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The Effect of Siberian Ginseng (*Eleutherococcus Senticosus*) on Substrate Utilization and Performance During Prolonged Cycling

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It has been suggested that *Eleutherococcus senticosus* (ES), also known as Siberian ginseng or ciwuija, increases fat utilization in humans. The purpose of this study was to examine the physiological responses to supplementation with ES in endurance cyclists. Using a randomized, double-blind crossover design, 9 highly-trained men (28 ± 2 years, $\dot{V}O_{2max}$ 57.3 ± 2.0 ml · kg^{-1} · min^{-1}) cycled for 120 min at ≈60% $\dot{V}O_{2max}$ followed by a simulated 10-km time trial. Diet was controlled, and ES (1,200 mg · day^{-1}) or a placebo (P) were administered for 7 days prior to each of the two trials. Oxygen consumption, respiratory exchange ratio, and heart rate were recorded every 30 min, and rating of perceived exertion, plasma [lactate], and plasma [glucose] were recorded every 20 min during the 120 min of steady state cycling. There were no significant differences ($p > .05$) between the ES and P groups at any steady-state time interval or during the cycling time trial (ES = 18.10 ± 0.42, P = 17.83 ± 0.47 min). In contrast with previous reports, the results of this study suggest that ES supplementation does not alter steady-state substrate utilization or 10-km cycling performance time.

Key Words: glycogen sparing, fat utilization, ciwujia, endurance cycling, acanthopanax senticosis

Introduction

It is well documented that glycogen depletion is a primary limiting factor in the capacity for prolonged strenuous work. It has been demonstrated that if muscle glycogen can be spared, the amount of work that one can perform will be extended (1, 7, 12, 13, 17, 18). Theoretically, increasing the rate of fat oxidation will result in glycogen sparing and prolong work duration, delaying the onset of fatigue. Ginseng, the root of the Araliaceous plant, commonly known as Panax ginseng, has been used for several thousand years as a tonic, prophylactic agent, and "restorative"; however, its efficacy has been established primarily through clinical experience as

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opposed to scientific verification of its pharmacological effects (4). Several species of ginseng are known to exist: American, Chinese, Korean, Japanese, and Siberian (5). The ginseng plant has been used to treat a plethora of disorders ranging from anemia and chronic fatigue to diabetes, heart disease, and kidney disease. It has also been suggested to improve oxygen utilization, indicating an increase in fat utilization and subsequent sparing of carbohydrate stores (4).

Wild Panax ginseng was an extremely rare and expensive herb, therefore it could not be the source of raw material for mass production of pharmaceutical products (6). Consequently, in the late 1950s, a Russian research group began looking for ginseng substitutes and discovered a new medicinal plant *Eleutherococcus senticosus* (ES) also known as Siberian or Russian ginseng, Ciwujia, eleuthero, eleuthero ginseng, Acanopanax senticosus, touch-me-not, and devil's bush. Although claimed to have the same stimulant and tonic effects as other ginsengs, it is an entirely different plant (6, 9). Baranov (6), in reviewing the medicinal uses of ginseng and related plants in the Soviet Union, concluded that the administration of ES has fewer side effects than Panax ginseng. It was noted that ES did not produce excitation in patients, and the effect on general immunity of an organism was more universal than that of Panax ginseng. Panax ginseng, under certain conditions, may produce a stress like syndrome; however, ES has demonstrated no such effect. The effect of both agents varies seasonally in the plant from which they are extracted but less so in ES (6).

Studies of ES supplementation have reported lower exercise and recovery heart rates and improvements in lactate clearance, the lactate threshold, $\dot{V}O_{2\ max}$, O_2 pulse, and exercise performance (3, 10, 29). In addition, the most dramatic finding is a reported 22–43% increase in fat utilization (10, 29). In contrast, several recent studies have reported no effect of ES supplementation on heart rate, [lactate] at relative workloads, steady state oxygen consumption ($\dot{V}O_2$), maximal oxygen consumption ($\dot{V}O_{2max}$), ratings of perceived exertion (RPE) or respiratory exchange ratio (RER) during treadmill or cycling of up to approximately a 50-min duration (11, 15, 24, 27).

While the results of recent ES supplementation studies are equivocal, a pair of studies have generated a great deal of interest in ES among endurance athletes. Wu et al. (29) utilized a protocol providing progressive resistance every 3 min for 18 min. Three days of placebo supplementation were compared to 14 days of ES supplementation (800 mg · day^{-1}) in 16 healthy males 25–35 years of age. A significant decrease in [lactate], RER, and HR at relative cycling workloads, a greater lactate clearance, a more rapid heart rate recovery, and a dramatic 43% increase in fat utilization was demonstrated with ES supplementation. However, subjects served as their own controls in a pre-post comparison, which may have given rise to a learning effect.

In the same manner as Wu et al. (29), Campbell et al. (10) also demonstrated a 43% increase in fat utilization during incremental cycling to exhaustion in 10 healthy 25–35-year-old subjects. However, the experimental design did not report whether they used a blind or double blind procedure, if diet was controlled, or whether they used a placebo control.

An increase in fat utilization with ES supplementation suggests a sparing effect on muscle glycogen stores and subsequent enhancement of endurance exercise performance. However, no studies have investigated activities of sufficient duration to evaluate the effect of ES supplementation on substrate utilization during

endurance exercise. Consequently, the present study was designed to investigate the effect of ES supplementation on various physiological parameters and substrate utilization during 2 hours of prolonged steady-state cycling followed by a maximal performance time trial.

Materials and Methods

Subjects

Ten male athletes volunteered to participate in the study. Subjects were recruited via personal communication with the primary investigator at local and regional cycling clubs. Prior to participation, each subject provided written informed consent and completed a health history questionnaire. The experimental protocol was approved by the Institutional Review Board for the use of human subjects in research. The subjects physical characteristics were as follows (mean ± *SE*): age 28 ± 2 years; body mass 82.0 ± 3.8 kg; height 1.82 ± 0.02 m; maximal oxygen consumption ($\dot{V}O_{2\,max}$) 57.3 ± 2.0 ml · kg^{-1} · min^{-1}.

Preliminary Testing

On the first visit to the laboratory, each subject performed a continuous graded exercise test using a cycle ergometer for the measurement of $\dot{V}O_{2\,max}$. Attainment of $\dot{V}O_{2\,max}$ was determined by the achievement of at least two of the following: A failure of oxygen consumption to increase with an increase in exercise intensity, attainment of age-predicted maximum heart rate, and/or a respiratory exchange ratio (RER) in excess of 1.10. Each subject was tested on his own bicycle mounted on an electronically-braked cycle simulator (Racer-Mate, Seattle, WA). Immediately following a 10-min warm up a work rate of 100 W was performed for 3 min. The work rate was increased by 50 W every 3 min until the subject could no longer maintain a pedal frequency of 80 revolutions · min^{-1}. Ventilatory gas exchange ($\dot{V}O_2$ and $\dot{V}CO_2$) via breath by breath open circuit spirometry (Physio-Dyne Instrument, Quogue, NY) and heart rate (Polar USA, Stamford, CT) were recorded every 30 s.

During the following 1–3 days, subjects returned to the laboratory for one abbreviated familiarization trial. This consisted of a 10-min warm-up followed by 45 min at a pedaling cadence of 80 revolutions · min^{-1} and an intensity corresponding with ≈60% of $\dot{V}O_{2\,max}$. This was immediately followed by a 10-km time trial.

Experimental Trials

Using a randomized, double-blind, crossover design, each subject completed two experimental trials. Prior to each trial, subjects resting RER was obtained by measuring respiratory gasses for 5 min after the subject was in a seated, resting position for at least 20 min. Each trial consisted of a 2-hour ride on the cycle ergometer, pedaling at 80 revolutions · min^{-1} at ≈60% of $\dot{V}O_{2\,max}$, followed immediately by a simulated 10-km time trial. The trials were separated by at least 13 days, during which time there was a 7-day washout period followed by 7 days of supplementation with either 1200 mg · day^{-1} ES (Endurox™, PacificHealth Laboratories, Woodbridge, NJ) or a placebo (P; calcium silicate). Subjects were tested at approximately the same time of day for each trial to account for diurnal effects. All subjects performed a diet log during the 3 days prior to, and on the morning of, the first testing session.

The subjects were then asked to replicate the diet log as closely a possible in the 3 days prior to, and the day of, the second testing session. Subjects were asked to abstain from exercise for the 24-hours prior to each testing session and to consume their typical pre-competitive meal 2-hours prior to each session. Water was provided ad libitum during the first trial, and the volume was recorded. Water intake for the second experimental trial replicated that of the first experimental trial.

Capillary blood samples (≈100 μl), collected from an earlobe puncture, and ratings of perceived exertion (RPE) (8) were recorded at rest and every 20 min during the 2-hour test. Blood samples were centrifuged in the cold, and the plasma was drawn off and frozen at –70 °C for subsequent analysis of [lactate] and [glucose] utilizing a P-GM7 multipurpose analyzer (Analox Instruments, London, UK). Heart rate was recorded, and respiratory gasses were collected and analyzed every 30 min (reported values represent 10-min averages across each time point) throughout the 2-hour test. Time to complete the 10-km time trial (TT) was recorded at the end of the trial.

Analysis of Data

Separate two-way (treatment [ES, P] by time) repeated measures analysis of variance (ANOVA) were used to analyze $\dot{V}O_2$, RER, HR, RPE, plasma [lactate], and plasma [glucose]. Paired groups *t* tests were used to evaluate differences between ES and P with respect to TT performance and diet composition. An alpha of 0.05 was considered to be statistically significant for all analyses.

Results

Mean physiological and performance data are presented in table 1. As expected, with the onset of exercise, $\dot{V}O_2$, plasma [glucose], and plasma [lactate] maintained a steady state, there was a gradual decrease in RER, and heart rate and RPE increased slightly over time in the placebo and ES groups. The results of the ANOVA indicated a nonsignificant two-way (treatment by time) interaction as well as a nonsignificant main effect for treatment (collapsed across time) for $\dot{V}O_2$, HR, RPE, plasma [lactate], and plasma [glucose]. The results of the two way ANOVA for RER indicated that there was a significant time by treatment interaction. The significant interaction was followed up with paired groups *t* tests (ES vs. P) for each time interval (rest, 30, 60, 90, and 120). The *t* tests revealed no significant differences between the treatments at any time interval. Duration of the TT was not significantly different between the P and ES trials (ES = 18.10 ± 0.42, P = 17.83 ± 0.47 min). The diet analysis revealed no differences between percentages of macronutrient intake or total energy consumption between trials (P: energy intake 12,540 ± 1,554 kJ, carbohydrate 55.7 ± 3.0%, protein 16.0 ± 1.3%, fat 27.9 ± 2.3%, alcohol 0.5 ± 0.4%; ES: energy intake 12,796 ± 1,987 kJ, carbohydrate 54.1 ± 2.2% , protein 17.7 ± 1.3%, fat 28.3 ± 1.8%, alcohol 0.1 ± 0.1%).

Discussion

The documented relationship between substrate utilization, muscle glycogen depletion, and the onset of fatigue (7, 14, 16) warrants that endurance athletes be concerned with the sparing of muscle glycogen to delay the onset of fatigue and maximize

Table 1 Physiological and Perceptual Responses after a 7-Day Supplementation with a Placebo or E. Senticosus

Parameter	Measurement time (min)								
	Rest	20	30	40	60	80	90	100	120
Oxygen consumption ($L \cdot min^{-1}$)									
Placebo	0.36 ± 0.01		2.67 ± 0.12		2.75 ± 0.12		2.73 ± 0.13		2.78 ± 0.13
E. Senticosus	0.36 ± 0.02		2.68 ± 0.13		2.75 ± 0.13		2.72 ± 0.13		2.78 ± 0.13
Respiratory exchange ratio									
Placebo	0.86 ± 0.01		0.92 ± 0.01		0.90 ± 0.01		0.88 ± 0.01		0.86 ± 0.01
E. Senticosus	0.84 ± 0.01		0.92 ± 0.01		0.91 ± 0.01		0.88 ± 0.01		0.87 ± 0.01
Heart rate ($beats \cdot min^{-1}$)									
Placebo	56 ± 3		129 ± 2		131 ± 3		132 ± 2		137 ± 2
E. Senticosus	55 ± 3		129 ± 2		130 ± 3		131 ± 3		137 ± 3
Plasma glucose (mM)									
Placebo	5.3 ± 0.40	4.5 ± 0.15		4.3 ± 0.16	4.0 ± 0.12	4.1 ± 0.18		4.2 ± 0.01	4.2 ± 0.12
E. Senticosus	5.4 ± 0.50	4.6 ± 0.19		4.3 ± 0.21	4.2 ± 0.12	4.2 ± 0.12		4.2 ± 0.11	4.0 ± 0.12
Plasma lactate (mM)									
Placebo	1.4 ± 0.10	1.6 ± 0.24		1.6 ± 0.24	1.6 ± 0.19	1.6 ± 0.15		1.8 ± 0.15	1.5 ± 0.14
E. Senticosus	1.5 ± 0.17	1.5 ± 0.13		1.5 ± 0.14	1.5 ± 0.15	1.7 ± 0.01		1.6 ± 0.16	1.8 ± 0.19
Rating of perceived exertion									
Placebo		12.0 ± 0.2		12.8 ± 0.5	13.2 ± 0.4	13.5 ± 0.4		14.2 ± 0.6	14.4 ± 0.5
E. Senticosus		12.0 ± 0.3		12.6 ± 0.3	13.4 ± 0.6	13.7 ± 0.5		14.0 ± 0.5	14.4 ± 0.4

Note. Data are reported as mean ± *SE*. There were no statistically significant differences noted between treatments at any measurement time.

exercise performance. To this end, the purpose of the present study was to examine the physiological responses to supplementation with ES in endurance cyclists during prolonged cycling. The exercise protocol utilized in this study was chosen for several reasons: (a) 2 hours of steady state exercise followed by a high intensity finish simulates the scenario encountered by cyclists and triathletes during competition in long endurance events; (b) activities of this duration have been demonstrated to significantly decrease muscle glycogen and alter the fractional utilization of carbohydrate and fat (7, 18); and (c) this type of endurance exercise test has been shown to be highly reproducible, especially when coupled to a familiarization trial (21, 26).

If ES supplementation promoted an increased reliance on fat, as reported in previous research (10, 29), at some time during the exercise bout, this should have resulted in a lower RER and an improvement in 10-km cycling time. Neither the RER nor 10-km cycling time were significantly different between the ES and P conditions, suggesting that ES supplementation had no influence on relative substrate utilization.

Given the fact that the results of this study are in contrast with the findings of several previous studies (3, 10, 29), one must first consider the similarities and differences in experimental design. Two factors warranting consideration are the ES dosage and the duration of the administration period. We chose a dosage and administration period of 1,200 mg $\cdot$ d^{-1} for 7 days, respectively, which is consistent with studies reporting significant physiological effects (150–1,200 mg $\cdot$ d^{-1}, 7–14 days) (3, 10, 29). An additional factor that must be considered is pre-exercise dietary control. It has been well established that variations or modifications of food intake in the days and hours prior to exercise can have a significant impact on substrate utilization (2, 20, 23). None of the studies reporting an apparent shift in substrate utilization with ES supplementation reported any control of the pre-exercise diet. In the present study, all subjects recorded a diet log for the 3 days prior to, and the day of, the first testing session and then replicated this as closely a possible in the 3 days prior to, and the day of, the second testing session. While not as ideal as dietary control via a metabolic kitchen, the replication and compliance to this diet was high among the subjects and is supported by the fact that the resting RER measures prior to each test were not significantly different (P 0.86 ± 0.02, ES 0.84 ± 0.02).

The training states of the subjects is also an area of potential concern. It is well documented that during exercise, a trained muscle will demonstrate a greater reliance on muscle triglycerides and free fatty acids as fuel sources than will an untrained muscle (19, 22, 25, 28). In the present study, only highly trained subjects were utilized in an effort to minimize any variance in substrate utilization as well as to simulate the endurance athlete population that would benefit from increased fat utilization. In addition the subjects in the present study were in a maintenance phase of their training, which would help to control for any training effect between testing periods. Previous reports (3, 10, 29), indicating an increase in fat utilization associated with ES supplementation, used subjects that were not highly trained. The research design of previous studies (3, 10, 29), indicating significant physiological and performance effects with ES supplementation, were reported as pre-post, nonrandomized designs thereby allowing for the possibility of significant learning effects, which would increase the likelihood of committing a type I error. This was accounted for in the present study by utilizing a randomized, double-blind, crossover design as well as a familiarization trial to control for potential learning effects and to minimize the between-test variance.

The current study utilized a highly reproducible endurance cycle protocol with control of dietary intake, something that previous studies reporting positive results have failed to do. When considering ergogenic aids, with possible effects of sparing muscle glycogen and subsequently prolonging the ability to maintain work output, protocols of a significantly long duration are necessary. Our research demonstrated no significant differences between placebo or ES during prolonged steady state or performance trials.

In conclusion, this is the first study to investigate the effect of ES supplementation in highly trained athletes during a long duration exercise bout. The lack of difference in biochemical, physiological, or psychological data between the ES and P groups does not support the glycogen sparing and subsequent ergogenic effect reported in previous ES investigations. Future studies with ES should continue to focus on endurance exercise protocols and possibly examine the effects of ES in the fasted state ir a high fat diet.

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