Inflammation is a physiological response to injury that causes redness, swelling, and pain. While acute inflammation is a normal response to high-intensity training, chronic inflammation results in depressed immunity and impaired muscle response (12). Acute inflammation is localized and specific to the working muscle, assisting in muscle repair by promoting breakdown and regeneration. However, exhaustive exercise, overtraining, poor nutrition, and lack of sleep result in chronic inflammation that spreads throughout the entire body (12). Chronic inflammation can impede muscle growth and training progress. Athletes will maximize training benefits by balancing inflammation, thereby limiting the chronic response without quenching the natural acute response. Therefore, the purpose of this article is to summarize nutritional strategies to help balance exercise-induced inflammation to optimize performance outcomes.

**PROTEIN**

Most athletes understand the importance of consuming protein to build muscle, but they may not realize that protein also synthesizes anti-inflammatory immune cells and antibodies to protect the body. Research has shown that 20 – 25 g of protein following exercise maximizes protein synthesis to enhance muscle repair regeneration (7,14). Additionally, spreading protein intake throughout the day (i.e., eating 20 – 30 g in each meal rather than 60 g at night) maintains positive protein balance to support muscle and immune function (10). For example, following an exercise session, athletes could consume 20 oz of milk, a grilled chicken sandwich, or a protein shake. To include a protein source in each meal, add eggs or Greek yogurt to breakfast, along with 3 – 6 oz of meat at lunch and dinner.

**OMEGA-3 FATTY ACIDS**

Omega-3 fatty acids are found in fatty fish such as salmon, tuna, and mackerel, as well as plant foods such as walnuts, flaxseed, and chia seeds. The American diet is typically rich in omega-6 fatty acids due to excessive use of vegetable oils in food processing. Therefore, most athletes tend to consume low levels of omega-3 fatty acids and high levels of omega-6 fatty acids. Omega-3 fatty acids produce compounds that naturally quench inflammation, while omega-6 and saturated fatty acids produce inflammatory compounds. Since athletes induce muscle damage and inflammation during training, increasing intake of omega-3 fatty acids will help balance the ratio of omega-3 to omega-6 fatty acids in favor of limited inflammation. Researchers found that men exercising for four weeks, who supplemented with omega-3 rich marine oil, significantly reduced markers of muscle damage and inflammation compared to a placebo (6). Therefore, it is typically recommended that athletes aim for 1 – 3 g of omega-3 fatty acids per day, but not exceed 3 g. The best sources of omega-3 fatty acids are fatty fish such as salmon or mackerel. Vegetarian sources of omega-3 fatty acids can be consumed by adding walnuts, flaxseed, or chia seeds to oatmeal, cereal, yogurt, or smoothies. However, these omega-3 sources are considered inferior to fish sources due to their inefficiency at converting to longer-chain fatty acids in the anti-inflammatory
process. Alternatively, athletes may choose to supplement with an omega-3 fatty acid dietary supplement certified by the National Sanitation Foundation (NSF).

ANTIOXIDANT NUTRIENTS
High-intensity training produces oxidative stress above that of daily living activities, resulting in muscle damage and fatigue. Antioxidants quench oxidative stress by ridding the body of free radicals and reactive oxygen species that initiate destructive cellular chain reactions (9). Examples of antioxidants include vitamins C, E, and A, along with other phytochemicals (chemicals that naturally occur in plants) in fruits and vegetables. Consuming antioxidant-rich fruits and vegetables is superior to taking large doses of antioxidant supplements because supplements have been shown to inhibit muscle recovery and impair beneficial training adaptations (9). For example, eating a vitamin C-rich orange following a hard workout is better than taking a vitamin C supplement. Other antioxidant-rich foods include dark leafy greens, nuts, seeds, avocados, broccoli, peppers, berries, tomatoes, carrots, sweet potatoes, and squash.

One especially rich antioxidant source is tart cherry juice, which is high in anthocyanins, an antioxidant found in purple and red fruits and vegetables (2). Consuming tart cherry juice before and after exercise has been shown to maintain muscle strength and reduce muscle pain by reducing inflammation and oxidative stress (2). For antioxidant intake utilizing tart cherry juice, try drinking 12 oz of tart cherry juice with breakfast and another 12 oz after exercise.

VITAMIN D
Vitamin D functions as a hormone in the body and has a role in regulating muscle protein synthesis as well as anti-inflammatory compounds (8). Low levels of vitamin D promote inflammation while inhibiting protein synthesis, and vitamin D deficiency has been linked to muscle weakness and fatigue (8). Vitamin D is synthesized in the body in response to sunlight, but many athletes train indoors or at latitudes that do not support year-round vitamin D synthesis. Therefore, these athletes are more dependent on dietary sources of vitamin D, a limited supply that includes fatty fish, egg yolks, and fortified dairy products. Given widespread vitamin D deficiency, many manufacturers now fortify foods such as plant milks, irradiated mushrooms, and grains. Athletes with vitamin D deficiency have higher levels of inflammatory markers, which, if sustained, may cause chronic inflammation (13). Therefore, athletes at lower latitudes should spend approximately 15 min in sunlight between the hours of 10:00 a.m. and 3:00 p.m. to synthesize vitamin D (3). The amount of sunlight required to synthesize vitamin D does not require tanning or burning of the skin. An additional option is to consume 1,000 IU vitamin D per day from foods or NSF-certified dietary supplements. If choosing foods, look for fortified sources as natural sources may be limited. For example, eggs contain about 40 IU per yolk, fortified whole milk contains about 120 IU per cup, and salmon contains about 450 IU per 4 oz (11).

NITRITES AND NITRATES
In recent years, research on nitrates and nitrates has exploded as these compounds have the potential to increase nitric oxide, a potent vasodilator that expands blood vessels and increases blood flow. Increasing nitric oxide during exercise, via high intake of nitrates and nitrites, improves oxygen cost during exercise (4). Nitrate supplementation has also been shown to improve time trial performance in cyclists (5). Furthermore, nitrate supplementation protects the mitochondria, the cellular powerhouse and site of energy production, from excessive production of reactive oxygen species that cause oxidative stress. As a result, increasing nitric oxide corresponds to enhanced recovery and reduced inflammation following exercise (4,5). A popular and widely researched source of nitrates is beetroot juice, but nitrates are also found in spinach, lettuce, radish, turnip, cabbage, celery, and green beans.

HERBS AND SPICES
Often overlooked, herbs and spices enhance the flavor of otherwise mundane meals while also reducing exercise-induced inflammation (1). Herbs and spices contain a variety of antioxidants, minerals, and vitamins, often with very few calories. Examples for increasing consumption of anti-inflammatory herbs and spices include sprinkling cinnamon on oatmeal, adding rosemary to chicken, sautéing garlic into mixed vegetables, adding ginger to stir fry, and consuming turmeric in curry.

REFERENCES


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