Effects of a Commercial Herbal-Based Formula on Exercise Performance in Cyclists

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ABSTRACT

EARNEST, C. P., G. M. MORSS, F. WYATT, A. N. JORDAN, S. COLSON, T. S. CHURCH, Y. FITZGERALD, L. AUTREY, R. JURCA, and A. LUCIA. Effects of a Commercial Herbal-Based Formula on Exercise Performance in Cyclists. Med. Sci. Sports Exerc., Vol. 36, No. 3, pp. 504–509, 2004. Introduction/Purpose: We examined the effects of a commercially marketed herbal-based formula purported to increase endurance on oxygen consumption (VO2) in 17 competitive category III/IV amateur cyclists [mean (SEM) age: 31.1 (1.8) yr; height: 178.5 (1.8) cm; weight: 77.1 (1.6) kg]. Methods: Each cyclist participated in two (pre/post) cycling tests progressing 25 W·min−1 starting at 100 W administered in a randomized, placebo-controlled, double-blind fashion. The second trial was performed 14 d after the ingestion of a manufacturer recommended loading phase (4 d × 6 caps·d−1) and a maintenance phase (11 d × 3 caps·d−1). Three treatment capsules contained 1000 mg of Cordyceps sinensis (CS-4) and 300 mg Rhodiola rosea root extract as the primary ingredients; 800 mg of other ingredients included calcium pyruvate, sodium phosphate, potassium phosphate, ribose, and adenosine and 200 mcg of chromium. Results: Using a 2 × 2 ANOVA, we observed no significant treatment effect for any between or within group variables including peak VO2 [treatment 4.14 (0.2) L·min−1; placebo 4.10 (0.2) L·min−1], time to exhaustion [treatment 38.47 (1.7) min; placebo 36.95 (1.8) min], peak power output (PO) [treatment 300.00 (12.1) W; placebo 290.63 (12.9) W], or peak heart rate. We also observed no differences for any subpeak exercise variable including the PO eliciting 2 mmol·L−1 blood lactate (BLa) [treatment 201.00 (18.1) W; placebo 167.50 (19.2) W] and 4 mmol·L−1 BLa [treatment 235.88 (15.8) W; placebo 244.78 (14.9) W], ventilatory threshold, respiratory compensation point, or VO2 L·min−1 and gross efficiency at each stage. Conclusion: A 2-wk ingestion schema of a commercial herbal-based formula is insufficient to elicit positive changes in cycling performance. Key Words: HERB, SUPPLEMENT, NUTRITION, CYCLING

In an effort to improve or maintain endurance performance, cyclists traditionally use carbohydrates, water, and electrolyte ingestion schemas during training and competition. Beyond these three basic categories, research efforts have validated few legal dietary supplements that will improve cycling performance. Two herbal supplements traditionally used in Chinese and Ayurvedic (i.e., holistic) medicine have been marketed to endurance athletes as a means of increasing parameters associated with oxygen uptake. These are Cordyceps sinensis and Rhodiola rosea.

In brief, Cordyceps sinensis has been a popular herbal medicine in China for centuries (29,30). The active component associated with Cordyceps is mycelium, which is obtained from the parasitic fungus of a colonizing larvae of the moth that inhabits the host’s body (29,30). To obtain the active ingredient, the mycelium is derived from the mycelial strain Paecilomyces hepiali to form CS-4. This latter component has been shown to increase the cellular energy state in mouse liver by 18% as assessed by 31PNMR spectroscopy (5). In addition, CS-4 significantly decreased oxygen consumption (VO2) and mortality in mice exposed to a hypoxic environment (14).

Rhodiola rosea is also a popular plant used in traditional medical systems in Eastern Europe and Asia with a reputation for stimulating the nervous system, decreasing depression, enhancing work performance, eliminating fatigue, and preventing high altitude sickness (3,29,30). Rhodiola has been categorized as an adaptogen due to its reported ability to increase resistance to a variety of chemical, biological, and physical stressors via cardioprotection and central nervous system enhancement (29,30). Some reports also claim that Rhodiola attenuates various conditions such as a decline in work performance, sleep difficulties, poor appetite, irritability, headaches, and fatigue associated with intense physical or intellectual strain (6,10,20,21). These “adaptogenic,” cardiopulmonary protective, and central nervous system activities have been attributed to Rhodiola’s ability to influence the levels and activity of monoamines and...
opioid peptides such as beta-endorphins (29,30). Interestingly, one study using Rhodiola crenulata in professional Chinese athletes did show an increase compared with controls after 75 d of supplementation (18).

Enhancing public visibility and the marketability of these supplements are reports that have accumulated over the last 10–12 yr suggesting that several Olympic teams have used adaptogens to enhance exercise performance. These sports include hockey, cross-country skiing, women’s soccer, cycling, and track. Perhaps one of the most intriguing “testimonial” reports was when Cordyceps gained world attention in 1993 following the success of Chinese female runners who achieved records in 1500-m, 3000-m, and 10,000-m events, while attributing their success to a diet containing Cordyceps. Unfortunately, few if any references exist in the more traditionally utilized Western literature substantiating the benefits of Cordyceps or Rhodiola in endurance athletes.

In this current investigation, we examine the effects of a commercially available multi-ingredient formula containing as its primary ingredients Cordyceps sinensis and Rhodiola rosea on oxygen uptake in competitive amateur cyclists.

METHODS

We recruited 17 amateur male competitive cyclists for this study. All cyclists were active in category III/IV racing events. We tested nine cyclists at The Cooper Institute Center for Human Performance and Nutrition Research in Dallas, TX. We tested eight cyclists at the Baylor University Cycling Research Center in Waco, TX, and examined all cyclists using the same protocol and same equipment at each laboratory (see below). All of the subjects in this investigation had previously undertaken maximal exercise testing in the aforementioned centers and were familiar with maximal exercise testing procedures. The research ethics committee from each university approved the study and before undertaking the testing of this investigation, all subjects signed a written informed consent statement outlining the potential risks associated with the trial.

Exercise testing procedures. All subjects reported to each laboratory for exercise testing on two separate days. All cyclists performed their first test on day 0 (baseline) without supplementation. We examined all cyclists a second time after a 14-d supplementation period. We chose this length of supplementation based on the product manufacturer’s recommendation. During the supplementation period, each subject ingested an adaptogen formula (treatment; detailed below) or a matched placebo. Each testing period entailed having the subject perform a staged cycling test to exhaustion. We adjusted the ergometer before each test to duplicate the measurements of each cyclist’s personal bicycle.

Exercise test. We performed each test on a Lode Excalibur Sport Ergometer (Groningen, The Netherlands) and analyzed the riders for cardiorespiratory parameters using a Parvomedics Truemax Metabolic System (Salt Lake City, UT). We instructed each subject to prepare for each test as if preparing for a race. This preparation included not changing their training parameters or dietary patterns for the week preceding each test. On the day before each test, subjects followed a similar type of high-carbohydrate (CHO) diet (CHO intake of ~450–500 g·d⁻¹). Two to three hours before the test, subjects ate a light snack. We also asked each subject to abstain from ingesting any drugs that would influence heart rate (HR) on the day of each test. The one exception was caffeine, which we asked the subjects to refrain from consuming for at least 5 h before testing.

Each cycling test began with a warm-up at 50 W (10 min) and then progressed to 75 W (2 min). After this warm-up, the test began by increasing the power output (PO) to 100 W. Once PO was set at 100 W, each stage inclusive of the 100-W stage lasted 4 min and progressed 25 W every 4 min until the rider reached exhaustion or could no longer maintain a pedal cadence of 50 rpm. During the test, subjects adopted a conventional (upright) cycling posture during the duration of the tests. This posture was characterized by a trunk inclination of ~75% and by the cyclists placing their hands on the handlebars with elbows slightly bent (flexion ~10%). We allowed each rider to choose their preferred cadence within the range of 70–90 rpm. Though we desired to have each rider perform a maximal exercise test, per se, we do not consider this a true VO₂max test, which would optimally be shorter. Instead, we applied a slow rate of PO increase in this study in an effort to delineate where potential treatment effects might lie [i.e., (i) submaximal efforts, (ii) efforts surrounding various thresholds (outlined below), or (iii) efforts near peak performance]. Thus, we will refer to all “maximal” data as peak data.

Measurements during the tests. We collected gas exchange data continuously using an automated computerized breath-by-breath Parvomedics Truemax Metabolic System using a pneumotachometer and a paramagnetic O₂ analyzer and infrared CO₂ analyzer to perform O₂ and CO₂ analyses, respectively. This system has been shown to be accurate as compared with Douglas bag criteria (1). In addition, each center used the same calibration procedures for each metabolic cart inclusive of a 3-L calibration syringe, and calibration gases of similar concentration (16% O₂, 4% CO₂, and balanced nitrogen) that were obtained from the manufacturer of the metabolic cart. We averaged all gas exchange data in 60-s intervals, and only the last minute of each stage was used in our analyses. The following variables were measured during each test: VO₂, pulmonary ventilation (VE), ventilatory equivalents for oxygen (VE·VO₂⁻¹) and carbon dioxide (VE·VCO₂⁻¹), and end-tidal partial pressure of oxygen (PETO₂) and carbon dioxide (PETCO₂). We subsequently used these parameters to examine the PO where ventilatory threshold (VT) and respiratory compensation point (RCP) occurred. The VT was determined using the criteria of an increase in both VE·VO₂⁻¹ and PETO₂ with no concomitant increase in VE·VCO₂⁻¹, whereas the RCP was determined using the criteria of an increase in both the VE·VO₂⁻¹ and VE·VCO₂ and a decrease in PETCO₂ (15). VO₂peak and peak power output (PO; W) was chosen as the peak values observed during the last full min completed during the cycling tests. Blood samples...
(25 μL) for the measurement of blood lactate (BLa; Analox GM7 MicroStat Analyzer; London, UK) were taken from fingertips at rest and during the last 30 s of each stage starting at 100 W. VO2 and PO at 2 mmol·L−1, and 4 mmol·L−1 were determined from individual VO2-PO and blood lactate-PO relationships. For those PO eliciting a respiratory exchange ratio (RER) value ≤1.00, we also calculated gross efficiency (GE). GE is defined as the ratio of work accomplished per minute [i.e., W converted to kcal·min−1] compared with the energy expended per minute [i.e., VO2 (average for the last minute of each PO) converted to kcal·min−1], using the corresponding energy equivalent for each VO2 value based on RER (4).

**Supplementation.** We used a commercially available supplement known as Optygen™ for this study (First Endurance; Salt Lake City, UT; www.firstendurance.com). We instructed riders to consume their respective treatments according to manufacturer recommendations and ingest their supplements in two phases: A loading phase (6 capsules·d−1 for 4 d) and a maintenance phase (3 capsules·d−1 for 11 d). We provided subjects with identical capsules for each treatment condition. Each set of capsules (i.e., treatment and placebo) was colored in a dark red, nontransparent capsule. The placebo was comprised of methycellulose, an inert substance with no significant caloric value or biologic activity. Although each product had a distinctive odor, we were unable to precisely match the smell of the active treatment. Each three capsules contained a manufacturer claimed combined quantity of 1000 mg of Cordyceps CS-4 (*Cordyceps sinensis*) (mycelia biomass) minimum 7% cordycepic acid and 300 mg of Rhodiola extract (*Rhodiola rosea* root) containing a minimum 2.5% salidroside/minimum and 3.0% rosavins as its primary ingredients. The supplement also contained a “proprietary blend” of 800 mg of combined calcium pyruvate, sodium phosphate, potassium phosphate, ribose, and adenosine. However, as is stated by DSHEA, “When the dietary ingredients in a supplement are considered to be a proprietary blend, just the total amount of the blend need be stated. In the absence of individual amounts, FDA requires that the dietary ingredients in a proprietary blend are to be listed in order of predominance by weight (www.cfsan.fda.gov/~dms/guidance.html).” Therefore, we have no further information regarding the exact weight of each substance contained in the matrix. This product also contains 200-mcg chromium (as chelate). Lastly, even though we received from the manufacturer a certificate of analysis attesting to the veracity of the product, we did not have the product independently analyzed.

**Statistics.** We analyzed our data using a 2 × 2 [treatment (placebo/treatment) × time (pre/post)] ANOVA. Our primary analysis examined the relationship between treatment and peak VO2, peak HR, and time to exhaustion for each testing period. As a secondary analysis, we examined the VO2 and GE for the O2 cost averaged over the final minute of each stage below an RER of 1.0. During this latter analysis, we also examined the PO corresponding to the accumulation of 2 mmol·L−1 and 4 mmol·L−1 of BLa during each trial condition, as well as the PO at VT and RCP. If we observed a significant statistical result, we used a Fischer’s least significant difference posthoc analysis to examine statistical differences for each statistically significant parameter. Results are shown as mean (SEM).

**RESULTS**

All 17 subjects successfully completed each testing period, with nine subjects assigned to the treatment group and eight subjects to the placebo group. The rider characteristics for the treatment group were age: 31.6 (2.8) yr, weight: 76.6 (2.1) kg, and height: 176.0 (2.3) cm. The rider characteristics for the placebo group were age: 30.5 (2.2) yr, weight: 77.7 (2.6) kg, and height: 181.3 (2.6) cm. We did not observe any statistically significant difference between or within treatment groups for any peak exercise variables including peak VO2, time to exhaustion, peak W, or peak HR (Table 1). Furthermore, we did not observe any statistically significant difference between or within treatment group differences for any of the subpeak exercise variables including the PO eliciting 2 mmol·L−1 and 4 mmol·L−1 BLa (Table 1), VT, RCP, or VO2 (Fig. 1) or GE (Fig. 2) at any stage.

**DISCUSSION**

The primary findings from our study is that a formula based primarily on two herbs, *Cordyceps sinensis* and *Rhodiola rosea*, and a matrix of other ingredients marketed to enhance ATP production and endurance performance had no effect on exercise performance. These findings included

| Table 1. Data represent peak exercise and various threshold data for each treatment group. |
|---------------------------------|-----------------|-----------------|-----------------|-----------------|
| **Baseline** | **Post** | **Baseline** | **Post** |
| Mean | SEM | Mean | SEM | Mean | SEM | Mean | SEM |
| Peak VO2 (L·min−1) | 4.10 | 0.2 | 3.99 | 0.2 | 4.14 | 0.2 | 4.08 | 0.1 |
| Time to exhaustion (min) | 36.95 | 1.8 | 38.51 | 1.6 | 38.47 | 1.7 | 39.29 | 1.5 |
| RER | 1.10 | 0.0 | 1.10 | 0.0 | 1.10 | 0.0 | 1.10 | 0.0 |
| Peak PO (W) | 290.63 | 12.9 | 300.00 | 10.6 | 300.00 | 12.1 | 305.56 | 10.0 |
| Peak HR (beats·min−1) | 183.63 | 4.0 | 181.75 | 3.5 | 185.69 | 3.7 | 189.33 | 3.3 |
| PO at 2 mmol·L−1 BLa | 167.50 | 19.2 | 178.75 | 19.5 | 201.00 | 18.1 | 200.00 | 18.4 |
| PO at VT | 235.88 | 15.8 | 234.38 | 17.9 | 244.78 | 14.9 | 260.56 | 16.8 |
| PO at RCP | 253.16 | 13.8 | 265.62 | 10.3 | 266.73 | 13.1 | 253.14 | 9.8 |

RER, respiratory exchange ratio; HR, heart rate; PO, power output (W); VT, ventilatory threshold; RCP, respiratory compensation.
peak VO₂, peak PO₂, and time to exhaustion. We also did not observe any treatment effects on subpeak exercise performance inclusive of various “threshold” parameters traditionally examined in the study of exercise physiology. Therefore, it appears that this commercial product confers no ergogenic effect when ingested over a 14-d treatment period. Whether this formula will prove to have a benefit to exercise when ingested over longer periods has yet to be determined.

The comparison of our data to previous studies is difficult, as most references to the effects of the herbs contained in this formula appear in non-English journals (i.e., Chinese and Russian), as conference abstracts (5,27,28), or as review articles that cite many non-English reports (3,10,29). Thus, one must presume that the authors of these reviews have read and correctly interpreted the information presented. Though we do not doubt the validity of these reports, per se, it is difficult to make thorough comparisons.

The effect of Cordyceps sinensis has been reviewed thoroughly elsewhere as to its effects on various physiological functions (29,30). Given the breadth of these reports, it is likely that a “physiologic effect” does exist via Cordyceps use. However, Cordyceps’ role in enhancing exercise performance is unclear. As with many dietary supplements, the efficacy of Cordyceps is largely anecdotal and heavily leveraged on media reports attesting to the purported use by successful Chinese athletes. Currently, we are aware of only two conference abstracts attesting to the role of Cordyceps in energy metabolism. The first was performed in mice, where it was shown that the administration of Cordyceps showed an increase in 31PNMR spectroscopy hepatic ATP (5). Though no evidence was provided in this report regarding the effects of Cordyceps in muscle tissue, should these effects be noted in muscle, an increase in exercise performance might be possible. To this end, Xia et al. (28) have presented conference data in elderly humans showing an increase in pre/post VO₂max [mean (SEM); 1.9 (0.1) L·min⁻¹ vs 2.0 L·min⁻¹ (0.1)] (28). These effects were noted at peak exercise, as well as during anaerobic threshold as determined by the visual plotting of VCO₂ vs VO₂ and VE/QO₂ vs time [1.15 (0.1) L·min⁻¹ vs 1.3 L·min⁻¹ (0.1)]. Though statistically significant, the calculation of statistical power surrounding these data reveals values of 0.10 and 0.20 for each respective comparison. Another distinguishing feature is that this particular study used a 6-wk ingestion schema, which may be necessary to observe a treatment effect if one does indeed exist.

The reported data regarding Rhodiola rosea is equally difficult for comparison purposes. In one full paper, a Rhodiola rosea extract was administered to students for 20 d during a stressful examination period (21). The most significant improvement in the Rhodiola group was a reported

![FIGURE 1—Data (mean ± SEM) represent the oxygen consumption (VO₂) during the last minute of each stage for each treatment group.](image-url)
improvement in physical fitness, mental fatigue, and neuromotoric tests. However, it is unclear how these measurements were ascertained, though similar effects have been reported by others (20). However, it does appear as though Rhodiola does not increase oxyhemoglobin saturation, at least with acute exposure, as a recent trial entailing 60 min of acute hypoxic exposure (13.5% O₂) and 7 d of Rhodiola supplementation (447 mg·d⁻¹) showed no benefit (27). In fairness, we would like to caution the reader that our observation is also made from a conference report and that a complete analysis of the study protocol is not possible. The one report that we have found examining humans has shown a modest increase in VO₂max in professional Chinese athletes using *Rhosea crenulta* (18). However, this type of Rhodiola is a different species, which likely confers different chemical properties and biologic function.

This formula also contained chromium and an 800-mg proprietary blend composed of calcium pyruvate, sodium phosphate, potassium phosphate, D-ribose, and adenosine. In short, all of these ingredients are promoted to enhance energetics in humans. When applicable, even though some of these ingredients have demonstrated an ergogenic effect during exercise, the quantities contained in this formula are not present in the quantities found to be effective in the literature. For example, chromium has been promoted to enhance insulin sensitivity and, subsequently, glucose and fatty acid disposal (16,17,19). However, no ergogenic benefit can be assigned to the use of chromium during exercise performance (7). Further, even though some evidence suggests that pyruvate may have an ergogenic benefit when administered in large, gram quantities (i.e., ~30 g·d⁻¹) the quantities present in this formula are dramatically lower than these reports showing efficacy (22–24).

An interesting observation at this point is that DSHEA does not require companies to reveal the actual concentration of an ingredient when presented in a proprietary blend. Thus, it is safe to assume that the pyruvate present in this product’s matrix is below the 800 mg listed on the label. In addition to pyruvate, there is some data available to suggest that sodium phosphate and potassium phosphate may improve several indices of performance including maximal leg power, oxygen consumption, and endurance performance (8,12,13,26). For the same reasons cited above, the administration of phosphates in trials demonstrating efficacy is larger (~4 g·d⁻¹) than what is present in this formula. The data are even less impressive for D-ribose, a carbohydrate involved in purine nucleotide metabolism and serves as a backbone for de novo ATP synthesis.

Supplementation with this molecule has been shown to have some clinical efficacy in clinical populations with AMP deaminase deficiency and myoadenylate deaminase deficiency (9,25). However, two trials in healthy strength
training athletes have shown no benefit from D-ribose supplementation and no data have been reported on its effects on endurance performance (2,11).

Our study and its conclusions have several limitations. First, we did not have the product independently analyzed. Though we obtained a certificate of analysis with an accompanying product identification number, we cannot be certain that all of the ingredients listed were present. Second, we cannot say to what amount those ingredients as its primary ingredients and other matrix material postulated to improve ATP production has no effect on cycling performance when ingested for 14 d. Whether a longer supplementation period will prove efficacious is still a matter for scientific inquiry.

REFERENCES