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The Effect of Pyruvate Supplementation on Critical Power

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ABSTRACT

The critical power (CP) cycle ergometer test, theoretically, provides an estimate of a power output that can be maintained without fatigue. It has been suggested that pyruvate (PYR) supplementation may enhance endurance capacity. Therefore, the purpose of this study was to examine the effect of PYR supplementation on CP. Using a double-blind random design, 9 male and 9 female (mean age ± *SD* = 20.7 ± 3.5 years) university crew team members were assigned to 1 of 2 treatment conditions: (a) placebo (PL, $n = 9$) or (b) pyruvate (PYR, $n = 9$). Prior to supplementation, CP for each subject was determined from 3 workbouts to exhaustion on a cycle ergometer. Each subject was posttested at the same power outputs after ingesting the PL or PYR supplement for 14 consecutive days. The results indicated that PYR supplementation had no ($p > 0.05$) effect on CP (PL group, pretest CP = 203 ± 45 W, posttest CP = 201 ± 49 W; PYR group, pretest CP = 202 ± 47 W, posttest CP = 207 ± 45 W). These data suggest that 8.1 $g \cdot d^{-1}$ of PYR does not elicit improvements in endurance capability as measured by the CP test.

Key Words: ergogenic aids, endurance performance, cycle ergometry

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Introduction

Pyruvate (PYR) is a 3-carbon compound formed from the glycolytic breakdown of glucose or glycogen (2, 3, 10, 17). It has been suggested that PYR is primarily metabolized to lactate and acetyl CoA during anaerobic and aerobic activities, respectively (3). The metabolic fates of PYR can influence athletic performance because lactate accumulation results in muscular fatigue, and acetyl CoA ultimately produces energy from the citric acid cycle and the electron transport system (2, 3).

Three studies (21–23) have examined the potential for PYR to provide ergogenic benefits. Early research by Stanko and Adibi (21) showed that rats fed supplemental PYR and dihydroxyacetone (DHA) for 112 days had an increase in total carcass glycogen. Because muscle glycogen concentration is related to endurance capacity, Stanko and Adibi (21) hypothesized that PYR and DHA may have ergogenic benefits for humans. Recently, Stanko et al. (22, 23) reported a 20% increase in arm and leg endurance following 7 days of dietary supplementation with PYR (25 $g \cdot d^{-1}$) and DHA (75 $g \cdot d^{-1}$) and suggested that the enhanced endurance capacity was related to an increase in muscle glucose extraction.

Theoretically, critical power (CP) represents the maximal power output that can be maintained without fatigue (6, 9, 11, 12, 14, 16, 17, 19). Although CP may overestimate the maximal rate of fatigueless work (7, 12, 14), it has been shown to be highly reliable (6, 14, 18) and modifiable with training (6, 12, 19). Furthermore, the parameters of the CP test have been used to examine the effects of dietary supplements on aerobic and anaerobic capabilities (20, 24). The sensitivity of CP to detect changes in aerobic capability may, therefore, provide a method to examine the potential endurance-related effects associated with PYR supplementation. Thus, the purpose of the present investigation was to determine the effect of PYR supplementation on CP.

Methods

Subjects

Nine female and 9 male university crew team members volunteered to participate in this study (Table 1). The study was approved by the University Institutional Review Board for Human Subjects and all subjects completed a health history questionnaire and signed a written informed consent prior to testing.

CP Test

The CP was determined using methods described by Housh et al. (9). Each subject performed 3 workbouts

Table 1. Descriptive characteristics (mean ± *SD*) and critical power (CP) responses.

	Placebo (n = 9)	Pyruvate (n = 9)
Age (years)	19.6 ± 1.3	21.8 ± 4.4
Height (cm)	172.7 ± 7.5	171.6 ± 10.7
Body weight (kg)	66.7 ± 5.6	70.7 ± 10.7
Pre-CP (W)	203 ± 45	202 ± 47
Post-CP (W)	201 ± 49	207 ± 45

to exhaustion on a calibrated electronically braked cycle ergometer (Corvial 400, Quinton Instruments) at power outputs ranging from 150 to 300 watts (W) for females and 250 to 400 W for males. The initial power output, based on body weight and fitness level, was selected by an investigator experienced in administering the CP test such that the time to exhaustion for the workbout would be approximately 4–6 minutes. The subsequent power outputs were selected based on the results of the initial workbout so that time to exhaustion was between 1 and 10 minutes, as suggested by Poole et al. (19). On the first day of testing, each subject performed 2 workbouts. Rest periods between workbouts continued until the subject's heart rate returned to within 10 b·min^{-1} of preexercise levels (9). Day 2 was a rest day and on day 3 the subjects performed the final workbout. This protocol was consistent with previous investigations (9, 18, 19) and resulted in times to exhaustion ranging from 1.0 to 13.6 minutes. The environmental conditions within the laboratory remained constant across all trials. Prior to each workbout, the seat height of the cycle ergometer was adjusted for near full extension of the subject's legs while pedaling. Toe clips were adjusted to prevent the feet from slipping off the pedals during the testing. Each subject warmed up for 4 minutes by pedaling at 70 rev·min^{-1}, as determined by the rev·min^{-1} monitor on the cycle ergometer, against at a power output of 30 W. After a 2-minute rest period, the subject began pedaling at a rate of 70 rev·min^{-1} and the appropriate resistance was set within 2–3 seconds. If the rev·min^{-1} fell below 70, verbal encouragement was used to help motivate the subject to return the pedaling rate to 70 rev·min^{-1}. Each test was immediately terminated when the pedaling rate fell below 65 rev·min^{-1}. Following each workbout, the subject was allowed to cool down by pedaling against zero resistance until their heart rate returned to approximately 100 b·min^{-1}.

For each workbout, the time limit (TL) was recorded to the nearest 0.1 second and work limit (WL) was calculated by multiplying the imposed power output (P) by the TL (WL = P × TL). The WL values were then plotted versus the TL values for the 3 workbouts, and the CP was defined as the slope of the WL versus TL relationship (4, 8, 16, 17).

Supplementation Protocol

Following pretesting, the subjects were randomly assigned to 1 of 2 treatment conditions using a double-blind design: (a) 8.1 g·d^{-1} of cornstarch capsules as a placebo (PL, n = 9) or (b) 8.1 g·d^{-1} of PYR capsules (PYR, n = 9) for 14 consecutive days. This PYR supplementation protocol was recommended by the manufacturer (Experimental and Applied Sciences Inc., Golden, CO).

During the treatment time period, the subjects were instructed to eat food and drink water ad libitum. Daily monitoring found that each subject complied with the investigators instructions not to change from their normal diet and to follow the supplementation protocol. Furthermore, no side effects were reported for either the PL or PYR group.

Statistical Analysis

Data were analyzed using a 2-way mixed-factorial analysis of variance, treatment (PL, PYR) by test (pretest, posttest). A probability of $p \leq 0.05$ was considered statistically significant.

Results

Table 1 describes the CP results (mean ± *SD*) for each test and treatment. The results indicated a nonsignificant 2-way interaction as well as nonsignificant main effects for test (collapsed across treatment) and treatment (collapsed across test).

Discussion

The results of the present investigation indicated that 14 days of dietary supplementation with PYR (8.1 g·d^{-1}) had no significant effect on CP. These findings, however, were not consistent with those of Stanko and coworkers (21–23).

Stanko and Adibi (21) found that the addition of PYR and DHA to the diet of rats for 112 days resulted in an enhancement of energy expenditure. It was hypothesized (21) that an increase in substrate cycling may be associated with the phosphorylation of PYR and DHA, and the authors stated that ''. . . enrichment of diet with these trioses may increase [substrate] cycling in glycolytic pathways.'' With human subjects, Stanko et al. (22, 23) suggested that their findings of a 20% increase in arm and leg endurance following dietary consumption of PYR (25 g·d^{-1}) and DHA (75 g·d^{-1}) for 7 days was associated with a greater glucose extraction that spared muscle glycogen and delayed the onset of fatigue.

In the present investigation, CP was not affected by 14 days of dietary supplementation with PYR (8.1 g·d^{-1}). The difference between the results of the pres-

ent study and those of Stanko et al. (22, 23) may be due to differences in the supplementation dosage. Stanko et al. (22, 23) administered 25 $g \cdot d^{-1}$ of PYR for 7 days. In the present investigation, 8.1 $g \cdot d^{-1}$ of PYR (as recommended by the manufacturer) was administered for 14 days. It is possible that higher doses of PYR (>8.1 $g \cdot d^{-1}$) are required to enhance endurance capabilities. Furthermore, in the studies by Stanko et al. (22, 23) the subjects received 25 $g \cdot d^{-1}$ of PYR along with 75 $g \cdot d^{-1}$ of DHA, whereas the subjects in the present investigation received only PYR. It is possible that an interaction between PYR and DHA accounted for the enhanced endurance capacity. Future research is warranted to determine the effects of varying dosages of PYR as well as combining PYR with DHA for improving CP and enhancing endurance performance.

Practical Applications

In the present study, dietary supplementation with 8.1 $g \cdot d^{-1}$ of PYR for 14 days had no significant effect on CP. Thus, the present findings suggest that PYR supplementation (using the dosage recommended by the manufacturer) provides no ergogenic benefit as measured by the CP cycle ergometer test. Future research using varying dosages of PYR is warranted to provide a better understanding of the usefulness of PYR as an ergogenic aid.

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