Can sodium bicarbonate intake contribute to judo fights performance?

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ABSTRACT

The objective of this study was to investigate the effect of the $NaHCO_3$ ingestion on the judo performance. Six male athletes ingested 0.3 g • kg^{-1} body weight of $NaHCO_3$ or $CaCO_3$ (placebo) 2 h before 3 fights of 5 min, with 15 min recovery. Immediately afterwards, and 15 min after each fight, the athletes related their perceived exertion. The blood lactate concentration was verified in rest, after warming up, 0, 3, 5, 7, 10 and 15 min after each fight. The same experimental protocol was repeated twice by each athlete, except for the ingested substance. The study adopted the counterbalanced double-blind model. There was no significant difference for the performance variables. The perceived exertion did not differ among the treatments, and the blood lactate concentration was significantly greater ($p < 0.05$) after $NaHCO_3$ ingestion in the first moments of the protocol. In conclusion, the ergogenic effects of $NaHCO_3$ are not enough to contribute to the improvement of the performance in judo fights. However, the model limitations must be considered when generalizing these results. Future studies should use other tools to evaluate the performance in judo.

INTRODUCTION

The main physiological characteristic of judo fights is the intermittence. It consists of a series of supra-maximal exertions (with mean duration of 15 to 30 seconds), alternated with 10 to 15 seconds of recovery[(1)]. In these short intervals, there is not sufficient time for a suitable ATP resynthesis by the aerobic ways, which makes these exertions highly dependant on the lactic anaerobic way[(2)]. The importance of the glycolytic anaerobic way of energy production for judo may be demonstrated by the high blood lactate concentration in athletes of this modality[(3)].

In exercises with the mentioned characteristics above, the high H^+ ions concentration has been mentioned as one of the main causes of muscular fatigue[(4-5)]. The decrease of the intramuscular pH is related with a series of events which harm the muscular contraction-relaxation and energy obtaining processes[(4-6)].

In this context, several studies have researched the ergogenic action of alkaline substances in activities of high intensity and short duration. The increase of the blood pH caused by the alkalosis would provide delay in the fatigue occurrence and improvement in exercise with this characteristic[(7-14)]. Nonetheless, some studies fail to show the efficiency of this resource[(15-20)]. Despite that, the use of alkaline substances seems to be especially efficient in improving the performance in intermittent series of supra-maximal exercises, or in series of exercises with approximate duration of 60 s up to approximately five minutes[(7-8,10,21)]. According to Robertson *et al.*[(9)], alkalosis causes a special effect in exercises with predominance of upper limbs, such as judo. Therefore, it is important to investigate the effect of the induced alkalosis on judo performance, once there is no consensus in the literature concerning the use of alkaline substances as ergogenic resource in anaerobic exercises. Moreover, athletes of this modality may theoretically benefit from the use of such resource.

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Received in 24/2/06. Final version received in 15/6/06. Approved in 20/7/06.

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Keywords: Martial arts, Alkalosis. Lactate. Fatigue.

Thereby, the aim of this study was to verify whether the sodium bicarbonate ($NaHCO_3$) ingestion is a reliable way of improving performance in judo fights. The investigation on the sodium bicarbonate ingestion effect on the blood lactate concentration and on the perceived exertion was also aimed in this study.

METHODS

Subjects

Seven male judo fighters participated in this study. They were selected according to the following inclusion criteria: to be between 18 and 30 years of age; to dedicate to judo training for at least 6 weekly hours; to have a minimum brown belt graduation; to regularly compete in regional or higher championships. One of the athletes got injured between the test days, consequently leaving the study. Three of the subjects were competitors of state level; two of regional level; and one of national level.

Protocol

Before the beginning of the tests, the subjects answered a questionnaire in order to verify their competitive level, the training status and the judo practice time. After reading and signing the consent form, the volunteers were submitted to an anthropometrical and body composition evaluation. All the experimental procedure was approved by the Ethics in Human Research Committee of the Institute of Biomedical Sciences of the São Paulo University.

The volunteers presented to the laboratory in two different days (separated for a minimum of two days and maximum of seven days) in order to perform the tests. They ingested 0,3 g • kg^{-1} of body weight of $NaHCO_3$ or placebo (calcium carbonate – $CaCO_3$), in each of the experimental procedures. The substances were ingested via gelatin capsules, 120 min prior to the fights. The same experimental protocol was repeated by each athlete, except for the administered substance. This study adopted the counterbalanced double-blind model.

Two hours after the ingestion of the capsules, the subjects performed three fights of five minutes of duration (even if there was an *ippon*, which would end the fight in regular competitions), with intervals of 15 min of passive recovery. The opponents were selected according to body weight so that there were not fights between athletes with difference higher than 10% of the body weight. In the two days, both the opponents as well as the fights were not changed, with only one subject being evaluated per session. According to Franchini *et al.*[22], this procedure guarantees the metabolic response similarity between the different test days. No kind of encouragement was given to the athletes during the fights.

The volunteers were instructed to arrive at the tests site well-fed and in an euhydration state, without ingestion of any kind of food in the two hours which preceded the capsules intake. They were also instructed to eat similarly in the eve of the two test days, as well as not to practice intense exercises in the 16 hours preceding the tests. During the entire experimental period the athletes ingested water *ad libitum*.

Before the first fight, the athletes had a free warm-up of 10 min. All of them performed a combination of running; stretching; knock out absorbing and projection movements.

The blood collections for later blood lactate concentration analysis occurred in the following moments: in rest after the placebo or $NaHCO_3$ ingestion; after the warm-up; immediately after the warm-up; immediately after each fight; and 3, 5, 7, 10 and 15 min after each fight. The perceived exertion was verified immediately after and 15 min after each fight. Blood samples of 25 µL were collected from the earlobe, through heparinized capillary tubes and immediately stored in microtubes containing 50 µL of sodium fluorite solution 2%. All samples were refrigerated immediately after collection, and later analyzed in an automatized lactometer (YSI 2300 – Yellow Springs, Ohio, USA) for measurement of the blood lactate concentration. The perceived exertion was reported using the Borg's scale[23] of 6-20 points.

Figure 1 illustrates the experimental outlining of this study.

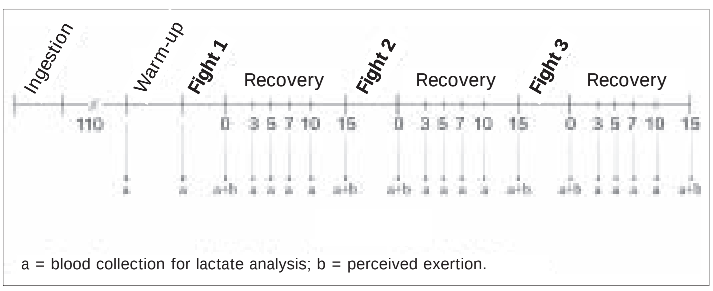

Figure 1 – *Experimental outlining of the study*

The body composition was verified through hydrostatic weighting. The body weight was measured using a digital scale (Kratos CAS, models linea – precision of 100 g), and the height through a board stadiometer.

The fights were filmed and later verified regarding their temporal characteristics (exertion time; recovery time; standing fight time and fight time on the ground) as well as the technical actions of the evaluated subjects counted (number of standing attacks; number of attacks on the ground; total of attacks and total of movements which resulted in punctuation). The exertions times during each fight were added in order to determine the total time of exertion. The same procedure was used for determination of the total time of recovery, standing fight and fight on the ground.

Statistical analysis

The results are expressed in mean ± standard deviation. The data of performance, blood lactate concentration and perceived exertion were compared between the experimental treatments in order to verify significant differences through variance analysis for repeated measurements. Several variance and co-variance structures were tested (non-structured; auto-regressive; symmetric and Toeplitz) with the purpose to find the best adjustment to the repeated measurements. After this adjustment, the model with the co-variance structure which best adapted to the dependence structure of the data was selected. Later, t-Student tests were conducted for dependent samples in order to establish the significant differences whenever they occurred. The significance level $p < 0,05$ was chosen before the beginning of the study. All analyses were done with the aid of the software SAS *for Windows*® version 8.

RESULTS

The main characteristics of the participant subjects of this study are presented in table 1.

TABLE 1
Main characteristics of the participants of this study (n = 6)

	Age (years)	Judo time (years)	Weight (kg)	Height (cm)	Fat (%)
Mean ± SD	20 ± 1,9	10,2 ± 1,3	74,2 ± 7,2	174,2 ± 5,5	7,9 ± 0,6
Variation	17-22	8-12	64,8-84	167-180,5	7,4-8,7

Temporal characteristics

The statistical analysis did not show any significant difference between the treatments for the temporal variables of the fights, showing that the subjects were submitted to periods of exertion and recovery similar in both treatments (table 2).

TABLE 2
Temporal characteristics of the three fights, in both treatments (mean ± SD)

	Fight 1		Fight 2		Fight 3	
	$NaHCO_3$	Placebo	$NaHCO_3$	Placebo	$NaHCO_3$	Placebo
ET (s)	236 ± 24	233 ± 19	243 ± 12	241 ± 12	234 ± 20	231 ± 21
RT (s)	64 ± 24	67 ± 19	57 ± 12	58 ± 12	66 ± 20	69 ± 21
SFT (s)	170 ± 29	165 ± 42	174 ± 44	169 ± 54	164 ± 38	174 ± 36
FTG (s)	66 ± 26	68 ± 32	69 ± 38	73 ± 50	70 ± 41	59 ± 33

ET = exertion time; RT = recovery time; SFT = standing fight time; FTG = fight time on the ground.

Performance

Table 3 presents the sum of the technical actions of the three fights in each treatment. There was no statistically significant difference between the treatments for any performance variable.

TABLE 3
Indicative variables of the performance in the fights (the data correspond to the sum of the indices of each fight; mean ± SD)

	$NaHCO_3$	Placebo
Standing attacks	41,8 ± 11,0	37,0 ± 16,3
Attacks on the ground	7,8 ± 4,7	9,0 ± 4,9
Total of attacks	49,6 ± 10,9	46,0 ± 16,5
Attacks which resulted in punctuation	8,5 ± 9,8	8,3 ± 9,4

Blood lactate concentration

The mean of the blood lactate concentration was higher in all collection moments when the athletes ingested sodium bicarbonate (figure 2). The variance analysis showed that the blood lactate was significantly higher after the $NaHCO_3$ ingestion ($p < 0,01$). There was statistically significant difference between treatments after fight 1 ($p < 0,05$). In the 3rd minute after fight 1 tendency to significant difference between treatments was observed ($p = 0,09$), as well as after fight 2 ($p = 0,05$).

Perceived exertion

According to what is illustrated in figure 3, the perceived exertion did not differ between the experimental treatments. However, there was significant difference between the indices immediately after and 15 minutes after the fights in both experimental treatments ($p < 0,0001$).

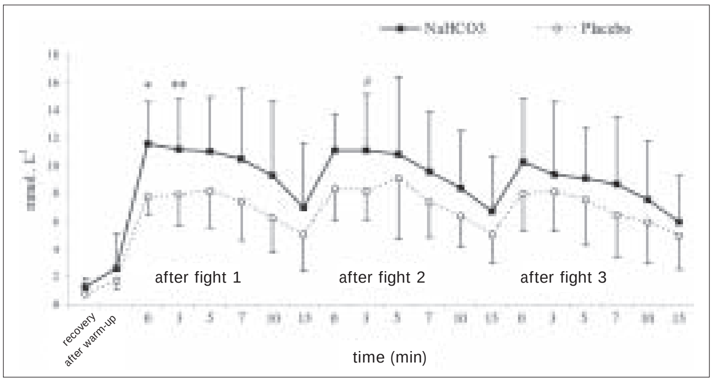

Figure 2 – *Response of the blood lactate concentration in both treatments (* p < 0,05; ** p = 0,09; # p = 0,05)*

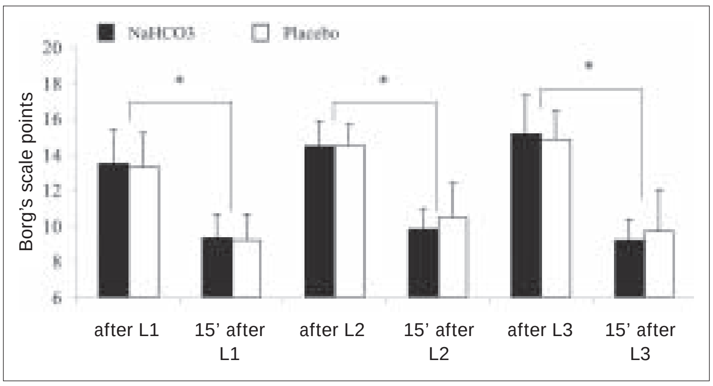

Figure 3 – *Perceived exertion reported in the different moments of collection (* p < 0,0001)*

DISCUSSION

Although there were some conflicting results, the literature has shown that the administration of alkaline substances improves performance in activities with characteristics similar to judo[7,9,11]. According to Hickner *et al.*[24], one of the main limitations of studies which evaluate performance in modalities of domain fight is the kind of test used. The use of tests extremely specific to the motor gestures and physiological demand of the fight is needed in order to avoid results of little practical application. A protocol of three fights was used with the purpose to simulate the competition environment.

Considering that the technical-tactic aspects have a great influence on the final result of a fight, victories or defeats were not considered as indicative of performance. We suppose that the counting of the number of attacks and the quantity of movements which resulted in punctuation would be better indicators of performance. This thought relies on the fact that an athlete physically fit, theoretically speaking, is able to perform a higher number of attacks than when he is in fatigue state. Likewise, his attacks would have, theoretically, greater strength, velocity and coordination, which could make them more efficient.

The results of the present study showed that the administration of alkaline substances was not capable of improving performance in judo fights. However, the hypothesis that the alkalosis induction could not, somehow, contribute to fights performance cannot be discarded. Certainly, the great quantity of variables related to performance in a judo fight (tactic and psychological factors, besides the opponents performance itself, for instance) contributed so that differences between the treatments were not observed.

Two hypotheses may be formulated to explain the results of the present study: either the used test, despite its great ecological validity, was not sensible enough to detect alterations in the performance caused by the sodium bicarbonate ingestion; or the improvement magnitude in the performance caused by the sodium bicarbonate ingestion was not sufficient in order to reflect in performance improvement in fights. From this flow of thinking, the major issue that the present study raises is: to what extent improvement in the "physical" aspects of the athlete is capable of inducing improvement in performance in fights, in which the technical and tactic aspects are also very important? It is concluded from the data obtained in this study that possible improvement in the "physical" aspects did not reflect in performance improvement in fights. Anyway, the limitation of this study, such as the low sample number and the limitations of the used method (which despite being extremely applied, does not allow large control over other variables which influence performance) should be pondered when interpreting the results.

Future studies which need to evaluate judo performance will have to choose between highly specific protocols, ecological validity and low control of intervenient variables (which was the case of the present study), or protocols of higher accuracy and sensibility and lower practical application. Tests such as the Wingate for upper limbs and the *Special Judo Fitness Test* have been used in order to evaluate judo fighters performance[3,25] and are options of test with higher accuracy but lower specificity[25].

The blood lactate concentration mean was higher after $NaHCO_3$ ingestion in all moments of the collection. Significant differences were only observed in the first minute after the first fight. Such fact is an indication that there is a tendency to decrease the alkalosis effects with time progression, once the difference between the groups tend to decrease. Future studies should search for answers for this issue, evaluating the duration of the bicarbonate blood concentration increase after the alkalosis induction, since the decrease of efficiency of the $NaHCO_3$ after some hours could alter the ingestion strategy or even the decision to ingest it or not.

Studies that used different exercise protocols and different doses of bicarbonate found conflicting results of blood lactate. According to our results, some studies also found significant increase of the blood lactate concentration after the alkalosis induction[8,10,12-14,26-27]. Conversely, other studies verified either a non-significant tendency of increase of blood lactate, or no difference at all[7,15-17,19,20,28]. Obviously, these divergences are due to different doses administration as well as the several types of exercises applied. Differences in the blood lactate and performance were not observed in the studies in which the exercises did not have sufficient lactic anaerobic demand, besides not causing an extreme acidosis profile[15,17,19,26].

The present study was the first one to evaluate judo in combat situations. Considering the judo fights characteristics (promotion of an extreme acidosis and fatigue profile; presentation of great lactic anaerobic demand and constitution of subsequent series of intermittent supra-maximal exertions), the effects observed over the blood lactate concentration are consistent with other works which used exercise protocols with similar characteristics[13,15,17,19,26]. Such fact reinforces the hypothesis that the controversial results obtained so far may be related to the inadequacies of the test protocols, and not to the inconsistent effect of the sodium bicarbonate.

It has been demonstrated that the dose used in the present study is more efficient in the performance improvement than a 0.2 $g \cdot kg^{-1}$ or lower dose. Higher does on the other hand, do not promote more benefits than the 0.3 $g \cdot kg^{-1}$ dose[12]. The $NaHCO_3$ ingestion promotes significant increase of the HCO_3^- plasmatic concentration, as well as of the blood pH and the BE (*base excess*)[7,9,16,19,27,28].

The hypothesis that the H^+ ions are buffered in the muscular cells is discarded due to the impermeability of the sarcolemma to the HCO_3^-[29]. Nevertheless, the high concentration of HCO_3^- caused by the $NaHCO_3$ ingestion promotes increase of inflow of the H^+ ions of the muscular cells to the blood, where they are buffered[30].

Consequently, the intramuscular acidosis decreases, which extends the functioning of the glycolytic way and delays fatigue[14]. Such mechanism could explain the higher blood lactate concentration observed in this study. Besides the higher lactate production caused by the intramuscular pH decrease, other mechanisms may contribute to the increase of the blood lactate concentration after the sodium bicarbonate ingestion. Some authors suggest increase in the lactate inflow rate, since the exit of this anion is connected to the H^+ exit in the symport performed by the MCT-1 (*monocarboxilate transporter*)[31]. Other still produced evidence of lower lactate pick up by the non-exercised muscles[14].

There is a straight relation between muscular acidosis and fatigue, due to the following effects of the H^+ ions: 1) inhibition of the maximal velocity of muscular shortening[4]; 2) inhibition of the miofibrilar ATPase and the enzymes important for the regulation of the glycolytic anaerobic process of energy obtaining[4,6]; 3) reduction of the crossed bridges formation through inhibition of the Ca^{++} to the TNC site of the troponin[4-6]; and 4) reduction of the Ca^{++} return by the inhibition of the sarcoplasmatic ATPase, which leads to reduction in the Ca^{++} release[4]. Therefore, as previously mentioned, a reduction in the H^+ concentration in the muscular cell promotes delay in fatigue besides allowing that the glycolytic way is used for a longer period.

Although the performance evaluation in fights had not been sensible enough to detect alterations in performance, the increase of the blood lactate concentration after alkalosis induction observed in the present study suggests that this resource may potentially delay fatigue, as well as contribute to performance of judo fighters. The high blood lactate is an indication of higher energy production by the glycolytic way, which meant that theoretically the intramuscular acidosis was lower.

Lavender and Bird[11] claimed that the pH return close to resting indices, caused by the higher inflow of H^+ ions during alkalosis causes a more complete recovery between series in intermittent exercises. Therefore, we hypothesized that the fatigue sensation could be lower due to the alkalosis induction, both after the fight as well as before the following combat. Nonetheless, it was observed that there was no alteration in the perceived exertion caused by the $NaHCO_3$ ingestion. These results are according to the ones by Kozak-Collins *et al.*[32] and Stephens *et al.*[27], who used scales similar to the ones from this study. Poulus *et al.*[33], using another scale that measured fatigue, also verified that there was no alteration in the fatigue sensation derived from the $NaHCO_3$ utilization. According to the same authors, the fatigue sensation depends on metabolic, circulatory and psychochemical alterations, among others. The alterations in the acid-base balance caused by studies like this are only one among several physiological processes which involve the fatigue phenomenon. Such episode may explain the fact that there were not significant differences in the perceived exertion in any moment of the collection. However, used the scale was efficient in distinguishing fatigue (post-fights) and recovery moments.

In conclusion, although the sodium bicarbonate ingestion increases the blood lactate (indicating more extended utilization of the glycolytic way), which theoretically could contribute to performance in fights, the present study provides strong evidence that such strategy is innocuous in application terms, both for performance improvement as well as for decreasing the perceived exertion. Nonetheless, the method's limitations, such as the strong influence of technical, tactic and psychological aspects, should be considered. Moreover, there is the risk that the athletes present sensibility to the minimum necessary dose, which would be extremely counterproductive in terms of performance.

Future studies should use tests combinations with different degrees of objectiveness and specificity, such as the Wingate for upper limbs and *Special Judo Fitness Test*.

ACKNOWLEDGMENTS

The authors thank the Institute of Mathematics and Statistics of USP for the conduction of the statistical analysis; the FAPESP for the financial support; to Prof. Dr. Emerson Franchini for the contributions during the Project; to the physical trainers Marcos Antônio Lopes and Jaime Bragança; to the scholars André Massaru and Milena Bushatsky and to the athletes for the collaboration in this study.

All the authors declared there is not any potential conflict of interests regarding this article.

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