Sports Supplements: Efficacy, Safety, Permissibility

Green Tea Extracts, Green Tea Catechins, and Epigallocatechin-3-gallate (EGCG)

Introduction

Other than essential nutrients, such as vitamins and minerals, foods contain numerous phytonutrients, also referred to as phytochemicals that may influence physiological processes in the body. Many of these phytonutrients have been studied for their potential beneficial effects on health, and some have also been theorized to have positive effects on physical and sport performance. One example is caffeine, which has been studied extensively for its potential effects on both health and exercise performance.

Green tea, a popular drink in Asian countries, is derived from the unfermented leaves of the plant *Camellia sinensis*, which contains numerous phytonutrients, particularly a class known as polyphenols. Among the polyphenols is a subclass of flavonoids, which also contains a smaller group of compounds known as catechins. Green tea is rich in catechins, and the most abundant green tea catechin (GTC) is epigallocatechin-3-gallate, or EGCG. Other catechins in green tea include epigallocatechin, epicatechin gallate, epicatechin, gallocatechin, and gallocatechin gallate. Green tea extracts (GTE) contain a mixture of catechins and are marketed as dietary supplements. The Supplement Facts label should denote the percentage of the product derived from polyphenols and, specifically, EGCG. GTE may contain caffeine or be decaffeinated. Although green tea contains caffeine, recent research has focused on the potential health and ergogenic effects of GTE and GTC, particularly EGCG.

Hypothesized Mechanisms

Several recent reviews have presented possible mechanisms whereby catechins, particularly EGCG, may help prevent chronic diseases, most notably cardiovascular disease, cancer, and obesity (1-3). Some of these proposed mechanisms may also enhance exercise performance, either as an ergogenic aids for competition or facilitation of the recovery process from intense training. Such mechanisms include:

- Increased antioxidant activity
- Increased anti-inflammatory activity
- Increased sympathetic nervous system activity
  - Increased energy expenditure
  - Increased oxidation of fat
- Influence on gene functions

Most of the available research regarding the potential ergogenic effect of catechins during exercise, both in mice and humans, has focused on the increased oxidation of fat as an energy source during aerobic endurance tasks.

Effects on Exercise Performance

Research relative to the ergogenic effects of GTC, especially EGCG, is somewhat limited, and that which is available may be confounded by supplementation protocols. Although a few studies used GTC, specifically EGCG, many studies used a green tea extract (GTE), which contains caffeine. Caffeine influences sympathetic nervous system activity and may act synergistically with GTC to increase energy expenditure (3). Extensive research has documented the efficacy of caffeine supplementation to
enhance exercise performance (4). The following discussion incorporates studies with GTE with and without caffeine, GTC, and EGCG.

**Mice studies** Several studies from the Biological Sciences Laboratories at Kao Corporation, a Japanese company that markets products containing green tea catechins, have shown that a green tea extract enhanced exercise performance in mice. This GTE contained 81% total catechins, with 41% EGCG and the remainder mainly a mixture of 5 other catechins. The caffeine content was 0.1%.

The first study consisted of two placebo control trials with supplementation over the course of 10 weeks. In one trial mice were fed GTE, either 0.2 or 0.5% of body weight, while in the second trial mice received EGCG at 0.1 to 0.5 body weight. The mice were subjected to a swim-to-exhaustion test against a current in a swim flume prior to and following the supplementation period. Mice receiving the GTE extract improved swimming endurance by 8-24%. The respiratory quotient (RQ) was lower, indicating a higher rate of fat oxidation during the test. Plasma lactate concentrations were lower, suggesting less reliance on carbohydrate as an energy source. The authors also noted that EGCG alone also enhanced endurance capacity, suggesting that the endurance-improving effects of GTE were mediated, at least in part, by EGCG. The authors hypothesized that the stimulation of fatty acid use is a promising strategy for improving endurance capacity (5).

In a subsequent study, mice were divided into four groups: nonexercise control; exercise control; exercise and small dose GTE (0.2% body weight); and exercise and large dose GTE (0.5% body weight). Supplements were provided over the course of 8-10 weeks, and the mice were subjected to run-to-exhaustion treadmill tests. Running times in mice fed the large dose GTE were 30% higher than in the exercise control mice and, similar to the swimming study, were accompanied by a lower RQ and higher fat oxidation activity, suggesting the endurance-improving effects of GTE were mediated, at least partly, by increased metabolic capacity and utilization of fatty acid as a source of energy in skeletal muscle during exercise (6).

A third study involved the interaction of exercise training and GTC supplementation to help prevent the age-associated decrease in physical performance in mice predisposed to accelerated aging. Over the course of 8 weeks, mice exercised and received either 0.35% GTC per body weight or nothing. Exercise performance was measured by treadmill run time to exhaustion. At the end of the experiment, the endurance capacity of the GTC-fed mice remained the same and was significantly higher than the mice not receiving GTC, whose exercise performance deteriorated with aging. The GTC-fed mice also experienced an increase in skeletal muscle fatty acid oxidation. The authors concluded that GTC supplementation helps suppress the aging-related decline in physical performance and energy metabolism (7).

**Human studies** Several recent studies reported an increase in fat oxidation associated with acute or chronic GTE supplementation. In one well designed crossover study, GTE (total: 890 mg polyphenols; 366 mg EGCG) was consumed in the 24-hour period before moderate-intensity exercise. Compared to the placebo trial, average fat oxidation rates were 17% higher, and the contribution of fat oxidation to total energy expenditure was also significantly higher by a similar percentage. The authors concluded that acute GTE ingestion can increase fat oxidation during moderate-intensity exercise (8). In another study, daily GTE supplementation (572.8 mg) over the course of 10 weeks of endurance exercise training, compared to a placebo/exercise group, significantly increased fat oxidation during moderate-intensity exercise. The authors concluded that GTE supplementation augmented the increase in fat oxidation associated with endurance exercise training (9). However, another well designed crossover study
reported no significant effect of chronic GTE supplementation on fat oxidation during moderate-intensity exercise. Endurance-trained males performed a 2-hour moderate intensity cycling test prior to and after consuming GTE (160 mg total/70 mg EGCG) daily for three weeks. The GTE supplementation had no effect on any markers of fat or energy metabolism. However, the dosage was considerably less than that used in studies reporting increased fat oxidation (10).

Several studies have investigated the effect of EGCG and GTE on markers of exercise performance. In one short-term crossover supplementation study, subjects consumed a total of seven separate doses (135 mg each) of EGCG over the course of 2 days. The subjects underwent an incremental cycle ergometer protocol to voluntary fatigue. However, there were no significant changes in maximal work rate, maximal heart rate, or maximal respiratory exchange ratio, nor any differences in maximal cardiac output in a subgroup of subjects. The authors suggested EGCG may increase arterial-venous oxygen difference. However, given the non-significant effects of EGCG supplementation on most study variables, the increase in maximal oxygen uptake may have been a chance finding (11). Another study compared the effects of EGCG to both a placebo and caffeine. In a well-designed crossover study, trained cyclists consumed a placebo, EGCG (270 mg), or caffeine (3 mg/kg) daily over a 6-day period and one hour before exercise testing, which consisted of 60 minutes cycling at moderate intensity immediately followed by a self-paced 40-kilometer cycling time trial. The authors reported no significant effect of EGCG supplementation on fat oxidation or cycling performance. However, caffeine supplementation did enhance cycling performance (12). In a similar well-designed crossover study with endurance-trained males, GTE (159 mg/day total catechins) over the course of 3 weeks. Subjects cycled at moderate intensity for 2 hours, followed by a 30-minute time trial. There was no effect on energy metabolism or cycling performance (13).

Based on the research currently available, it is possible that GTE or EGCG will enhance fat oxidation during exercise. However, even if fat oxidation is increased, it likely will not enhance exercise performance. In support of this viewpoint, caffeine supplementation has been shown to enhance performance in prolonged aerobic endurance exercise, and one of the earliest hypotheses underlying its ergogenic effect was an increased use of fatty acids as an energy source, sparing the use of muscle glycogen. However, subsequent research does not support that this hypothesis (14). Moreover, the current research available, while limited, does not support an ergogenic effect of GTE or EGCG supplementation on exercise performance in humans, although some investigators recommend additional research to document whether higher GTE doses could influence energy metabolism and performance in athletes (13).

Other possible applications for athletes

Weight loss Athletes in weight-control sports, such as wrestling, have utilized numerous techniques to lose excess weight, particularly body fat. Various dietary supplements, such as ephedrine, have been popular but their use has been curtailed because of associated adverse health effects. GTC have been studied as a means to reduce body weight mainly because their effect on the sympathetic nervous system could increase energy expenditure and fat oxidation. Other potential mechanisms include modifications in appetite and decreased nutrient absorption (3).

Over the course of the past five years GTC, with or without caffeine, have been studied for their effect on weight loss, and most of the studies have involved overweight individuals, not lean athletes attempting to lose weight for sport competition. A recent meta-analysis evaluated 15 randomized control studies relative to the effect of GTC, both with and without caffeine, on a variety of
anthropometric variables, including body mass index (BMI), body weight, waist circumference (WC), and waist-to-hip ratio (WHR). The authors concluded that supplementation of GTC with caffeine decreased BMI, body weight, and WC, but the authors noted that the clinical significance of these reductions is modest at best. Moreover, these effects were most likely attributed to the effects of caffeine because studies that evaluated GTC supplementation without concomitant caffeine administration did not show benefits on any of the assessed anthropometric endpoints (15).

Intense training GTE or EGCG supplementation, particularly when combined with other phytonutrients and nutrients, may have some potential to help prevent some of the adverse effects associated with intense exercise training. For example, a recent study reported that supplementation with 120 mg of EGCG, 1000 mg of quercetin, 400 mg of isoquercetin, and 400 mg of eicosapentaenoic acid and docosahexaenoic acid for 2 weeks prior to and during 3 days of heavy exertion was effective in countering inflammation in trained cyclists (16). Additional research is merited.

Summary

Although green tea is rich in phytonutrients that may help protect laboratory animals from various chronic diseases, research findings with humans are still not as supportive (17). Animal studies also suggest GTE and EGCG may enhance fat oxidation and aerobic endurance exercise performance, but research with humans is not very supportive. Additional research with increased dosages is recommended.

References


