The Effect of Beta-Alanine Supplementation on Reducing Blood Lactate Concentration and Improving Sports Performance

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Abstract

Background and Objective: Dietary supplements are a common strategy used by athletes and adults to improve physical function and recovery, and muscle mass. Beta-alanine (βA) is an inessential amino acid that can improve the performance of athletes. βA is one of the dietary supplements involved in delaying or reducing fatigue and is of interest to athletes, coaches, and sports scientists. This study aimed to investigate the effect of 4-week βA supplementation on soccer athletes' onset of blood lactate accumulation (OBLA) in leg and chest press training volume and running time of 800 m. **Materials and Methods:** A total of 20 football athletes were randomly divided into two βA supplement and placebo groups. The supplement group (6.4 g of βA per day) and placebo group (6.4 g of starch per day) were eaten for 4 weeks after the briefing session and pretest on blood lactate concentration indices, leg and chest press volume training, and running time of 800 m. Functional evaluations and posttest blood samples were collected from the individuals on day 28. **Results:** The findings show that OBLA considerably rose right away following activity in both the supplement and placebo groups. It fell in both groups 15 min after activity, with the supplement group showing a significant difference ($P \geq 0.05$). In either research group, as well as between pretest and posttest times, there was no statistically significant difference in the training volume of the chest press and leg press activity ($P \geq 0.05$). There was a significant temporal interaction of 800 m between the supplement and placebo groups. **Conclusion:** Short-term βA supplementation reduced OBLA during the postexercise recovery period, while no effect on footballers' performance was observed in these tests.

Keywords: Anaerobic function, beta-alanine, lactate

Introduction

Intense exercise increases lactate levels.[1] Muscle acidosis is mainly produced by anaerobic glycolysis and increasing adenosine triphosphate hydrolysis. It is theoretically considered the main environmental factor for muscle fatigue in high-intensity training.[2] Muscle acidosis leads to physiological disorders in reducing creatine phosphate[3] and inhibiting essential enzymes such as phosphofructokinase in glycolysis.[4,5] It also causes a decrease in the sensitivity of myofibrils to calcium ions[5] and dysfunction of the muscle system.[6] These physiological disorders can devastate speed and strength.[6] The accumulation of H + ions is essential to fatigue.[7]

Research has shown that using supplements to improve performance and prevent injury is one of the suggestions of today.[8,9] Research has shown that the use of supplements to improve performance and prevent injury is one of the suggestions of today. Supplements and vitamins can be considered an inseparable part of the therapeutic project and correction of physical activities.[10,11] Research has shown that methods can improve buffer capacity, including βA supplementation to increase carnosine and reduce fatigue during strenuous activity.[7] Because performance during this type of activity may be impacted by increasing H + (hydrogen ion) and Improved with greater buffer capacity, carnosine is particularly helpful for high-intensity exercise due to its biological role as a muscle buffer.[12] Based on this, carnosine is focused on increasing muscle content to optimize muscle performance due to its ergogenic properties with high absorption.[13]

Access this article online	
Quick Response Code:	Website: www.matrixscipharma.org
	DOI: 10.4103/mtsp.mtsp_12_22

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How to cite this article: Mohammed SS, Rahimi MR, Sayfaddin DL. The effect of beta-alanine supplementation on reducing blood lactate concentration and improving sports performance. Matrix Sci Pharma 2022;6:75-80.

Received: 15-Dec-2022 **Revised:** 17-Dec-2022
Accepted: 19-Dec-2022 **Available Online:** 08-Feb-2023

βA is a nonprotein amino acid that serves as a restriction on the production of carnosine in skeletal muscle.[14] βA supplementation between 4 and 24 weeks seems to boost skeletal muscle carnosine by up to 200%.[15] Glenn *et al*. showed that βA supplementation (4 doses per day with 800 mg beta-alanine [βA] +8 g dextrose) for 28 days, 24% of onset of blood lactate accumulation (OBLA) after the cycling test to exhaustion (equivalent to 120% of maximum oxygen uptake) decreased in female cyclists.[16] Hill *et al*. examined the effect of βA consumption on athletic performance, which showed that performance improved after 10 weeks of supplementation.[17]

Previous studies have studied the effect of βA on the improvement of total work done,[18] time to exhaustion,[18,19] and physical working capacity at the fatigue threshold.[20] Most previous studies on the effects of βA on ergometry have been performed (Stellingwerff *et al*.,[18] 2012 #505). Therefore, whether βA supplementation has an ergogenic effect during the running performance must be determined. The present study examines the effect of βA supplementation on performance of 800 m, resistance activity, OBLA, time, and exercise volume. It seeks to answer whether the possible reduction of lactate after training improves performance with βA. Is it dependent or not?

Materials and Methods

Subjects

The study included 20 male athletes between the ages of 18 and 25 who routinely attended three football practice sessions each week. The athletes had not taken any supplements or performance-enhancing drugs in the past 3 months. First, in the briefing session, the subjects were introduced to the type of plan, goals, and method of its implementation in writing and orally. Subjects were then reassured that the information received from them would remain completely confidential, and a coding method was used to examine the data. They were allowed to withdraw if they did not wish to continue cooperating. Subjects consciously signed a written consent form and completed questionnaires of personal information and medical and sports records. In the present study, the provisions of the Research Ethics Statement of Kurdistan University, the principles of the Helsinki Declaration, and the rules of medical ethics have been fully observed. Subject characteristics are summarized in Table 1.

Experimental design

This study was performed as a randomized, double-blind, placebo-controlled study by the pretest–posttest method. Subjects were divided into βA supplement groups and placebo into equal pairs based on the time of 800 m. Blood lactate concentration and performance of footballers were evaluated before and after the test. Subjects were asked to abstain from exercise 24 h before the start of the test session. One week before the beginning of the test, their anthropometric characteristics and a maximum repetition (1RM) were measured in chest press and leg press movements. Athletes received a βA or placebo supplement of 6 g per day (4 × 1.5-g doses) for 4 weeks. Before and after 4 weeks of taking βA and placebo supplements, the subjects participated in 800 m running tests and resistance activities (including 1 set of chest presses and foot presses with 75% intensity of 1RM with the number of repetitions up to fatigue).[21] Before the activity, the subjects performed 5 min of warm-up and 5 min of dynamic stretching movements, and after the test, they had a cooling program of 5–10 min.

Method of collecting blood samples and preparing plasma

Blood was taken from the subjects to collect blood samples before, immediately, and 15 min after 800 m. At each stage of blood sampling, 2–4 cc of blood was taken from each subject in a sitting position from the arm vein by a laboratory specialist, and it was centrifuged at 2500 rpm for 15 min. Isolated plasmas were measured immediately using a lact2 kit (Lactate Scout, SensLab GmbH, Leipzig, Germany) for lactate concentration.

Supplementation

During the study, individuals were asked to refrain from taking other supplements or change their regular dietary and exercise patterns. Participants were randomly assigned to receive β-alanine or a placebo in a double-blind manner. Supplements were provided to the participants in identical, unmarked, sealed containers supplied by Athletic Edge Nutrition, Miami, Florida. Subjects received βA supplement (6.0 g·d-1 βA, 600 mg N-Acetylcysteine, 2.7 mg alpha-lipoic acid, 45 IU Vitamin E) or a PL (6.0 g·d-1 Rice Flour Maltodextrin).[22] Both groups took the same supplement protocol, four capsules four times a day for 4 weeks, with adequate meals and water.[17]

Statistical analysis

Data values are expressed as the mean ± standard error of the mean.[23] The repeated-measures analysis test was applied to clarify significant differences between the groups. The Bonferroni *post hoc* test was used to compare lactate levels in the supplement and placebo groups in three periods before, immediately, and 15 min after the activity. A correlated *t*-test was used to analyze the pretest and posttest performance data. All analyses were conducted using SPSS version 25.0 (SPSS Inc., Chicago, Ill., USA) and GraphPad Prism 8.4 software

Table 1: Mean and standard deviation of descriptive characteristics of subjects

Group	Number (person)	Age (years)	Weight (kg)	Height (m)	BMI (kg/hm^2)
Supplement	10	21.5±2.06	61.9±5.93	1.69±5.04	21.63±2.20
Placebo	10	21.20±2.09	65±7.46	1.74±5.53	21.16±1.60

BMI: Body mass index

programs (GraphPad Software Inc., San Diego, CA, USA). The statistical significance level was set at ($P \leq 0.05$).

Results

The values of descriptive, anthropometric, and measured variables are also presented in Table 2 as mean and standard deviation.

Table 2: Mean and standard deviation of research variables

Variable	Group	Mean±SD
1RM chest press (pretest) (kg)	Supplement	52.66±10.86
	Placebo	57.9±8.23
1RM chest press (posttest) (kg)	Supplement	60.44±12.51
	Placebo	67.10±9.94
Training volume of chest press (pretest) (kg)	Supplement	487.44±89.43
	Placebo	495.85±75.58
Training volume of chest press (posttest) (kg)	Supplement	473.77±63.93
	Placebo	428±98.15
1RM leg press (pretest) (kg)	Supplement	174.45±68.93
	Placebo	160.65±30.44
1RM leg press (posttest) (kg)	Supplement	283.80±67.34
	Placebo	293.20±56.09
Leg press training volume (pretest) (kg)	Supplement	2995±1126.23
	Placebo	3104.15±1159.48
Leg press training volume (posttest) (kg)	Supplement	2350.60±676.18
	Placebo	2570.50±968.79
800 m running time (pretest) (s)	Supplement	159.66±10.68
	Placebo	160.41±9.23
800 m running time (posttest) (s)	Supplement	158.73±12.47
	Placebo	164.41±10.81
Pretest lactate (before activity) (mmol/l)	Supplement	3.54±0.58
	Placebo	3.24±0.48
Pretest lactate (immediately after activity) (mmol/l)	Supplement	16.24±1.05
	Placebo	16.95±1.84
Pretest lactate (15 min after activity) (mmol/l)	Supplement	13.55±2.76
	Placebo	15.04±2.62
Posttest lactate (before activity) (mmol/l)	Supplement	3.38±0.62
	Placebo	2.87±0.58
Posttest lactate (immediately after activity) (mmol/l)	Supplement	16.61±2.32
	Placebo	15.67±2.79
Posttest lactate (15 minutes after activity) (mmol/l)	Supplement	11.98±1.40
	Placebo	13.68±2.03

SD: Standard deviation, 1RM: one-repetition maximum

The effect of beta-alanine supplementation on blood lactate concentration

The results of the analysis of the variance test with repeated measurements for the average lactate levels are significant in terms of time ($P < 0.05$), but the interaction effect of time × group ($P > 0.101$) and the intergroup effect ($P > 0.428$) are not significant. It can be said that there is a statistically significant difference in lactate levels before, immediately after the test, and 15 min after it in both supplement and placebo groups [$P < 0.05$; Table 3].

The effect of beta-alanine supplementation on training volume in chest press activity

The results of the analysis of variance with repeated measurement for the average exercise volume in chest press showed the effect of time ($P > 0.283$), the interaction effect of time × group ($P > 0.471$), and the intergroup effect ($P > 0.733$). It is not statistically significant [$P > 0.05$; Table 4].

The effect of beta-alanine supplementation on 1RM chest press

The results of the analysis of the variance test with repeated measurements for the mean RM1 of chest press showed that the effect of time ($P > 0.001$) is statistically significant. Still, the interaction effect of time × group ($P < 0.695$) and the between-group effect ($P \geq 0.199$) is not statistically significant. It can be said that there is a significant difference in 1RM chest press in the pretest and posttest in both supplement and placebo groups [$P > 0.05$; Table 5].

The effect of beta-alanine supplementation on training volume in leg press activity

Based on the results of variance analysis with repeated measurement for the average training volume of leg press activity, it can be said that the effect of time ($P < 0.032$) is statistically significant. The interaction effect of time × group ($P > 0.471$) and the intergroup effect ($P > 0.733$) are not statistically significant. It can be said that there is a significant difference in leg press volume in the pretest and posttest in both supplement and placebo groups [$P > 0.05$; Table 6].

The effect of beta-alanine supplementation on 1RM leg press

According to the results of the analysis of variance with repeated measurement for the mean 1RM foot press, it can be said that

Table 3: The results of repeated measures analysis of variance for mean lactate levels

Source	Sum of squares	df	Mean square	*F*	Significant	Partial Eta squared
Between groups						
Group	3.899	1	767.143	0.659	0.428	0.035
Error	106.493	18	5.916	-	-	-
Intergroup						
Time	3835.716	5	767.143	264.244	0.001*	0.936
Time × group	30.469	3.452	8.834	2.101	0.101	0.105
Error	2099.35	27	77.754	-	-	-

*Significance level $P \leq 0.05$

Table 4: The results of analysis of variance test with repeated measurement for exercise volume in chest press

Source	Sum of squares	df	Mean square	*F*	Sig	Partial Eta squared
Between groups						
Group	3307.937	1	3307.933	0.121	0.733	0.007
Error	217,442.512	17	12,790.736	-	-	-
Intergroup						
Time	15,738.080	1	15,738.080	1.230	0.283	0.067
Time × Group	6953.290	1	6953.290	0.544	0.471	0.031
Error	217,442.513	17	217,442.736	-	-	-

Table 5: The results of the analysis of the variance test with repeated measurement for the mean 1RM of chest press

Source	Sum of squares	df	Mean square	*F*	Significant	Partial Eta squared
Between groups						
Group	334.766	1	334.766	1.787	0.199	90.095
Error	3184.444	1	187.320	-	-	-
Intergroup						
Time	682.685	1	682.685	22.598	0.001	0.936
Time × Group	4.791	1	4.791	0.159	0.695	0.009
Error	513.578	17	30.210	-	-	-

*Significance level $P \leq 0.05$. 1RM: One-repetition maximum

Table 6: The results of analysis of variance test with repeated measurement for the average volume of leg press exercise

Source	Sum of squares	df	Mean square	*F*	Sig	Partial Eta squared
Between groups						
Group	3307.933	1	3307.933	1.787	0.733	0.007
Error	466,608.290	17	27,447.546	-	-	-
Intergroup						
Time	15,738.080	1	15,738.080	1.230	0.032*	0.067
Time × Group	6953.290	1	6953.290	0.544	0.471	0.031
Error	217,442.513	17	12,790.736	-	-	-

*Significance level $P \leq 0.05$

the effect of time is statistically significant ($P \geq 0.001$). The interactive effect of time × group ($P > 0.307$) and intergroup effect ($P > 0.926$) is not statistically meaningful. It can be said that there is a significant difference in leg press 1RM in the pretest and posttest in both supplement and placebo groups [$P < 0.05$; Table 7].

The effect of beta-alanine supplementation on 800 m running time

According to the results of the analysis of variance with repeated measurements for the average time of two 800 m, it can be said that the effect of time ($P \geq 0.118$) and the intergroup effect ($P \geq 0.509$) are not statistically significant. While the effect of the time × group interaction ($P \geq 0.017$) is statistically significant [$P \geq 0.05$; Table 8].

Discussion

The results of the present study showed that the lactate levels increased immediately after the 800-meter running activity following 4 weeks of βA supplementation in both the supplement and placebo groups. No statistically significant difference was observed between them, while after 15 min after the two 800 m, the concentration of lactate in the supplement group was significantly reduced compared to the placebo group [Table 8]. The results of the present study were in line with the results of the research of Perim *et al*.(2019) and Huerta *et al*.(2020),[24,25] While it was inconsistent with the research results of Freitas *et al*.(2019).[26] One of the reasons for the inconsistency can be pointed to the type of activity used in the study of Rossi *et al*.; in that study, the implementation of high-intensity interval activity (HIIA) after a period of resistance training, 28 days of βA supplementation had a significant effect on strength. The lower body had no resistance in men after a period of training. Another reason for the discrepancy between the results of the current research and the results of previous research is the period of supplementation. So that most of the studies showed performance improvement due to the long-term use of βA supplementation for longer periods.[16] Previous research has shown that βA supplementation (e.g., 2.3 g/day to 4.6 g/

Table 7: The results of the analysis of variance test with repeated measurements for the mean 1RM leg press

Source	Sum of squares	df	Mean square	*F*	Sig	Partial Eta squared
Between groups						
Group	48.400	1	48.400	0.009	0.926	0.000
Error	98,332.215	18	187.320	-	-	-
Intergroup						
Time	146,289.025	1	146,289.025	120.133	0.001*	0.870
Time × Group	1345.600	1	1345.600	1.105	0.307	0.058
Error	21,919.015	18	1217.723	-	-	-

*Significance level $P \leq 0.05$. 1RM: One-repetition maximum

Table 8: The results of the analysis of the variance test with repeated measurements for the average running time of 800 m

Source	Sum of squares	df	Mean square	*F*	Significant	Partial Eta squared
Between groups						
Group	103.362	1	103.362	0.456	0.509	0.025
Error	4092.546	18	227.364	-	-	-
Intergroup						
Time	23.409	1	23.409	2.698	0.118	0.130
Time × Group	60.614	1	60.614	6.986	0.017*	0.280
Error	156.179	18	8.677	-	-	-

*Significance level $P \leq 0.05$

day for 2–10 weeks) increased muscle carnosine levels at higher doses.[27] A recent review of the ergogenic benefits of βA supplementation suggests that exercise bouts of 1–3 min provide the most significant benefit over shorter bouts.[28]

In general, βA supplementation did not significantly affect blood lactate concentration immediately after exercise. In contrast, it significantly reduced blood lactate concentration during the recovery period after exercise. In 15 min after two 800 m, a greater decrease in blood lactate levels was observed in the supplement group than in the placebo group.[29] It has been suggested that an increase in muscle carnosine levels may lead to an increase in muscle buffering capacity, thus improving performance by limiting the accumulation of hydrogen ions (H+).[29]

In the present study, the performance of athletes, including the training volume of chest press and leg press, was not significantly different in any of the supplement and placebo groups. The mean 1RM of chest and leg press in both groups of the present study had a significant increase in the posttest compared to the pretest [Tables 5 and 7]. In some studies, researchers investigated the effect of βA supplementation on sports performance, which showed that βA supplementation in the long term leads to improved sports performance in participants.[16] In contrast to these findings, Glenn *et al*.(2015) showed that high-dose βA supplementation had no significant effect on peak anaerobic power in elite cyclists.[16]

In the present study, the time of two 800 m in the supplement group showed a decrease after 28 days of receiving the supplement. Still, it was not statistically significant, while in the placebo group, the time component of two 800 m increased significantly in the posttest. It seems that 4-week supplementation did not significantly affect athletes' performance. As previously mentioned, the results of most studies have proven supplementation for more than 4 weeks on performance.[13] Long-term supplementation of βA by increasing muscle carnosine levels and thereby buffering lactic acid delayed fatigue and thus improved anaerobic performance in people.[24]

In the present study, despite the lack of significant difference in the training volume of chest press and leg press, the average 1RM of leg press and chest press increased significantly in the posttest compared to the pretest. This average increase can probably be due to the pH regulation capacity of βA supplementation.[30] A recent study showed that βA supplementation improves the number of repetitions performed in moving a weight equal to 65% of 1RM.[31] These findings indicate that this supplement increases the amount of work performed in a training session and supports the results of Hoffman *et al*. of increased exercise volume in a strength training program compared to placebo after βA supplementation.[32] However, in the present study, there was no significant difference in the exercise volume of leg press and chest press in any of the groups.

Conclusion

It can be said that βA supplementation significantly reduces lactate levels during recovery in soccer players, and probably soccer players can experience reduced fatigue and improved recovery time by taking βA supplements with a similar dose.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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