Effects of Six Weeks of β-alanine Administration on VO_2 max, Time to Exhaustion and Lactate Concentrations in Physical Education Students

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ABSTRACT

Objectives: Supplementation with β-alanine has been proposed to improve performance in some exercises such as cycling and running. Also, it has been demonstrated that great deals of proton ions are produced in the skeletal muscles during exercise that result in acidosis, whereas β-alanine may reduce this effect. Therefore, the aim of this study is to assess the effects of alanine supplementation on VO_2 max, time to exhaustion and lactate concentrations in physical education male students.

Methods: Thirty-nine male physical education students volunteered for this study. Participants were supplemented orally for 6 week with either β-alanine (5*400 mg/d) or placebo (5*400 mg dextrose/d), randomly. VO_2 max and time to exhaustion (TTE) with a continuous graded exercise test (GXT) on an electronically braked cycle ergometer; and serum lactate and glucose concentrations were measured before and after supplementation.

Results: Supplementation with β-alanine showed a significant increase in VO_2 max ($P<0.05$) and a significant decrease in TTE and lactate concentrations ($P<0.05$). A significant elevation in lactate concentrations and a non significant increase in TTE were observed in placebo group. Plasma glucose concentrations did not change significantly in two groups after intervention.

Conclusion: It can be concluded that β-alanine supplementation can reduce lactate concentrations during exercise and thus can improve exercise performance in endurance athletes.

Key words: β-alanine, supplementation, performance

Original Article

INTRODUCTION

Ingestion of some amino acids has presumable roles in performance improvement in athletes.[1-3] Among them, β-alanine supplementation has been suggested to improve performance during high-intensity exercises.[4,5] On the other hand, it has been shown that large amounts of H^+ are produced in the muscles during high-intensity exercise and result in pH reduction.[6] There are many cellular pH buffers defend against exercise-induced

acidosis,[7] which include phosphocreatine, inorganic phosphates and histidine-containing dipeptides. Carnosine (β-alanyl-L-histidine) is the main histidine-containing dipeptide in humans. [8] Additionally, Hill *et al*.[5] and Harris *et al*.,[9] showed that 28 days of β-alanine supplementation increased intramuscular levels of carnosine by nearly 60%. Antioxidant function[10] muscle contractility regulation,[11] and pH buffering,[12,13] are the possible physiological roles of carnosine in skeletal muscle. Thus, the possible role of carnosine could be prevention of skeletal muscle acidity in improving exercise performance.[4,14]

Prolonged exercise can result in oxidative stress and muscle fatigue,[15] which may be prevented by carnosine due to its antioxidative properties.[16] On the other hand, β-alanine administration could increase carnosine content of skeletal muscles by 40–80%.[17-19] Increase of carnosine concentrations in muscle results in altered buffering capacity,[18-19] and thus affects performance. Furthermore, some studies have shown that carnosine acts as a Ca^{++} sensitizer for the sarcomeres in muscles[20-21] and thus could prevent fatigue.[22] However, synthesis of carnosine in muscle is limited by the availability rate of β-alanine, which can be overcome by β-alanine supplementation.[19,23,24]

Although it has been estimated that carnosine is responsible for nearly 10% of the total buffering capacity in human muscle,[19] the importance of acidosis control in exercise performance is still controversial. There are few studies on β-alanine supplementation and its possible effects on endurance exercise; therefore, the purpose of this study is to assess the effects of β-alanine administration on VO_2 max, time to exhaustion and lactate concentrations in male physical education students.

METHODS

Thirty-nine male physical education students volunteered for this investigation. These students were fit (BMI<25) and active (physical activity≤2 hr/d), but not involved in professional sports. Participants' age, weight and height were 21.1±0.7 years, 71.8±8.8 kg and 178±7 cm, respectively, for β-alanine (n=20) group and 21.9±1.5 years, 74.9±8.3 kg and 180±5 cm for placebo group (n=19), respectively (NS). Before initiating the study, all participants were informed of all procedures of the study and signed an informed consent. None of the participants had ingested β-alanine, or any other nutritional supplements, for a minimum of 3 months before the initiation of the study. Participants were asked to abstain from exercise 24 h before trial initiation and to maintain their current physical activity and dietary patterns. Participants were asked to fill a "food record" for the 2 days before intervention. After pre-testing, the participants were randomly assigned to one of the two groups: a) β-alanine (2 g/day), b) placebo (2 g dextrose per day).The supplements had the same appearance, and ingested four times per day for 42 consecutive days before post-testing. All participants completed all experiments, and there were no complaints of side effects of the supplements.

This study was a placebo-controlled, double-blind clinical trial. Participants were supplemented orally for 6 weeks with either β-alanine (Ajinomoto, USA, Inc) or placebo (dextrose). The study was approved by the Ethics Committee (Esfahan Sport Medicine Association, Iran). Supplements were provided in capsules of 400 mg and were administered each day as five divided single doses, with at least 2 h in between ingestions. Thus, daily doses consisted of 2 g/day during the study.Venous blood samples were obtained from all participants between 5:00 and 6:00 p.m, after intensive endurance exercising, at the baseline and after intervention. All measurements were done before the start of the supplementation (pre) and after the intervention (post).

Prior to and following the supplementation protocol, participants performed a continuous graded exercise test (GXT) on an electronically braked cycle ergometer (Lode, The Netherlands) to determine VO_2 max and time to exhaustion (TTE).

For each GXT, the primary power output was set at 30 W and elevated 30 W every 2 min until the participant could not maintain the required power output at a pedaling rate of 70 rpm due to fatigue.

Plasma samples were obtained for the determination of plasma lactate and glucose concentrations immediately prior to each GXT and 2 min post-exercise.

Glucose and lactate were analyzed using YSI auto-analyzer (Yellow Springs, OH).

Dietary analyses were performed using Nutritionist IV software.

Statistical analyses were conducted using the Statistical Program for the Social Sciences (SPSS version 13, Inc, Chicago, IL) computer software package. Data are presented as mean ± standard deviation. Independent t test was used to analyze

the differences in performance between the trials. Paired t test was used to analyze before and after test data for each group differences. An alpha level of $P<0.05$ was considered statistically significant.

RESULTS

Table 1 shows the mean ± SD values of exercise performance indices for the pre-and post-supplementation. Supplementation with β-alanine demonstrated a significant increase in VO_2 max ($P<0.05$). On the other hand, TTE and lactate concentrations decreased after 6 weeks of supplementation with β-alanine ($P<0.05$). The placebo group showed a significant increase in lactate concentrations ($P<0.05$), but a non significant increase in TTE. No significant changes in plasma glucose concentrations were detected after exercise in two groups.

The post-exercise concentrations of plasma lactate were significantly higher ($P<0.05$) than baseline in two groups. However, the post-exercise concentrations of lactate were significantly lower ($P<0.05$) during the alanine supplementation compared to the placebo group. Dietary intake before each trial was similar for energy and macronutrients [Table 2].

DISCUSSION

The findings of our study suggest that supplementation with β-alanine may improve the endurance exercise performance as measured by the VO_2 max, TTE and plasma lactate concentrations. Several studies support our findings.[17,25-27]

Also, Harris *et al*.,[18] showed that supplementation with creatine + β-alanine resulted in significant increases ($P<0.01$) in muscle carnosine content. The increased muscle carnosine content was accompanied with an improvement in VO_2 max and TTE in response to a maximal graded exercise test performed on a cycle ergometer. Their results were consistent with ours.

Another study demonstrated that supplementation with both β-alanine and creatine improved cycling performance (TTE).[5]

However, β-alanine administration alone improved performance just in the first minute of exercise.[4] They concluded that this was due to H^+ buffering by carnosine during this transitional period.

Our data demonstrate that the significant improvements in the performance indices with β-alanine supplementation were due to pH reduction.

The improvement in TTE seen in the placebo group participants might be due to the encouragement provided by our staff and also the participants' psychological status.

Also, the findings of the present study might have been influenced by the fluctuations in the skeletal muscle response to oral supplementation with β-alanine.

Our data suggest that supplementation with β-alanine may delay the onset of fatigue and thus improve performance during incremental cycle exercise in men.

The glucose concentrations did not change significantly in our study, due to different individual

Table 1: Comparison of exercise performance indices, pre-and post-supplementation (mean ±SD)

Variables	β-alanine		Placebo	
	Pre	Post	Pre	Post
VO_2 max ($L.min^{-1}$)	2.62±0.82	2.79±0.73[a,b]	2.85±0.67	2.81±0.79
TTE (s)	923.6 ±237.5	992.4±225.5[a,b]	917.5±243.8	926.5±240.5[a]
Lactate (mg/dl)	15.5±6.2	27.9±14.4[a,b]	14.8±7.1	36.0±12.6[a,b]
Glucose (mg/dl)	79±14	83±11	84±8	80±14

[a]Significant differences after exercise between two groups [b]Significant differences after exercise within a group

Table 2: Dietary intake of subjects for 2 days before intervention (mean±SD)

Trial	Energy (kcal)	Protein (g)	Carbohydrates (g)	Fat (g)
β-alanine	2,625±820	105±32	326±185	105±82
Placebo	2,577±625	99±27	312±154	102±93

response and insufficient dose or duration. The participants in this study, however, were male physical education students rather than untrained participants.

We did not measure the muscle carnosine content. However, according to the hypothesis, β-alanine supplementation would prevent the drop in intracellular pH during high-intensity contractions and result in less circulating acidosis finally due to elevation of myocellular carnosine content. It has long been suggested that acidosis limits muscle contractility.[28] Furthermore, several studies have shown the importance of pH regulation on performance during endurance exercise, by a pre-exercise alkalosis intervention.[29]

This suggests that the difference between groups is related to the presumable enhancement of muscle carnosine content.[18,30]

Future studies should examine muscle carnosine levels along with VO_2 max and plasma lactate concentration during strenuous exercise with variable quantities of β-alanine supplementation Also, further investigations are necessary to determine the effects of β-alanine supplementation during more prolonged and submaximal exercise.

CONCLUSION

It can be concluded from this study that β-alanine administration can reduce acidosis during high-intensity exercise and thus can improve exercise performance in endurance athletes. Also it is found that six weeks of supplementation with β-alanine at the mentioned prescribed dose did not result in significant changes in glucose concentrations.

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