

Research Article

Effect of beta-alanine supplementation on carnosine amount and muscle strength of the upper and lower extremities of bodybuilding athletes

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Abstract

Background: The purpose of the present study is to investigate the effect of one session of exhaustive activity with supplementation of beta-alanine on the level of carnosine and muscle strength of upper and lower extremities of bodybuilding athletes.

Materials and Methods: Twenty bodybuilders were randomly divided into two equal groups of 10 who were taking supplemental beta-alanine and placebo. The experimental group consumed beta-alanine for 21 days and the placebo group received dextrose. The level of carnosine and muscle strength of the upper and lower extremities were measured before and after supplementation. Blood sampling was done before and after supplementation after session of exhaustive workout. Paired t-test and ANCOVA were used for data analysis using SPSS 21 software at a significant level ($p < 0.05$).

Results: The results of paired t-test showed that in all three variables of lactate, carnosine and growth hormone only in the beta-alanine group, a significant change was observed between pre-test and post-test ($P < 0.05$). And amount of these variables in the post-test showed a significant difference compared to the pre-test. Also, ANCOVA test results indicated that there was a significant difference between the two groups of beta-alanine and placebo in all three variables ($P < 0.05$).

Conclusion: Beta-alanine supplementation with an exhaustive exercise session increases the level of carnosine in blood and hence increases the fatigue tolerance of bodybuilding athletes and ultimately improves the muscle strength of the upper and lower extremities of athletes and bodybuilders. Therefore, bodybuilders can use this supplement to improve their performance.

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1. Introduction

In high-intensity activities, the energy consumption of muscle cells may increase by more than 100 times (1), which requires more energy than what is supplied by the capacity of the aerobic system; as a result, the muscle cells tend to increase their energy needs through an anaerobic system. Although this system responds somewhat to the need for energy during intense activity, many factors such as accumulation of metabolites, as well as loss of substrate reserves, will result in muscle fatigue and loss of performance (2,3). So far, many physiological factors have been expressed in recognizing and justifying the function of this system, in which the role of acidic-basic equilibrium seems significant. In a way that energy outflow reduction of the anaerobic system, and consequently the athlete's decline in performance, is considered to be largely due to the decrease in the pH of the cell and its environment. Therefore, it seems that the use of methods that helps to maintain the stability of the acidic-basic balance can, by delaying the process of muscular fatigue, make the athlete more active at a higher intensity and lead to the athlete's functional development (4). Metabolic acidosis caused by activity is one of the most important factors affecting muscle performance during high intensity activities (5); hence, a group of supplements and substances that contribute to delaying or reducing fatigue have been welcomed by athletes, including beta-alanine supplements, due to controversial findings reported about its effect on exercise fatigue. Due to the specific role of beta-alanine as a carnosine substrate (the main contributor to H⁺ buffering during high intensity exercise), the use of beta-alanine has become commonplace as an ergogenic assistant of athletic performance (6).

Beta-alanine is an unnecessary acid that is synthesized by the bacteria in the intestine due to the breakdown of the pyrimidine chain and the de-carboxylation of L Aspartate (7, 8). Research shows that in the pathway for the synthesis of carnosine, the concentration of beta-alanine as a substrate can play a limiting role (9). Therefore, its use as a dietary supplement with the aim of increasing the substrate to produce carnosine and counteracting metabolic acidosis resulting from activity, and therefore increasing exercise performance and increasing fatigue resistance seems logical; for example, Varanoske et al in their research to investigate the effect of beta-alanine consumption on performance, and blood carnosine in men and women, concluded that beta-alanine use can improve performance, increase blood carnosine levels and postpone fatigue, and increase the athlete's tolerance to increase exhaustion time (10). On the other hand, Van et al (2) examined 10 weeks of resistance training with beta-alanine on peak performance, fat mass index and hypertrophy. At the end of 10 weeks, there was no change in power peak in Scott's movements and chest press, but there was a significant change in hip and breast hypertrophy (2). Therefore, in this study, researchers are looking for an answer to the question, whether the use of beta-alanine affects the level of blood carnosine and the performance of bodybuilders after a session of exhausting activity?

2. Materials and Methods

Subjects

This is a quasi-experimental study with pretest-posttest design including experimental group supplemental beta-alanine consumption and placebo group, placebo consumption. The statistical population of the present study are athletes referring to gyms in 4 regions north, south, east and west of Shahre Ray, who have a history of at least 2 years of resistance exercise, including 20 athletes available according to the criteria for entry and exit, randomly divided into experimental and placebo groups. After identifying the research samples based on the criteria for entry and non-entering the research and random division into two groups (Each group includes 10 people). Required explanations were given about the stages of the research, and the voluntary and informed participation consent form was signed by research subjects. For the purpose of pre-test measurements, the samples were requested to be present at the gym according to the timetable. After attending the subjects, the initial information form was completed by them and then anthropometric measurements were performed from each person.

Exercise protocol

The subjects performed their resistance exercises 20 days, under the supervision of the investigator, according to the general practice protocol set out in Table 1. Before supplementing and practicing, the subjects performed an exhausting activity session that included chest press and leg press movements in three sets with

an intensity of 70 to 75% of a maximum repetition until exhaustion was achieved. The rest between sets was 90 and between movements was 3 minutes (11). Immediately after a exhaustive activity session, blood samples were taken at a rate of 5 cc. 1RM test of squat movements and chest press were used to measure the strength of the muscles of the lower and upper limbs. In this way, the subject first chooses a light weight and performs the movement, then according to the subject's strength, each time some weight is added to the barbell until the other person cannot perform the movement, which in 4 to 6 movements of the subjects to They reached their maximum repetition. Between each movement, the subjects rested for two minutes (12).

Then, the daily dose of 6 g of beta-alanine supplement (3 g before and 3 g after exercise) was given to the supplement group for 20 days (13), and the placebo group received 6 g of dextrose powder daily in packages similar to beta-alanine packages. The subjects of the present study performed chest press and leg press movements on the 20st day similar to an exhausting exercise session before receiving beta-alanine, and the second blood sample was performed immediately after exhausting exercise (14).

Statistical analysis

the two groups, as in the pre-test, were followed up in the post-test. Shapiro Wilk test was used to test the normality of data. Then the paired t-test was used to compare the results of intra-group and covariance analysis to compare the results between the groups of the means. All statistical analyzes were performed at the significance level of 0.05 and using SPSS version 20 software.

3. Results

Anthropometric characteristics of the subjects are presented in Table 2. The results showed that the subjects are normal in terms of anthropometric characteristics. To compare the difference in mean in one group, paired t-test was used. Table 3. Results showed that there was a significant difference between the pre-test and post-test groups in all three variables in the beta-alanine group ($P < 0.05$). In order to compare the difference between upper and lower limb muscle strengths and carnosine in both groups, the covariance analysis test was used, the results of the test were reported in Table 4. The results of the covariance analysis showed that there was a significant difference between the two groups on muscle strength and carnosine level in athletes ($P < 0.05$).

Table 1: Table 1. General Resistance Exercises for 20 day

Session pre week	Movement	No. of Turn & Repetition	Intensity
First session	Bench Press	8-8- 10-12	70 to 75% 1RM
	Pull Ups	6×4	70 to 75% 1RM
	Lateral Raises	8-8-10-12	70 to 75% 1RM
	Biceps Curl	10-12-12	70 to 75% 1RM
	Pulling Row	8-8-10-12	70 to 75% 1RM
	Dumbbell Triceps Extension	8-10-12	70 to 75% 1RM
	Crunch	20×4	70 to 75% 1RM
Second session	Leg press	8-10-12-12	70 to 75% 1RM
	Leg Extension	8-10-12	70 to 75% 1RM
	Back Extension	8-10-12-12	70 to 75% 1RM
	Lungs	(8-10-12) RL (8-10-12)	70 to 75% 1RM
	Box Squat (go up)	L (20×5) R (20×5)	70 to 75% 1RM
	Hug Squat	8-8-10-12	70 to 75% 1RM
Third session	Bench Press	8-10-12	70 to 75% 1RM
	Lateral Raises	8-10-12	70 to 75% 1RM
	Biceps Curl	8-10-12-12	70 to 75% 1RM
	Pulling Row	8-10-10-12	70 to 75% 1RM
	Leg Press	8-8-10-12	70 to 75% 1RM
	Leg Extension	8-10-12	70 to 75% 1RM
	Back Extension	8-10-12	70 to 75% 1RM

Table 1. Anthropometric characteristics of subjects

Variable	Beta-alanine	Placebo
Age	0.65 ± 29.30	± 1.47 28.23
Weigh (kg)	0.21 ± 85.33	2.56 ± 86.80
Height	1.32 ± 180.62	2.44 ± 182.51

Table 3. covariance analysis for inter-group differences

Variable		Placebo	Beta-alanine	Sig.
Carnosine (ng/L)	Pre-test	15.04±5.7	13.54±0.29	0.000*
	Post-test	13.77±0.93	20.93±0.55	
Lactate(mmol/L)	Pre-test	0.95±0.1	0.94±0.26	0.000*
	Post-test	9.2±0.26	4.37±0.19	
Muscle Strength of Upper Limbs ((Chest Press	Pre-test	73.1±1.52	73.7±2.35	0.059
	Post-test	73.8±3.11	76.4±4.16	
Muscle Strength of Lower Limbs ((Foot Press	Pre-test	80.7±1.33	81±0.81	0.000*
	Post-test	76.4±4.16	83±2.04	

* Significance level (P ≤ 0.5) was considered

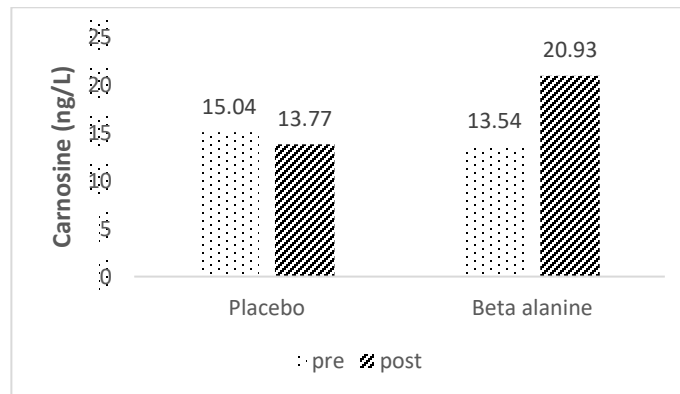


Figure1. Comparison of the mean carnosine pre- and post-supplementation

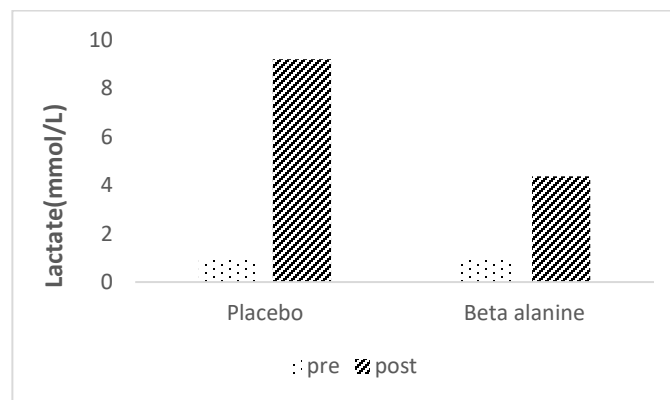


Figure2. Comparison of the mean lactate pre- and post-supplementation

4. Discussion

The purpose of this study was to investigate the effect of one session of exhaustive activity and supplementation of beta-alanine on the level of carnosine and muscle strength of the upper and lower extremities of athletes. The results showed that all of the variables in the post-test showed a significant difference compared to the pre-test ($P < 0.05$) only in the experimental group. Also, there was a significant difference between the experimental and placebo groups in all variables ($P < 0.05$). The findings of the present study are consistent with the findings of Kendrick et al (15), Hoffman et al (16), Van et al [2], regarding increase of carnosine but are inconsistent with the results of Kern et al (17) and Black et al (18). Perhaps this inconsistency is related to the exercise protocol, the number of sessions per week and the length of the course, the age of the subjects, the type of subjects, and the amount of supplements consumed. The subjects of the study were bodybuilding athletes who had a resistance training during the past year. The daily supplementary dose was 6 grams and the duration of the test was 21 days. While subjects from different research groups were athletes from different disciplines and non-athletes, and the supplementation rate was from 2.8 g to 6 g per day. In their study, Black et al (18) investigated the effect of beta-alanine use in 28 days on muscle pH and muscle strength during high intensity exercises, and concluded that the supplementation of beta-alanine does not have a significant effect on the level of muscle carnosine and inner-muscle pH and performance during high intensity exercises; however, it prevented blood pH decrease and increased the performance by about 2-3% during circular exercises, but these changes were not statistically significant (18). There were also many individual differences in the amount of carnosine in response to beta-alanine intake.

One of the main reasons for the differences between studies, are consumption doses and different strategies for beta-alanine use (19-21). Lilly et al (22) concluded in their review that supplementation of beta-alanine for up to 2 weeks could lead to an increase in the level of carnosine in the muscles, which may promote athlete's performance as well. However, due to the fact that carnosine is synthesized in muscle and other tissues from the alanine-histidine and carnosine synthase, and since this enzyme is more likely to be combined with histidine and the concentration of histidine in the exercised muscles is higher than that of alanine, it is clear that carnosine synthesis is higher in the presence of Beta-alanine because a combination of both enzymes is found in exercised muscles (23). In previous studies, it has been shown that in intensive exercises, carnosine increase is due to an increase in the number of pairing of actin and myosin proteins, and ultimately the optimal action potential, while increasing carnosine in prolonged and continuous resistance exercises due to stimulate the use of muscle fibers and maintenance of fibrous muscle levels and leads to increase of carnosine (24). Therefore, increasing the amount of carnosine in the muscles of the subjects of the present study can be attributed to their history of resistance training [at least one year] and stimulation of the use of muscle fibers and beta-alanine consumption. The findings of this study were consistent with the findings of Stoot et al (4). Harris et al (25), regarding the effect of beta-alanine supplementation on the strength of athletes. On the other hand, they were inconsistent with findings of Kendrick et al (15), Smith et al (26).

In general, the lack of inconsistency may have been in the exercise program, the number of sessions, the involved muscle group, the diet, the sex of the subjects, the age of the subjects, the type of muscle intramuscular, and the amount consumed. Smith et al (26) examined the effect of 8 weeks of supplementation of beta-alanine in intensive exercises on muscular neural fatigue, strength peak, body composition, and hypertrophy. At the end of 8 weeks, no changes in body composition and muscle hypertrophy were observed. Kwang et al reviewed 10 weeks of supplemental beta-alanine supplementation with resistance training on peak power indexes, fat mass index and hypertrophy. At the end of 10 weeks, there was no change in power peak in Scott's and Chest's movements; there was no change in fat mass index, but significant changes were observed in the hypertrophy of the chest and thigh muscles (6). The exact mechanism of hypertrophy and subsequent changes to increase the power of beta-alanine supplements and resistance training is precisely unrecognized. However, probably due to the fact that supplements of beta-alanine, is an amino acid and structure of skeletal muscle are forced by the amino acid and carnosine in supplements as an enzyme helps to increase protein synthesis in skeletal muscle and also the absorption of beta-alanine in muscle through transporters of amino acid Chloride and sodium is intracellular. This mechanism as an infrastructure for transporting beta-alanine increases energy metabolism and cellular mobility, and subsequently increases the level of contractile proteins of actin and myosin in myositis, which confirms the effect of muscle hypertrophy (4). There is also the presence of histidine as a vital role in protein synthesis in the liver and in exercise and resistance exercises that require coordination of muscle neurons as a transducer

of nerve signals from the myelin sheath and increased concentration and decreased fatigue (27), increased exercise volume and compatibility in resistance exercises. These adaptations and increased exercise volumes will preserve glycogen reserves and increase protein levels in the muscles, and this performance in continuous and prolonged exercises results in compatibility of physiological conditions and muscle hypertrophy and, subsequently, increased power (4). Although the study period was 21 days and 21 days of resistance training cannot result in hypertrophy, among the limitations of the present study we can refer to the lack of placebo group that without resistance training, has a beta-alanine intake which could have been helpful in case of selection of a placebo group without resistance training and comparing the effect of resistance training together with consumption of beta-alanine supplement; therefore, further research is needed to determine whether a session of resistance training of supplemental beta-alanine training can affect hypertrophy and the potency of growth factors.

5. Conclusion

Finally, the supplementation of beta-alanine with an exhaustive exercise session increases the level of blood carnosine and hence increases the fatigue tolerance of bodybuilding athletes and ultimately improves the muscle strength of the upper and lower extremities of bodybuilding athletes, and athletes can use this supplement to improve their performance.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval the research was conducted with regard to the ethical principles (Ethic Code: IR.SSRC.REC.1398.134).

Informed consent Informed consent was obtained from all participants.

Author contributions

Conceptualization: A.A., SH.R.M.; Methodology: A.A., SH.R.M.; Software: A.A., S.K.M.S.; Validation: A.A., SH.R.M.; Formal analysis: A.A., S.K.M.S.; Investigation: A.A., SH.R.M.; Resources: A.A., SH.R.M.; Data curation: A.A., SH.R.M.; Writing - original draft: A.A., SH.R.M.; Writing - review & editing: A.A., SH.R.M., S.K.M.S.; Visualization: SH.R.M.; Supervision: SH.R.M.; Project administration: A.A.; Funding acquisition: A.A., SH.R.M.

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