LEARNING OBJECTIVES

- To learn the proposed mechanisms as to how quercetin supplementation is theorized to benefit physically active individuals.
- To learn the effect quercetin supplementation may have on exercise performance in physically trained as well as physically untrained individuals.

**Key words:**
Exercise, Dietary Supplement, Sports Supplement, Ergogenic, Performance Enhancement

INTRODUCTION

Sports supplements are becoming increasingly popular and are being used by athletes spanning the continuum from middle school to professional sports. In their recent joint position statement on *Nutrition and Athletic Performance*, the American Dietetic Association (ADA), Dietitians of Canada (DC), and American College of Sports Medicine (ACSM) noted that, although some athletes, particularly those involved in weight-control sports, may need supplements to obtain adequate amounts of essential vitamins and minerals, many athletes may use supplements with the goal of performance enhancement (19).

Literally, thousands of sports supplements have been developed and marketed to athletes over the years. Although several may be classified as drugs, such as caffeine and ephedra, most are nutrients such as various forms of carbohydrate, fat, protein, amino acids, vitamins, minerals, and herbs. In recent years, other compounds found in plants, known as phytochemicals or phytonutrients, have been theorized to enhance physical performance.

Quercetin is classified as a flavonoid, a phytonutrient found in a variety of fruits and vegetables, especially berries, apples, pears, peppers, and green leafy vegetables. For several decades, *in vitro* and animal studies have shown that quercetin possesses various qualities, such as antioxidant, anti-inflammatory, antihypertensive, anti-infectious, and other effects that may offer great potential for the prevention and treatment of disease (3). More recently, quercetin has been studied for its potential to prevent or mitigate some of the adverse effects of intense exercise and to enhance physical performance.

Quercetin currently is available as a sports supplement in various forms (soft chews, powder, concentrate, ready to drink, and food bars) and is marketed as a means to boost energy and enhance fitness. Research protocols relative to its exercise-related effects typically involve supplementation with 1,000 mg daily, usually in two 500 mg doses, and the supplementation period has ranged from less than a week to 6 weeks but typically 1 to 3 weeks. David C. Nieman, Dr. P.H., FACSM, director of the Human Performance Laboratory at Appalachian State University, and J. Mark Davis, Ph.D., FACSM, director of the Exercise Biochemistry Laboratory at the University of South Carolina, lead two of the principal research groups studying quercetin supplementation and exercise-related interactions.
QUERCETIN SUPPLEMENTATION AND RECOVERY FROM INTENSE EXERCISE

Athletes and others who exercise intensely may be subject to oxidative damage in muscle tissue from free radicals and also may have impaired immune functions that may contribute to the development of upper respiratory tract infections (URTIs). Such events could compromise optimal training and impair subsequent competitive performance. Quercetin, through its antioxidant, anti-inflammatory, and anti-infectious actions, has been theorized to prevent or mitigate such adverse effects that often follow intense exercise training.

Both laboratory and field studies have evaluated the antioxidant effects of quercetin supplementation to prevent exercise-induced oxidative damage. In one of Nieman’s laboratory studies, subjects consumed quercetin or placebo daily over the course of 6 weeks, during which they undertook an intense cycling protocol for 3 hours daily over the course of 3 consecutive days. The investigators noted that, despite previous data demonstrating potent antioxidant actions of quercetin in vitro, this laboratory study indicates that this effect is absent in vivo and that chronic quercetin ingestion does not exert protection from exercise-induced oxidative stress and inflammation (14). Nieman’s research group also conducted a unique field study that evaluated the effect of quercetin supplementation on numerous variables in runners competing in the 161-km (100-mile) Western States Endurance Run, a rugged mountain trail race involving a total of approximately 18,000 ft ascent and 23,000 ft descent in the Sierra Nevada Mountains of California. Although only approximately 60% of the runners in the study finished the race, approximately 20 runners in both the quercetin and placebo groups did finish. There were no differences between groups for markers of oxidative damage, indicating that oral quercetin supplementation does not alter antioxidant capacity, oxidative damage, muscle damage, or inflammation during an ultramarathon challenge (15,18).

Research with animals has shown that quercetin supplementation may help prevent URTI after intense exercise (8). Although research with humans is limited, the effects may be similar. Using the intense exercise protocol with trained cyclists as mentioned previously (cycle intensely for 3 hours daily over 3 consecutive days), Nieman and his associates reported that, although quercetin supplementation did not affect exercise-induced changes in various measures of immune function, it did reduce the incidence of URTIs during a 2-week recovery period. They indicated that quercetin may have had a direct antipathogenic effect, possibly suppressing activity of cold viruses (16). The International Society of Exercise and Immunology recently issued a position statement on immune health, and noted evidence is accumulating that flavonoids, such as quercetin, can augment some aspects of immune function and reduce illness rates in exercise-stressed athletes (21).

QUERCETIN SUPPLEMENTATION AND PERFORMANCE ENHANCEMENT

The main proposed mechanism underlying enhanced physical performance from quercetin supplementation is an increase in muscle mitochondria, the energy-producing powerhouses in the muscles for aerobic endurance exercise. Davis and his associates evaluated the effects of 7 days of quercetin supplementation in mice, reporting a significant increase in various markers for mitochondrial biogenesis (7). A study with untrained, young adult male subjects found a modest increase in several genetic markers of mitochondrial biogenesis, but the increases were not statistically significant (17). Other than mitochondria biogenesis, quercetin also may function as an adenosine receptor antagonist and provide caffeine-like psychostimulant activity (4,6), which could enhance aerobic endurance performance similar to the ergogenic effects consistently reported with caffeine supplementation. However, at this time, there is insufficient evidence to support any theory underlying the purported performance-enhancing effect of quercetin supplementation in humans.

Untrained Subjects

The performance-enhancing effects of quercetin supplementation have been studied in both physically untrained and physically trained individuals. With untrained subjects, several well-designed studies have reported modest increases in $\text{VO}_{2\text{peak}}$, substantial increases in cycling time to fatigue, and small but significant improvement in 12-minute treadmill time trial performance (6,17). Conversely, other well-designed studies with untrained subjects revealed no significant effect of quercetin supplementation on $\text{VO}_{2\text{max}}$, $\text{VO}_{2\text{peak}}$, psychological perception of effort during exercise, or performance on a 10-minute maximal-effort cycling test (5,10).

These research findings with untrained subjects are clearly variable. One possible explanation may be the response of subjects to quercetin supplementation. Research has shown that quercetin supplementation in doses of 500 and 1,000 mg/day results in large but highly variable increases in plasma quercetin among individuals, irrespective of sex, age, body mass index, diet, or self-reported physical fitness level (12). Whether the magnitude
of the increase in plasma values influences physical performance is not known. If it does, it would be of interest to determine if responders who increase plasma quercetin levels experience enhanced performance and if nonresponders do not.

**Trained Subjects**

In highly trained subjects, Davis and his associates (6) reasoned that their training may have maximized mitochondrial capacity and, thus, suggest that they may not benefit from quercetin supplementation. In general, research supports this suggestion. Nieman’s research group monitored numerous physiological and metabolic variables, such as fuel utilization, gross efficiency, and perceived effort, during the course of a 3-hour cycling task in well-trained cyclists. As compared with the placebo, quercetin supplementation over the course of 3 weeks had no effect on any of the measured variables (9). In the Western States Endurance Run discussed previously, quercetin supplementation had no effect on the ratings of perceived exertion at various checkpoints along the route or on the time to finish the race in these elite ultramarathon runners (20). One study evaluated the effect of an antioxidant sports drink with or without (placebo) quercetin on 30-km cycling time trial performance in elite competitive cyclists. A baseline trial was completed, which was followed by the quercetin and placebo trials. The authors concluded that the quercetin drink significantly improved time trial performance. However, the significant difference was based on a comparison between the quercetin trial and the baseline trial, not between the quercetin and placebo trials. There was no significant difference in time trial performance between the quercetin and placebo trials, which renders the conclusion questionable (13). A study with moderately trained men and women revealed no performance-enhancing effect on a maximal effort uphill treadmill run and a battery of four physical performance tests after 42 to 54 days of quercetin supplementation (2).

In one study using an acute dose (2,000 mg) design, quercetin had no effect on performance in a 15-minute cycling time trial, which was performed after 30 minutes of submaximal cycling in a hot (40°C) environment (4). Quercetin supplementation also has been studied for its effect on sprint-type performance and was found to have no performance-enhancing effect on sprint time during two bouts of twelve 30-meter maximal-effort sprints. Quercetin supplementation actually appeared to impair sprint performance because the percentage of fatigue decrement (slower times as sprints progress) was greater in the quercetin trial (1).

**SUMMARY**

The ADA, DC, and ACSM (19) have classified sports supplements in four categories based on their effectiveness:

- sports supplements that perform as claimed
- sports supplements that may perform as claimed
- sports supplements that do not perform as claimed
- sports supplements that should not be used because they may be dangerous or prohibited

Quercetin may perform as claimed if used as a means to prevent illness after intense exercise, although more research is needed to support this effect. However, based on the available evidence for performance enhancement, it would appear that quercetin would be classified as a sport supplement that does not perform as claimed, at least for well-trained individuals. Research findings are equivocal as to the effect on performance in untrained individuals, so it may perform as claimed until future research helps settle this issue. Whether quercetin supplementation will benefit individuals who are beginning an aerobic exercise program is not known. No research has been uncovered that has evaluated the effect of quercetin supplementation during the early stages of exercise training to determine whether it may enhance exercise performance, and mitochondria biogenesis, beyond that associated with exercise training alone.

For individuals who desire to use quercetin, recommended dosages do not exceed 1,000 mg daily. Although most sports supplements are safe, as with the use of any dietary supplement, consumers should consult with their health care provider beforehand, particularly if taking other drugs. Quercetin may interact with several drugs, including aspirin. Additionally, athletes who may be tested for doping should be aware that many supplements, particularly those purchased on the Internet, may be contaminated with substances that can lead to a positive doping test.

Sports scientists interested in conducting research with quercetin may want to consider flavonoid cocktails that contain...
other flavonoids as well, such as kaempferol and hesperidin. Research regarding possible health benefits has revealed highly significant synergistic effects of various flavonoid combinations (11), and such synergistic effects also may be applicable to exercise performance.

References


Disclosure: Author declares no conflicts of interest.

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CONDENSED VERSION AND BOTTOM LINE

Quercetin is a phytoneutrient with antioxidant, anti-inflammatory, and other properties that may be theorized to help prevent some adverse effects of intense exercise training and to enhance aerobic endurance exercise performance. Sports supplements containing quercetin have been marketed to physically active individuals. Research is rather limited, but some studies indicate that quercetin supplementation may help prevent upper respiratory tract infections that often occur after prolonged bouts of intense exercise. Research findings are equivocal as to whether quercetin supplementation increases aerobic endurance capacity in untrained, nonexercising individuals. No data are available to support a beneficial effect on sedentary individuals engaging an exercise program above and beyond that associated with the effect of exercise training alone. Quercetin supplementation does not benefit individuals or athletes who already are well trained. Although quercetin is considered safe in recommended dosages, individuals should consult with their health care providers regarding its use. Athletes who may be tested for doping should be aware that some sports supplements may be contaminated with prohibited drugs.