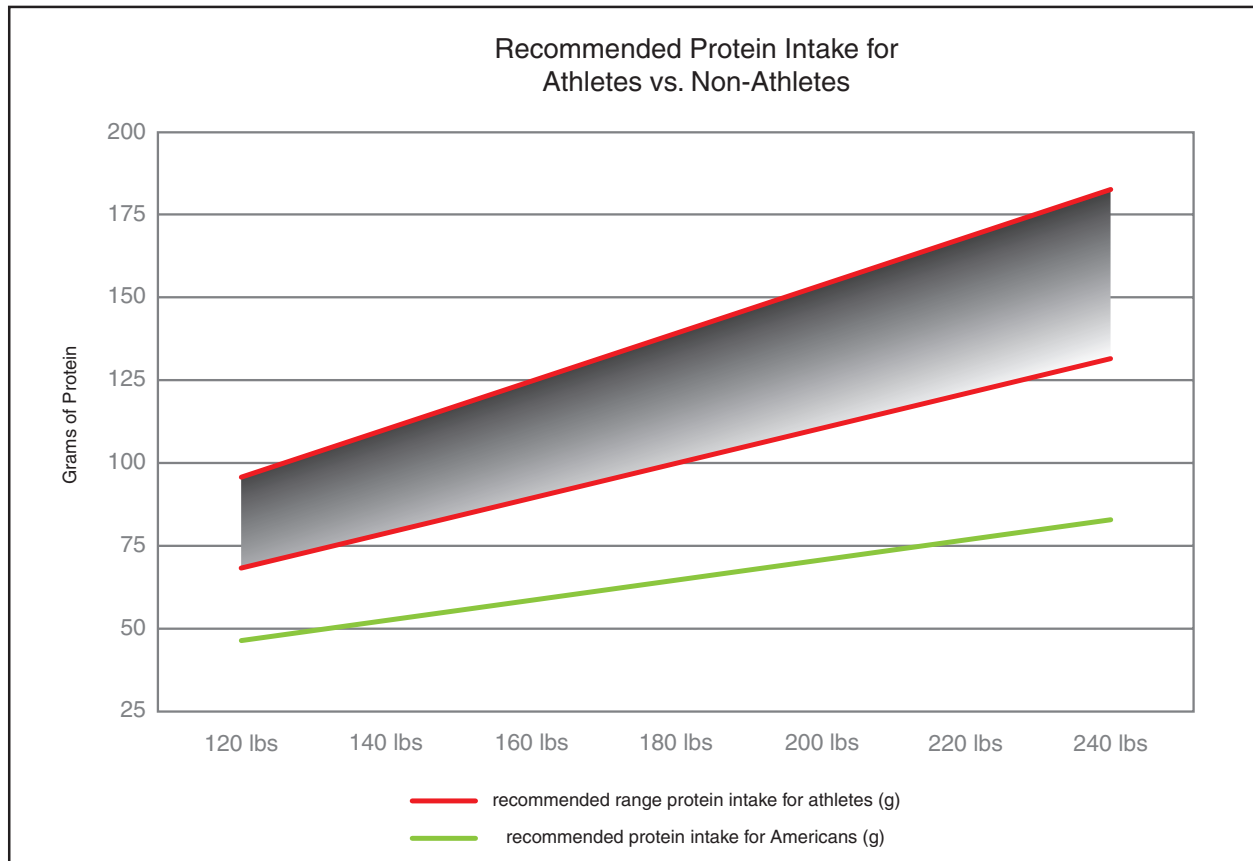
Protein Provides Strength

The primary function of protein is growth and repair of body tissue (anabolism). Muscle contains approximately 40% of the total protein in the adult body and accounts for a large proportion of the total protein turnover in the body. When amino acid requirements are not met in the diet, muscle protein is broken down to free amino acids to supply the body with amino acids (catabolism). When more protein is broken down than synthesized (resulting in a negative protein turnover state), the individual loses muscle protein. Muscle remains in a negative protein turnover after exercise until adequate protein and energy are available for recovery.

When a person synthesizes more protein than is broken down, one can build muscle mass, particularly with the inclusion of resistance training. During resistance training, microtrauma occurs in the working muscle fibers and will need to be repaired. Consuming adequate high-quality protein in the diet after exercise will replenish the amino acid pool and increase the availability of amino acids for muscle. This will curb the catabolism and promote anabolism by repairing the microtrauma and increasing muscle protein synthesis activity. When there is excess protein intake, the body will utilize as much as possible, but unlike carbohydrate and fat, the body cannot store excess amino acids and any surplus amino acids are converted to glucose and fatty acids (1,5).

Although not a major energy source for athletes, protein intake remains a critical nutrient for athletic performance. The daily recommended protein intake for athletes ranges from 1.2-1.7 g·kg⁻¹ body weight, which is greater than the Recommended Daily Allowance (RDA) for protein of 0.8 g·kg⁻¹ body weight (6). This can generally be met by consuming protein-rich foods without the use of supplements. During digestion, protein in the gut is broken down into free amino acids that are absorbed into the blood, forming an amino acid pool. Free amino acids are transported into cells (such as muscle cells) to make cell protein, which have various functions in the body including energy and structure.

Figure 1



Source: National Academy of Sciences. Institute of Medicine. Food and Nutrition Board, Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids (2002/2005).

Dietary Intake of Protein

Care should be taken to consume a diet containing adequate energy and a selection of high-quality protein foods. The quality of protein in a food is determined by its essential amino acid content (1,8). Branched chain amino acids (BCAAs), leucine, isoleucine and valine, are the most common essential amino acids in protein and are metabolized mainly in skeletal muscle to produce aerobic energy, unlike the other 17 amino acids. The BCAAs are present in all protein-rich foods, particularly red meat and dairy products (7). Some foods contain all the essential amino acids and in amounts sufficient to maintain protein synthesis, while others are lacking in at least one amino acid. The former are called complete protein foods, primarily found in animal sources, while the latter includes grains, vegetables and fruits. Although it is also possible to obtain sufficient essential amino acids from a diet that excludes complete protein foods entirely by combining grains, vegetables and fruits, this requires knowledge of which foods to combine and due diligence on the athlete's part. As a result, vegetarian and vegan athletes constitute a group that may be at greater risk for insufficient dietary protein intake (8,9).

Muscle Protein Turnover

As stated earlier, the body primarily does not use protein as a source for fuel, but as substrate for muscle tissue maintenance

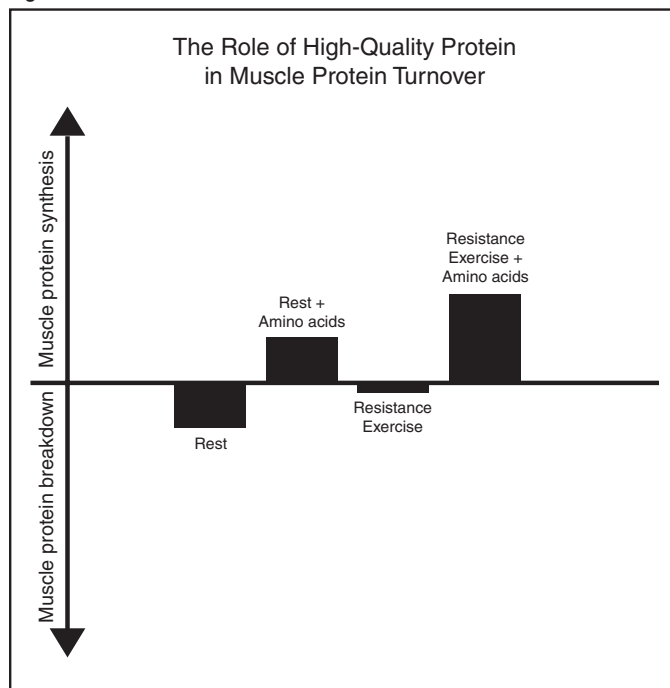
and growth. During all types of exercise, muscle is broken down to provide amino acids needed by the body for proper functioning such as circulation, respiration and digestion. Protein turnover during exercise is catabolic in nature (14). After exercise, when amino acid concentrations are decreased, protein consumption will provide necessary amino acids for muscle tissue repair and promote a more anabolic profile (6,14). Adaptation to endurance training improves the efficiency of carbohydrate and fat as fuel and resistance training builds muscle mass (15).

Endurance Training

Since carbohydrates are the nutrient of focus when it comes to fueling the body for endurance exercise, protein may be an underappreciated nutrient for these athletes. However protein is particularly essential after exercise during the recovery period. Amino acid oxidation during endurance exercise amounts to only 1-6% of the total energy cost of exercise (16), which will need to be replenished. Evidence regarding the effect of coingestion of protein and carbohydrate during exercise on athletic performance remains inconclusive but an increasing area of research interest (6). Previous research with male cyclists were unable to show improvement in performance when a supplemental carbohydrate-protein beverage was consumed, compared to a carbohydrate only supplement. As expected, the carbohydrate helped increase

time to exhaustion, but the added protein did not enhance the effect of the carbohydrate supplement (17,18). However, other studies successfully demonstrated in male cyclists and runners, (19,20) that consumption of a carbohydrate-protein supplement increased their aerobic endurance performance with a longer time to exhaustion. The carbohydrate-protein beverages used in these studies were comparable in their carbohydrate and protein content.

Figure 2



Source: Derived from Phillips SM. Protein requirements and supplementation in strength sports. *Nutrition* 2004;20:689-95.

Resistance Training

Similar to endurance exercise, resistance training involves muscle tissue being broken down to provide free amino acids to be used by the body, creating a catabolic state. Resistance exercise does not induce an acute increase in protein turnover or oxidation during exercise. It is the post-exercise (recovery) period when both the rates of muscle protein synthesis and muscle protein breakdown are increased (21). Dietary protein increases the amino acid availability to replenish the lowered levels of amino acids, so that positive muscle protein balance may occur, in order to support muscle growth (6). Following exercise, the maximal response of muscle protein synthesis can be attained with the ingestion of 15 g essential amino acids, which stimulates muscle protein synthesis greater than exercise or amino acid ingestion alone (21, 22) (Figure 2). The inclusion of lean beef in a healthy diet can contribute protein and essential amino acids necessary to build muscle, and a moderate serving of 4 ounces of cooked lean beef has been shown to increase muscle protein synthesis in both young and elderly by 50% (23).

Why Iron Status is Important

Iron is a vital component of the hemoglobin and myoglobin proteins, which are found in red blood cells and muscle, respectively. Hemoglobin and myoglobin deliver oxygen to tissues during aerobic activity. Athletes, particularly endurance athletes, depend on efficient oxygen delivery to working muscles for peak performance. When iron status becomes low, less oxygen is delivered to the muscles resulting in performance levels plateauing and eventually declining in individuals. Recent research suggests that even moderate exercise may lead to iron depletion when intake and iron stores are inadequate. Researchers previously found that sedentary women who started a program of moderate aerobic exercise showed evidence of iron loss (24).

The RDA for iron is 15 mg/d for women and 11 mg/d for men (25). In general, men consume the recommended amounts of iron, but the average iron intake among U.S. women falls short at 10.6 mg/d (25-27). Some research indicates that endurance athletes may need up to 30% more iron than the average adult (28) and these stores need to be replaced on a continual basis. Studies have routinely found that athletes, especially female athletes, are often iron-deficient or anemic (28-30). One study showed that iron deficiency developed over an 11-week cross-country season, with 17% of males and 45% of females becoming iron deficient (30). Dietary choices may explain most of this, but evidence also suggests iron status may be depleted with the increased gastrointestinal blood loss after running and an increased red blood cell and whole-body iron turnover (25,28). Increasing iron intake in iron-deficient athletes not only improves blood biochemical measures and iron status but also enhances favorable endurance performance by increases in work capacity as evidenced by increasing oxygen uptake, reducing heart rate, and reducing muscle fatigue (6, 24, 31). There are two forms of dietary iron: heme iron which is found in meat, poultry and fish and non-heme iron, which is present in a variety of plant sources. The absorption of heme iron by the body is much greater than non-heme iron; however, absorption of non-heme iron can be increased by other components of the meal, especially heme iron containing protein. For example, three ounces of cooked lean beef added to the diet, provides as much iron as three cups of raw spinach.

The Female Athlete Triad

The Female Athlete Triad refers to three distinct but interrelated conditions: energy availability, menstrual function and bone mineral density. When not properly balanced and functioning, these conditions may be associated with eating disorders, functional hypothalamic amenorrhea and osteoporosis (32). Physically active girls and women are often concerned with body image, body fat, and body weight in the context of performance, particularly seen in activities that emphasize a lean physique.

Exercise alone is not a risk for the development of the Female Athlete Triad, but an energy deficit where caloric intake does not match the body's energy expenditure is. Surveys of female athletes commonly report an underconsumption of energy (33). When energy availability is too low, whether by increasing energy expenditure or decreasing energy intake, the body compensates by reducing the amount of energy used for cellular maintenance, thermoregulation, growth and reproduction in order to restore energy balance and promote survival. Eating disorders such as anorexia nervosa and bulimia nervosa are often seen in those diagnosed with the Female Athlete Triad. Female endurance athletes must consume sufficient energy and nutrients to avoid amenorrhea. Amenorrhea occurs for many reasons, including high physical stress, high psychological stress, inadequate energy intake, poor iron status, high cortisol levels, and low body-fat levels. It is likely that female endurance athletes have all of these factors working against them. Amenorrhea is strongly associated with a loss in bone density and an increase in stress fracture risk (34, 35). There is a strong base of evidence associating intense exercise's effect on the female reproductive system (36). Additionally, low bone density combined with consistent high-intensity activity places the athlete at higher osteoporosis risk later in life.

The Female Athlete Triad is a potentially life-threatening illness that can affect many active female athletes. It is important for coaches, athletic trainers, parents, athletes and physicians to provide support and recognize signs of the Female Athlete Triad as early as possible. Although some factors that encourage the onset of the Female Athlete Triad are clearly out of a female athlete's control, food intake is not. Nutrition for many athletes is a balancing act, where they need to consume enough calories and nutrients to meet their needs to ensure optimal performance, but many tend to restrict their energy intake to control body weight, particularly in events in which they have to carry their body mass. These opposing dietary concerns can place athletes at nutritional risk. Proper nutrition including sufficient caloric intake as well as iron and protein content within a well-balanced diet can help prevent the onset of the Female Athlete Triad. Pre-menopausal females, both athletes and nonathletes, are particularly susceptible to iron depletion due to the significant amounts of hemoglobin lost through menstruation. Instituting an appropriate diet, such as one including 4 to 6 ounces of red meat two to three times per week (37), and moderating frequency of exercise may result in the natural return of the menses (38).

Conclusion

Regular exercise requires increased dietary recommendations of macronutrients (protein, carbohydrate and fat) and some micronutrients such as iron. Deficiencies of these nutrients may compromise athletic performance. Therefore, it is important for

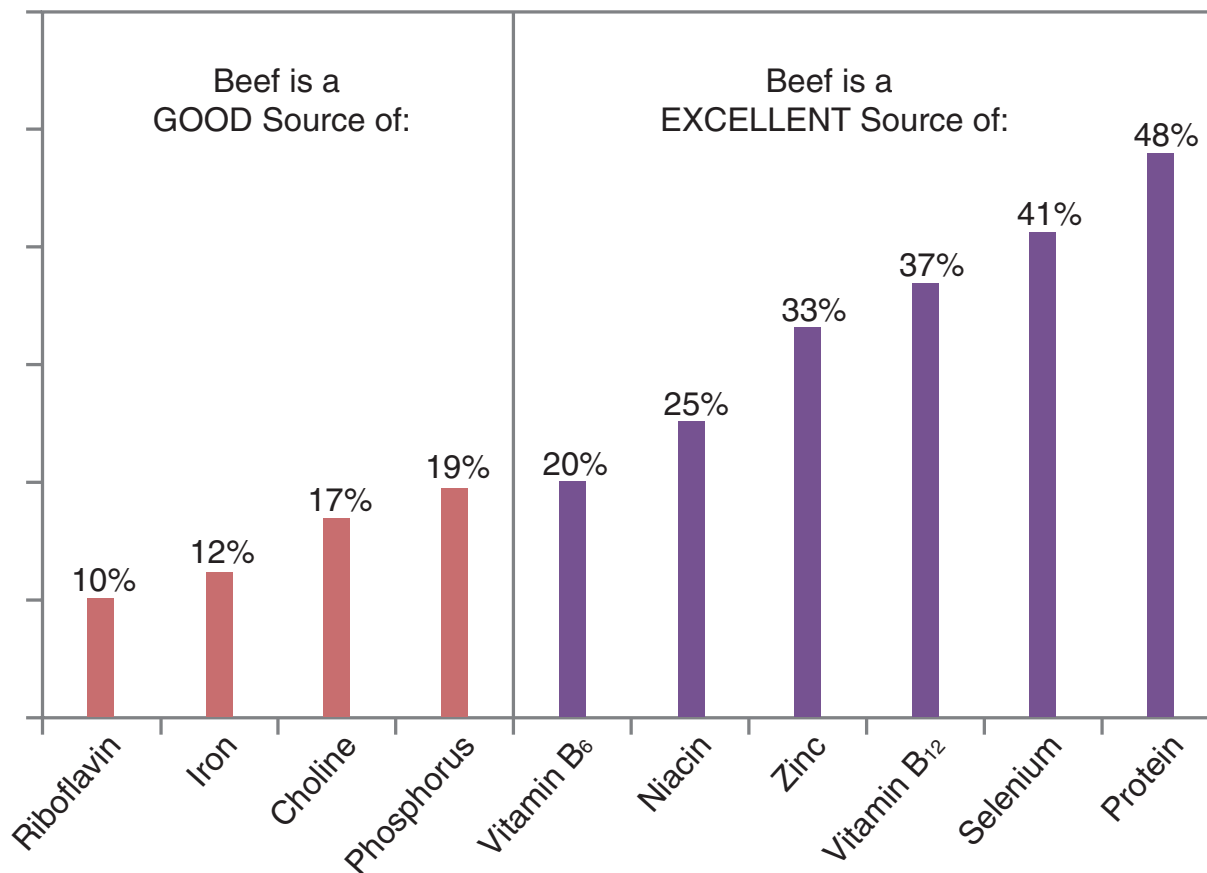
physically active individuals and athletes to meet at least the RDA for these nutrients, if not the increased levels recommended by the American College of Sports Medicine (6). The Dietary Guidelines for Americans, 2010 recommends Americans to focus on consuming nutrient-dense foods such as vegetables, fruits, whole grains, fat-free or lowfat milk and milk products, seafood, lean meats and poultry, eggs, beans and peas, and nuts and seeds (39). Lean beef is an excellent source of readily bioavailable iron, zinc, and high-quality protein – nutrients particularly important for physically active people.

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Lean Beef Can Boost Benefits of Physical Activity

On average, a 3-ounce serving of cooked lean beef provides about 150 calories, yet it supplies more than 10 percent of the Daily Value for:



Source: U.S. Department of Agriculture, Agricultural Research Service, 2010. USDA Nutrient Database for Standard Reference, Release 23. Nutrient Data Laboratory homepage www.nal.usda.gov/fnic/foodcomp

Lean beef can be an important component to a healthful diet for athletes. One 3-ounce serving provides about 25 grams of protein, the amount shown to optimally support muscle synthesis (10,11). Nutrients such as iron, zinc, and protein are recognized for their role in supporting physical activity. B vitamins have various important roles in the body including helping cells convert carbohydrates into energy. In addition, beef is an excellent source of essential amino acids, particularly leucine, that is not only a building block of protein, but also plays a significant role in stimulating skeletal muscle protein synthesis. Several studies have demonstrated leucine's function as a nutritional signaling molecule that upregulates protein synthesis by enhancing both the activity and synthesis of proteins involved in mRNA translation, following food intake (12,13).

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