Electrolytes and Antioxidants for Exercise

By Ronald Steriti, ND, PhD

Although exercise is one of the best ways to improve your health, vigorous exercise is associated with increased metabolic and nutritional demands. Your body needs specific nutrients, including:

- Electrolytes to replace minerals lost in sweat, and
- Antioxidants to combat free radicals formed during exercise.

In this article, we will briefly review electrolytes and antioxidants for exercise and summarize relevant research articles that show how they improve sports performance.

Electrolytes

Electrolytes are minerals that turn into charged particles when dissolved in water. The body uses them to conduct nerve impulses, which contract and relax muscles. The main electrolytes are sodium, calcium, magnesium and potassium. Electrolytes are lost in sweat.

- A recent *New England Journal of Medicine* study found that 13 percent of Boston marathon runners studied had a serious imbalance of fluid and electrolytes after the race. [1]

Sodium

Hyponatremia is a deficiency of sodium, which is of particular concern to marathon runners. Salt tablets are commonly recommended during races. Unfortunately, hyponatremia is not caused by a deficiency of sodium, which is abundant in diet.

- Drinking too much water (over-hydration) causes hyponatremia by diluting sodium. [2]

The problem of over-hydration is particularly serious during marathons in hot weather. Some runners drink a lot of water before, during and after the race. Unfortunately, this dilutes the blood and makes mineral deficiencies worse.

Taking salt tablets may not be the answer. Excessive sodium consumption leads to an imbalance of the other minerals, since sodium is not the only electrolyte lost in sweat. Other important electrolytes include calcium, magnesium and potassium. A balanced electrolyte replacement formula is recommended. [3]

- Sodium bicarbonate ingestion (0.2 g/kg) was shown to improve performance of a prolonged intermittent-sprint test with seven female team-sport athletes. [4]
- One study showed that metabolic alkalosis induced by sodium bicarbonate consumption resulted in increased time to fatigue and peak power output (by approximately 12%) during a progressive wrist flexion exercise. [5]
- Sodium citrate ingestion prior to an intense bicycle exercise resulted in a normal blood pH even though lactate levels were increased. Blood pH normally rises during intense exercise, which causes an acidic state (e.g. lactic acidosis). An exhaustion time was recorded during

the exercise trial without sodium citrate, however, no exhaustion was noted during the exercise trial with sodium citrate. [6]

- A random, double-blind study examined the effects of sodium citrate (0.5 g/kg) consumption before a 5-km treadmill run with 17 trained college runners. The time required to complete the run was faster with sodium citrate (1153.2 vs. 1183.3 seconds). [7]
- Sodium bicarbonate (0.3 g/kg) was shown to improve sprint performance during prolonged intermittent cycling. [8]

Calcium

Calcium is an important component of bone. Exercise has been shown to cause an increase in osteoclast activity, which breaks down bones to release calcium. Calcium is of particular concern with female and post-menopausal athletes at risk for decreased bone density (osteoporosis).

- Calcium levels rise and urinary excretion increases after intense exercise. [9, 10]
- One study showed that drinking 1 gram of calcium in mineral water suppressed the burst of osteoclastic (bone destruction) activity induced by an endurance cycling exercise. [11]
- Another study showed that a year of supplemental calcium intake prevented cortical but not trabecular bone loss in young adult female distance runners. [12]

Magnesium

Calcium and magnesium play opposite roles in nerve transmission. Calcium contracts muscles, and magnesium relaxes them. It has been proposed that muscle cramps, which are fairly common in endurance sports, may be due to a deficiency of magnesium.

Constipation is key sign of a magnesium deficiency, whereas loose stools are the main side effect of excess magnesium supplementation. One way to determine the appropriate amount of magnesium to take is to increase one capsule at a time until you have loose stools, and then reduce it until the stools are normal. This method adjusts the dose to be optimal for the person.

- Exercise increases the nutritional demand for magnesium, which may result in deficiency and cause reduced exercise performance. [13, 14]
- Plasma magnesium concentrations decrease during prolonged, intense exercise, which may reflect redistribution from plasma to the working muscle. [15]
- Magnesium deficiency is a common cause of muscle cramps, although it may not be the sole cause. [14, 16]
- A double-blind study of 26 untrained subjects in a 7-week strength-training program found that magnesium supplementation could benefit strength training. [17]
- Another study demonstrated improved swimming, cycling, and running times in triathletes. [18]
- A significant positive correlation was reported between plasma magnesium and aerobic capacity in male university athletes. [19]

Antioxidants

Several studies have shown that exercise results in increased oxidative stress, along with an increase in our body's antioxidant defenses. [20-23]

The use of dietary antioxidants to reduce exercise-induced oxidative stress is currently being studied, primarily with vitamins C and E. [24, 25]

Vitamin C

Vitamin C is an antioxidant that is needed to synthesize carnitine, which is required for the oxidation of fatty acids that are used for energy during endurance exercise.

- One study showed that people with a marginal vitamin C status oxidized less fat and had more fatigue during a treadmill test. [26]
- Another study found that supplementation with vitamin C (3 grams per day) reduced muscle soreness, delayed the release of creatine kinase, and prevented blood glutathione oxidation with little influence on muscle function loss. [27]
- An earlier study showed that supplementation with ascorbic acid (1 gram) reduced the oxidative stress caused by strenuous short-term aerobic exercise. [28]
- Vitamin C supplementation (200 mg of ascorbic acid twice a day for two weeks) had modest beneficial effects on muscle soreness, muscle function, and plasma concentrations of malondialdehyde (a marker of oxidative stress). Furthermore, although plasma interleukin-6 increased immediately after exercise in both groups, values in the vitamin C group were lower than in the placebo group 2 hours after exercise. [29]

Vitamin E

Vitamin E has significant antioxidant and anti-inflammatory properties. Exercise is associated with a reduction in alpha-tocopherol (vitamin E), which is consumed to protect red blood cells from oxidative damage during exercise. [30, 31]

- One study showed that vitamin E and endurance exercise reduced oxidative stress, improved aerobic fitness, and reduced blood pressure and weight in older adults. [32]

Vitamins C and E

Many studies combine both vitamins C and E to reduce oxidative stress during strenuous exercise.

- One recent study showed that supplementation with 400 IU of vitamin E and 1 gram of vitamin C reduced the rise in protein carbonyls (a marker of oxidative stress) after 30 minutes of aerobic exercise [33]
- A randomized, double-blind study in runners (11 females and 11 males) found that supplementation with both vitamins E and C (300 mg vitamin E, 400 IU RRR-a-tocopheryl acetate and 1,000 mg vitamin C) prevented increases in lipid peroxidation during an ultramarathon race (50 km, forest trail through hilly terrain). [34, 35]
- An earlier study (22 runners during a 50 km ultramarathon) found similar results with 1,000 mg vitamin C and 300 mg RRR-a-tocopheryl acetate. [36]

- Another study examined the effects of a 2-month antioxidant regimen (vitamin A, C, and E) had on white blood cell counts and granulocyte percentages after exhaustive aerobic cycling. The antioxidant vitamin treatment was effective in preventing the inflammation-like response after exercise. [37]
- The effect of antioxidants was studied in eighteen women undergoing eccentric exercise. Fourteen days prior to and 3 days after, they received antioxidant supplements (400 IU vitamin E, 1 g vitamin C and 90 μg selenium per day) or placebo. The antioxidants attenuated the increase in creatine kinase and muscle soreness response to the exercise. [38]
- One study examined the effects of antioxidant supplementation (150 μg of selenium, 2,000 IU of retinol, 120 mg of ascorbic acid and 30 IU of alpha-tocopherol) in triathletes during a duathlon (5-km run, 20-km bike and 5-km run). Plasma glutathione peroxidase activity decreased and CD4+ cell concentration increased in the supplement group. [39]
- Basketball players were supplemented with an antioxidant formula (600 mg alpha-tocopherol, 1,000 mg vitamin C and 32 mg beta-carotene) or placebo over 32 days during a regular competition season. Measures of oxidative stress and vitamin C status were significantly improved in those receiving the antioxidant formula. [40]

Glutathione

Glutathione is one of the most important cellular antioxidants. The liver contains large amounts of glutathione where it is used to detoxify toxins.

- Strenuous exercise has been shown to deplete reduced glutathione levels, which can be used as a marker of oxidative stress. [41, 42]

N-Acetylcysteine (NAC)

Exercise decreases reduced glutathione and increases oxidized glutathione concentrations, which are the result of oxidative stress. N-acetylcysteine was shown to attenuate both effects. [43]

- Several studies have shown that N-acetylcysteine reduced muscle fatigue during prolonged exercise. [44, 45]

Alpha-lipoic acid

Alpha-lipoic acid is an anti-oxidant that can reduce the oxidized forms of vitamin C, glutathione, CoQ10 and alpha-tocopherol.

- One study showed that orally supplemented alpha-lipoic acid favorably influenced tissue antioxidant defenses and counteracted lipid peroxidation at rest and in response to exercise. [46]

Lycopene

Lycopene is a carotenoid with powerful antioxidant properties that is abundant in red tomatoes. [47]

- Supplementation with lycopene (30 mg per day for 1 week) was shown to reduce exercise-induced asthma. [48]

Conclusion

Vigorous exercise is associated with increased metabolic and nutritional demands. Electrolytes and antioxidants can prevent nutrient deficiencies and improve sports performance. A balanced electrolyte replacement formula with sodium, calcium, magnesium and potassium is recommended. Vitamins C and E are the primary antioxidants used in studies. Additional antioxidants are also being studied for sports performance, including: glutathione, N-acetylcysteine, alpha-lipoic acid and lycopene.

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