

Original Communication

The Effect of 4 Weeks Treatment with a 2-gram Daily Dose of Pyruvate on Body Composition in Healthy Trained Men

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Received: September 18, 2008; Accepted: January 18, 2009

Abstract: The principal aim of this study was to determine the effects of short-term (28 days) pyruvate supplementation on body composition in young healthy men. Twenty-two young (mean age, 22.2 ± 2.7 years) male soccer players were allocated to two randomly assigned groups in a placebo-controlled, double-blind design. Subjects in the pyruvate group orally ingested tablets that contained pyruvate at a dose of 2 g per day in two equal doses for 4 weeks. There were no statistically significant changes in weight and body-mass index (BMI) within or between groups ($p > 0.05$) after the supplementation protocol. Percentage of body fat decreased similarly in both pyruvate and placebo groups after the supplementation protocol ($p > 0.05$). There were no changes in waist-to-hip ratio (WHR), arm fat index (AFI), and total or regional muscle mass within or between groups ($p > 0.05$). No subject reported any side effects from pyruvate or placebo treatment. The results of the present study indicate that supplementation with pyruvate during training does not significantly alter the body mass, fat, and muscle mass in healthy trained men. Pyruvate supplementation appears to be ineffective as a fat loss strategy in young athletes.

Key words: supplementation, placebo, body fat, total muscle mass, BMI

Introduction

Different nutritional products that claim to be performance-enhancing are popular with recreational and elite athletes of all nations, levels of competition, and sport disciplines. In particular, dietary supple-

ments are marketed aggressively to all types of athletes, a circumstance that has generated its own controversy in this very profitable industry [1]. The most controversies exist about effects and consequences of supplements for weight loss in sports nutrition. Weight or fat reduction in athletes is generally mo-

tivated by a desire to either achieve a pre-designed weight in order to compete in a specific weight class or category, or to optimize performance by improving power-to-weight ratio [2,3]. Aside from multivitamins, different weight loss formulations seem to be most popular supplements in both the athletic and non-athletic environments [4,5]. Pyruvate is a three-carbon ketoacid produced in the end stages of glycolysis. It can be reduced to lactate in the cytoplasm or oxidatively decarboxylated to acetyl CoA in the mitochondrion. Pyruvate purportedly enhances weight loss and reduces weight regain, decreases body fat, suppresses appetite, elevates energy levels, and increases endurance and exercise performance [6,7]. The ergogenic effects of pyruvate linked with body composition modification, fat reduction, and weight regain suppression could be of interest to athletes. Yet, the scientific support for pyruvate as either a weight loss aid or as a way to boost energy levels is somewhat controversial. Few studies in humans have evaluated pyruvate's role as a fat- and weight-loss supplement. Several studies have shown that treatment subjects lost somewhat more fat and weight than the control group [8–10]. Yet, the studies typically recruited morbidly obese women, under the conditions of a low-calorie diet combined with restricted energy expenditure, with relatively small differences observed in treatment subjects induced by dosages considerably larger (22 to 44 grams of pyruvate) than those available to consumers. As such, the results of these studies are specific to these criteria and cannot be reliably generalized to the population at large, particularly athletes. Commercially available preparations provide about 500 mg to 1 gram of pyruvate, usually taken a few times a day for a daily intake of 1 to 5 grams. To date, no studies have been performed with dosages typically available to athletes. According to several investigations, pyruvate is one of the most popular weight-loss supplements in athletes [11,12]. However, there is poor scientific evidence currently available to support weight loss claims in healthy trained men. Therefore, the main aim of this study was to determine the effects of short-term (28 days) pyruvate supplementation on body composition and exercise performance in young male athletes.

Methods

Subjects

Twenty-six healthy young (mean age, 25.1 ± 3.4 years) male soccer players gave their informed consent and volunteered to participate in the study with the approval of the University's Ethical Advisory Commission. All subjects were members of same professional top-level soccer team, playing in the 1st National League during the season 2007/08. The study was conducted at the TIMS Sport Sciences Center at Novi Sad, Serbia. All participants were fully informed verbally and in writing about the nature and demands of the study as well as the known health risks. They completed a health history questionnaire and were informed that they could withdraw from the study at any time, even after giving their written consent. Inclusion criteria included (a) participation in consistent soccer training (average of six times or 12 hours per week) for the past 4 years, (b) absence of musculoskeletal dysfunctions, metabolic, and heart diseases, and (c) avoidance of dietary supplementation with pyruvate (or any weight loss supplementation) in the prior 2 months. Exclusion criteria included only playing position (goalkeeping) due to different training habits and physiological profiles; 4 athletes were excluded based on these criteria. The final sample included 22 athletes.

Experimental Procedures

The athletes were allocated to two randomly assigned groups using a random numbers tables, in a double-blind design. All study personnel and participants were blinded to treatment assignment for the duration of the study. Subjects in the pyruvate group (PYR) orally ingested tablets that contained pyruvate at a dose of 2 grams per day in two equal doses for 28 days. Subjects in the placebo group (PLA) ingested an equal number of identical looking caps that contained cellulose. The groups were matched (PYR vs. PLA) for subjects' age, weight, height, body fat, and maximal oxygen uptake. Maximal oxygen uptake was determined previously using a maximal multi-stage 20-m shuttle-run test [13]. There were no statistical differences between the groups ($p > 0.05$) on the items they matched on (Table I). According to standard procedures suggested by the Anti-Doping Agency, before the use of a dietary supplement in an athletic environment, evidence of quality assurance and accordance with good manufacturing practice

Table 1: Physical characteristics of subjects

	Pyruvate (<i>n</i> = 11)	Placebo (<i>n</i> = 11)
Age (years)	22.5 ± 2.3	21.9 ± 3.1
Height (cm)	182.3 ± 5.1	180.6 ± 6.2
Weight (kg)	81.3 ± 4.2	80.7 ± 5.2
Body fat (%)	8.8 ± 2.7	9.0 ± 2.3
Total muscle mass (%)	53.4 ± 2.4	54.1 ± 3.2
VO ₂ max (ml/kg/min)	58.3 ± 4.2	57.9 ± 3.5

Note. Values are means ± SD. VO₂ max – maximal oxygen uptake. There were no significant differences between groups (*p* > 0.05).

(GMP) were obtained from the relevant institution. After analysis with high-performance liquid chromatography, the National Institute of Health (No. 3856D-02) certified the purity, composition, and quality of the pyruvate preparation used in the present study, along with verification of absence of contaminants that might have other stimulant properties (e.g., creatine and related compounds). Lama Inc., Belgrade, Serbia provided both supplement and placebo treatment in numbered containers for allocation concealment. Subjects were instructed to take one pill in the morning upon waking and one pill just prior to sleep with pill counts used to determine subject compliance. Baseline testing was performed prior to supplementation, and the athletes are familiar with testing procedures as part of their regular training process. Before and after the supplementation protocol, each subject underwent a series of body composition tests. All subjects were assessed on the same day, and the tests were performed in the same order. In order to assess potential side effects to the supplementation regimen, all subjects were instructed to report any adverse effects of supplementation (e.g., nausea, headaches, diarrhea, flatulence).

Dietary Control and Training

Three days prior to the baseline testing, subjects met a nutritionist who instructed them to undertake a prescribed dietary pattern throughout the course of the study and to refrain from using any other supplementation. During the supplementation regimen all subjects consumed a similar standardized diet to ensure adequate macro- and micronutrient intake (daily energy intake and protein intake were similar between groups). Compliance was monitored by

analyzing 3-day food records pre- and post-supplementation. Diet records were analyzed for composition using food analysis software package (Nutribaze, Phoenix, Arizona, USA). Between the baseline and experimental testing, all subjects followed a similar specific training program [14], with compliance with an exercise regime controlled by a certified conditioning coach. Subjects were strongly instructed to limit exercise to the prescribed training regimen.

Body composition

All anthropometric parameters were determined before and after the supplementation protocol. Height was measured using a stadiometer (Seca 202, USA) to the nearest 0.1 cm while body mass was obtained to the nearest 0.1 kg using a calibrated balance beam scale (Avery Ltd, Model 3306 ABV, UK). The subjects were measured nude, in the same state of hydration and nourishment after voiding. Body-mass index (BMI) was calculated as weight (kg)/height (m)². Waist and hip circumferences were measured using a Gulick anthropometric tape (Creative Health Products, Plymouth, USA) with waist-to-hip ratio (WHR) calculated. Three limb circumferences (calf, forearm, thigh) were identified and measured using anthropometric tape and percentage of muscle mass was estimated according to anthropometric protocol of Martin *et al.* [15] (standard error of estimation (SEE) = 6.1 %). Skinfold thicknesses at seven sites were obtained using a Harpenden caliper (British Indicators Ltd., St. Albans, UK). The skinfold sites are triceps, subscapula, mid-axillary, anterior suprailiac, chest, abdomen, and thigh. The landmarks are identified and measured according to Wilmore & Behnke [16] with the median of three measurements used to represent skinfold thickness. Percentage of

Table II: Body composition in pyruvate and placebo trials

Variables	Pyruvate (<i>n</i> = 11)		Placebo (<i>n</i> = 11)	
	<i>Pre</i>	<i>Post</i>	<i>Pre</i>	<i>Post</i>
Body mass (kg)	81.3 ± 4.2	80.2 ± 3.8	80.7 ± 5.2	80.0 ± 5.0
BMI (kg/m ²)	24.5 ± 0.8	24.2 ± 0.9	24.7 ± 1.0	24.5 ± 1.0
WHR	0.83 ± 0.03	0.82 ± 0.04	0.84 ± 0.04	0.83 ± 0.04
Body fat (%)	8.8 ± 2.7	8.4 ± 3.3	9.0 ± 2.3	8.6 ± 3.1
AFI (%)	11.5 ± 2.0	11.2 ± 2.4	12.1 ± 2.9	11.8 ± 3.1
Total muscle mass (%)	53.4 ± 2.4	55.3 ± 3.9	54.1 ± 3.2	55.8 ± 3.6
cAMA (cm ²)	58.8 ± 4.1	60.2 ± 5.2	60.6 ± 5.2	61.9 ± 7.1

Note. Values are means ± SD. Abbreviations BMI = body mass index; WHR = waist-to-hip ratio; AFI = arm fat index; cAMA = corrected mid-upper-arm muscle area. No significant differences were demonstrated ($p > 0.05$)

body fat was determined according to equations of Jackson & Pollock [17]. Arm fat index (AFI) and corrected mid-upper-arm muscle area (cAMA) were calculated according to Gibson [18]. The same trained technician performed the pre- and post-tests on each subject for anthropometric measurements. The primary outcome measure of the study was the degree of change from baseline to 4 weeks in body-fat percentage as estimated by skinfold method.

Statistical analyses

The data are expressed as means ± standard deviation. Pre- and post-differences (body mass, BMI, body fat, WHR, AFI, total muscle mass, cAMA) were analyzed by a paired *t*-test. Independent *t*-test was used to assess between-group differences in body composition. *P* values of less than 0.05 were considered to be statistically significant. The data were analyzed using the statistical package SPSS, PC program, version 10.0 (SPSS Inc., USA).

Results

There was no protocol deviation in either study group. No subjects were lost to follow-up, drop-out or withdrawal from the study. Complete data sets were available for 22 participants who completed the 4-week trial and all analyses are based on these 22 subjects. Results are shown in Table II and Figure 1. There were no statistically significant changes in weight and BMI within or between groups ($p > 0.05$) after the supplementation protocol. Percentage of body fat decreased similarly in both pyruvate and

placebo groups after the supplementation protocol ($p > 0.05$). There were no changes in WHR, AFI, total, or regional muscle mass within or between groups ($p > 0.05$). No subject reported any side effects from pyruvate or placebo treatment.

Discussion

The present study has provided direct analysis of the effects of typically recommended doses of pyruvate supplementation on body composition in healthy trained men. The results indicate that treatment with a 2-g daily dose of pyruvate in male soccer players has inconsequential effects on body weight, total and regional fatness, and muscle mass.

In the context of obesity management, pyruvate (alone or co-administered with caffeine or dihydroxyacetone) has been promoted as a pro-lipolytic and slimming agent [3,8–10]. While the lipolytic effects of methylxanthines (caffeine) are well documented [19], the influences of pyruvate on fat and body weight reduction have not been studied extensively, and the possible mechanism of fat utilization (i.e. enhanced thermogenesis, decreased lipogenesis) is unknown. During the 1980 s, several studies showed that a mixture of pyruvate and dihydroxyacetone prevented fat accumulation associated with ethanol consumption in animals, along with reduced triglyceride synthesis in liver [20,21]. Authors claimed that pyruvate could inhibit lipid accumulation and enhance energy expenditure. On the other hand, human studies on pyruvate supplementation and its effect on body composition have produced highly equivocal results [8–10,22]. Kalman *et al.* [10] found that the daily ingestion of 6 g of pyruvate for 6 weeks, in conjunction with mild physical activity, resulted in

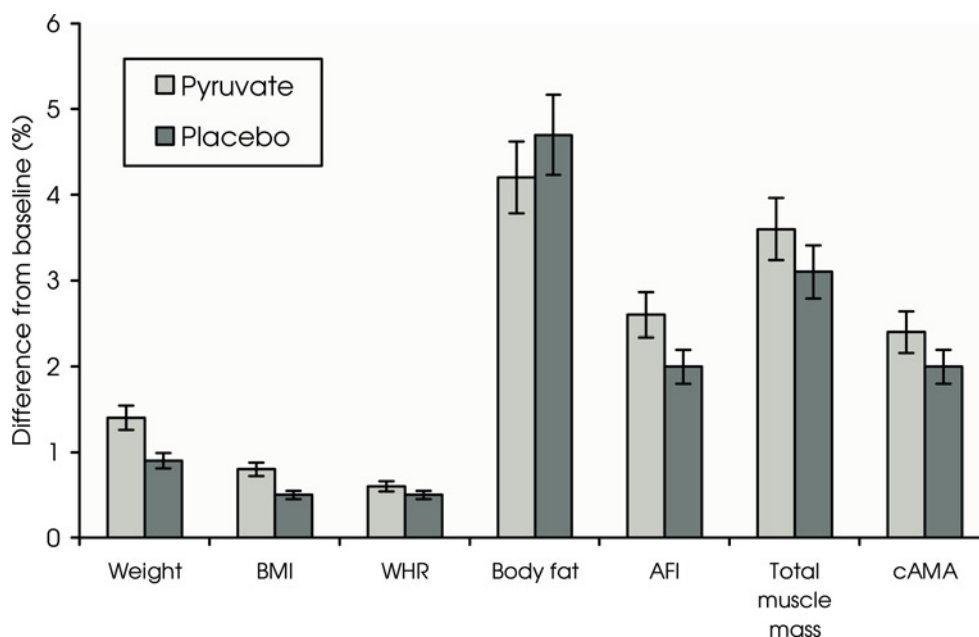


Figure 1: Percentage change of body composition pre- to post-supplementation. Abbreviations: BMI = body mass index; WHR = waist-to-hip ratio; AFI = arm fat index; cAMA = corrected mid-upper-arm muscle area. No significant differences were demonstrated ($p > 0.05$).

a significant decrease in body weight and fat mass in healthy overweight Caucasian men and women. On the other hand, Koh-Banerjee *et al.* [23] evaluated the effects of 5 g of calcium pyruvate supplementation for 30 days in twenty-three untrained females participating in a supervised exercise program. Results indicated that pyruvate supplementation during training did not significantly affect body composition and may negatively affect some blood lipid levels. Turner *et al.* [24] observed body composition changes in twelve (9 females and 3 males) competitive Division I collegiate anaerobic athletes during a 3-week double-blind supplementation period. Authors found that body weight, BMI, resting metabolic rate, and percent fat (determined by hydrostatic weighing) did not differ between the two groups following the 3-week supplementation period.

In the present study, subjects in placebo and pyruvate groups had similar body mass and BMI at baseline. This did not change in either group despite the 4-week supplementation. Body fat decreased in both pyruvate and placebo groups after supplementation protocol, but without reaching statistical significance. Other indicators of regional fatness and muscularity (WHR, AFI, cAMA) didn't change in either group after the administration protocol. In terms of adjusting body composition, it appears that pyruvate supplementation is ineffective treatment for the promotion of fat loss in top-level athletes. These

results are in disagreement with the results of a few previously reported studies concerning administration of pyruvate in humans. Several studies investigated the effect of pyruvate in promoting fat loss during calorie-restricted diets [8,9]. Stanko *et al.* [8] found greater weight and fat loss in 13 obese women supplemented with dihydroxyacetone and pyruvate in a metabolic ward during severely restrictive hypocaloric feeding. A subsequent study from the same laboratory [9] reported that significant weight and fat loss with 22–44 g pyruvate supplementation for 6 weeks were found in 17 hyperlipidemic patients consuming a low-cholesterol, low-fat diet. Although studies reported that the pyruvate group experienced significantly more fat loss than the placebo group, the changes were not that great. The differences reported were 0.8 to 1.3 kg between two groups. Moreover, the subjects also lost lean tissue mass, suggesting that pyruvate supplementation does not help spare tissue protein during periods of severe caloric restriction. A few issues need to be addressed in the above studies. The amount of pyruvate that the subjects consumed was relatively large. Although 1 to 5 g of pyruvate are typically recommended per day, most studies have used 20 g or more (even 44 g), expensive doses that are also difficult to consume.

It seems that besides the lipolytic effects of pyruvate supplementation, pyruvate may influence satiety and food (energy) intake, which requires further in-

vestigation [22,25]. Despite the claims regarding pyruvate effects on muscle mass as an anti-catabolic agent [22], there was no significant increase in muscle mass in either group after the supplementation protocol, suggesting that pyruvate does not have the potential to influence muscle hypertrophy. However, no measurement was made of plasma testosterone levels; thus, it is unclear whether pyruvate affects the endocrine system.

The main advantages of the present study include the use of experienced top-level athletes, controlled and comparable conditions for all subjects during the study, and a double-blind, placebo-controlled design. Nonetheless, it is apparent that ingestion of 2 grams of pyruvate had no beneficial effect for the small sample of individuals in our study. Since no other comparable studies exist on a particular dosage of pyruvate in the field of sports nutrition, it would be premature to conclude that pyruvate has no fat reduction effect in trained or untrained individuals. The purity of the pyruvate, the duration of supplementation, and the training status and hormonal milieu of the individual may affect the efficacy of this supplement. Some investigators have hypothesized that pyruvate could promote reverse electron transport in hepatocyte mitochondria, which could be associated with rapid mitochondrial uptake of fatty acids, marked thermogenesis, and fat loss [25]. Therefore, future research should examine the acute and chronic responses of lipid metabolism to pyruvate consumption; such investigations would be greatly improved if some biochemical markers of glucose and fatty acid metabolism, or circulating hormones, were to be measured.

Limitations of the present study warrant mention. Our study suffered from small sample size and power to enable detection of possible significant differences. The ideal sample size with top-level athletes as participants is difficult, particularly for elite soccer teams during the competitive season. Another limitation was the short duration of intervention (28 days). Moreover, volunteers were asked to adhere to a prescribed training regimen with soccer-specific exercise. Changes in exercise regime (i.e. resistance training) could affect pyruvate metabolism and metabolic responses to exercise [23,25], requiring further investigation. Therefore, a longer duration of pyruvate supplementation coupled with a long-term, periodic training program may be necessary to determine whether pyruvate has a considerable ergogenic effect in active men.

Subjects in our study reported no acute side effects, yet caution should be used before recommending

pyruvate supplements to athletes. Both animal and human studies have reported different, mild side effects (e.g., nausea, diarrhea, flatulence, headache) [8–10,20–23]. Frequent consumption of pyruvate in athletes requires a clear understanding of all the potential benefits and risks of usage. Another concern regarding pyruvate supplementation is the purity of the dietary supplement. Independent evaluations have found that the amount of supplement in over-the-counter products ranged from 0% to 150% of what the content stated on the label [22,26].

In summary, the findings of the present study indicate that supplementation with pyruvate during training does not significantly alter the weight, fat, or muscle mass in young trained subjects. Pyruvate supplementation appears to be an ineffective fat loss strategy in elite athletes. In moderate doses (2 g/day), pyruvate did not have any side effects in this study group.

Acknowledgements

This study was partially supported by the Serbian Ministry of Science (Grant No. 145082).

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