

Effects of beta-alanine supplementation on exercise performance during a competitive wrestling season: An 8-week open label study

Benjamin D. Kern*
Physical Education Department
Center High School
500 S. Broadway
Center, Colorado 81125
USA
Email: bkern@center.k12.co.us

Tracey L. Robinson
Department of Human Performance and Physical Education.
Adams State College
208 Edgemont
USA
Email: trobins@adams.edu

Anssi H. Manninen
Advanced Research Press, Inc.
690 Route 25A
Setauket, New York 11733
USA
Email: anssi.manninen@gmail.com

*Corresponding author

Abstract

Background

The goal of wrestlers during a competitive season is to maintain or lose body weight without compromising athletic performance. However, some studies have reported decrements in exercise performance associated with weight loss and/or the strain of a competitive season. The purpose of this study, therefore, was to examine the effects of 8 week beta-alanine (β -ala) supplementation on exercise performance in Division II collegiate wrestlers during a competitive season.

Methods

25 college wrestlers (age 18 to 22 y) volunteered to participate in this study, and 18 subjects (mean BMI 24.7 ± 3.7) completed the study. Each participant ingested 4 g/d of β -ala in an open-label manner during the final eight weeks of their competitive season. The subjects followed a standard training protocol for collegiate wrestling as dictated by the head coach. They were also required to maintain uniform body mass during the entire eight weeks, as per weight bracket allowance during the competitive season. Before and after supplementation, subjects performed a 400 m sprint and 90 degree flexed-arm hang to exhaustion. Immediately prior to and following the pre treatment and post treatment 400 m sprint, subjects blood lactate was taken via finger stick and analyzed to determine lactate increase during the 400 m sprint.

Results

The subjects showed significant decrease ($p < 0.01$) in 400 m sprint time ($- 3.5 \text{ s} \pm 3.3 \text{ s}$, mean \pm SD) and significant increase ($p < 0.01$) in 90 degree flexed-arm

hang ($+ 8.5 \text{ s} \pm 14.6 \text{ s}$, mean \pm SD). No significant change ($p > 0.05$) in blood lactate values were observed.

Conclusion

The results of our study suggest that supplementation of β -ala may improve exercise performance in wrestlers during a competitive season. Because of the design of this experiment, it is impossible to identify exactly how much of the positive effects experienced by the subjects was a direct result of the supplementation. However, due to the large increase in performance and the similarity of results in comparison to other β -ala studies, we feel our study strongly suggests efficacy of β -ala supplementation. The ergogenic effects of β -ala supplementation during a competitive wrestling season needs to be confirmed in placebo-controlled trials.

Keywords: ergogenic aids, dietary supplements, sports nutrition, carnosine, lactate, wrestling

Background

Ergogenic aids, or substances and methods that enhance exercise performance, are as ancient as sports themselves. Nutritional ergogenic aids are known from ca. 500-400 B.C., when athletes and warriors used products such as deer liver and lion heart to impart certain performance benefits [1]. In modern times, athletes have focused on “high-tech” dietary supplements, such as creatine monohydrate [2] and post-exercise recovery drinks [3]. The latest addition to our ergogenic arsenal appears to be β -alanine (β -ala) [6-9,20], a nonessential amino acid that is found in many foods we eat. Recent studies have demonstrated that oral β -ala supplementation increases muscle carnosine content by ~ 60 -80% [10,11]. Carnosine, a dipeptide composed of the amino

acids beta-alanine and histidine, has anti-fatigue properties, which are likely related to its ability to buffer increased muscle acidity following high-intensity exercise [4]. High H^+ concentration is thought to play a key role in muscular fatigue.

Sprinting distances of 400 m to 800 m closely mimics the metabolic demands experienced during a collegiate wrestling match, and could be considered anaerobic in nature. Likewise, the intensity of muscle contraction required to hang from a bar with elbows flexed at 90° is similar to that of holds performed by wrestlers during a match, and when performed to failure, is highly anaerobic (20 s to 2 min). In order to be successful, wrestlers must maintain or lose bodyweight throughout the competitive season without compromising athletic performance. However, extreme weight reduction methods commonly used by competitive wrestlers [5,28] and the physical demands of training throughout the competitive season [29] tend to impair exercise performance.

The purpose of this study was to examine the effect of 8 week β -ala supplementation on 400 m sprint time, 90° flexed-arm hang time, and blood lactate accumulation (during 400 m sprint) of Division II collegiate wrestlers during a competitive season. Our study did not utilize a placebo controlled design due to the fact that the subjects were involved in their competitive season.

Methods

Subjects

25 NCAA Division II collegiate wrestlers (age 18 to 22 y) volunteered for this study, and 18 completed the study (Mean BMI 24.7 ± 3.7). 5 subjects did not complete the study due to attrition from the wrestling team, while 2 subjects

could not complete the testing due to injury. The school's Institutional Review Board approved all procedures prior to the initiation of the study. Each subject was informed of potential risks of participating in the study and gave written consent before participation. No subjects reported using sport supplements or other performance enhancing substances.

Nutritional Protocols

During the study, subjects were asked to maintain their current diet and abstain from using any dietary supplements or medications. They were also required to maintain uniform body mass during the entire eight weeks, as per weight bracket allowance during the competitive season. Following pre-testing, subjects were issued a 4 week supply of a β -ala supplement (IntraXCell, Athletic Edge Nutrition, Miami, FL), and a folder containing an 8 week dosing register, and an 8 week journal template with 2 entries per week. A daily serving (6 capsules) of this supplement provided 4 g of β -ala, a 402 mg proprietary blend of N-acetylcysteine/ α -lipoic acid, and 15 mg of vitamin E (d-alpha tocopherol acetate). Subjects were issued the second 4 week supply of the β -ala supplement following the first 4 weeks of the supplementation period. Subjects were instructed to ingest 6 capsules of the β -ala supplement per day, in three equal doses (i.e., 2 capsules 3 times daily), and record the exact day and time of dose in the dosing register.

Exercise Protocols

In both pre and post testing, subjects were encouraged to run as fast as possible in the 400 m sprint and hang as long as physically possible during the flexed-arm hang. All tests were administered by the same technicians in both pre and post testing, and identical protocols were followed in each, including time of day and day of the week. Prior to sprinting continuously 400 m, subjects' resting blood lactate was taken via lactate test strip analyzer (Accusport

Portable Lactate Analyzer). Subjects were timed in the 400 m sprint using a hand held stopwatch. Immediately following the 400 m sprint, subjects' blood lactate was again taken using identical procedure and equipment as before the sprint.

Approximately 7 hours after testing 400 m sprint and blood lactate, subjects were required to hang from a straight 1 ¼" diameter bar. Subjects were instructed to use an underhand grip and maintain 90° flexion at the elbow joint for as long as possible. The degree angle was ensured by the technician's visual assessment. This was aided by using a 6" triangle square placed on the subject's flexed elbow and drawing two perpendicular lines at 90° on the subjects arm with permanent marker. This method is consistent with the research conducted by Clemons et al. indicating the undergrip 90° flexed-arm hang as a valid test of weight-relative strength, and "eyeballing the 90° angle" as a reliable test-retest practice [21]. The subjects' time started at the moment the body was suspended and ceased the instant 90° elbow flexion was compromised. Time was measured using a hand held stopwatch.

Statistical Analysis

Mean and standard deviation were calculated for change in lactate during the 400 m sprint (LAD), 400 m sprint time, and 90° flexed arm hang time. The mean of each descriptive statistic was tested for significance from pre to post test using a dependent t-test. Significance was accepted at a level of $p \leq 0.05$.

Results

Mean 400 m sprint time during the pretest was 68.24 seconds \pm 3.523 seconds and the mean 400 m sprint time during the posttest was 64.82 seconds \pm 3.370 seconds (Figure 1) This change was accepted as significant with $p = .000$.

Mean flexed-arm hang time in the pretest was 58.48 seconds \pm 3.184 seconds and mean flexed-arm hang time posttest was 67.00 seconds \pm 3.888 seconds (Figure 2) This change was also accepted as significant with $p = .000$. Mean LAA during the pretest was +2.964 mmol/l \pm 2.335 mmol/l and mean LAA during the posttest was +2.975 mmol/l \pm 1.978 mmol/l (Figure 3) This change was determined to be non-significant, as $p = .791$. One subject reported frequent gastrointestinal discomfort during the supplementation period. However, it is unclear whether supplementation contributed to this condition.

Discussion

Collegiate and other competitive wrestlers often utilize calorie restriction and dehydration in order to manipulate body weight for the purpose of qualifying in their respective weight allowance bracket. Collegiate wrestling places great strain on the musculoskeletal system throughout a competitive season. Extreme weight reduction/maintenance practices [5,28] combined with the strain of a competitive wrestling season [29] tends to decrease athletic performance, often quite dramatically. Despite the fact that our subjects were examined during the competitive season, the results indicated clear improvements in wrestling-related performance tests, including 400 m sprint and 90° flexed arm hang time. 400 m sprint closely mimics the metabolic demands experienced during a collegiate wrestling match. Likewise, 90° flexed-arm hang is similar to that of holds performed by wrestlers during a match.

Our study did not utilize a placebo controlled design due to the fact that the subjects were involved in their competitive season. The coach of the team did not desire to have the potential for discrepancies in performance during the competitive season, yet the researchers sought the need to experiment on the subjects during the competitive season in order to assess whether β -ala

supplementation could augment exercise performance under conditions that may inhibit performance. Because of the design of this experiment, it is impossible to identify exactly how much of the positive effects experienced by the subjects was a direct result of the supplementation. However, due to the large increase in performance and the similarity of results in comparison to other β -ala studies [6-9], we feel our study strongly suggests efficacy of β -ala supplementation.

It was our intent to focus on the *practical application* of this product during the most physically demanding time of the year, the competitive season. It is important to note that the subjects in this study had already completed their off-season and pre-competition training. Additional large improvements in exercise capacity during the competitive season are not typical in any sport, especially wrestling where calorie reduction and dehydration are common practice. Therefore, the fact that β -alanine supplementation resulted in large improvements in exercise performance has added significance.

It is likely that β -ala supplementation increased buffering capacity due to elevated muscle carnosine concentrations. However, muscle buffering capacity or muscle carnosine content was not measured in our experiment. Other recent studies have demonstrated that β -ala supplementation increases muscle carnosine content by ~ 60-80% [10,11]. The pK value of carnosine is 6.9 [19], suggesting it is an ideal buffer at physiological pH. Based on data from muscle biopsies, sprint running significantly decreases intramuscular pH from 7.0 at rest to < 6.5 post-exercise [12]. At this level of pH, the increased H^+ concentration may inhibit several vital processes required for muscle contractions to continue at desired power output [13]. Most of the studies which have shown strong evidence of the effect pH on muscular fatigue have been conducted at relatively low temperatures (< 15 °C), while warmer temperatures that approach physiological temperatures (30 °C) show much less of an inhibitory effect of pH [14]. Thus, the role of pH in fatigue is

controversial. Carnosine, however, has other important roles, including antioxidant activity, a metal chelator, a Ca^{2+} and enzyme regulator, an inhibitor of protein glycosylation and protein-protein cross-linking [4,24-27]. These actions may also affect exercise performance.

In this study, supplementing with β -alanine had no significant impact on blood lactate accumulation during 400 m sprint. During short-term, high-intensity exercise, lactate accumulates as a result of lactic acid production being greater than its removal [22]. Since lactic acid dissociates a H^+ at physiological pH, most exercise physiology textbooks tell us that lactate accumulation is associated with acidosis [e.g., 22]. However, Robergs et al. have argued that lactate production actually retards, not causes, acidosis [23]. They feel that exercise-induced acidosis is caused by an increased reliance on nonmitochondrial ATP turnover. Thus, it is unclear what is the true meaning of blood lactate measurement.

The β -ala supplement used in our study also provided a 402 mg proprietary blend of N-acetylcysteine/ α -lipoic acid and 15 mg of vitamin E. N-acetylcysteine is an effective scavenger of free radicals as well as a major contributor to maintenance of the cellular glutathione status in muscle cells [30]. There is some evidence that N-acetyl-cysteine supplementation can delay muscular fatigue [15-18]. However, these studies used much larger doses of N-acetylcysteine than provided by the supplement used in our study. Lipoic acid is characterized by high reactivity towards free radicals and is capable of regeneration of vitamin C and E [31]. Also, it elevates tissue levels of glutathione [31]. Many experimental and clinical studies have suggested beneficial effect of lipoic acid in such diseases as diabetes, atherosclerosis and heart diseases [31], but there is no evidence that it affects exercise performance. While increased tissue levels of glutathione and supplemental vitamin E may offer some health benefits for athletes, it is likely that β -ala was the main driving force behind the ergogenic effects.

Although our study is limited by its open-label design, the strengths of this study are as follows: 1) a highly homogeneous study population; 2) the measurement stability, which resulted from the maintenance of uniform body mass during the entire eight weeks; 3) tests were performed on highly trained individuals, reducing the chance of the training effect skewing the results; 4) the subjects had already completed their off-season and pre-competition training prior to taking the tests, which pretty much nullifies the training effect variable; 5) the age range, activity level and gender of the subjects are very relevant to the typical individual who would be using this type of ergogenic supplement. Thus, the findings of this study may be useful for sports nutritionists, strength coaches and athletes who are looking for a legal and well-tolerated dietary supplement that can improve anaerobic exercise performance.

Conclusion

The results of our study suggest that supplementation of β -ala may improve exercise performance in wrestlers during a competitive season. Specifically, the subjects showed significant decrease in 400 m sprint time and significant increase in 90° flexed-arm hang. However, the ergogenic effects of β -ala supplementation during a competitive wrestling season needs to be confirmed in placebo-controlled trials.

Abbreviations

The abbreviations used are: β -ala = beta-alanine; BMI = body mass index; LA = lactate; FAH = flexed-arm hang.

Competing interests

The authors declare that they have no competing interests.

Acknowledgements

Athletic Edge Nutrition donated the products and ~150 US dollars for lactate measurements. No other funding was received. The mention of any dietary supplement ingredient in this paper does not constitute an endorsement by the authors.

References

1. Applegate EA, Grivetti LE. Search for the competitive edge: a history of dietary fads and supplements. *J Nutr.* 1997 May;127(5 Suppl):869S-873S.
2. Kreider RB. Effects of creatine supplementation on performance and training adaptations. *Mol Cell Biochem.* 2003 Feb;244(1-2):89-94.
3. Manninen AH. Hyperinsulinaemia, hyperaminoacidaemia and post-exercise muscle anabolism: the search for the optimal recovery drink. *Br J Sports Med.* 2006 Nov;40(11):900-5.
4. Begum G, Cunliffe A, Leveritt M. Physiological role of carnosine in contracting muscle. *Int J Sport Nutr Exerc Metab.* 2005 Oct;15(5):493-514.
5. Oppliger RA, Steen SA, Scott JR. Weight loss practices of college wrestlers. *Int J Sport Nutr Exerc Metab.* 2003 Mar;13(1):29-46.

6. Stout JR, Cramer JT, Mielke M, Okroy J, Torok DJ, Zoeller RF. Effects of twenty-eight days of beta-alanine and creatine monohydrate supplementation on the physical working capacity at neuromuscular fatigue threshold. *J Strength Cond Res.* 2006 Nov;20(4):928-31.
7. Stout J, Cramer JT, Zoeller RF, Torok D, Costa P, Hoffman JR, Harris RC, Okroy J. Effects of beta-alanine supplementation on the onset of neuromuscular fatigue and ventilatory threshold in women. *Amino Acids.* 2007 Apr;32(3):381-6.
8. Zoeller RF, Stout JR, Okray JA, Torok DJ, Mielke M. Effects of 28 days of beta-alanine and creatine monohydrate supplementation on aerobic power, ventilatory and lactate thresholds, and time to exhaustion. *Amino Acids.* 2006 Sep 5; [Epub ahead of print]
9. Hoffman J, Ratamess, N, Kang J, Mangine G, Faigenbaum A, Stout J. Effect of creatine and beta-alanine supplementation on performance and endocrine responses in strength/power athletes. *Int J Sport Nutr Exerc Metab.* 2006 Aug;16(4):430-46.
10. Harris RC, Tallon MJ, Dunnett M, Boobis L, Coakley J, Kim HJ, Fallowfield JL, Hill CA, Sale C, Wise JA. The absorption of orally supplied beta-alanine and its effect on muscle carnosine synthesis in human vastus lateralis. *Amino Acids.* 2006 May;30(3):279-89.
11. Hill CA, Harris RC, Kim HJ, Harris BD, Sale C, Boobis LH, Kim CK, Wise JA. Influence of beta-alanine supplementation on skeletal muscle carnosine concentrations and high intensity cycling capacity. *Amino Acids.* 2007 Feb;32(2):225-33.
12. Costill DL, Barnett A, Sharp R, Fink WJ, Katz A. Leg muscle pH following sprint running. *Med Sci Sports Exerc.* 1983;15(4):325-9.
13. Haub MD. Buffers: Bicarbonate, citrate and phosphatate. In: Wolinsky I, Driskell JA, eds. *Nutritional Ergogenic Aids.* Boca Raton, FL: CRC Press, 2004:257-273.
14. McCully KK, Authier B, Olive J, Clark BJ 3rd. Muscle fatigue: the role of metabolism. *Can J Appl Physiol.* 2002 Feb;27(1):70-82.

15. Reid MB, Stokic DS, Koch SM, Khawli FA, Leis AA. N-acetylcysteine inhibits muscle fatigue in humans. *J Clin Invest.* 1994 Dec;94(6):2468-74.
16. Medved I, Brown MJ, Bjorksten AR, Murphy KT, Petersen AC, Sostaric S, Gong X, McKenna MJ. N-acetylcysteine enhances muscle cysteine and glutathione availability and attenuates fatigue during prolonged exercise in endurance-trained individuals. *J Appl Physiol.* 2004 Oct;97(4):1477-85.
17. Matuszczak Y, Farid M, Jones J, Lansdowne S, Smith MA, Taylor AA, Reid MB. Effects of N-acetylcysteine on glutathione oxidation and fatigue during handgrip exercise. *Muscle Nerve.* 2005 Nov;32(5):633-8.
18. McKenna MJ, Medved I, Goodman CA, Brown MJ, Bjorksten AR, Murphy KT, Petersen AC, Sostaric S, Gong X. N-acetylcysteine attenuates the decline in muscle Na⁺,K⁺-pump activity and delays fatigue during prolonged exercise in humans. *J Physiol.* 2006 Oct 1;576(Pt 1):279-88.
19. Skulachev VP. Biological role of carnosine in the functioning of excitable tissues. Centenary of Gulewitsch's discovery. *Biochemistry (Mosc).* 2000 Jul;65(7):749-50
20. Suzuki Y, Osamu I, Naoki M, Hideyuki T, Kaoru T. High levels of skeletal muscle carnosine contributes to the latter half of exercise performance during 30-s maximal cycle ergometry sprinting. *Japanese J Physiol.* 2002;52:199-205.
21. Clemons JM, Duncan CA, Blanchard OE, Gatch WH, Hollander DB, Doucet JL. Relationships between the flexed-arm hand and select measures of muscular fitness. *J. Strength Cond. Res.* 2004;18(3):630-6.
22. Brooks GA, Fahey TD, White TP. Fatigue during muscular exercise. In: *Exercise Physiology: Human Bioenergetics and Its Applications.* New York, NY: McGraw-Hill, 1999:800-822.

23. Robergs RA, Ghiasvand F, Parker D. Biochemistry of exercise-induced metabolic acidosis. *Am J Physiol Regul Integr Comp Physiol*. 2004 Sep;287(3):R502-16.
24. Cariballa SE, Sinclair AJ. Carnosine: physiological properties and therapeutic potential. *Age Ageing*. 2000 May;29(3):207-10.
25. Johnson P, Aldstadt J. Effects of carnosine and anserine on muscle and non-muscle phosphorylases. *Comp Biochem Physiol B*. 1984;78(2):331-3.
26. Batrukova MA, Rubtsov AM. Histidine-containing dipeptides as endogenous regulators of the activity of sarcoplasmic reticulum Ca-release channels. *Biochim Biophys Acta*. 1997 Feb 21;1324(1):142-50.
27. Hipkiss AR. Glycation, ageing and carnosine: are carnivorous diets beneficial? *Mech Ageing Dev*. 2005 Oct;126(10):1034-9.
28. Kinningham RB, Gorenflo DW. Weight loss methods of high school wrestlers. *Med Sci Sports Exerc*. 2001 May;33(5):810-3.
29. Buford TW, Rossi SJ, Smith DB, O'Brien MS, Pickering C. The effect of a competitive wrestling season on body weight, hydration, and muscular performance in collegiate wrestlers. *J Strength Cond Res*. 2006 Aug;20(3):689-92.
30. Kerksick C, Willoughby D. The antioxidant role of glutathione and N-acetylcysteine supplements and exercise-induced oxidative stress. *J Int Soc Sports Nutr*. 2005 Nov;2(2):38-44.
31. Bilska A, Wlodek L. Lipoic acid - the drug of the future? *Pharmacol Rep*. 2005 Sep-Oct;57(5):570-7.

Figure Legends

Figure 1. Mean 400 m sprint time

Figure 2. Mean flexed-arm hang time

Figure 3. Mean LA Δ