Is Ginseng an Ergogenic Aid?

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Ginseng is one of the most popular herbal supplements in the world. Although it is used for the treatment and prevention of many ailments, it is also used to increase work efficiency and is purported to increase energy and physical stamina. Athletes use ginseng for its alleged performance-enhancing attributes. However, many studies examining the pharmacological effects of ginseng on physical performance have not employed sound scientific design and methodology. The purpose of this review is to provide an update on published empirical research focusing primarily on the efficacy of ginseng with respect to physical and athletic performance. Despite attempts in recent investigations to improve on the scientific rigor used in examining the ergogenic properties of ginseng, the authors conclude that many of the same methodological shortcomings observed in earlier studies persist. Enhanced physical performance after ginseng administration in well-designed investigations remains to be demonstrated.

Keywords: herbal supplement, pharmacological effects, performance enhancement, athletic performance

The world market for herbal supplements and remedies is increasing at a phenomenal rate (PRWeb Press Release Newswire, 2008). The top-selling herbal products in the United States include echinacea, saw palmetto, ginkgo biloba, ginseng, and St. John’s wort, among others (Healing Herbs and Natural Remedies, 2008). In a national survey examining the prevalence of herbal supplement use in a sample of adults residing in the United States, nearly one in five surveyed had consumed herbs during the preceding year (Bardia, Nisly, Zimmerman, Gryzlak, & Wallace, 2007). Additional survey results collected from college (Froiland, Koszewski, Hingst, & Kopecky, 2004) and elite athletes, both in the United States and abroad (Petroczi & Naughton, 2008; Slater, Tan, & Teh, 2003; Sundgot-Borgen, Berglund, & Torstveit, 2003; Ziegler, Nelson, & Jonnalagadda, 2003), indicate that ginseng is one of the most popular herbal supplements consumed by athletes.

Ginseng is used worldwide to treat and prevent many ailments, but it has also been administered to increase occupational efficiency involving physical labor and is purported to provide energy and increase physical stamina. Athletes use ginseng for its alleged performance-enhancing attributes (Froiland et al., 2004;
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Petroczi & Naughton, 2008; Slater et al., 2003; Sundgot-Borgen et al., 2003; Ziegler et al., 2003). However, the efficacy of ginseng has been inferred primarily through anecdotes, testimonials, clinical experience, and animal research, as opposed to scientific verification of its pharmacological effects on humans engaged in the type of physical performance pursued by athletes.

The purpose of the current review is to provide an update on empirical research published since our two earlier reviews (Bahrke & Morgan, 1994, 2000). There have been other reviews published since our most recent review, but with a single exception (Palisin & Stacy, 2006), they did not focus on physical or athletic performance (Attele, Wu, & Yuan, 1999; Lieberman, 2001). Furthermore, these related reviews did not include the many varieties of ginseng (Davydov & Krikorian, 2000; Goulet & Dionne, 2005), nor have extensive and detailed summaries been provided (Vogler, Pittler, & Ernst, 1999). We focus primarily on the efficacy of ginseng with respect to physical and athletic performance in the current review. Specifically, in this article we provide an update on (a) the physiological effects of ginseng and ginseng-related products on physical activity, stress, and fatigue; (b) the psychological, behavioral, and cognitive effects of ginseng; (c) the quality, purity, and bioavailability of ginseng products; and (d) the potential adverse health effects, drug interactions, and safety of ginseng.

Varieties of Ginseng

Ginseng root is processed and distributed in various forms including powder, liquid extracts, tablets, capsules, and chewing gum. Roots are graded (sorted) according to their source, age, part of the root, and method of preparation. The chemical composition of commercial ginseng products is variable because of the genetic nature of the plant source, the cultivation methods, and the drying and curing process (Hong et al., 2005; Hu, 1976; Lim, Mudge, & Vermeylen, 2005). In addition, some manufacturers add various substances (e.g., minerals and vitamins) to ginseng products, and there have been reports of drugs and alcohol being present in ginseng products (“Ginseng Warning,” 1997).

Several species of ginseng are known to exist: American, Chinese, Korean, Japanese, and Siberian (Barna, 1985). Three medicinal species of ginseng are currently recognized: *Panax ginseng* C.A. Meyer (Chinese or Korean ginseng, a perennial herb indigenous to the mountainous forests of eastern Asia), *Panax japonicus* C.A. Meyer (Japanese ginseng, from India, Southern China, and Japan), and *Panax quinquefolius* (American ginseng, found growing in rich woodland in the eastern and central United States and Canada; Court, 1975; Popov & Goldwag, 1973; Williams, 1957).

A preparation of Korean ginseng containing a standardized concentration of ginsenosides has been used in a number of clinical and pharmacological studies. This preparation, known as G115 (G115 is the registered trademark of a ginseng extract containing all ginsenosides from the Korean *Panax ginseng*; GPL Ginsana Products SA, Lugano, Switzerland) and marketed under the name *Ginsana*, is widely used to treat a variety of problems such as reduced performance associated with general fatigue states. Because these preparations sometimes contain other substances (e.g., alcohol, vitamins, minerals; Pietta, Mauri, & Rava, 1986), it is difficult to conclude that ginseng per se is efficacious.
Siberian or Russian ginseng, although reported to have the same stimulant and tonic effects as the other ginseng products, is an entirely different plant, *Eleutherococcus senticosus* (Baranov, 1982; Brekman, 1965). The terms *ciwujia*, *devil's bush*, *wild pepper*, and *shigoka* are often used as synonyms for Siberian ginseng.

*Eleutherococcus senticosus* has been used as an inexpensive substitute for the ginseng roots of *Panax ginseng* C.A. Meyer (Araliaceae) in republics of the former Soviet Union and other countries. In reviewing the medicinal uses of ginseng and related plants in the Soviet Union, Baranov (1982) concluded that (a) administration of *E. senticosus* (eleuthero), unlike ginseng, never produces excitation in patients; (b) the effect of eleuthero on the general immunity of an organism is more universal than that of ginseng; (c) ginseng has antistress effects but, under certain conditions, might produce a stresslike syndrome (eleuthero has no such effect); and (d) the effect of both ginseng and eleuthero varies seasonally, but this is less so for eleuthero.

Like Siberian or Russian ginseng, *Panax japonicus* C.A. Meyer has been used in Japan as a substitute for *Panax ginseng* C.A. Meyer in the treatment of gastrointestinal disorder and as an antitussive, expectorant, and antipyretic. American ginseng (*Panax quinquefolius*) is sold worldwide in forms such as processed roots, powders, teas, and capsules. It is used as an analeptic, tonic, stomach-pain analgesic, and adaptogenic agent (any substance that exerts effects on both sick and healthy individuals by "correcting" any dysfunction without producing unwanted side effects; Davydov & Krikorian, 2000). It has also been widely promoted as an aphrodisiac (Liberti & Der Marderosian, 1978).

The main active constituents of the Panax species are recognized to be triterpenoid glycosides or saponins and are termed ginsenosides by Chinese, Korean, and Japanese researchers, and the active components of *Eleutherococcus senticosus*, whose structures and distribution vary with species and variety, are termed panaxosides by Russian workers. Identification of the active elements, establishment of reliable techniques for isolating and standardizing the active components, and extensive evaluation of the active components and pharmacological properties has occurred during the past few decades (Hou, 1977; Iwabuchi, Yoshikura, Ikawa, & Kamisako, 1987; Iwabuchi, Yoshikura, & Kamisako, 1988; Kasai, Yamaguchi, & Tanaka, 1987). Chromatographic methods are now available for identifying saponins that make ginseng detection and differentiation relatively simple (Liberti & Der Marderosian, 1978; Phillipson & Anderson, 1984; Pietta et al., 1986; Shibata, Fujita, Itokawa, Tanaka, & Ishii, 1963; Tanaka, Nagai, & Shibata, 1966; Yamaguchi, Kasai, Matsuura, Tanaka, & Fuwa, 1988). Ginseng saponins have been investigated (Iida, Tanaka, & Shibata, 1968; Tanaka et al., 1966; Li et al., 2000), and at least 31 have been isolated from extracts of *Panax ginseng* roots (Court, 1975; Hou). The major saponins have been named ginsenosides Rx, where x is a, b, c, d, e, f, g1, g2, g3, h1, h2, or o, according to their position on thin-layer chromatograms (Shibata et al., 1965).

Among the various types of ginseng, Korean ginseng appears to be relatively rich in ginsenosides. In Korean *Panax ginseng*, ginsenosides Rx1, Rx3, and Rx4 are major saponins, and although American *P. quinquefolius* is similar in its constituents there are significant differences (Besso et al., 1982; Phillipson & Anderson, 1984). The most significant difference between American and Korean ginsengs is
that American ginseng is believed to have cooling and energizing effects on the body, whereas Korean ginseng is thought to have warming and calming effects. The roots of Japanese ginseng, _Panax japonicus_, contain mainly different saponins, which are known as chikusetsu-saponins. Only two saponin glycosides are common to Japanese, Chinese, Korean, and American ginseng, namely, Rg2 and Ro (Russian panaxosides do not correspond with those of the ginsenosides).

The active constituents of Russian ginseng (_S. senticosus_) are a series of eleutherosides coded A to F (Elyakov et al., 1964). The major eleutherosides are completely different in chemical structure from the ginsenosides. The resultant variety of saponins that can co-occur, each with its own pharmacological activity, is probably responsible for the lack of consensus among researchers on the pharmacology of ginseng. In fact, in the United States, the 2002 Farm Security and Rural Investment Act (U.S. Department of Agriculture, 2002) states that

> the term “ginseng” may only be considered to be a common or usual name (or part thereof) for any herb or herbal ingredient derived from a plant classified within the genus _Panax_ and only labeling or advertising for herbs or herbal ingredients classified within that genus may include the term “ginseng.” (pp. 407–408)

Ginseng grows wild, is also cultivated, and is generally harvested after growing for 6–7 years. Although the entire ginseng plant contains pharmacologically active properties (Petkov et al., 1992), it is the root of the plant that is considered most valuable. In fact, over $81,000 has been paid for a small, 124-year-old ginseng root (CNN.com/WORLD, 2001). Extracts of red and white ginseng contain different ginsenosides (Chong & Oberholzer, 1988). White ginseng is produced by air-drying the root, and red ginseng is produced by steaming the root, followed by drying. Red ginseng has been used to treat weak constitution, ulcers, cold symptoms, and anemia and as an analeptic, a stomachic, and an erythropoietic in traditional Chinese medicine (Matsuda, Namba, Fukuda, Tani, & Kubo, 1986). The latter function, erythropoiesis, is potentially relevant for application with athletes engaged in endurance events. The ginsenoside content of dried ginseng root can vary with root age, method of preservation, and season of harvest (Liberti & Der Marderosian, 1978). High-quality ginseng should be collected in the autumn and never before 5–6 years of growth (Popov & Goldwag, 1973). For example, although most roots present at least four detectable ginsenosides, after 6 years of growth roots show more extensive patterns and might yield up to nine ginsenosides (Liberti & Der Marderosian).

**Physiological Effects**

Previous reviews have documented the physiological effects of ginseng (Bahrke & Morgan, 1994, 2000). Studies dealing with the cardiovascular effects of ginseng have reported that various preparations and concentrations can reduce, elevate, or stabilize blood pressure and influence platelet aggregation. It appears that ginsenosides can have hypertensive, as well as hypotensive, effects. These effects, however, are transient, relatively minor, and dose dependent. Research published since our last review also indicates that ginseng might improve cardiovascular and pulmonary function, and this could enhance physical performance.
In a randomized, double-blind, placebo-controlled trial, Stavro, Woo, Heim, Leiter, and Vuksan (2005) investigated the effect of six batches of North American ginseng root that varied in quality and ginsenoside content on blood pressure in 16 hypertensive individuals (but not performance in healthy athletes). None of the North American ginsengs differed from placebo in their effect on overall mean blood-pressure change, suggesting that North American ginseng has no effect on blood pressure in hypertensive individuals.

The effects of ginseng on pulmonary function and exercise capacity have been reported in earlier studies. Many of these investigations, however, were conducted with patients suffering from compromised pulmonary function and low levels of exercise capacity. In an investigation designed to evaluate the effects of ginseng extract (GI15) on pulmonary function and exercise capacity, Gross et al. (2002) assigned 94 patients with moderately severe chronic obstructive pulmonary disease to either an experimental group that received 100 mg of GI15 twice daily or a control group that received a placebo over a 3-month study period. Pulmonary-function tests of maximum voluntary ventilation and maximum inspiratory pressure were administered before treatment and every 2 weeks during the 3-month period. Exercise tests and VO$_{2\text{max}}$ measurements were performed before beginning treatment, at 6 weeks, and after 3 months. In the experimental treatment, but not the placebo treatment, all parameters significantly increased above baseline and surpassed the changes noted in the placebo group. Maximum voluntary ventilation increased 40%, maximum inspiratory pressure improved 47%, and VO$_{2\text{max}}$ increased 38%. No side effects were observed. It appears that ginseng might have its most significant effects in individuals with compromised respiratory systems, but this cannot be taken to assume it would have an effect on healthy athletes.

**Effects on Physical Activity, Stress, and Fatigue**

Ginseng and ginseng-related products have been used for years as an energy booster and as a general tonic. Some reports suggest that ginseng might enhance antibody production and natural-killer-cell activity and play a role in the prevention and therapy for respiratory disorders (Choi, 2008). There is evidence that intense physical training can produce temporary changes in the endocrine and immune systems, and one of the reasons athletes use *Panax ginseng* or *Eleutherococcus senticosus* is the belief that these herbs decrease the incidence of colds and infections and enhance recovery from intense training.

**Stress and the Immune System**

Gaffney, Hugel, and Rich (2001a), in a 6-week, double-blind, placebo-controlled study, examined the ability of *Panax ginseng* (type not specified) and *Eleutherococcus senticosus* to influence measures of stress and selected parameters of immune-system status in competitive club-level male athletes engaged in normal training during the competitive season. Thirty participants were matched for training stress and received a 33% ethanolic extract containing *Panax ginseng*, *Eleutherococcus senticosus*, or a placebo. A pretest and posttest were used to evaluate the effects of 6 weeks of supplementation on cortisol, testosterone, and
testosterone-to-cortisol ratio (TCR), as well as circulating numbers of T cells, T-helper cells (CD4), T-suppressor cells (CD8), CD4-to-CD8 ratio, natural killer cells, and B lymphocytes. None of the immune-system variables changed significantly or showed any clear trend from pre- to posttest in any of the treatment groups. No significant change in testosterone, cortisol, or total TCR was observed in the *Panax ginseng* treatment group. In the *Eleutherococcus senticosus* treatment group, however, TCR significantly decreased by 28.7%. The main contribution to this decrease appeared to be a nonsignificant trend toward increased cortisol rather than a small decrease in mean testosterone levels. These results suggest that *Eleutherococcus senticosus* increased rather than decreased hormonal indices of stress. Research has been done on animals that suggests a threshold of stress below which *Eleutherococcus senticosus* increases the stress response and above which it decreases the stress response (Gaffney et al., 2001a).

Gaffney, Hugel, and Rich (2001b) have proposed a mechanism of action for *Panax ginseng* and *Eleutherococcus senticosus* that attempts to explain why these herbs produce the paradoxical effect of sometimes increasing and sometimes decreasing the stress response. The mechanism suggests that this biphasic effect results from increased occupancy of positive- and negative-feedback stress-hormone receptors by their natural ligands to inhibition of specific enzymes that function to limit receptor occupancy. Specifically, Gaffney et al. (2001b) suggest that *Panax ginseng* inhibits 11-beta hydroxysteroid dehydrogenase 1 and *Eleutherococcus senticosus* inhibits catechol-O-methyl transferase, both of which reside in close proximity to stress-hormone receptors and catalyze the degradation of stress hormones into inactive compounds. In addition, Gaffney et al. (2001b) suggest that the increased energy claimed to result from *Panax ginseng* and *Eleutherococcus senticosus* might be a consequence of their increasing the occupancy of stress-hormone receptors that function to redistribute the body’s energy reserves from regeneration to activity.

In an investigation designed to examine the efficacy of ginseng in modulating secretory immunoglobulin A (SIgA), exercise performance, and recovery from repeated bouts of strenuous physical exertion, Engels, Fahlman, and Wirth (2003) used a double-blind, placebo-controlled, randomized design with 38 active healthy adults who supplemented their diets with a standardized ginseng concentrate (400 mg G115) or placebo for 8 weeks. Before and after the treatments, each participant performed three consecutive 30-s Wingate tests interspersed with 3-min recovery periods. SIgA secretion rate (S-SIgA) and the relation of SIgA to total protein were calculated from measures of saliva flow rate, and absolute SIgA and salivary protein concentration samples were collected before and after exercise testing. Peak and mean mechanical power output and exercise heart-rate recovery were also measured. Of the 38 participants initially enrolled in this investigation, 11 failed to complete one or more basic study requirements, and the final data analyses were performed on measurements obtained from 27 participants. Compared with rest, S-SIgA, SIgA-to-protein ratio, and saliva flow rate were significantly lower after exercise than at baseline. Likewise, both peak and mean mechanical power output significantly declined across consecutive Wingate tests. Postintervention minus preintervention changes in scores for salivary parameters, exercise performance, and exercise heart-rate recovery were similar between the treatment groups. These findings do not support the hypothesis that ginseng affects
mucosal immunity as indicated by changes in secretory IgA at rest and after an exercise-induced state of homeostatic disturbance. Supplementation with ginseng failed to improve physical performance and heart-rate recovery of individuals undergoing repeated bouts of exhaustive exercise.

**Strength and Power Performance**

In an investigation by Youl Kang, Hwan Kim, Jun Lee, and Byrne (2002) designed to assess the anabolic effects of ginseng ingestion on growth hormone, testosterone, cortisol, and insulinlike growth factor-1 to acute resistance exercise, 8 male college students were randomly administered 20 g of Korean red ginseng root extract or water immediately after a standardized exercise bout. The exercise consisted of a seven-repetition maximum of the half squat, bench press, two-leg curl, arm curl, two-leg extension, abdominal crunch, leg press, and chest press. Venous blood samples were drawn before and immediately after exercise and at again at 15, 30, 60, and 120 min after exercise. Human growth hormone, testosterone, cortisol, and insulinlike growth factor-1 levels were determined by radioimmunoassay. The responses of plasma hormones did not differ significantly after the treatments. These results do not support the use of ginseng to promote anabolic hormonal status after resistance exercise.

**Aerobic Exercise Performance**

To evaluate the effectiveness of 14 days of treatment with *Eleutherococcus senticosus* (900 mg/day) as an ergogenic nutritional supplement, Chase, Darby, Liang, and Morgan (2000) employed a double-blind, crossover study with 11 participants performing four running trials before and after treadmill running at 80% of VO$_{2\text{max}}$ until volitional exhaustion after *Eleutherococcus senticosus* and placebo treatments. There was no statistically significant difference between trials for any of the dependent variables including time to exhaustion. The investigators concluded that 14 days of supplementation with *Eleutherococcus senticosus* has no ergogenic effect on metabolism and performance.

To determine whether *Panax quinquefolium* attenuates creatine kinase level induced by aerobic endurance exercise in humans, Hsu, Ho, Lin, Su, and Hsu (2005) divided 13 male college students into a ginseng group and a placebo group. In a double-blind study, participants received supplementation (400 mg, four per day) for 4 weeks, followed by a 4-week washout period, before crossing over and receiving the alternate treatment for the next 4 weeks. Treadmill running at 80% of VO$_{2\text{max}}$ was performed after each treatment. Plasma creatine kinase and lactate were measured before the exercise, at 15 and 30 min during exercise, immediately after exercise, and 20, 40, 60, and 120 min after exercise. In addition, time to exhaustion and oxygen pulse were also measured. Although ginseng supplementation for 4 weeks before exhaustive aerobic treadmill running was associated with reduced leakage of creatine kinase from skeletal sarcoplasm into the blood during exercise, it did not enhance performance.

It has been reported by Kim, Park, Chang, and Sung (2005) that administration of *Panax ginseng* increases endurance time to exhaustion. In their study, 7 sedentary males performed incremental exercise to volitional exhaustion on a treadmill before and after 8 weeks of *Panax ginseng* extract administration. Exer-
Exercise duration until exhaustion was significantly increased by 1.5 min, leading the investigators to conclude that ginseng has ergogenic properties. There are a number of reasons that these findings and conclusions must be viewed with caution. First, a small sample size of 7 males served as participants, and these individuals served as their own controls. Second, the control testing was carried out before the ginseng intervention, and it is possible that there was an order effect. That is, the conditions should have been rotated and randomly assigned to the participants (i.e., AB and BA). Third, the participants were recruited on the basis that they "had not performed any systematic training," and this is problematic for two reasons. First, pretest sensitization might have taken place, and second, the results cannot be generalized to athletes. Fourth, there was no blinding, and therefore the observed results might have been caused by the halo effect, Hawthorne effect, demand characteristics, or expectancy effects.

In a double-blind, placebo-controlled investigation to determine the effectiveness of a moderately high dose of *Panax notoginseng* (a species of the genus *Panax*) on aerobic capacity, endurance, and blood pressure in young adults, Liang, Podolka, and Chuang (2005) randomly assigned 29 untrained adults to an experimental group or placebo control group. For 30 days, participants in the experimental group consumed 1,350 mg/day of *Panax notoginseng*, while participants in the control group consumed a placebo. Endurance time to exhaustion during cycle exercise was significantly improved in the experimental group by more than 7 min, and mean blood pressure and oxygen consumption decreased during endurance exercise. The significant improvement in endurance time demonstrated by this investigation compared with others is noteworthy for several reasons: A relatively high dose of assayed ginseng was used, duration of consumption was for 30 days, and the type of ginseng consumed was *Panax notoginseng*, as opposed to the more frequently used *Panax ginseng*. In addition, the experimental design was comparatively rigorous, being double-blind with random assignment of a moderate number of participants to either a treatment or a placebo group. The investigators report that participants were randomly assigned to the placebo and ginseng treatments, but there was a substantial difference in VO2max at the outset of the study. The entire point of using randomization is to ensure that experimental and placebo groups are equivalent from the outset of a study on all variables of relevance to the inquiry. The effect size for the difference in VO2max was large (.81), and this is problematic. In other words, the ginseng group, for some reason, was superior to the placebo group from the outset on an important dimension of physical fitness.

**Anaerobic Exercise Performance**

To investigate the effects of ginseng supplementation on supramaximal exercise performance and short-term recovery, Engels, Kolokouri, Cieslak, and Wirth (2001) used a double-blind protocol and randomly assigned 24 healthy, active women to either a ginseng or a placebo treatment. Each participant added a standardized extract (400 mg G115) of *Panax ginseng C.A. Meyer* or a placebo to their normal diet for 8 weeks. Before and after the treatment period, each participant performed an all-out-effort, 30-s leg-cycle-ergometry test followed by a controlled recovery. Nineteen participants completed the study. Of the 5 lost to follow-up, 3 were from the placebo group and 2 were from the ginseng group. Results revealed no significant differences between the ginseng and placebo treatment groups for
peak or mean anaerobic power output, rate of fatigue, or immediate postexercise recovery heart rates. Engels et al. (2001) concluded that prolonged supplementation with ginseng had no ergogenic benefits during and after brief, supramaximal exercise. Effect sizes for the ginseng treatment were small (peak anaerobic power, .00; mean anaerobic power, .06; rate of fatigue, .38).

To determine the effects of ginseng supplementation on lactate threshold and physical performance, Kulaputana, Thanakomsirichot, and Anomasiri (2007) randomly assigned 57 physically active young men to either a ginseng \( (n = 28) \) or a placebo group \( (n = 29) \). Participants in the ginseng group consumed 3 g of ginseng orally each day for 8 weeks. Blood lactic acid levels and heart-rate responses were measured during incremental cycle-ergometer work before and after the 8 weeks of treatment. Selected markers for liver and renal function were also monitored. Lactate threshold, exercise heart rate, total exercise time, and peak power output did not differ between ginseng and placebo groups, demonstrating in a well-controlled study (randomized, double-blinded, placebo-controlled, treatment-compliance monitoring) that ginseng supplementation did not exert an ergogenic effect on the physical performance of a relatively large group of physically active young men. The reports described in this section are summarized in Table 1.

In conclusion, additional, well-designed research is needed to determine whether supplementation with ginseng and related products can improve performance and alleviate stress and fatigue when functional abilities are diminished, such as through repetitive bouts of strenuous physical work. Moreover, the potential use of ginseng and related products to enhance performance, recovery, and muscle growth from anaerobic exercise has not yet been adequately investigated.

**Psychological, Behavioral, and Cognitive Effects**

Although the positive effects of ginseng and ginseng-related products on psychological function, moods, behavior, stress reduction, and chronic pain in humans have been reported in a few of the earlier studies in this area—perhaps resulting from several central and peripheral physiological effects including cardiovascular, neural, and hormonal effects (Bahrke & Morgan, 1994, 2000)—a more recent research study failed to demonstrate enhanced mood after ginseng administration in healthy young adults. Using a double-blind, placebo-controlled, randomized clinical trial, Cardinal and Engels (2001) examined psychological well-being in healthy young adults. Ninety-six adults were randomly assigned to one of three experimental conditions: placebo, 200 mg ginseng \( (Panax ginseng C.A. Meyer concentrate G115 in capsular form) \), or 400 mg ginseng \( (Panax ginseng C.A. Meyer concentrate G115 in capsular form) \). Participants were given a 60-day supply of their respective supplement along with written instructions about proper intake and storage of the capsules over the 8-week study period, and a postintervention appointment was scheduled for each participant. Eighty-three (or 86.5%) of the original participants completed the study, with the primary reason for attrition being noncompliance with the study protocol. Positive affect, negative affect, and overall mood measures were obtained pre- and postintervention. Ginseng supplementation had no effect on positive affect, negative affect, or overall mood, leading the researchers to conclude that chronic ginseng supplementation at either the clinically recommended dose or at twice that level does not enhance mood in
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*Note.* TC = testosterone-to-cortisol; M = male; F = female; HR = heart rate; hGH = human growth hormone; IGF-1 = insulin-like growth factor-1; RER = respiratory-exchange ratio; RPE = rating of perceived exertion; VO$_{2\text{max}}$ = maximal oxygen uptake; BP = blood pressure.
healthy young adults. It might be, however, that ginseng has little or no effect when administered to healthy adults scoring in the normal range on mood states. The investigators did not examine the effects of ginseng in study participants with elevated mood scores.

In sports in which quick decision making is required, it is not unusual for athletes to consume products thought to provide an advantage over the competition. However, although previous research suggests that chronic administration of ginseng can improve cognitive performance in humans (Bahrke & Morgan, 1994, 2000), it has not examined the effects of a single dose of ginseng on cognitive performance in healthy adults or in athletes.

In an investigation to determine whether acute administration of ginseng (G115) had any consistent effect on mood and cognitive performance in humans, Kennedy, Scholey, and Wesnes (2001b) used a placebo-controlled, double-blind, balanced, crossover design. Quality of memory, speed of memory, quality of attention, and speed of attention served as the cognitive measures. Twenty healthy young-adult volunteers received 200, 400, and 600 mg of G115 and a matching placebo, in counterbalanced order, with a 7-day washout period between treatments. After a baseline cognitive assessment, further test sessions took place at 1, 2.5, 4, and 6 hr after the day’s treatment. Significant improvement was found for quality of memory and the associated factor known as secondary memory at all points after the administration of 400 mg of ginseng. The 200- and 600-mg doses were both associated with a significant decrement in attention speed at later testing times only. Subjective ratings of alertness were also reduced 6 hr after the two lowest doses (200 mg and 400 mg). These results indicate that modulation of mood and cognitive performance might occur after acute administration of ginseng, but there is not a linear dose-response effect. That is, a moderate dose of 400 mg seems to enhance performance, whereas low (200 mg) and high (600 mg) doses impair it. It would be noteworthy, of course, if similar results were found in exercise and sport settings.

In a subsequent investigation, but with different dosages, Kennedy, Scholey, and Wesnes (2001a) examined the effects of a combination of standardized extracts of Ginkgo biloba (GK501) and Panax ginseng (G115) on mood and selected aspects of cognitive performance (quality of memory, speed of memory, quality of attention, and speed of attention). Using a placebo-controlled, double-blind, balanced, crossover design, 20 healthy young-adult volunteers received 320, 640, and 960 mg of the extract combination and a matching placebo in a random order, with a 7-day washout period between treatments. After a baseline cognitive assessment, further testing took place at 1, 2.5, 4, and 6 hr after the day’s treatment. There was a dose-response improvement in performance on the quality-of-memory factor at the highest dose (960 mg). Additional analysis indicated that this effect was differentially targeted at secondary memory rather than the working-memory component. There was also a dose-response decrement in performance of the speed-of-attention factor for the 320- and the 640-mg dose. The results of this study suggest that ingesting single doses of a Ginkgo biloba and Panax ginseng combination can affect the cognitive performance of healthy young volunteers in a dose-response manner in that low doses are associated with performance decrements while high doses enhance performance. The underlying mechanisms for these effects remain to be elucidated.
In a related investigation, Kennedy, Scholey, and Wesnes (2002) directly compared the effects of single doses of *Ginkgo biloba*, ginseng, and a gingko-ginseng combination on aspects of mood and cognitive performance using participants from the same cohort of healthy young-adult volunteers. In a randomized, placebo-controlled, double-blind, balanced, crossover design, 20 participants received what investigators referred to as “the most beneficial dose” from each of their previous Cognitive Drug Research battery–based studies: 360 mg of *Ginkgo biloba*, 400 mg of ginseng, 960 mg of a product combining the two extracts with an inert substance, and a matching placebo. Treatment was random and there was a 7-day washout period between treatments. Cognitive testing involved the Cognitive Drug Research Battery and two serial-subtraction mental-arithmetic tasks. Mood was assessed with the Bond–Lader visual analog scales. After a baseline cognitive assessment, further testing took place at 1, 2.5, 4, and 6 hr after the day’s treatment was taken. All three treatments were associated with improved secondary-memory performance as measured by the Cognitive Drug Research Battery, with the ginseng condition resulting in some improvement in the speed of performing memory tasks and in the accuracy of attentional tasks. After ginkgo and the ginkgo-ginseng combination, performance of both subtraction tasks was improved at the later testing sessions. No change in the speed of performing attention tasks was found. Improvement in self-rated mood was also found after ginkgo and, to a lesser extent, the combination product. These results suggest that ingesting single doses of *Ginkgo biloba*, *Panax ginseng*, and a product combining the two extracts can beneficially influence the cognitive performance of healthy young volunteers. Although findings of this nature are often advanced as evidence of the efficacy of ginseng and related substances to enhance performance in athletes, there is an absence of compelling research evidence to support such views. This research lacks what is known as external validity, and it would be a fundamental scientific error to make such generalizations.

The electroencephalographic (EEG) effects of single doses of *Ginkgo biloba* and *Panax ginseng* in healthy young volunteers have also been examined by Kennedy et al. (2003). Using a double-blind, placebo-controlled, balanced crossover experiment, the effects of single doses of *Ginkgo biloba* (360 mg GK501), *Panax ginseng* (200 mg G115), and a placebo on auditory-evoked potential using contingent negative variation and resting power within the delta, theta, alpha, and beta wavebands were evaluated in 15 healthy volunteers. Each participant was assessed on three separate occasions, 4 hr after consuming the treatment of the day. Seven days elapsed between testing sessions. Results indicated that ginseng led to a significant shortening of the latency of the P300 component of the evoked potential. Both ginseng and *Ginkgo biloba* led to significant reductions in frontal “eyes closed” theta and beta activity, with additional reduction for ginseng in the alpha waveband. These findings demonstrate that *Panax ginseng* can directly modulate cerebroelectrical activity and that these effects are more pronounced than those of *Ginkgo biloba*. This potential for ginseng to enhance cognitive performance and mood has been reviewed in greater detail by Kennedy and Scholey (2003) and Scholey and Kennedy (2002). It should also be noted that EEG data cannot be used as evidence of activity in subcortical regions, and there is a need for neuroimaging research (e.g., MRI, PET, SPECT) designed to elucidate the impact of ginseng use on various brain regions.
In one of the few ginseng-administration studies conducted with athletes, improved psychomotor performance at rest and during graded exercise after ginseng treatment (350 mg/day for 6 weeks) in young athletes was demonstrated by Ziemba et al. (1999). In a double-blind study, 15 soccer players underwent either ginseng treatment or placebo treatment. Before and after treatment all participants performed an incremental bicycle-ergometer exercise with intensity increasing 50 W every 3 min until volitional exhaustion (time-to-exhaustion data not presented). Reaction time was measured before exercise and during the last 2 min of each exercise load. Although neither ginseng nor placebo influenced VO2max or lactate threshold, ginseng treatment was associated with shortened reaction times at rest and during exercise.

To elucidate the mechanisms for the glucoregulatory properties and enhancement of cognitive performance after ginseng administration, in a double-blind, balanced crossover study, Reay, Kennedy, and Scholey (2006) used a “cognitive demand” test battery at baseline, 30 min after administration of either ginseng or a placebo, and another 30 min later after consumption of a drink containing glucose or a placebo. Both ginseng and glucose were associated with enhanced cognitive performance. Ginseng was associated with a reduction in blood glucose levels 1 hr after consumption when ingested without glucose, confirming that ginseng might lower blood glucose levels and enhance cognitive performance. Although the mechanisms responsible for ginseng’s glycemic effect or its cognitive effects were not clarified by that investigation, possible mechanisms for lower blood glucose levels and improved cognitive performance could include the modulation of glucose disposal, glucose transport, or insulin secretion. The reports described in this section are summarized in Table 2.

In conclusion, although current research supports the general finding that supplementation with ginseng and related products might modulate mood, improve cognitive performance, and decrease reaction time, the ecological validity of applying such results, primarily obtained using nonathletes in laboratory settings, to athletes and athletic environments is questionable.

Quality, Purity, and Bioavailability

Variability in herbal products, including ginseng, is a major concern because most dietary supplements are not subject to the same regulations as pharmaceuticals, and these herbal products might lack purity or potency. Hence, research involving herbal products is associated with major “sourcing” problems, and it is imperative that investigators assay the content of products employed in experiments designed to quantify efficacy. In our view, it is noteworthy that nearly all the investigations in the current review failed to include an assay of the actual content of the substances used in the experiment.

To determine the variability in a range of ginseng-containing products available in the United States, Harkey, Henderson, Gershwin, Stern, and Hackman (2001) identified and measured the concentration of marker compounds by using high-performance liquid chromatography and liquid-chromatography tandem mass spectrometry. Twenty-five commercial ginseng preparations of *Panax ginseng* or *Eleutherococcus senticosus* were obtained from a local health food store and analyzed for seven ginsenosides and two eleutherosides. All plant species
<table>
<thead>
<tr>
<th>Reference</th>
<th>Participants</th>
<th>n and gender</th>
<th>Ginseng type</th>
<th>Duration</th>
<th>Data collected</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardinal &amp; Engels (2001)</td>
<td>Healthy young adults</td>
<td>43 M, 40 F</td>
<td><em>P. ginseng</em>, 200 or 400 mg</td>
<td>8 weeks</td>
<td>Psychological well-being</td>
<td>No effect</td>
</tr>
<tr>
<td>Kennedy et al. (2001b)</td>
<td>Healthy young adults</td>
<td>20</td>
<td>200, 400, or 600 mg G115</td>
<td>1 day</td>
<td>Mood and cognitive performance</td>
<td>Modulation of mood, no linear dose-response effect</td>
</tr>
<tr>
<td>Kennedy et al. (2001a)</td>
<td>Healthy young adults</td>
<td>10 M, 10 F</td>
<td>320, 640, or 960 mg combination G115 and <em>Ginkgo biloba</em> (GK501)</td>
<td>1 day</td>
<td>Mood and cognitive performance</td>
<td>Improved cognitive performance</td>
</tr>
<tr>
<td>Kennedy et al. (2002)</td>
<td>Healthy young adults</td>
<td>5 M, 15 F</td>
<td>360 mg <em>Ginkgo biloba</em>, 400 mg ginseng, or 960 mg combination</td>
<td>1 day</td>
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<td>Improved cognitive performance</td>
</tr>
<tr>
<td>Kennedy et al. (2003)</td>
<td>Healthy young volunteers</td>
<td>5 M, 15 F</td>
<td>360 mg <em>Ginkgo biloba</em> or 200 mg <em>P. ginseng</em></td>
<td>1 day</td>
<td>EEG</td>
<td>Modulation of cerebroelectrical activity</td>
</tr>
<tr>
<td>Ziemba et al. (1999)</td>
<td>Young male soccer players</td>
<td>15</td>
<td>350 mg/day ginseng</td>
<td>6 weeks</td>
<td>Psychomotor performance</td>
<td>Decreased reaction times</td>
</tr>
<tr>
<td>Reay et al. (2006)</td>
<td>Healthy young adults</td>
<td>27</td>
<td><em>P. ginseng</em></td>
<td>1 day</td>
<td>Cognitive performance</td>
<td>Enhanced cognitive performance</td>
</tr>
</tbody>
</table>

Note. M = male; F = female; EEG = electroencephalogram.
were correctly identified by botanical plant species, but concentrations of marker compounds differed significantly from labeled amounts. There was also significant product-to-product variability; concentrations of ginsenosides varied by 15- and 36-fold in capsules and liquids, respectively; and concentrations of eleutherosides varied by 43- and 200-fold in capsules and liquids, respectively. The results of the survey suggest that standardization for quality assurance is important in designing and evaluating ginseng studies.

In a study to determine whether the commercial formulations of several botanical dietary supplements, including ginseng, had consistent labeling and whether quantities of marker compounds agreed with the amounts on the label, Krochmal et al. (2004) purchased six bottles each of two lots of supplements from nine manufacturers and analyzed the contents using established commercial methodologies at an independent laboratory. Product labels were found to vary in the information provided, such as serving recommendations and information about the herb itself (e.g., species, part of the plant, marker compound). With regard to marker-compound content, little variability was observed between different lots of the same brand, but the content did vary widely between brands (e.g., total ginsenosides ranged from 5.3 to 18.2 mg per serving). Furthermore, the amounts recommended for daily use also differed between brands, increasing the potential range of a consumer’s daily dose. Ginseng was among the most variable. This study emphasizes the importance of standardized manufacturing practices and reliable labeling information.

Using high-performance liquid chromatography to evaluate the effects of different samples of *Panax quinquefolius* cultivated in Wisconsin and Illinois, Yuan et al. (2001) found considerable variability in the brainstem activity of neonatal rats for the two samples. In a comparison of six ginsenosides from these two specimens, data revealed remarkable variability in the total concentration and in the percentages of individual ginsenosides. For example, of the two major ginsenosides, the Illinois-cultivated *Panax quinquefolius* had 30% less ginsenoside Rb1 and 25% more ginsenoside Re than did the Wisconsin-cultivated *Panax quinquefolius*.

As part of a program for assessing the quality of herbal medicines, Khan et al. (2001) analyzed 21 over-the-counter *Panax ginseng* products in various doses, including 8 liquid samples and 13 solid samples. Chromium, mercury, and arsenic were not present in amounts above their limits of detection in both liquid and solid samples, but cadmium, lead, and nickel were present in most of the samples. Chlorinated pesticide levels varied widely in these samples. The total concentration of pesticides was below 100 ppb in most samples, but the total concentration exceeded 100 ppb in five samples. In addition, the U.S. Food and Drug Administration recently issued a warning that certain ginseng products are considered adulterated because they contain unsafe chemical residues from the pesticides procymidone and quintozene (Anonymous, 2005). In another investigation examining the concentrations of cadmium, lead, mercury, and metalloid arsenic in dietetic products, Dragun et al. (2003) found the highest concentration of mercury in a ginseng-based sample. Raman, Patino, and Nair (2004) failed to find unacceptable concentrations of metals such as lead and mercury in eight botanical dietary supplements including ginseng. However, these supplements were also evaluated for microbial contamination, and most samples showed the presence of
bacteria, fungi, or both. These results serve to identify the problem of environmental contamination of dietary supplements and emphasize the necessity to develop validated quantitative methods to analyze such contaminants in the various herbal products currently available.

The results cited herein also emphasize that future investigations on the effectiveness of ginseng should rely on the use of standardized methods and preparations. In fact, Sievenpiper, Arnason, Vidgen, Leiter, and Vuksan (2004), after conducting a systematic quantitative analysis of the literature and finding a high coefficient of variation in ginsenosides across species, assay technique, and ginsenoside type, concluded "that until these issues are resolved, the reproducibility of ginseng's composition, safety, and efficacy cannot be trusted" (p. 840).

In an attempt to authenticate the differences between various types of Panax ginseng and to offer confidence to consumers, Hon, Chow, Zeng, and Leung (2003) developed a set of microsatellite markers with discrete genotypes for American ginseng (Panax quinquefolius) that are able to differentiate Panax quinquefolius from Panax ginseng with resolution down to specific, individual farm level—that is, confirmation of its botanical identity and origin. Compared with other molecular techniques, microsatellite-marker technology is more robust, accurate, reproducible, reliable, and sensitive. Also to ensure quality control and standardization of ginseng, Asafu-Adjaye and Wong (2003), using liquid chromatography in an interlaboratory study involving 12 collaborating laboratories, reliably identified six common ginsenosides in dry root powder from Panax ginseng, Panax quinquefolius, and two selected commercial ginseng products. In response to the need to standardize the quality and purity of ginseng products, the Korean Ministry of Agriculture and Forestry ("Korea Promoting," 2002) submitted a draft on the international food standard for ginseng to the Italian-based executive office of the Codex Alimentarius Commission. This commission was created by the Food and Agriculture Organization and the World Health Organization to facilitate standardization of food. The draft includes basic conditions including the definition range and structural elements of ginseng.

One of the factors in determining the ergogenic effects of ginseng is the systemic availability and degradation of the constituent ginsenosides after oral administration in humans. Using mass spectrometry, Tawab, Bahr, Karas, Wurglics, and Schubert-Zsilavecz (2003) studied the degradation of ginsenosides in the gastrointestinal tract of humans after oral administration of ginseng. Plasma and urine samples from 2 human participants were screened for ginsenosides and their possible degradation products. It was shown that two hydrolysis products of the protopanaxatriol ginsenosides G-Rh and G-F might reach the systemic circulation. In addition, compound K, the main intestinal bacterial metabolite of the protopanaxadiol ginsenosides, was detected in plasma and urine. These substances or components are probably responsible for the action of ginseng in humans.

**Adverse Effects, Drug Interactions, and Safety**

The adverse effects associated with ginseng consumption have been reported previously (Bahrke & Morgan, 1994, 2000). Although ginseng is thought to be relatively safe, several recent reports on its adverse effects have been published. A systematic attempt to document and evaluate all the available data on the safety of
Panax ginseng root extracts was conducted by Coon and Ernst (2002). Data from clinical trials suggest that the incidence of adverse events with ginseng monopreparations is similar to that of placebo. The most commonly experienced adverse effects are headache, sleep disturbances, and gastrointestinal disorders. The possibility of more serious adverse effects is indicated in isolated case-study reports and data from spontaneous reporting schemes, but causality is often difficult to determine from the evidence provided. Combination products containing ginseng as one of several constituents have been associated with serious adverse events and even fatalities. Interpreting these cases is difficult, however, because ingredients other than Panax ginseng might have caused the problems. Possible drug interactions have been reported between Panax ginseng and warfarin, phenelzine, and alcohol. Collectively, these data suggest that Panax ginseng monopreparations are rarely associated with adverse events or drug interactions. Combined preparations are more often associated with such events, but causal attribution is usually not possible.

Although many investigations examining the effects of ginseng have been published, many of these studies involved small numbers of participants, including case-study reports. Case-study reports are limited in their representativeness. They do not necessarily allow valid generalizations to the population from which they came, and they are vulnerable to subjective biases. Case-study reports might be selected because of their dramatic rather than typical attributes or because they neatly fit an observer’s preconceptions. Case-study reports should prompt additional investigation with a greater number of participants. Results of case studies can be used as hypotheses to be tested using rigorous experimental designs incorporating appropriate control and placebo paradigms.

The efficacy and safety of ginseng have also been evaluated by Kitts and Hu (2000), who concluded that "while some epidemiological or clinical studies have reported indications of efficacy for specific health benefits or potential toxicity, there are an equal number of studies that provide contradictory evidence," and furthermore "this situation has lead to questionable conclusions concerning specific health benefits or risks associated with ginseng" (p. 473). Ernst (2002) also examined the risk–benefit profile of several commonly used herbal therapies including ginseng and concluded that "well-conducted clinical trials do not support the efficacy of ginseng to treat any condition" and that "none of these herbal medicines are free of adverse effects" (p. 42).

When reports of adverse effects from herbal preparations are carefully assessed, it is often found that the effects are not caused by the herbs listed on the label but, rather, by adulteration or contamination of the declared ingredients. A case of ginseng-induced mania in a healthy 26-year-old man with no history of psychiatric illness was reported by Engelberg, McCutcheon, and Wiseman (2001). The presenting symptom at the time of hospitalization was the patient’s increasingly bizarre behavior. This individual had been consuming two or three capsules of Chinese red Panax ginseng 5 days per week for 2 months in an attempt to boost his energy. The product label claimed that each capsule contained the equivalent of 250 mg of ginseng root. Laboratory analysis of the same brand of product revealed no evidence of controlled drugs or other notable contaminants. The symptoms resolved after treatment and discontinuation of the ginseng preparation, and the cause of the mania was attributed to the patient’s use of ginseng.
Development of manic symptoms in a patient taking ginseng has been reported by Vazquez and Aguera-Ortiz (2002). The patient, a 56-year-old woman with previous affective disorder, and taking antidepressant medication, developed a manic episode while consuming ginseng. Symptoms disappeared after treatment including discontinuation of the ginseng supplement. Nonetheless, the question that remains unanswered in such cases is whether the development of mania was caused by the antidepressant drug, the ginseng, or the interaction of the two. A case of transient ischemic attack secondary to hypertensive crisis related to the consumption of *Panax ginseng* has been reported by Martinez-Mir, Rubio, Morales-Olivas, and Palop-Larrea (2004). The patient, a 64-year-old man, complained of fugax amaurosis on two occasions, with arterial blood pressure readings of 200/120 and 220/130 mm Hg after 13 days of ginseng consumption. Blood pressure returned to its previous level 1 week after cessation of the *Panax ginseng*. One year later at follow-up, the patient remained normotensive.

Photosensitivity reaction in a woman using an herbal supplement has been described by Palanisamy, Halter, and Olson (2003). This 32-year-old woman suffered a phototoxic reaction after taking a dietary supplement containing ginseng, goldenseal, bee pollen, and other ingredients. The condition slowly resolved after discontinuation of the supplement and treatment with subcutaneous and topical corticosteroids. Although the individual ingredients in the dietary supplement have not been associated with cases of photosensitivity it is possible that the combination of ingredients interacted to cause the toxic reaction. Caution is urged in the use of combined herbs and supplements in new formulations that have not been evaluated in controlled trials.

A case of anaphylactic reaction resulting from ingestion of Asian ginseng syrup in a 20-year-old man has also been reported by Wiwanitkit and Taungjaruwinai (2004). Because ginseng is a widely consumed herb, potential adverse effects such as allergic reaction need to be emphasized.

Ginseng and *Eleutherococcus senticosus* have also been reported to interact with certain oral-health drugs such as aspirin and corticosteroids, suggesting that use of these products might be associated with various adverse reactions that can influence oral health and treatment. According to Abebe (2003), dentists and dental hygienists need to be aware of these interactions and offer appropriate oral-health care to individuals using these substances.

A case of menstrual alterations related to ginseng consumption has been reported by Palop-Larrea, Gonzalez-Perales, Catalan-Oliver, Belenguer-Varea, and Martinez-Mir (2000). A 48-year-old woman, who had never experienced menstrual disorders in the past, was admitted after a 3-week history of metrorrhagia after self-medication with three daily capsules for 2 months of a ginseng compound. A companion advised her to take the ginseng to improve her work performance. The metrorrhagia disappeared 4 days after she discontinued taking the ginseng. More recently, Kabalak, Soyal, Urfalioglu, Saracoglu, and Gogus (2004) also reported menometrorrhagia and tachyarrhythmia after use of oral and topical ginseng for cosmetic reasons in a 39-year-old female patient. The patient was advised to stop using ginseng capsules and ginseng cosmetics, and her menometrorrhagia did not recur during the following 6 months. Given the extensive literature documenting menstrual dysfunction among female endurance
athletes, extra caution might be warranted when using various ginseng preparations. With the many adverse effects associated with the use of ginseng, all users would be wise to exhibit caution.

Conclusions

Ginseng is one of the most popular herbal supplements in the world. It is widely used by the general public to increase work capacity and output and by athletes to enhance performance. In the current review we have provided an update of empirical research published since our two earlier reviews by focusing primarily on the efficacy of ginseng with respect to physical and athletic performance. We have updated the physiological effects of ginseng and ginseng-related products on physical activity, stress, and fatigue in humans; the psychological, behavioral, and cognitive effects; the quality, purity, and bioavailability of ginseng products; and the adverse health effects, drug interactions, and safety of ginseng.

Although the effects of ginseng on pulmonary function, exercise capacity, and chronic fatigue have been reported in several earlier studies, many of these investigations were conducted with patients suffering from compromised pulmonary function and low levels of exercise capacity. In addition, older individuals suffering from chronic fatigue often turn to herbal products such as ginseng to help combat fatigue, whereas athletes often use ginseng for prevention and treatment of overtraining. The studies reviewed here have also been conducted with patients and elderly individuals, and these results, obtained from ill and older adults, cannot be applied to healthy, young athletes.

Athletes are also known to use *Panax ginseng* or *Eleutherococcus senticosus* believing that these herbs decrease the incidence of colds and infections and enhance recovery from intense training. However, although previous and recent investigations reveal that ginseng and ginseng-related products might reduce inflammation and produce antistress adaptogenic activity and excitability in mice and rats, as well as enhance physical performance, these effects are rarely evident in humans studied in well-designed investigations. Several recent investigations also revealed that supplementation with ginseng does not improve physical performance and recovery of individuals undergoing exhaustive exercise.

The positive effects of ginseng and ginseng-related products on psychological function, moods, behavior, stress reduction, and chronic pain in animals have been reported in a few of the earlier studies in this area that we have reviewed. Findings from recent investigations using animals generally tend to support these earlier reports. However, although a few investigations reviewed here demonstrated decreased levels of stress, anxiety, and pain after administration of ginseng and ginseng-related products to animals, ginseng administration in humans has not been shown to enhance mood in healthy young adults.

In sports in which quick decision-making is required, it is not unusual for athletes to consume products thought to provide an advantage over the competition. Previous research suggests that chronic administration of ginseng can improve cognitive performance in animals and in humans. Although current research supports this general finding, the ecological validity of applying such results obtained in laboratory settings to athletes and athletic environments is questionable.
Many studies examining the pharmacological effects of ginseng and related products on humans engaged in physical performance such as that pursued by athletes frequently have not employed sound scientific design and methodology. For example, small numbers of participants might have been inadequate to provide the statistical power needed to detect significant changes. There has also been a noticeable lack of double-blind and placebo-controlled investigations. Many of the studies reporting a positive influence of ginseng were supported by the supplier of the ginseng used in the various studies, but this potential conflict of interest has not been clearly stated in the published research. This is especially problematic where blind paradigms have not been employed.

Variability in ginseng preparations is also a major concern because most dietary supplements are not subject to the same regulations as pharmaceuticals, and these herbal products might lack purity or potency. Hence, research involving herbal products, including ginseng, is associated with major “sourcing” problems, and it is imperative that investigators assay the content of products employed in experiments designed to quantify efficacy. It is noteworthy that only a few of the investigations in the current review included an assay of the actual content of the substances used in the experiment. In addition, there has been little or no effort to confirm whether participants took the prescribed ginseng (i.e., compliance). This emphasizes the need for future investigations in this area to use standardized preparations and methods.

It is important to recognize that adverse effects associated with ginseng consumption have been reported. Ginseng is thought to be relatively safe, and the most commonly experienced adverse effects are headache, sleep disturbances, and gastrointestinal disorders. However, several recent reports on the adverse effects of ginseng indicate that more severe outcomes can occur. These include ginseng-induced mania, transient ischemic attack, photosensitivity reaction, anaphylactic reaction, and menstrual dysfunction.

In summary, we conclude that despite attempts in recent investigations to improve on the scientific rigor used in examining the ergogenic properties of ginseng, many of the same methodological shortcomings observed in earlier studies persist. Compelling evidence in support of enhanced physical performance after ginseng administration in humans participating in well-designed investigations remains to be demonstrated.

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