No Ergogenic Effect of Ginseng Ingestion

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The purpose of this study was to examine the effects of ginseng extract ingestion on physiological responses to intense exercise. Subjects performed a control ride (CN) on a cycle ergometer, followed by placebo (PL) and ginseng (GS) treatments. Ginseng was ingested as 8 or 16 mg/kg body weight daily for 7 days prior to trial GS. Venous blood was sampled for FFA, lactate, and glucose analyses. Due to similar findings for both dose groups, the subjects were considered as one group. Lactate, FFA, $\dot{V}O_2$, $\dot{V}E$, and RPE increased significantly from 10 through 40 min. RER increased during the first 10 min of exercise and then remained stable, with no intertrial differences. Glucose did not vary significantly from 0 to 40 min or among treatments. RPE was significantly greater and time to exhaustion was significantly less during trial CN than PL or GS, while PL and GS trials were similar. The data indicated that with 1 week of pretreatment there is no ergogenic effect of ingesting the ginseng saponin extract.

**Key Words:** exhaustion, aerobic, lactate, glucose, free fatty acids

Ginseng (Panax species) occupies an important position among the traditional Chinese medicinal herbs. Today it is widely marketed and consumed internationally, and it has been used for more than 4,000 years in the Orient as an "energy booster" and general tonic. Acute pretreatment of mice with crude ginseng root extract was reported to significantly improve their swimming and running endurance (1, 2, 12). It has also been reported that oral administration of ginseng root powder can have beneficial mental and physical effects in humans (for reviews, see 3 and 8). In addition to these ergogenic effects, there are a myriad of purported health benefits attributed to the ingestion of ginseng (7, 9, 14). These reports and others were recently reviewed (3), and we concur with the reviewers' conclusion that few of these reports are empirically based or are prospectively designed and appropriately controlled investigations using human...
subjects. Readers are referred to Bahrke and Morgan (3) for a recent review of some of the methodological problems associated with studies of ginseng supplementation and physical performance.

The present investigation was designed because of our interest in identifying substances that may have an ergogenic effect after treatment lasting less than 1 week. The purpose of this study was to determine the effect of ginseng consumption on endurance during submaximal cycle exercise. It was hypothesized that ginseng ingestion, for 1 week, would improve endurance compared to placebo ingestion.

Methods

Subjects

Permission to undertake this study was obtained from the institute's human ethics committee. Eight subjects, 7 males and 1 female, volunteered and gave their informed written consent to participate in this study. All subjects were familiar with exhaustive exercise, but their aerobic fitness varied substantially. Most subjects engaged in regular recreational fitness activities and some were training for competitive sports. Their age, weight, height, and peak VO₂ during cycle exercise were 27.2 ± 4.8 years, 77.2 ± 14.2 kg, 1.80 ± 0.8 m, and 48 ± 8 ml · kg⁻¹ · min⁻¹, respectively. All subjects were medically screened to ensure good health before commencing experimentation.

Preparation and Analysis of Ginseng Extract

The ginseng preparation was not obtained commercially but was specifically produced for the present study by the University of Alberta Chemistry Department (Dr. H.J. Liu). The dried roots of *Panax quinquifolium* L. were ground, triturated with diethyl ether, and decanted to give a residue. The residue was triturated with 90% methanol and concentrated to produce a powder. The powder was dissolved in water and extracted further with food-grade ethanol. The ethanol extract was concentrated to produce the crude ginsenosides that were used in the present study.

To identify major components in the ginseng extract used, the preparation was subjected to a liquid chromatography–mass spectrometry (LC–MS) analysis. The analysis was done on a Finnigan TSQ-700 MS/MS equipped with a Finnigan electrospray interface (ESI) coupled to a Waters 600 HPLC with a WHISP autosampler. The LC analyses were done using a C18 Whatmann 4.25 mm × 15 cm column, under isocratic conditions, using 0.3 ml/min flow rate of 0.5% acetic acid in a methanol:water (20:80) mobile phase. Standard ESI conditions were used (capillary heated to 200 °C, N₂ sheath gas at 40 psi, no auxiliary gas, spray current at 1.5 mA). The third quadrupole of TSQ-700 mass spectrometer was scanned in positive ion mode from 300 amu to 1,250 amu in 3 s.

The reconstructed ion liquid chromatogram of our extract was compared with a Sigma preparation of American ginseng root (Sigma Cat. #G7253, Lot #81H0043) and with commercial products from Ginsana Products (Lugano, Switzerland) and Atkins Ginseng (Atkins Ginseng Farms, Ontario, Canada). The preparations (10 mg each) were extracted under identical conditions with 3 ml of absolute ethanol. The chromatographic pattern and mass spectra of major unidentified components were similar in all extracts. The extract from the ginseng used
in our study produced the strongest signal of all extracts, which were extracted and analyzed under identical conditions. The ethanolic extract of our ginseng preparation was further tested for the presence of three ginsenosides: Rb1, Rc, and Re. The following ginsenoside standards were obtained from Sigma: Rb1 (CAS 41753-43-9, MW 1109.3, cat. #G0777, lot #81H4033), Rc (CAS 11021-14-0, MW 1079.3, cat. #G0902, lot #81H4032), and Re (CAS 51542-56-4, MW 947.2, cat. #G1027, lot #81H4034). All three ginsenosides produced strong M+ ions under the ESI conditions employed, and all three were identified in our ginseng root extract at appropriate retention times.

**Treatments**

Subjects were randomly assigned to two dosage groups; one received 8 mg/kg and the other group received 16 mg/kg of both the placebo (PL) and the ginseng (GS) extract. PL consisted of Metamucil®. Both the GS and PL were contained in an opaque gel capsule and were taken orally each morning for 7 days prior to performance testing. Allotment to dose group and the sequence for completing the PL and GS rides were done in double-blind, counter-balanced fashion. One week elapsed between GS and PL trials. Subjects were asked at the end of the experiment if they could guess which treatment was the GS treatment; they could not.

**Exercise Protocol**

Peak aerobic power (\(\dot{V}O_2\max\)) was determined 7 days before the first trial. \(\dot{V}O_2\max\) was defined as the highest oxygen consumption reached during a progressive incremental test on an electronically braked cycle ergometer (Siemens Ergomed RE 930™). The test began with subjects pedaling at a power output of 75 W, and exercise intensity was increased by 37.5 W/min until the subject was unable to maintain a pedaling rate of 60 rpm. Oxygen uptake (\(\dot{V}O_2\)) during exercise was determined with an automated metabolic cart (Sensormedics MMC Horizon™ System 4400). Based on the \(\dot{V}O_2\max\), intensities equivalent to approximately 50, 60, and 70% of \(\dot{V}O_2\max\) were estimated. Following 30 min of rest, the subjects were asked to cycle at these calculated power outputs while their heart rates and \(\dot{V}O_2\) were monitored. Subjects exercised at each intensity for 4 min. The regression of \(\dot{V}O_2\) on power output was then computed for each subject, and the power output required to elicit 75% \(\dot{V}O_2\max\) was calculated; this intensity was then used for the subsequent three test rides to exhaustion.

**Rides to Exhaustion**

Each subject did three rides to exhaustion. A control ride (CN) was completed first, followed by PL and GS rides. The order of PL and GS treatments was balanced among the subjects.

Subjects were given and asked to consume a standardized commercial meal beverage (Ensure Plus®, Ross Laboratories) as either breakfast or lunch before their test. They were also asked not to exercise for 24 hr before any test day and to avoid alcoholic beverages and caffeine for 48 hr before each test day. All tests for each individual were conducted at the same time and on the same day each week. Prior to each test, the subjects were instrumented with a disposable rectal thermistor and
a heart rate monitor (Polar Electro PE3000, Stamford, CT). Blood pressure was measured before exercise. A 20-gauge flexible Teflon indwelling catheter (Insyte®) was inserted into a forearm antecubital vein. The catheter was flushed and locked with a solution of 1% heparinized saline. Subjects moved to a sitting position on the stationary bicycle. Following 8 min rest, an initial 1-ml blood sample was taken and the subjects began pedaling at a power output calculated to elicit 50% of their \( \dot{V}O_2 \max \). After 5 min at this rate, the power output was increased to 75% \( \dot{V}O_2 \max \). The subjects exercised at this intensity until exhaustion. They were required to maintain a minimum pedaling rate of 60 rpm and to not exceed 100 rpm. Blood samples (each 1 ml) were obtained, and \( \dot{V}O_2 \) and rectal temperature (T\(_r\)) were measured at 5 and 10 min and each tenth minute until exhaustion. A final blood sample was taken at exhaustion. Heart rate was monitored continuously during each test. Subjects were asked to assess their rate of perceived exertion (RPE) at each sampling interval using a Borg scale (4).

**Blood Analyses**

Aliquots of each blood sample were deproteinized immediately in perchloric acid and subsequently analyzed for lactate concentration (10). Blood glucose concentration was immediately assayed on whole blood using an autoanalyzer (YSI Model No. 23A Glucose Analyzer, Yellow Springs, OH). Another aliquot was centrifuged and the plasma was assayed for free fatty acids (FFA) concentration (Wako Chemicals NEFA kit, Dallas, TX).

**Data Analyses**

Univariate analysis of variance (ANOVA) procedures with repeated measures were used to evaluate the effects of dose and treatment on time to exhaustion, blood metabolite concentrations, \( \dot{V}O_2, \dot{V}_p \), respiratory exchange ratio (RER), and RPE, both within and between dose groups. Initially, ANOVAs were calculated to determine any between-group effect of the two dose groups. There were no significant differences between the two dose groups; thus, they were treated as one group using a two-factor ANOVA for repeated measures on both trial and time factors. Time to exhaustion was analyzed with a one-way repeated-measures ANOVA. When the ANOVA yielded a significant F ratio, the means were contrasted to determine significantly different means. SuperANOVA® software (Abacus Concepts, Inc., Berkeley, CA) was used for all statistical analyses. Statistical significance was set at \( p < .01 \). Values are expressed as mean ± SD unless otherwise stated.

**Results**

Mean \( \dot{V}O_2 \max \) was 3.65 ± 0.64 L/min or 48 ± 8 ml \( \cdot \) kg\(^{-1} \) \( \cdot \) min\(^{-1}\). The mean power output at the 75% \( \dot{V}O_2 \max \) intensity used for the endurance rides was 204 ± 45 W.

Times to exhaustion (TE) for CN, PL, and GS were 50.7 ± 12.2, 65.7 ± 20.4, and 61.6 ± 22.2 min, respectively, and ranged from 34.7 to 110.0 min. TE for CN was significantly less than both the PL and GS trials. When analyzed in order of trial completion, TE was significantly longer for the second trial than the first trial, regardless of treatment; TE on the second and third trials did not differ significantly.
There was no significant difference between the two dose groups for TE during the GS trial. Seven of the 8 subjects were able to complete 40 min of exercise; thus, the intertrial comparisons of data collected during exercise were limited to 40 min.

RPE showed a similar effect of trial as seen with TE. RPE values were significantly greater for CN compared with GS or PL values. There were no differences observed between the GS and PL trials. Mean values for RPE from 0 to 40 min are shown in Figure 1.

Both heart rate and rectal temperature increased progressively during exercise, but there were no significant differences between trials. Mean values for heart rate were 119 ± 6, 149 ± 9, 157 ± 9, 161 ± 10, and 165 ± 10 beats/min after 5, 10, 20, 30, and 40 min of exercise, respectively. The corresponding rectal temperature values were 37.3 ± 0.3, 37.4 ± 0.4, 37.8 ± 0.4, 38.1 ± 0.4, and 38.3 ± 0.4 °C.

**Blood Metabolites**

There were no significant intertrial differences for any of the measured metabolites before or during exercise, or at exhaustion. Mean lactate concentration increased progressively and significantly until 20 min, when it plateaued at 3.5–4 mmol/L (Figure 2). The mean values for lactate before exercise and at exhaustion were 0.9 ± 0.2 and 3.5 ± 1.1 mmol/L for CN, 1.1 ± 0.2 and 3.8 ± 1.5 for PL, and 1.0 ± 0.2 and 3.8 ± 1.5 for GS.

Two of the subjects had abnormally but consistently low glucose concentrations on all trials, accounting for 14 values in the 1.46 to 2.45 mmol/L range, values that are unphysiological. Their glucose values therefore were not included in the statistical analyses. These subjects displayed normal exercise tolerance and normal responses in all other ways, and their other variables were included for all other analyses. The mean values for the whole blood glucose for the 6 remaining subjects...
Figure 2 — Blood lactate concentration. Values are mean ± SD.

did not change significantly with time over the course of the endurance ride. The mean values before exercise and at exhaustion were 4.8 ± 0.9 and 3.6 ± 0.9 mmol/L for CN, 4.1 ± 1.2 and 3.9 ± 0.9 for PL, and 3.9 ± 1.1 and 4.5 ± 0.9 for GS.

Plasma FFA concentrations increased significantly with exercise, but there were no intertrial differences in this regard. The mean values before and after exercise were 0.534 ± 0.409 and 0.957 ± 0.820 mmol/L for CN, 0.548 ± 0.495 and 0.785 ± 0.718 for PL, and 0.443 ± 0.296 and 0.830 ± 0.966 for GS.

Gas Exchange

Mean values for VO\textsubscript{2} and RER are presented in Figures 3 and 4. There were no significant effects of treatment on these variables. Both VO\textsubscript{2} and RER increased significantly from 5 to 10 min, at the point power output was increased from 50 to 75% VO\textsubscript{2}max. No further significant changes in gas exchange or RER were observed after 10 min. The mean VO\textsubscript{2} values at 75% VO\textsubscript{2}max from 10 through 40 min of exercise were 2.829 ± 0.582 L/min for CN, 2.803 ± 0.590 for PL, and 2.794 ± 0.555 for GS; there were no differences between trials in this regard. These oxygen uptake values represented 77 ± 4% of VO\textsubscript{2}max for the CN trial, 76 ± 6% for PL, and 76 ± 4% for GS.

Discussion

The main finding of the present study was that the ingestion of GS for 1 week, at doses of 8 or 16 mg/kg body weight, did not influence endurance performance, nor did the GS have a measurable effect on lactate, glucose, or FFA concentrations in the blood before or during exercise at 75% VO\textsubscript{2}max to exhaustion. The literature regarding GS as an ergogenic aid is conflicting given the differences in exercise protocol, animal investigated, dosage, and vehicle of GS treatment used (1–3, 5, 6,
Figure 3 — Oxygen consumption. Values are mean ± SD.

Figure 4 — Respiratory exchange ratio. Values are mean ± SD.
There are very few reports of controlled laboratory studies with human subjects. Our results extend the work of Teves et al. (13), who found no significant ergogenic effect of GS ingestion in subjects during submaximal treadmill running to exhaustion.

Studies reporting that endurance performance in rodents is increased following GS treatment suggest that the observed increase in endurance performance is induced through a shift in substrate utilization by decreasing carbohydrate metabolism and increasing the proportion of energy transduced to the exercising muscles via lipid metabolism (5, 6, 14). Consistent with a substrate shift theory, some studies that attributed ergogenic properties to ginseng reported evidence of significant decreases in lactate production and stability of plasma glucose concentrations during exercise following ginseng treatment (1, 5, 12). In contrast, our results show no evidence of a change in substrate utilization after GS treatment in humans. The blood metabolite concentrations and RER values were similar on all trials, contrasting with what would be expected if there was a shift to more lipid metabolism after the GS treatments.

One explanation for the contrasting results in the rodent and human studies could be related to the various doses of ginseng ingested or injected. Avakian and Evonuk (1), using 2 mg/100 g i.p. injections of a pure methanol extract of Panax ginseng in rats, reported an increase in exercise endurance times. Teves et al. (13) had human subjects ingest 2 g of P. ginseng root (1.5% active glycoside), and in the present study our subjects ingested a purified ethanol-extracted ginsenoside dose of 8 or 16 mg/kg. The total dose/weight ingested in this study is 5% of that used in the Avakian study and approximately 50% of the dose used by Teves et al. (13); thus, we cannot preclude the possibility of significant effects with higher doses. It is noteworthy that the dose recommended in commercially available preparations ranges from 200 to 400 mg daily. Commercially available preparations, however, rarely specify the concentrations of the various ginsenosides. Therefore, interstudy comparisons are futile unless the various GS fractions of the preparations used are known.

Ratings of perceived exertion were significantly greater during the first trial, the CN ride, than either of the subsequent PL or GS treatments. This “order effect” was also observed for times to exhaustion. TE for Trial 1, the control trial, was significantly less than the placebo and ginseng values. These results emphasize that the reliability of using time to exhaustion during submaximal exercise as a criterion variable becomes questionable without familiarization testing (11).

As indicated in the introduction, our interest is in physical performance enhancement after only 1 week of treatment. This investigation was designed to address such a treatment duration; thus, the results of this investigation do not address whether an ergogenic effect could be achieved with more prolonged use of ginseng.

The small sample size used in this investigation could also be considered a limitation for some of the variables, such as time to exhaustion. We have previously demonstrated that the reproducibility of time to exhaustion is problematic when considering the statistical power of exercise physiology experiments designed to evaluate the effects of a treatment (11). Using statistical power analysis methods described in McLellan et al. (11) and the values from the present subjects for the PL and GS trials, we calculated that 70 subjects would have to be tested to detect a significant treatment effect for time to exhaustion for a power of 0.8. Executing a
study with such a large sample size is prohibitive for most exercise physiology laboratories. Thus, it becomes all that much more important to use other variables in addition to time to exhaustion, such as the blood metabolite and gas exchange variables employed in the present investigation. For example, given the 8 subjects used in the present investigation, a high statistical power of 0.9 was calculated for the treatment effect for lactate concentration.

In conclusion, 7 days of ingesting Panax ginseng did not increase endurance times for individuals cycling at 75% \( \dot{V}O_{\text{max}} \). The experimental hypothesis was rejected. Future work with ginseng should emphasize using standardized doses and GS fractions.

References


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