Series No. FS/N 020

BEEF FACTS: Nutrition

Dietary Beef and Exercise

Nutrition and appropriate food choices are important for exercise and optimal athletic performance (1-3). Nutrients such as iron, zinc, and protein are being recognized for their role in supporting physical activity. Because beef is an excellent source of these essential nutrients, its inclusion in a healthful diet may benefit exercise performance.

Iron's Role in Exercise and Athletic Performance

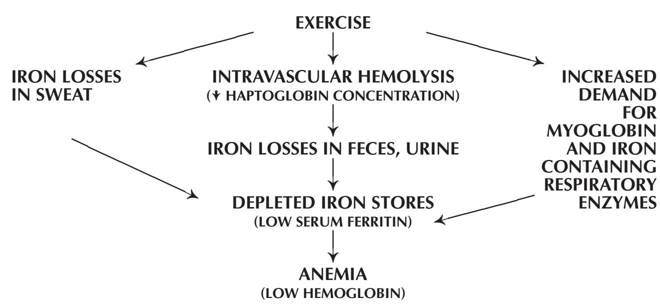
How can iron influence physical activity? Iron is an essential trace element necessary for the formation of hemoglobin and myoglobin, the oxygen-carrying components of red blood cells and muscle cells, respectively (2,3). Iron also exists in cytochromes, which facilitate energy transfer within cells. During exercise, iron plays a major role in oxygen delivery to tissues, as well as in energy metabolism (2,3).

What is the effect of exercise on iron status? Iron deficiency is reported in athletes, particularly female endurance and adolescent athletes. Iron depletion, the first stage of iron deficiency, is most commonly found and is indicated by low blood levels of ferritin (<12 μg/dL) (3,4). The incidence of iron deficiency anemia, a more severe form of iron deficiency, is less prevalent than iron depletion in athletes as well as in the general population (5).

A variety of factors contribute to low iron status among athletes (6, Figure 1). Exercise-associated factors that can place athletes at high risk of iron deficiency include increased iron needs, hemolysis of erythrocytes and iron losses in sweat, feces, and urine. In some athletes, a training-induced increase in plasma volume may lead to a transient, nonclinical "sports anemia" in which blood levels of ferritin and hemoglobin are diluted (7). This condition is not associated with any impairment in oxygen-carrying capacity and as such does not reduce performance.

The intensity and duration of training can influence iron status. In a study of men aged 19 to 29 years, resistance (strength) training was associated with a significant reduction in serum ferritin and other iron indices (8). However, in an investigation of older men aged 56 to 69 years who participated in 12 weeks of resistance training, body iron stores were unchanged (9). The older men trained for fewer days/per week which likely allowed more time for iron stores to recover from previous training episodes.

Figure 1. Possible Mechanisms for Exercise-induced Iron Deficiency (6).



For athletes, as well as non-athletes, inadequate intake of iron-rich foods such as meat (e.g., beef) and consumption of foods with low iron bioavailability can contribute to low iron status (1). The absorption of food iron varies according to the form of iron, heme or nonheme, the presence of enhancing (e.g., vitamin C) or inhibitory (e.g., phytates in bran) factors, and the body's iron status. Heme iron, found in meat, is highly absorbed, whereas the absorption of nonheme iron is much lower (10). Athletes such as wrestlers, gymnasts, and dancers who restrict their calorie intake for weight control purposes are likely to have low iron intakes (1,3). Increased iron needs of female athletes because of iron lost during menstruation, and of adolescents because

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of their high needs for this nutrient for growth can potentially compromise iron status.

Does iron deficiency compromise exercise performance? Because of iron's crucial role in oxygen transport and utilization, a deficiency of this nutrient could theoretically reduce exercise performance (2). Iron deficiency anemia may compromise the ability to exercise, but whether or not mild iron deficiency negatively impacts physical performance is unresolved (4,5,11). However, when 15 women with normal iron status and 15 iron depleted women participated in physical performance tests, the iron depleted group had significantly lower maximum oxygen consumption levels, an indicator of aerobic work capacity (11).

Zinc's Role in Exercise and Athletic Performance

Zinc is essential for many enzymes involved in energy metabolism during exercise (e.g., carbonic anhydrase, lactate dehydrogenase, superoxide dismutase). In addition, this trace element plays a role in tissue repair (3,4). For these reasons, zinc's role in exercise and its relationship to athletic performance are receiving attention.

Does exercise affect zinc status? Although some studies have reported low blood zinc levels in athletes (e.g., endurance training), other investigations have found blood zinc levels within the normal range in athletes (4,12-14). Low blood zinc levels were reported in professional football players who participated in a daily physical training program of progressively increased workloads (13).

Inconsistent findings related to the zinc status of athletes may be explained by the relatively poor ability of blood zinc levels to accurately reflect overall zinc status of the body (15). During exercise, zinc may be redistributed from less to more metabolically active tissues. Runners were found to have lower blood zinc levels but higher red blood cell zinc concentrations, possibly suggesting a redistribution of zinc during exercise (16). In addition, there may be an adaptation in zinc metabolism during exercise. Low blood zinc levels and increased urinary zinc excretion following strenuous exercise tend to return to pre-exercise levels after the exercise (4,6).

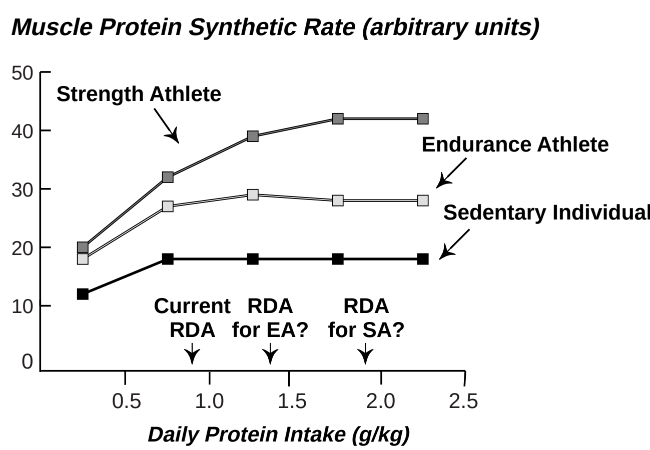
Does zinc status affect exercise performance? Under some conditions physical activity contributes to low blood zinc levels suggestive of zinc deficiency. However, it has yet to be conclusively demonstrated that exercise per se causes zinc deficiency or that mild hypozincemia compromises athletic performance (3).

Protein's Role in Exercise

Although not the major energy source for athletes, protein intake of athletes is nevertheless important for athletic performance.

Does exercise increase protein needs? The protein needs of athletes depend on several factors. These include the intensity and duration of exercise, the availability of carbohydrate (i.e., dietary protein needs increase when carbohydrate stores are limited), type of exercise (i.e., strength training, endurance training, aerobic exercise), training, gender, and age. Some evidence indicates that dietary protein needs increase with rigorous physical activity (17). Athletes involved in strength training may need to consume as much as 1.6 to 1.7 g protein/kg body weight/day, or approximately twice the current Recommended Dietary Allowance (RDA) for protein (17,18, Figure 2). Athletes involved in endurance training may need about 1.2 to 1.6 g protein/kg/day, or approximately 1.5 times the current RDA (18).

Figure 2. Proposed Effects of Increasing Dietary Protein on Muscle Protein Synthetic Rate in Sedentary Individuals Versus Endurance (EA) and Strength (SA) Athletes (17).



If exercise increases protein needs, the additional protein can generally be met by athletes' increased food intake (1). However, athletes with poor nutritional habits or who consume low energy (calorie) intakes to achieve a desired appearance or compete at a lower weight class may not meet their protein needs (2).

Does increasing dietary protein enhance recovery of protein stores following exercise? Sufficient dietary protein is needed by competitive endurance athletes to optimize protein use during exercise and to provide sufficient amino acids to repair tissue and enhance muscle recovery following exercise. However, little is known regarding how much protein is needed to provide a sufficient supply of amino acids to enhance the utilization of protein post-exercise (19).

Increasing protein intake may increase muscle mass in older adults who participate in resistance training. Various combinations of dietary and exercise interventions are being explored to help reduce age-related decreases in skeletal muscle or sarcopenia (20). This condition increases older adults' risk of major chronic diseases. High intensity resistance training is associated with increased muscle mass in healthy older adults (20,21). Low protein, isoenergetic diets result in loss of muscle mass in older adults (20). But whether or not increasing protein intake above recommended dietary intakes improves body composition (e.g., increases muscle mass) in healthy older weight lifters is not clearly established.

Researchers demonstrated that increasing dietary protein intake influenced the relative uptake and efficiency of nitrogen use in healthy older adults participating in resistance training, but muscle mass was not increased (22,23). The subjects in these studies consumed lactoovovegetarian (meat-free) diets. These findings, along with observations that muscle mass increases in older adults who participate in resistance training and consume their usual (presumably meat-containing) diets, suggest that the *source* of protein (i.e., vegetable versus animal) may influence the development of muscle mass during resistance training in older adults (21). Lower net protein synthesis has been found in older women who consumed a diet high in vegetable protein than in those who ate an equivalent amount of protein from a diet rich in animal protein (24).

Beef and Exercise Performance

Because beef is an excellent source of readily bioavailable iron, zinc, and high quality protein, nutrients important in exercise physiology, consuming a beef-containing diet can be expected to help optimize athletic performance.

Meat diets versus vegetarian diets and performance. Theoretically, a vegetarian diet containing a high fiber (e.g., phytate) content can reduce the bioavailability of iron, zinc, and other trace elements. However, there is no conclusive evidence that the nutritional status of vegetarians is compromised because of their physical activity or plant-based diets (25). Nor is there conclusive evidence that a vegetarian diet per se is beneficial or detrimental to physical activity (25).

Effect of meat intake and training on iron status, fitness, and muscle mass. Intake of meat was more effective than iron supplements in protecting iron (hemoglobin and ferritin) status in previously sedentary women who participated in a 12-week moderate aerobic exercise program (26). Preliminary findings of a more recent study reveal that the addition of 2 to 3 ounces of lean beef/day for three months increased iron and zinc intake of female adolescent cross-county runners (27). Furthermore, both training and increased beef intake were linked to improved fitness levels (28). The adolescent runners who consumed beef had lower average competition times at one and three months and reportedly ran more miles/week than did the runners who did not consume the daily beef snack (28).

Consuming a meat-containing diet (beef, poultry, pork, fish) contributed to greater gains in fat-free mass and skeletal muscle mass in older men aged 51 to 69 years participating in a 12-week resistance (strength) training program than in those who consumed a lactoovovegetarian diet (21). The researchers concluded that intake of recommended servings of meat/day in the diet contributes to resistance-training gains in fat free mass and muscle mass in older men (21). Additional research is needed to determine whether a specific source of meat such as beef positively affects body composition in older adults participating in resistance training.

Summary

Regular exercise may increase the need for nutrients such as iron, zinc, and protein. Moreover, deficiencies of these nutrients may compromise athletic performance. It therefore is important for physically active individuals and athletes to meet at least the RDA (18) for these nutrients. The Food Guide Pyramid (29) recommends that all healthy Americans two years of age and older consume two 2-to-3 ounce servings of lean meat/day for a total of 5 to 6 ounces. Lean red meat such as beef is an excellent source of readily bioavailable iron, zinc, and high quality protein – nutrients particularly important for physically active people (10,30).

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