

BETA-ALANINE SUPPLEMENTATION SEEMS TO INCREASE PHYSICAL PERFORMANCE AND ACUTE RECOVERY IN COMPETITIVE JUDOKAS

Raul Lopez-Grueso; Adolfo Aracil; Jose Manuel Sarabia;
Carlos Montero

Sports Research Center, Miguel Hernandez University of Elche, Spain.

ABSTRACT

Introduction: This paper aims to test whether supplementation with beta-alanine (BA) increases performance in judo. **Method:** A simple-masked quasi-experimental pilot study was performed. Five judokas of the Spanish National Team were distributed into two groups: a) placebo (PLA, n = 3); and b) experimental (BA, n = 2). Participants performed the Special Judo Fitness test (SJFT) before (PRE) and after completion (POST) a period of 35 days of supplementation with 6 g day⁻¹ of maltodextrins (PLA) or the same dose of BA. During the SJFT and at recovery, the heart rate, number of projections, blood lactate, the rate of perceived exertion (RPE), and the subjective feeling of recovery (TQR 6-10) were measured. **Results:** The SJFT index at the POST evaluation improved by 10.1 ± 1.7% in the BA group and by 3.9 ± 3.9% in the PLA group. This improvement was due to the increase in the number of projections, which was accompanied by higher values blood lactate. Similarly, the BA group showed a faster recovery. **Discussion:** Beta-alanine supplementation for 35 days appears to improve the performance of judokas at the SJFT, possibly by a greater involvement of lactic anaerobic metabolism.

Key Words: beta-alanine, lactic anaerobic metabolism, judo, performance, recovery

RESUMEN

Introducción: El presente trabajo pretende comprobar si la suplementación con beta-alanina (BA) incrementa el rendimiento en judo. **Método:** Se realizó un estudio cuasiexperimental, simple ciego. Se distribuyó a cinco judocas de la Selección Española en dos grupos: a) placebo (PLA, n= 3); y b) experimental (BA, n=2). Los participantes realizaron el SJFT antes de comenzar (PRE) o tras finalizar (POST) un período de 35 días de suplementación con 6 g día⁻¹ de maltodextrinas (PLA) o BA. Durante el SJFT, y en la recuperación del mismo, se midieron: a) la frecuencia cardiaca; c) el número de proyecciones realizadas; d) la lactacidemia; e) la percepción subjetiva de esfuerzo; y f) la sensación subjetiva de recuperación. **Resultados:** En la evaluación POST el índice SJFT mejoró en un 10,1±1,7% en el grupo BA, mientras que sólo lo hizo en un 3,9±3,9% en el grupo PLA. Esta mejora se debió al incremento en el número de proyecciones, que se acompañó de mayores valores de lactacidemia. Del mismo modo, los judocas del grupo BA mostraron una recuperación más rápida. **Discusión:** La suplementación con beta-alanina durante 35 días parece mejorar el rendimiento de los judocas en el SJFT, posiblemente por una mayor implicación del metabolismo anaeróbico láctico.

Palabras clave: beta-alanina, metabolismo anaeróbico láctico, judo, rendimiento, recuperación

Correspondence:

Adolfo Aracil Marco
Sports Research Center.
Miguel Hernandez University
Avda. de la Universidad s/n
03202 Elche - ALICANTE
fito@umh.es

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INTRODUCTION

Intracellular acidosis is one of the mechanisms that may contribute to muscle fatigue (Hultman & Sahlin, 1980). Carnosine (beta-alanyl-L-histidine) can represent up to 7% of the total intracellular pH buffering capacity (Mannion, 1995). Beta-alanine (BA), a carnosine precursor, is the limiting factor in its biosynthetic pathway (Dunnett & Harris, 1999). Muscle carnosine increases among 60-87% after several weeks of supplementation with BA (Harris et al., 2006; Hill et al., 2007). Therefore, it can be hypothesized that BA can be used as an ergogenic supplement aimed to increase the intracellular pH buffering capacity, which would result, in turn, in an increased muscle tissue tolerance to high intensity lactic anaerobic efforts.

A standard competitive judo combat represents five minutes of high intensity intermittent effort, characterized by alternating periods of intense work (hajime) and rest (mate). During a typical competition the judoka can fight in up to seven combats in a day, separated by resting periods of 15-20 min. Consequently, due to the temporal structure and character of efforts in combat, it can be assumed that: a) the predominant energy pathway is lactic anaerobic (Callister, et al, 1991; Franchini, Takiko, Nakamura, Matsushigue & Peduti, 2003; Sbriccoli, Bazzucchi, Di Mario, Marzattinocci & Felici, 2007). Actually, blood lactate concentrations of 13-18 mmol•L⁻¹ have been reported at the end of the combat; b) one of the main limitations of performance is given by the decrease in pH (Ahmaidi, et al., 1996; Wilmore & Costill, 2004; Yates, Gadden & Cresanta, 1983); and c) the elapsed time between fights may be insufficient for a complete metabolic recovery (Bonitch-Góngora, Bonitch-Domínguez, Padial & Feriche, 2012). Consequently, eventually the judoka would face the next combat in a situation of accumulated fatigue (Touguinha et al., 2011). To avoid this, improving the aerobic metabolism can be very important (Franchini, Takito, Nakamura, Matsushigue and Kiss, 2003; Franchini, Moraes, Takito and Kiss 2009; Sikorski, 2010).

Therefore, the fundamental elements for the physical performance of competitive judokas are: a) be able to obtain high amounts of energy from the lactic anaerobic metabolic pathway; b) be able to buffer the increased production of H⁺ in order to prevent acidosis, thereby enabling to perform high-intensity efforts even in these conditions; and c) be able to quickly eliminate lactate between combats.

But, in addition to the physical fitness, performance in judo depends - unquantifiably- on the influence of the direct opposition of the rival. In this way, a judoka may have improved separately their conditional, technical or tactic capacities, but it is during the combat when he/she has to integrate all of them in order to increase his/her performance. Therefore, specific tests that evaluate the integrated ability of judokas to meet the demands of a judo combat have

been developed. Among them, one of the most used is the Special Judo Fitness Test (SJFT) developed by Sterkowicz (1995). This test has proved to be useful to distribute judokas in levels (Franchini, Takito, Kiss and Sterkowicz, 2005; Sterkowicz, 1996), as well as for monitoring their physical fitness (Franchini, Boscolo Del Vecchio and Sterkowicz, 2009). For this reason the SJFT seems a good surrogate to determine the performance level of competitive judokas.

Recent research has shown that BA supplementation seems to increase the performance of athletes from different disciplines, maybe by increasing the participation of lactic anaerobic metabolism (Baguet, Bourgois, Vanhee, Achten, & Derave, 2010; Chung et al, 2012; Derave et al., 2007; Ducker, Dawson & Wallman, 2013a; 2013b; Hill et al., 2007; Van Thienen et al, 2009). However, these potential effects have been poorly and incompletely studied (Tobias et al., 2013) in judo. Therefore, it seems interesting to analyze the possible effect of BA supplementation on the performance of judokas at the SJFT.

Aim and hypotheses

This paper is aimed to describe the possible effects of BA supplementation on the performance and the acute recovery of competitive judokas, using the SJFT as a surrogate of standardized competition. Either performance (SJFT index), metabolic (blood lactate) and psychological (rate of perceived exertion and subjective perception of recovery) will be compared among subjects taking or not BA as a dietary supplement.

We hypothesised that due to their relative higher intracellular buffering capacity, individuals taking the BA supplementation would show a higher performance at the SJFT by involving the lactic anaerobic metabolism in a large proportion than the not-supplemented individuals. In turn, they will show also a greater acute recovery post-competition.

METHOD

Participants

Eight judokas of the Spanish National Judo Team started the study. Due to injury or personal reasons unrelated with the study, three of them could not complete the full protocol and were excluded. The characteristics of the participants are shown in Table 1.

TABLE 1
Physical characteristics of the participants

Variable	PLA Group	BA Group
Men (n)	1	1
Women (n)	2	1
Total (n)	3	2
Age (years)	25.0 ± 1.0	23.5 ± 0.7
Height (m)	1.70 ± 0.04	1.60 ± 0.04
Body mass (kg)	66.3 ± 9.9	61.4 ± 1.4

None of the participants had taken BA prior to initiating the study and they were encouraged to continue their normal diets until they were informed of the study and agreed to participate. The participants were informed of the issues and risks associated with the experimental design before giving their written informed consent. The tenets of the Declaration of Helsinki, as well as the current Spanish Law for Scientific Research involving human subjects were followed at all times. All volunteers were informed that they could abandon the study without giving explanations about their reasons, and without this fact would have any implications for their careers.

Experimental design

A simple-masked quasi-experimental pilot study was performed. Judokas were divided into two groups: a) the control group (PLA, n = 3), that received maltodextrin as a placebo; and b) the experimental group (BA, n = 2), that received BA supplementation (see below). To avoid any possible interference of diet on performance, participants were urged to continue with their regular diet throughout the study, and especially during the day before the SJFT was performed. Athletes were encouraged to arrive each day well hydrated, after an overnight rest and without having consumed alcohol, caffeine or unprescribed drugs. Volunteers were asked orally about all of this topics before starting each SJFT. In parallel, the training load during the supplementation period was monitored and quantified by a qualified and professional judo coach, being similar for every participant.

Supplementation protocol

Judokas in the experimental group were supplemented with 6 g•day⁻¹ of BA for 35 days (10 gelatin capsules with 600 mg each of BA, distributed among the three main meals). It has been reported that similar doses increased the intracellular levels of carnosine (Hobson, Saunders, Ball, Harris & Sale, 2012; Hoffman, Emerson & Stour, 2012; Stellingwerff et al, 2012; Stellingwerff, Décombaz, Harris & Boesch, 2012; Décombaz, Beaumont, Vuichoud, Bouisset & Stellingwerff, 2011). The control group received the same amount of

maltodextrins (6 g•day⁻¹) in a similar fashion. Doses were provided to the volunteers every 7 days, in order to control that they were fulfilling the protocol.

Performance evaluation

On the day prior to starting the supplementation period (PRE) and on the day immediately after its end (POST), subjects performed the SJFT (Sterkowicz, 1995). Before starting the test, a warming-up of 20 minutes was performed independently by each judoka, under the coach supervision. The warming-up protocol consisted in continuous running, dynamic stretching exercises and joint mobility, as a general part, and a series of Uchi Komis and Ōnaque Komis, as an specific part.

The SJFT consists in intermittent specific judo actions. Two judokas (Uke A and B), similar in height and body mass (i.e., the same competitive category) to the judoka to be tested (Tori) are placed separated by 3 meters. The test is divided into three working periods of 15, 30 and 30 seconds, respectively, with resting intervals of 10 second between them. During the working periods, Tori should throw the Ukes using the Ippon-seoi-nage as many times as possible. In our protocol, the number of projections was recorded in situ by two independent evaluators.

The performance was evaluated using the Sterkowicz index, which was calculated according to the following formula (Sterkowicz, 1995):

$$\text{Index} = (\text{HRf} (\text{bpm}) + \text{HR1} (\text{bpm})) \cdot \text{Projections-1}$$

where "HRf" represents the heart rate immediately after completion of the test, "HR1" represents the heart rate 1 minute after finishing the test, and "projections" is the total number of projections in the test (sum of the 3 periods of 10, 30 and 30 seconds). A lower index is interpreted as a higher performance.

During a 15 minutes recovery period after finishing the test, the following variables were additionally recorded:

Heart rate

During the whole measurement period (i.e., including SJFT and recovery), heart rate (HR) was monitored using a heart rate monitor (Polar S810i, Polar Electro Oy, Kempele, Finland).

Blood samples and lactate quantification

Capillary blood samples were collected by puncturing the earlobe at rest, before starting the test, and at minutes 1, 3 and 14 after completing the SJFT. For the determination of blood lactate concentrations, a portable lactate

analyser (Lactate Scout, SensLab, Leipzig, Germany) was used. This post-exercise period has been previously described as the sensible recovery period for efforts involving lactic anaerobic metabolism (Bonitch Gongora et al., 2012).

Perceived exertion and acute recovery

The perceived exertion was assessed with the CR-10 RPE scale (Borg, 1998) immediately upon completion the SJFT. Similarly, the subjective perception of acute recovery was assessed with the TQR 6-20 scale (Kenttä G and Hassmen P, 1998), at minutes 1, 3 and 14 of the recovery period. In both cases, the printed numerical scales, with their verbal descriptors, were showed to the subjects, asking them to point with the finger the most appropriated to describe their recovery sensation. The indicated value was recorded by an investigator.

Statistical Analysis

Simple ANOVA analysis was performed after a post-hoc LSD test to compare the characteristics of the participants and the initial performance between groups. Using a mixed model for repeated measures and analysis of absolute changes (% change POST-PRE supplementation), statistical differences in test performance, heart rates and lactate values were determined. Correlations of different variables together were calculated with the Pearson correlation analysis.

Data analysis was performed using the Statistical Package IBM® SPSS® 21 (IBM Corporation, Chicago, USA) or Sigmastat software (Systat Software, Inc). Graphs were plotted using SigmaPlot 11.0 (Systat Software, Inc).

The results are expressed as mean \pm SD. The level of significance was set at $p < 0.05$.

RESULTS

One of the 2 participants in the BA group indicated light symptoms of paresthesia on the first day of supplementation, which disappeared the next day and were not reported again. None of the subjects of the PLA group indicated any problem with the ingestion of maltodextrins. The total confirmed intake of either BA or PLA, was 210 g per person.

Performance in SJFT

Table 2 summarizes the performance in the SJFT. In both groups, a decreasing trend in HR at POST was noted, both immediately after ending the test, and after one minute of recovery. In the BA group an increasing trend in the number of projections at POST was observed. These changes can be interpreted as that in both groups there was an improvement in the

performance at the SJFT. However, the percentage of increase in performance was relatively higher in the supplemented group.

TABLE 2
Performance in the SJFT pre and post supplementation

	PLA		BA	
	PRE	POST	PRE	POST
HR _f (bpm)	178.3 ± 4.7	171.7 ± 7.6	172.5 ± 3.5	170.0 ± 2.8
HR ₁ (bpm)	153.7 ± 10.7	136.0 ± 19.7	154.0 ± 4.2	135.0 ± 11.3
Projections (n)	26.0 ± 2	25.0 ± 1	26.0 ± 2.8	27.0 ± 2.8
Index	12.8 ± 0.4	12.3 ± 0.7	12.6 ± 1.7	11.4 ± 1.7
Δ Index	-	-0.5 ± 0.5	-	-1.3 ± 0
% Δ Index	-	-3.9 ± 3.9	-	-10.1 ± 1.7

Evolution of lactate concentration during recovery

Figure 1 shows the evolution of blood lactate concentration during the recovery in the PLA group (Figure 1, A) and the BA group (Figure 1, B). In the PRE evaluation, blood lactate levels upon finishing the test ranged among 10 to 12 mmol•L⁻¹ in both groups. During the recovery, blood lactate levels tended to remain constant in the PLA group and to increase in the supplemented group. At the POST evaluation, blood lactate concentrations ranging from 6 to 8 mmol•L⁻¹ were observed in the PLA group, while similar values to the PRE evaluation were obtained for the BA group.

For the whole sample blood lactate in the first minute after exercise tended to be positively correlated with the number of projections ($r = 0.467$, $p = 0.173$).

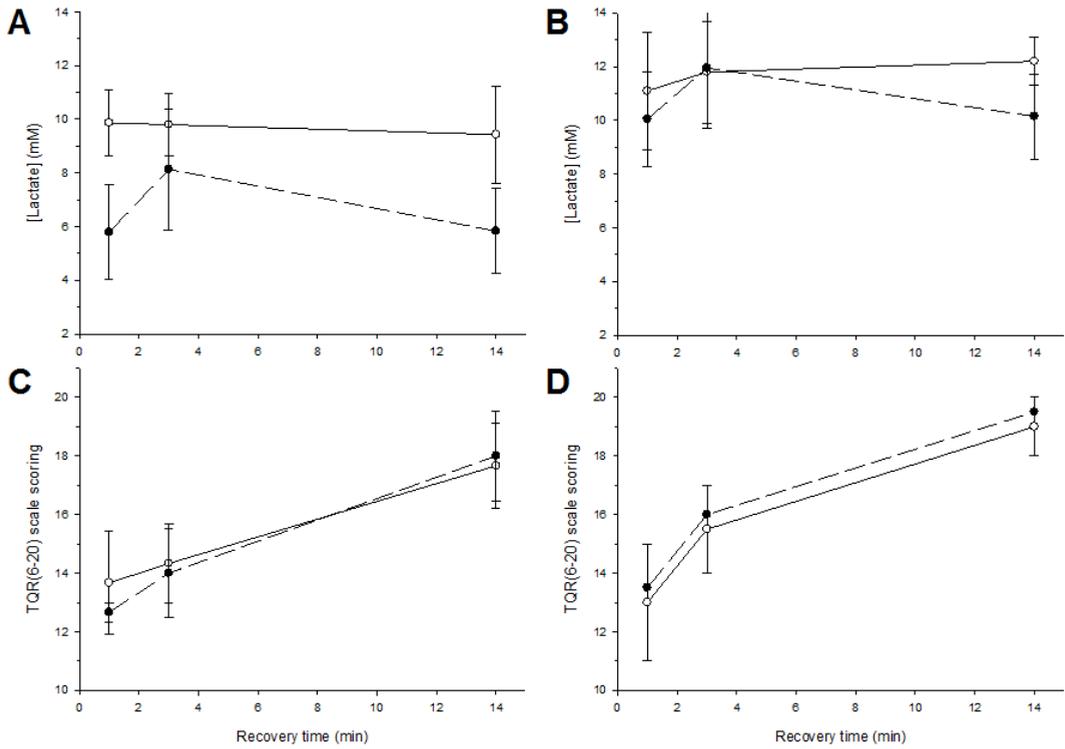


FIGURE 1: A and C: PLA group; B and D: BA group. Open circles: PRE evaluation. Black circles: POST evaluation

Subjective perception of effort and recovery

At both evaluations, PRE and POST, the PLA group showed the same values in the RPE scale (5.7 ± 0.7), while in the BA group the subjective perceived effort tended to increase in the POST evaluation (6.5 ± 0.5 POST vs 4.5 ± 0.5 PRE, non-significant differences). For the whole sample, the RPE scale values also tended to be positively correlated with the number of projections ($r = 0.201$, $p = 0.578$).

The evolution of acute perception of recovery after exercise is shown in Figure 1 (panel C: PLA; panel D: BA). When the recovery score in the first minute after finishing the effort was compared among PRE and POST evaluations, non-significant differences were noted. However, a trend in the BA group to recover faster and up to higher values during the recovery period, in comparison with the PLA group, could be observed at the POST evaluation.

DISCUSSION

The main objective of this pilot study was to examine whether BA supplementation ($6 \text{ g} \cdot \text{day}^{-1}$) for 35 days improves performance in a specific

judo test. The results showed a trend towards improved performance in the SJFT in both groups, which was greater for the supplemented group. However, due to the limited sample size of this study, no statistically significant differences were found in any of the variables studied. In the supplemented group, improvement seemed to be due to the increased number of projections made during the test, which was accompanied by higher blood lactate concentrations and greater self-reported intensity of effort. This could be interpreted as if there was a major requirement of lactic anaerobic metabolism in the intervention group after the supplementation period. Additionally, this increase in performance in the supplemented group was accompanied by a greater subjective perception of recovery during the fourteen minutes after testing. This could be explained by the fact that with the BA supplementation an increased intracellular pH buffering capacity could be reached, that, in turn, would reduce the subjective feeling of fatigue, despite the higher lactic anaerobic effort. In any case, despite not having reached statistical significance, the effects of supplementation with BA may be considered relevant from the point of view of sports performance. After supplementation with BA, judokas reached a number of projections or a Sterkowicz index to qualify them as "good" or "excellent" respectively (Franchini, Boscolo & Sterkowicz, 2009), whilst they started with qualifying scores of "average". In contrast, non-supplemented judokas started from similar scores than the supplemented ones, and did not improve them during the period of study, being their training similar to the supplemented ones.

The findings of this study are in line with previous studies that have demonstrated the effectiveness of this ergo-nutritional supplement in efforts of similar metabolic characteristics and duration (Harris & Sale, 2012), as well as in cyclists (Hill et al. 2007; Smith et al, 2009;. Van Thienen et al, 2009), sprinters (Derave et al, 2007) or middle distance runners (800m) (Ducker et al, 2013a), rowers (Ducker et al, 2013b; Baguet et al, 2010), swimmers (W Chung et al, 2012) or bodybuilding exercises (Howe, Bellinger, Driller, Shing & Fell, 2013;.. Sale, Hill, Ponte & Harris, 2012). Similarly, BA supplementation seems to improve performance when measured in standardized continuous incremental (Jordan, Lukaszuk, Misic & Umoren, 2010) or intermittent tests (Saunders, Sunderland, Harris & Sale, 2012).

In the specific case of judo, there is only one previous paper (Tobias et al., 2013) showing the effect of BA supplementation in judo and jiu-jitsu competitors. In this study, participants were divided into four groups: one control group that received placebo, another supplemented solely with BA, another exclusively supplemented with sodium bicarbonate and a fourth group supplemented with both BA and bicarbonate. A test of upper body was used for performance evaluation. Both the BA as sodium bicarbonate increased

performance in the test, and its effects were shown to be additive when given together. The group supplemented with BA alone showed an increase in test performance of about 8%.

The main novelty of our work is the use of SJFT reproducing a situation similar to high-level competition, with gestures, fighting and duration similar to a judo tournament, to see if BA supplementation has any effect also in these conditions. The choice of this test is justified by the participation of the whole body muscle mass for displacements and throwings, during a period of time similar to a judo combat. The performance improvement in the SJFT observed in our study coincides in magnitude with the previously described by Tobias et al (2013). As a novel contribution of our work a tendency to reach a faster and greatest subjective feeling of post-exercise recovery in subjects supplemented with BA was observed.

In previous works (Décombaz, Beaumont, Vuichoud, Bouisset & Stellingwerff, 2012; Tobias, et al, 2013), the BA supplementation was associated to the presence of paresthesias whose origin is unknown. In the case observed in our study, these effects were light and transient, and didn't force to suspend the supplementation protocol.

Therefore, our work supports the idea that BA can be used as an ergo-nutritional supplement for improving performance and recovery in judo competition. However, given the limited sample size of this study, and the scarcity of specific literature on the effect of BA in judo, it seems premature to undoubtedly recommend its use.

CONCLUSIONS

Supplementation with BA (6 g•day⁻¹) for 35 days appears to improve the performance of judo competition in the specific judo test "SJFT". This effect may be due to the greater involvement of lactic metabolism. Additionally, BA supplementation seems to accelerate the subjective post-exercise recovery status.

PRACTICAL APPLICATIONS

If it is confirmed in future studies that BA improves performance in judo competition, this substance could be used, either alone or combined with others (such as sodium bicarbonate or creatine) as an ergo-nutritional supplement. Similarly, this substance could also be used to accelerate the subjective feeling of recovery between combats during a competition.

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