Gatorade Sports Science Institute®

58

VOLUME 8 (1995)

NUMBER 5

SPORTS SCIENCE EXCHANGE

THE ROLE OF MEAT IN AN ATHLETE'S DIET:
ITS EFFECT ON KEY MACRO-AND MICRONUTRIENTS

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KEY POINTS

1. In the typical Western diet, meats such as beef, lamb, pork, veal, poultry, and fish are the predominant sources of protein, B vitamins, iron, and zinc.
2. Iron and zinc are the two nutrients most often deficient in vegetarian or modified-vegetarian diets. Also, iron and zinc are the most cited nutrients that may be deficient in the diet of athletes.
3. Athletes who choose to exclude meat from their diets must carefully plan diets to enhance nutrient availability, particularly for iron and zinc.

INTRODUCTION

Generations of athletes have consumed a diet centered around meat. In the 6th century B.C., a famous Greek athlete, Milo of Crotona, was the wrestling victor in five Olympian games and in many other sacred festivals. In what is probably an apocryphal account, he applied progressive resistance training by lifting a growing calf daily. When the calf was four years old, he carried her the length of the Olympian stadium, killed, roasted, and ate her. It was reported that Milo's normal daily intake of meat was about 20 pounds (Ryan, 1981).

Times have changed. As scientific evidence has solidified the link between high-fat, meat-based diets and increased risks of chronic diseases such as cancer and heart disease, more people are turning to a vegetarian style of eating for health reasons, rather than moral or ethical reasons. Almost seven percent of the American public, or about 12.4 million people, consider themselves vegetarians (Havala, 1994). Athletes, too, are becoming attracted to a more plant-based style of eating. Although most athletes do not eliminate all animal foods from the diet, increasing numbers of athletes avoid beef and other red meats on a fairly regular basis. (Snyder et al., 1989; Raben et al., 1992; Lyle et al., 1992). A survey of nationally competitive female runners showed that more than 40 percent avoided red meat for "health reasons" (Clark et al., 1988). Other reasons for avoiding meat include fat content, calorie content, and financial cost (Steen, 1991). In some cases athletes limit animal foods based on misconceptions, such as the erroneous association of milk with fluid retention (Kleiner et al., 1994).

Can an athlete achieve peak performance on a meatless diet? Can plant foods supply the right nutrients in adequate amounts to replace nutrients depleted during intense physical activity? The purpose of this review is to summarize the factors that influence the adequacy of a meatless diet for athletes and to provide practical guidelines to assist with the healthy planning of such diets.

THE ROLE OF MEAT IN THE DIET

Typical Western diets are made up of the following food groupings:

- Vegetables;
- Fruits;
- Breads, cereals, rice, and pasta;
- Milk, yogurt, and cheese;
- Meats, poultry, fish, dry beans and peas, eggs, nuts, and seeds;
- Fats, oils, and sweets.

In the typical Western diet, meats (including beef, lamb, pork, veal, poultry, and fish) are the primary staple around which meals are designed, and are the predominant sources of protein, B vitamins, iron, and zinc.

Just as no single vegetable or fruit can provide all of the critical nutrients common to its food group, no single type of meat can provide all of the protein, B vitamins, iron, and zinc necessary for a healthy and well-balanced diet. It is the variety of types and cuts of meats that provide the total array of nutrients necessary for an adequate diet.

For example, beef is only an average source of niacin, riboflavin, thiamin, and vitamin B_6 (1 serving provides 10-24 percent of the RDA for adults and children over 4 years of age). But most cuts of beef are excellent sources of zinc (1 serving provides 40 percent of the RDA for adults and children over 4 years of age). Likewise, pork is an excellent source of thiamin and iron, a good source of niacin (1 serving provides 25-39 percent of the RDA for adults and children over 4 years of age), and only an average source of riboflavin, vitamin B_6, and zinc. Because vitamin B_{12} is a byproduct of animal metabolism, virtually all types of meats are good or excellent sources of vitamin B_{12} (USDA, 1990).

Generally speaking, red meats like beef and the dark meat of poultry are better sources of iron and zinc than are white meats like fish and light meat of poultry. However, there are some exceptions. Pork is an excellent source of iron, as are clams and oysters. Oysters are also an excellent source of zinc (USDA, 1990).

The elimination of some or all meats from the diet does not mean that a well-balanced and adequate diet is impossible. Dry beans and peas (legumes) and nuts are somewhat similar to meats in providing protein and most vitamins and minerals. But there are some significant nutritional differences between plant and animal food sources of proteins.

Protein

The quantity of protein in the diets of athletes is rarely a concern, regardless of whether they are meat eaters or non-meat eaters. For example, an average of 21-25% percent of the energy in legumes comes from protein calories (Geil & Anderson, 1994), and protein constitutes 34% of the energy in soybeans. There is, however, a limitation to the quality of the protein from most legumes. With the exception of soybeans, legumes do not contain a full complement of the essential amino acids required for the efficient manufacture of protein by the human body. Well-processed soybean protein is equal in quality to animal protein (Young, 1991).

Previous vegetarian dietary guidelines recommended that a variety of plant protein sources (such as grains and beans) be combined simultaneously at one meal to complement each other and provide a complete protein source. Current research supports the notion that by eating a variety of legumes, as well as all other food groups throughout the day, one can obtain the full array of essential amino acids required for efficient protein metabolism.

According to World Health Organization (1985) recommendations, protein digestibility is reduced by about 10% in a vegetable-based diet due to the high fiber content of the diet. Accordingly, it is suggested that those who eat such diets should consume 110% of the calculated protein requirement to ensure adequate protein intakes (WHO, 1985).

B Vitamins

In spite of the fact that meats are a major source of B vitamins in the Western diet, whole and enriched grain products, eggs, legumes, nuts, seeds, fruits, vegetables, and dairy products are good and reliable sources of B vitamins and can fully supply the dietary requirements for B vitamins.

An exception to this rule is vitamin B_{12}, which is available only from animal products. A B_{12} supplement must be used if animal products are completely eliminated from the diet.

Iron

In absolute amounts, it is surprising to note that most meats are only average sources of iron when compared to many grains and legumes. However, the bioavailability of iron from meat versus vegetable foods makes a significant difference in the value of meat as a source of iron in the diet.

There are two forms of dietary iron, heme iron (from animal tissue) and non-heme iron. Heme iron is absorbed with the iron still contained within hemoglobin or myoglobin molecules. Absorption of heme iron is affected by the body's stores of iron, but it is not affected by intestinal factors or by meal composition. However, absorption of nonheme iron is very dependent on iron stores, intestinal factors and meal composition. Furthermore, heme and non-heme iron are absorbed from the intestine at differing rates. In the iron-replete individual, as little as 15% of heme iron that reaches the intestine is absorbed, whereas up to 35% may be absorbed in an individual with little or no iron stored in the body. Absorption of nonheme iron can range from 2% in the iron-replete individual consuming a meal of low iron availability to 20% in the person with minimal stores of iron who consumes a meal that contains highly bioavailable nonheme iron (Monsen & Balintfy, 1982). Intestinal factors and meal composition factors that affect absorption of nonheme iron are discussed later under "Practical Considerations."

Zinc

Meats, particularly red meats and oysters, are good or excellent sources of zinc and are the major sources of zinc in the Western diet. The bioavailability of zinc varies with the food source; some foods contain factors that inhibit zinc absorption. Factors that inhibit zinc absorption include fiber, phytic acid, oxalic acid, ethanol, tannins, iron, calcium, and tin. These constituents are found in varying amounts in soy protein, whole wheat, tea, coffee, celery, milk, cheese, corn tortillas, and beans (Shils & Young, 1984). Zinc from animal sources is generally regarded as more bioavailable than zinc from vegetable sources (Mares-Perlman et al., 1995).

INCIDENCE OF DIETARY DEFICIENCIES AMONG ATHLETES

Potential iron and zinc deficiencies are the two most noted drawbacks of vegetarian or modified-vegetarian diets, and are the most common dietary deficiencies among athletes (Dallongeville et al., 1989; Lamanca & Haymes, 1992; Nutter, 1991; Pate et al., 1993; Snyder et al., 1989; Telford et al., 1992, 1993; Williford et al., 1993).

Iron

Iron is an essential trace element required for the formation of hemoglobin, myoglobin, the cytochromes, and iron-containing enzymes critical in immune function (Haymes, 1987). Numerous recent studies have documented a prevalence of iron deficient conditions in both male and female athletes, but more commonly among women (Dallongeville et al., 1989; Lamanca & Haymes, 1992; Nutter, 1991; Pate et al., 1993; Snyder et al., 1989; Telford et al., 1992, 1993; Williford et al., 1993).

Iron depletion, the first stage of iron deficiency, is the most common iron deficiency condition documented among athletes, and is indicated by low serum ferritin values (<12 ug/dL). The next two stages of iron deficiency, iron-deficient erythropoiesis and iron-deficiency anemia, are much less commonly observed. Plasma volume expansion (which reduces the concentration of iron in plasma), low dietary iron intake, low bioavailability of dietary iron, and increased rates of iron excretion (Clarkson & Haymes, 1995) are suggested as possible reasons for the high prevalence of iron depletion in athletic populations.

The Recommended Dietary Allowance (RDA) for iron is 15 mg/d for women and 10 mg/d for men. The average iron intake among U.S. women is only 6 mg/1000 kcal or 10.6 mg/day. Most males consume more than the RDA for iron (Clarkson & Haymes, 1995).

The results of studies investigating iron status of athletes and exercising individuals indicate that athletes with decreased iron stores generally consume less dietary iron and fewer servings of meat on a regular basis. Subjects with low iron stores eat significantly less heme iron than do those with normal iron stores. However, no performance decrements have been demonstrated in these subjects (Lyle et al., 1992; Dallongeville et al., 1989; Pate et al., 1993; Snyder et al., 1989; Williford et al., 1993). Some studies that indicated lower iron intakes among subjects with decreased iron stores failed to demonstrate a correlation between heme iron intakes and serum or plasma ferritin values (Lamanca & Haymes, 1992; Telford et al., 1993).

Iron Supplements versus Iron From Meat.

Several researchers have studied the influence of the dietary source of iron on iron stores. Lyle et al. (1992) studied the effect of oral iron therapy versus increased consumption of meat in women participating in a moderate exercise program for 12 weeks. The additional meat was more effective in protecting hemoglobin and ferritin status than was iron supplementation. In contrast, a similar study repeated by the same researchers failed to find improved iron stores with extra meat consumption but did show increased iron stores with a daily supplement of 50 mg ferrous sulfate supplement (Rajaram et al., 1995). Thus, there is no clear choice between these two approaches to increasing iron intake.

Iron Depletion and Performance.

Although it is certain that iron-deficient erythropoiesis and iron-deficiency anemia will impair physical performance, whether or not iron depletion affects performance is uncertain. Most studies (Dallongeville et al., 1989; Dressendorfer & Sockolov, 1980; Dressendorfer et al., 1982; Haralambie, 1981; Janelle & Barr, 1995; Lyle et al., 1992; Pate et al., 1993; Singh et al., 1990; Snyder et al., 1989; Williford et al., 1993;) have shown no negative performance effects due to decreased iron stores; however, Telford and colleagues (1992) showed that improving low plasma ferritin levels (<30 ng/mL) in males was associated with an increase in performance during a 10s maximal exercise test.

Zinc

Zinc is one of the most widely distributed metals in the body and is an important co-factor for more than 100 enzymes involved in metabolic pathways, endocrine function, and immune integrity (Clarkson & Haymes, 1994). Carbonic anhydrase III, AMP-deaminase, and lactate dehydrogenase are zinc-dependent enzymes that serve important functions in energy metabolism during exercise.

Zinc status is difficult to measure. Although most studies measure levels of zinc in the serum, this is a relatively poor indicator of overall zinc status in the body. For example, a recent study suggested that prolonged, vigorous physical activity increases the content of zinc in mononuclear cells, but does not change the content of zinc in serum and red blood cells (Dolev et al., 1995).

At least one study suggested that training status may not affect bodily zinc stores. Deuster et al. (1989) reported no differences between fasting concentrations of plasma zinc, serum albumin, alpha2-macroglobulin, and erythrocyte zinc content between highly trained and untrained women. The highly trained women did, however, have significantly higher urinary zinc excretions after a 25 mg oral zinc load.

On the other hand, many studies of the zinc status of athletes have reported lower than normal levels of serum or plasma zinc (Dressendorfer & Sockolov, 1980; Dressendorfer et al., 1982; Haralambie, 1981; Singh et al., 1990). Possible reasons for this hypozincemia in athletes include low dietary zinc, low bioavailability of dietary zinc, excessive zinc loss during exercise, dilution of zinc by plasma volume expansion, and redistribution of zinc in the body (Clarkson & Haymes, 1994).

The RDA for zinc is 12 mg/day for women and 15 mg/d for men. The average zinc intake of both the sedentary and the athletic populations of U.S. women is approximately 10 mg/d, and that for men slightly exceeds the RDA (Clarkson & Haymes, 1994). In a recent study of vegan and lactovegetarian women zinc intakes were lower than recommended (8.5 mg/d and 8.2 mg/d, respectively) (Janelle & Barr, 1995).

Animal versus Plant Sources of Zinc.

The lack of meat sources of zinc in the diet may contribute to or increase the potential for the development of hypozincemia in athletes. Among the 25 major sources of zinc in the U.S. diet, meat or dishes containing meat comprise the top 10 (Mares-Perlman, 1995). Zinc bioavailability from some plant sources is limited by their contents of fiber and/or phytate. Although fractional absorption of zinc from plant-based diets can be similar to that from animal sources, the low zinc content of plant foods tends to result in a low net absorption (Janelle & Barr, 1995).

Zinc Supplementation and Performance.

A true clinical deficiency of zinc would certainly impede physical performance. Due to the critical role of zinc in regulating lactate dehydrogenase activity, among other clinical symptoms, zinc deficiency results in decreased muscle strength and endurance (Krotkiewski et al., 1982). Whether or not mild hypozincemia is an impediment to peak performance is uncertain, but appears unlikely. Zinc supplementation is common among athletes, but other than in cases of correcting a long-standing zinc-deficient diet, there is little evidence of a performance benefit from zinc supplementation. In fact, diet supplementation with 50 mg of zinc interferes with copper status in men. Furthermore, zinc intake in amounts 10 times the RDA can significantly reduce lymphoctye function and phagocytosis of bacteria by polymorphonuclear leukocytes, decrease HDL cholesterol levels, and increase LDL cholesterol. It is therefore recommended that zinc supplementation not exceed 15 mg/d. (Clarkson & Haymes, 1994).

PRACTICAL CONSIDERATIONS

Whether to include or exclude meat in the diet of an athlete is obviously a matter of personal choice; however, if the choice is made to decrease the amount of meat in the diet, then careful dietary planning is necessary to enhance nutrient availability, particularly for iron and zinc.

Diets that Increase Iron and Zinc Absorption

- *Include heme iron sources in the diet.* All types of meat contain this more-easily-absorbed form of iron. If only red meat has been eliminated from the diet, heme iron is still available from poultry and fish.
- *The "MFP Factor"*. Meat, fish, and poultry also contain a special quality called the "MFP Factor" that helps the body absorb more nonheme iron. When meat and vegetables are eaten together at the same meal, more nonheme iron is absorbed from the vegetables than if the vegetables had been eaten alone.
- *Include vitamin C sources.* Fruits, vegetables and other foods that contain vitamin C help the body absorb nonheme iron. For example, if citrus fruits are eaten along with an iron-fortified cereal, more iron will be absorbed from the cereal than if it had been eaten alone.
- *Avoid constituents that block iron and zinc absorption.* Some food constituents, e.g., tannins, polyphenols, phytates, and oxalates, can block the absorption of iron and zinc by the intestine. Coffee and tea (regular and decaffeinated), whole grains, bran, legumes, spinach, and a high fiber intake in general, are a few examples of foods that contain iron- and zinc-absorption blockers. These foods are best eaten with heme iron sources and/or vitamin C sources to help the body absorb more iron.

Include Good Sources Of Iron And Zinc In The Diet

There are good meatless sources of iron and zinc, as shown in the table on the following page. Because iron and zinc intake may be low or marginal in a completely plant-based diet, an extra effort must be made to include these sources in the diet on a daily basis.

Iron and Zinc Supplementation

Due to the rigorous demands of athletic participation, those who choose to completely eliminate meat from the diet may find it difficult to plan, prepare, or consume the quality and quantity of food required to meet recommended guidelines. Despite the fact that dietary supplements do not entirely replace food, when key nutrients are insufficient in the diet it is wise to use a supplement rather than face a potential nutrient deficiency. Daily supplementation of iron and zinc at the level of 100% of the RDA is a safe method of ensuring adequate intake of these nutrients.

CONCLUSION

As vegetarian styles of eating become more popular among athletes, the risk of poorly planned diets leading to nutrient insufficiencies and deficiencies increases. Suboptimal dietary intakes of iron and zinc resulting in decreased nutritional status have been observed in athletes who have eliminated meat. Marginal iron or zinc status may negatively affect exercise performance. Full-blown iron or zinc deficiency will definitely have a negative effect upon exercise performance.

It is possible to obtain all essential nutrients by eating a completely plant-based diet. However, the planning and execution of the diet is critical to both the health and performance of an athlete. Practically speaking, because vegan diets are also typically high in fiber, it may be difficult for an athlete to consume enough food to satisfy nutrient and energy needs without feeling so full that exercise performance is inhibited. Athletes must learn that it is not sufficient to merely cut meats out of the diet; these foods contain essential nutrients that must be carefully replaced by adding other foods to the diet. If the decision to consume a meatless diet is not based upon moral or ethical principles, it may be more practical to encourage the athlete to include some meat in their diet. It is also important that athletes base their dietary decisions on scientific evidence, rather than on myths and misconceptions.

See chart on next page.

GOOD MEATLESS SOURCES OF IRON AND ZINC[1]

	SERVING SIZE	IRON[2]	ZINC[2]
Breads, Cereals, and other Grains			
Bagel, plain, pumpernickel, whole-wheat	1 medium	+	-
Farina, cooked	2/3 cup	++	-
Muffin, bran	1 medium	+	-
Noodles, cooked	1 cup	+	-
Oatmeal, fortified, prepared	2/3 cup	++	-
Pita bread, plain or whole-wheat	1 small	+	-
Pretzel, soft	1	+	-
Ready-to-eat cereals, fortified	1 ounce	++	+
Rice, white, regular or converted, cooked	2/3 cup	+	-
Wheat germ, plain	4 tbsp	-	+
Fruits			
Apricots, dried, cooked, unsweetened	1/2 cup	+	-
Vegetables			
Beans, lima, cooked	1/2 cup	+	-
Spinach, cooked	1/2 cup	+	-
Fish and Seafood			
Carp, baked or broiled	3 ounces	-	+
Clams, steamed, boiled, or canned, drained	3 ounces	+++	-
Crabmeat, steamed	3 ounces	-	+
Lobster, steamed or boiled	3 ounces	-	+
Mackerel, canned, drained	3 ounces	+	-
Mussels, steamed, boiled, poached	3 ounces	+	+
Oysters:baked, broiled, or steamed	3 ounces	++	+++
canned, undrained	3 ounces	++	+++
Shrimp, broiled, steamed, boiled, or canned, drained	3 ounces	+	-
Trout, baked or broiled	3 ounces	+	-
Legumes			
Dried beans, cooked	1/2 cup	+	-
Lentils, cooked	1/2 cup	+	-
Soybeans, cooked	1/2 cup	++	-
Nuts and Seeds			
Pine nuts (pignolias)	2 tbsp	+	-
Pumpkin or squash seeds, hulled, roasted	2 tbsp	+	+
Milk, Cheese, and Yogurt			
Cheese, ricotta	1/2 cup	-	+
Yogurt: Flavored, made with whole or lowfat milk	8 ounces	-	+
Plain, made with lowfat or nonfat milk	8 ounces	-	+

[1] *Data from USDA (1990)*
[2] *Servings noted with a + contain at least 1.8 mg iron and 1.5 mg zinc*
Servings noted with a ++ contain at least 4.5 mg iron and 3.75 mg zinc
Servings noted with a +++ contain at least 7.2 mg iron and 6.0 mg zinc

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