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ACUTE EFFECTS OF ORAL SODIUM BICARBONATE ON BLOOD MARKER LEVELS IN ELITE JUDO ATHLETES

AKUTNI EFEKTI UPOTREBE NATRIJUM-BIKARBONATA NA NIVO MARKERA KRVI KOD ELITNIH DŽUDISTA

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Summary
Introduction. The aim of this study was to establish if sodium bicarbonate affects the blood marker levels after a Special Judo Fitness Test in elite judo athletes. **Material and Methods.** Ten male judo athletes (age 20 ± 2.1 years; body height 180.18 ± 8.11 cm; body mass 85.24 ± 23.17 kg; body mass index 25.2 ± 3.4 kg/m^2), judo masters (black belt holders) with at least 10 years of training and competition experience, agreed to participate in the current research. **Results.** The results showed a significant main effect of time ($p < 0.05$) for the following variables: uric acid, aspartate aminotransferase, alanine transaminase, creatine kinase, lactate dehydrogenase, phosphate, magnesium, calcium, sodium, potassium, and chloride. We found that creatine kinase, C-reactive protein, sodium and chloride were significantly different ($p < 0.05$) in the sodium bicarbonate group compared to placebo group after the Special Judo Fitness Test. **Conclusion.** The main finding of the present study was that sodium bicarbonate (0.3 g/kg) improved recovery compared to placebo in elite judokas. Therefore, coaches should consider sodium bicarbonate to improve athlete recovery during combat.
Key words: Sodium Bicarbonate; Blood; Exercise Test; Martial Arts; Athletic Performance; Recovery of Function

Sažetak
Uvod. Cilj ove studije bio je da se utvrdi da li natrijum-bikarbonat utiče na nivo markera krvi nakon specifičnog džudo-testa kod vrhunskih džudista. **Materijal i metode.** Deset muških džudista (uzrast 20 ± 2,1 godina; telesna visina 180,18 ± 8,11 cm; telesna masa 85,24 ± 23,17 kg; indeks telesne mase 25,2 ± 3,4 kg/m^2) koji su majstori džudoa (nosioci crnog pojasa) sa najmanje 10 godina obuke i takmičarskog iskustva, pristali su da učestvuju u tekućem istraživanju. **Rezultati.** Rezultati ukazuju na to da postoji glavni vremenski efekat za sledeće varijable: urea, aspartat aminotransferaza, alanin aminotransferaza, kreatin kinaza, laktat dehidrogenaza, fosfat, magnezijum, kalcijum, natrijum, kalijum i hlor. Otkrili smo da su kreatin kinaza, visoko senzitivni C-reaktivni protein, natrijum i hlor bili značajno različiti u grupi sa natrijum bikarbonatom u poređenju sa placebo grupom nakon *Special Judo Fitness Test.* **Zaključak.** Glavni nalaz ove studije bio je da je natrijum bikarbonat (0,3 g kg**−1**) poboljšao oporavak u poređenju sa placebom kod vrhunskih džudista. Zbog toga bi treneri trebalo da razmotre uzimanje natrijum bikarbonata kako bi poboljšali oporavak sportista tokom borbe.
Ključne reči: natrijum bikarbonat; krv; fizički test; borilačke veštine; atletske performanse; oporavak funkcije

Introduction

Competitive judo is a sport of high-intensity where athletes repeatedly push and pull each other in order to perform different techniques (throws, arm bars, chokes, pins…) [1, 2]. It has been acknowledged that judo is a difficult sport that requires a variety of unique traits in order to compete at a high level [3]. Strength and endurance of upper and lower body, anaerobic power, speed and trunk muscle functions are the most important factors for success in judo [4, 5]. Furthermore, core stability may improve judo performance because it will make it easier for the lower body to transmit forces to the upper body [6] during judo techniques and it can also improve balance control [7] which is essential for dealing with disturbances brought on by the opponent [1, 2].

Recovery of the organism is important due to the appearance of fatigue [8]. Fatigue can be compensated by recovery and leads to the restoration of allostatic balance of the organism by establishing resources on the psychological and physiological level

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Abbreviations

ALT – alanine transaminase
AST – aspartate aminotransferase
Ca – calcium
Cl – chloride
CK – creatine kinase
hsCRP – high-sensitivity C-reactive protein
K – potassium
LDH – lactate dehydrogenase
Mg – magnesium
$NaHCO_3$ – sodium bicarbonate
Na – sodium
SJFT – Special Judo Fitness Test
HR – heart rate

[9]. It is very important to monitor the training load, recovery and changes in psychological status in judo, in order to improve performance and avoid non-functional overload [10, 11]. In addition, it is documented that high-intensity physical exercises may lead to localized muscle damage and a significant increase in the levels of creatine kinase (CK), lactate dehydrogenase (LDH) and myoglobin buildup after combat [12]. Also, significant increase in LDH and CK levels after strength training with a multiple series protocol is also present [13, 14]. Rapid weight loss is another issue that has a negative impact on muscle damage in judo athletes leading to a significant decline in performance during competition [15]. Therefore, it is crucial to monitor the recovery of athletes in order to reduce these indicators of muscle damage in order to avoid them [12].

To enhance recovery during training and competition, judo athletes use various types of products, chocolate milk [16], beta-alanine supplementation [17, 18], caffeine-containing energy drinks [19], caffeine [20, 21], and creatine [22]. The usage of sodium bicarbonate ($NaHCO_3$) for recovery improves judo-related performance and blood lactate concentration [23, 24]. On the other hand, Šančić et al. showed that active recovery was better compared to $NaHCO_3$ intake when lactic acid levels were used to determine the recovery levels in judokas [25]. Although the mentioned studies have shown the positive effects on several markers of recovery in judo, to the best of the authors' knowledge there were no studies that included blood markers. Therefore, the aim of this study was to determine whether $NaHCO_3$ affects blood markers after a specific judo test in elite judokas.

Material and Methods

Ten male judokas, aged 20.1 ± 2.8 years, judo masters (black belt holders) with at least 10 years of training and competition experience, agreed to participate in the current research **(Table 1)**. The inclusion criteria were male gender, age from 18 to 25 years, judo masters (black belt holders) with at least 10 years of training and competition experience, absence of diseases and injuries, and using no supplementation 2 months before the start of this study. The protocol of the study was approved by the Ethics Committee of the Faculty of Sport and Physical Education, University of Niš (04-1847/2; November 26, 2020), in accordance with the International Ethical Guidelines. In addition, all participants were informed about the protocol and gave their written consent to participate in the study.

The study was a double-blind crossover trial with the order of treatments being randomly assigned. The washout period was 72 hours. All subjects received a dose of $NaHCO_3$ (0.3 g/kg body weight) [24] or a placebo (Ringer's solution) 120 minutes before the fatigue caused by the Special Judo Fitness Test (SJFT) which was validated in high-level judokas [26].

Venous blood samples were taken before starting the training protocol, in the morning between 7 and 8 a.m., and after an overnight 10-hour fasting. In the second phase of the experimental treatment, the acute effects of $NaCO_3$ supplementation were investigated. At this stage, experimental group (N = 5) were supplemented with $NaCO_3$, while the control group (N = 5) received placebo. After supplementation, the participants had a "washout" period lasting 72 hours, after which the identical protocol was repeated in the same participants after they switched groups. The second blood sampling was done 5 minutes after the end of the SJFT, while the last blood collection was performed 30 minutes after the second one.

The SJFT was performed in the following order: two subjects (Uke) of the same weight category and similar height were positioned at 6 meters from each other, while the tested subject (Tori) was standing in the middle. At the timekeeper's signal, the tested participant runs to one Uke, performs a throw and then does the same with the other Uke. The test consists of three parts: the first part lasts 15 seconds of throwing and 10 seconds of rest. The second part lasts 30 seconds of throwing and 10 seconds of rest. The third part lasts 30 seconds of throwing.

Immediately after the end of the third part, the heart rate (HR) was measured with a HR monitor (Polar Team System, Polar, Kempele, Finland) (after exercise) as well as after 60 seconds of rest (after recovery). The index was calculated by summing the results of the HR after the test and the HR after 60 seconds of recovery, which is related to the total number of throws (n).

Index = HR after the test + HR 1 min after the test/n

Measurements of anthropometric parameters (body height, body weight) were measured by an anthropometer and the bioelectrical impedance method (InBody 770) before testing. Blood analysis was per-

Table 1. Basic descriptive characteristics of the sample (mean ± SD)
Tabela 1. *Bazična deskriptivna statistika uzorka (aritmetička sredina ± standardna devijacija*

Age (years) *Starost (godine)*	Training background (years) *Godine treniranja (godine)*	Body height (cm) *Telesna visina (cm)*	Body mass (kg) *Telesna težina (kg)*	Body fat (%) *Procenat masti (%)*	Fat mass (kg) *Masti (kg)*
20.1 ± 2.8	10.3 ± 1.2	180.2 ± 8.1	85.2 ± 23.1	12.8 ± 5.3	11.8 ± 8.6

Table 2. Blood marker levels following $NaHCO_3$ or placebo
Tabela 2. *Markeri krvi nakon $NaHCO_3$ ili placeba*

Variables/*Varijable*	Group/*Grupa*	1	2	3
Uric acid (mmol/L) *Mokraćna kiselina*	$NaHCO_3$ Placebo	352.18 ± 53.94	347.78 ± 50.09* 345.82 ± 44.73*	448.75 ± 52.07* 444.07 ± 42.35*
AST (U/L)	$NaHCO_3$ Placebo	23.55 ± 5.97	31.12 ± 6.51* 28.64 ± 3.50*	30.75 ± 11.41 28.60 ± 6.27
ALT (IJ/l)	$NaHCO_3$ Placebo	15.82 ± 6.19	25.12 ± 10.95 21.27 ± 10.58	18.62 ± 10.10 19.30 ± 8.08
CK (U/L)†	$NaHCO_3$ Placebo	245.73 ± 107.84	338.37 ± 135.84* 395.00 ± 163. 19	271.80 ± 114.61 289.64 ± 105.19
LDH (U/L)	$NaHCO_3$ Placebo	369.18 ± 42.78	445.78 ± 52.10* 438.45 ± 55.46*	415.87 ± 106.76 435.70 ± 78.40
hsCRP (mg/L) †	$NaHCO_3$ Placebo	1.36 ± 1.48	1.60 ± 2.47 1.52 ± 2.56	0.48 ± 0.30* 0.75 ± 0.55*
Phosphate/*Fosfat* (mmol/1)	$NaHCO_3$ Placebo	1.21 ± 0.15	1.46 ± 0.26* 1.51 ± 0.20*	0.89 ± 0.19* 1.15 ± 0.24*
Mg (mmol/1)	$NaHCO_3$ Placebo	0.77 ± 0.04	0.83 ± 0.06* 0.81 ± 0.05*	0.72 ± 0.08* 0.75 ± 0.05*
Ca (mmol/1)	$NaHCO_3$ Placebo	2.46 ± 0.08	2.64 ± 0.18* 2.65 ± 0.06*	2.42 ± 0.12* 2.61 ± 0.05*
Na (mmol/1)†	$NaHCO_3$ Placebo	138.82 ± 4.12	149.78 ± 8.00* 142.00 ± 3.19	141.25 ± 4.59* 142.50 ± 0.97
K (mmol/1)	$NaHCO_3$ Placebo	4.06 ± 0.21	3.54 ± 0.32* 3.66 ± 0.28*	3.85 ± 0.44 4.10 ± 0.25*
Cl (mmol/1)†	$NaHCO_3$ Placebo	100.27 ± 2.97	106.00 ± 5.36* 101.55 ± 2.62	99.12 ± 3.44* 102.30 ± 1.34
Myoglobin/*Mioglobin* (mcg/l)	$NaHCO_3$ Placebo	84.43 ± 42.35	81.63 ± 22.85 74.77 ± 50.04	94.11 ± 24.14 92.07 ± 56.82

Legend: * - statistically significant differences within groups ($p < 0.05$); † - group x time interaction ($p < 0.05$); 1 - baseline; 2 - after SJFT (5 min.); 3 - after SJFT (30 min.); $NaHCO_3$ – sodium-bicarbonate; AST - aspartate aminotransferase; ALT - alanine transaminase; CK - creatine kinase; LDH - lactate dehydrogenase; hsCRP - high-sensitivity C-reactive protein; Mg – magnesium; Ca – calcium; Na – sodium; K – potassium; Cl – chloride
*Legenda: * - statistički značajna razlika unutar grupa (p<0.05); † - grupa x vreme interakcija (p<0.05); 1 - inicijalno; 2 - nakon SJFT (5 min.); 3 - nakon SJFT (30 min.); $NaHCO_3$ – natrijum bikarbonat; AST - aspartat aminotransferaza; ALT - alanin aminotransferaza; CK - kreatin kinaza; LDH - laktat dehidrogenaza; hsCRP – visoko senzitivni C-reaktivni protein; Mg – magnezijum; Ca – kalcijum; Na – natrijum; K – kalijum; Cl – hlorid*

formed before SJFT and two times after SFJT. During every time point, all subjects rated the perceived exertion on Borg's scale.

Biochemical parameters were determined at the Faculty of Medical Science in Niš using standard routines and methods. Serum was used for biochemical analyses, and the blood count with the leukocyte formula was determined from whole blood. Test tubes with K2 EDTA anticoagulant were used for blood sampling to determine the blood count, and for fibrinogen test tubes with citrate as an anticoagulant. Biochemical analyses were performed on a Beckman Coulter AU680 (Beckman Coulter, Brea, CA) biochemical analyzer, blood count on a Cell-Dyn Ruby hematology analyzer, and fibrinogen on a Thrombostat coagulometer (Thrombostat 1, Behnk Elektronik GmbH & Co, Germany). The following blood markers were taken for further analysis: uric acid, myoglobin, CK, LDH, aspartate-aminotransferase (AST), high-sensitivity C-reactive protein (hsCRP), sodium (Na), magnesium (Mg) calcium (Ca), potassium (K), chloride (Cl), phosphate.

To test the normality of the data, we applied the Shapiro-Wilk test. Additionally, the data were tested for homogeneity using Levene's test. After that, a two-way analysis of variance with repeated measurements was used with supplementation and time point as factors (supplementation × round). When necessary, a post hoc test was used to identify possible differences between conditions and time. For analysis of variance results, effect sizes were calculated using eta squared (η^2), classified according to Cohen. The level of statistical significance was set at $p < 0.05$. Statistical data processing was carried out in the statistical package IBM SPSS 24.

Results

Table 2 presents the results of uric acid, AST, alanine transaminase (ALT), CK, LDH, phosphate, hsCRP, Mg, Ca, Na, K and Cl measured in different periods of time. The results showed a significant main effect of time for the following variables: uric acid ($F = 44.7$; $p = 0.001$; $\eta^2 = 0.87$), AST ($F = 8.5$; $p = 0.004$; $\eta^2 = 0.55$), ALT ($F = 9.01$; $p = 0.003$; $\eta^2 = 0.56$), CK ($F = 8.4$; $p = 0.004$; $\eta^2 = 0.55$), LDH ($F = 10.0$; $p = 0.002$; $\eta^2 = 0.59$), hsCRP ($F = 21.7$; $p = 0.01$; $\eta^2 = 0.55$); phosphate ($F = 49.1$; $p = 0.001$;

$\eta^2 = 0.86$), Mg ($F = 8.7$; $p = 0.004$; $\eta^2 = 0.55$), Ca ($F = 12.4$; $p = 0.001$; $\eta^2 = 0.64$), Na ($F = 7.8$; $p = 0.005$; $\eta^2 = 0.53$), K ($F = 9.2$; $p = 0.003$; $\eta^2 = 0.57$) and Cl ($F = 4.23$; $p = 0.036$; $\eta^2 = 0.38$). Additionally, group x time interactions were found for CK ($F = 5.2$; $p = 0.02$; $\eta^2 = 0.43$), hsCRP ($F = 3.9$; $p = 0.04$; $\eta^2 = 0.64$), Na ($F = 5.3$; $p = 0.02$; $\eta^2 = 0.43$) and Cl ($F = 6.3$; $p = 0.01$; $\eta^2 = 0.47$).

Discussion

The purpose of the present study was to investigate the effects of $NaHCO_3$ ingestion on selected blood markers during SJFT. The main finding was that $NaHCO_3$ (0.3 g/kg) improved recovery compared to placebo in elite judokas. We found that CK, hsCRP, Na and Cl were significantly different in $NaHCO_3$ group compared to placebo group after SJFT.

It is well known that quick recovery after intense physical activity has many benefits for athletes, such as improved performance and reduced possibility of overtraining [27]. Faster recovery is of crucial importance in judo as well as in other high-intensity combat sports [28, 29]. It is also known that high-intensity activities can have impact on acid-base balance, while further exercise-induced acidosis can negatively affect performance and athlete's recovery [30]. In order to regulate exercise-induced metabolic acidosis, athletes often use various nutritional and pharmacological agents that affect pH values in blood and muscles [23]. Mueller et al. [31] found that $NaHCO_3$ supplementation is useful in reducing acidosis as well as improving sports performance. Several studies [23–25, 32] were conducted in order to determine if using $NaHCO_3$ helps in recovery of judokas. Artioli et al. [24] tried to determine the acute effects of $NaHCO_3$, and found no improvements following the first two matches, while an improvement was noted in matches 3 and 4. There is a lack of studies dealing with blood markers and $NaHCO_3$ supplementation in judokas, which would provide direct comparison and some significant conclusions. One research aimed to determine the effects of caffeine and $NaHCO_3$ supplementation as well as the separate effects on recovery in judokas [32]. However, regarding biochemical markers, plasma lactates were the only ones sampled, showing that the combination of supplements had the greatest impact on recovery. Potential stronger effects with combinations of supplements were confirmed by a recent review [33] showing a significantly greater ergogenic effect when combining $NaHCO_3$ and beta-alanine compared to isolated intake of beta-alanine (Cohen's $d = 0.43$ versus 0.24).

It is believed that 3 successive judo matches may induce an increase in muscle damage markers, especially, serum CK and LDH [34]. Therefore, it is of great importance that in the current study CK was significantly different in $NaHCO_3$ group compared to placebo group after the SJFT. Moreover, it is also important to mention that serum CK and LDH reach their peak 24 - 96 hours after the exercise [35]. We evaluated the recovery 30 minutes following the SFJT. Accordingly, it can be assumed that the difference may be even higher in the current study regarding CK levels. Therefore, future studies should include additional testing the day after SFJT.

The most recently published review article [36] showed that acute or chronic $NaHCO_3$ supplementation is effective in improving certain variables of physical performance in combat sports. The authors also claimed that the positive effects are most often visible following the onset of fatigue. We found that $NaHCO_3$ intake was significantly more effective than placebo for CK, hsCRP, Na and Cl recovery. However, no effects were observed for any other outcomes in the current study. The reason for this may be the training protocol or doses of $NaHCO_3$ in this study. Although all judokas were high level athletes and trained at least ten years, variations among individuals with regard to the blood marker levels may be a possible explanation for these results.

The current study has some limitations. The main limitation is that some markers of muscle damage were not sampled 12 and 24 hours after muscle damage. It could be speculated that $NaHCO_3$ supplementation would show significant effects compared to the placebo group. Moreover, the results should be applied only to male judokas since the study included only male athletes. The sample size was small. However, it is hard to find a larger sample size at this level of sport. In addition, official combats should be used to evaluate $NaHCO_3$ effects on blood markers. Nevertheless, this kind of studies are of great importance in judo as a predominantly anaerobic sport [37] having in mind that excessive physical load may lead to oxidative stress in athletes.

Conclusion

The current study showed that sodium bicarbonate may lead to better recovery after a Special Judo Fitness Test or combat simulation. This supports the fact that sodium bicarbonate ingestion is important to increase glycolytic energy production and performance during a simulated judo combat. Therefore, coaches should consider sodium bicarbonate ingestion to improve athlete recovery during combat.

References

1. Agostinho MF, Philippe AG, Marcolino GS, Pereira ER, Busso T, Candau RB, et al. Perceived training intensity and performance changes quantification in judo. J Strength Cond Res. 2015; 29(6):1570-7.

2. Barbado D, Lopez-Valenciano A, Juan-Recio C, Montero-Carretero C, van Dieën JH, Vera-Garcia FJ. Trunk stability, trunk strength and sport performance level in judo. PloS One. 2016;11(5): e0156267.

3. Magnani Branco BH, Lopes-Silva JP, da Silva Santos JF, Julio UF, Panissa VLG, Franchini E. Monitoring training during four weeks of three different modes of high-intensity interval training in judo athletes. Archives of Budo. 2017;13:51-62.

4. Callegari GA, Novaes JS, Neto GR, Dias I, Garrido ND, Dani C. Creatine kinase and lactate dehydrogenase responses after different resistance and aerobic exercise protocols. J Hum Kinet. 2017;58:65-72.

5. Teixeira AO, Paulitsch FS, Umpierre MM, Moraes MB, Rosa CE, Signori LU. Inflammatory response after session of resistance exercises in untrained volunteers. Acta Scientiarum - Health Sciences. 2015;37(1):31-9.

6. Franchini E, Del Vecchio FB, Matsushigue KA, Artioli GG. Physiological profiles of elite judo athletes. Sports Med. 2011;41(2):147-66.

7. Halson SL. Monitoring training load to understand fatigue in athletes. Sports Med. 2014;44(Suppl 2):S139-47.

8. Imed G, Mouna T, Fatma A, Nizar S. Comparison of muscle damage parameters between the training session and after a fight amongst judokas. J Physic Educ Sport. 2020;20(1):71-8.

9. Iwai K, Okada T, Nakazato K, Fujimoto H, Yamamoto Y, Nakajima H. Sport-specific characteristics of trunk muscles in collegiate wrestlers and judokas. J Strength Cond Res. 2008;22(2):350-8.

10. Kellmann M. Enhancing recovery: preventing underperformance in athletes. Champaign: Human Kinetics; 2002.

11. Kibler WB, Press J, Sciascia A. The role of core stability in athletic function. Sports Med. 2006;36(3):189-98.

12. Perrin P, Deviterne D, Hugel F, Perrot C. Judo, better than dance, develops sensorimotor adaptabilities involved in balance control. Gait Posture. 2002;15(2):187-94.

13. van Dieën JH, Luger T, van der Eb J. Effects of fatigue on trunk stability in elite gymnasts. Eur J Appl Physiol. 2012;112(4):1307-13.

14. Yoshitomi SK, Tanaka C, Duarte M, Lima F, Morya E, Hazime F. Respostas posturais à perturbação externa inesperada em judocas de diferentes níveis de habilidade. Revista Brasileira de Medicina do Esporte. 2006;12(3):159-63.

15. Roklicer R, Lakicevic N, Stajer V, Trivic T, Bianco A, Mani D, et al. The effects of rapid weight loss on skeletal muscle in judo athletes. J Transl Med. 2020;18(1):142.

16. Papacosta E, Nassis GP, Gleeson M. Effects of acute postexercise chocolate milk consumption during intensive judo training on the recovery of salivary hormones, salivary SIgA, mood state, muscle soreness, and judo-related performance. Appl Physiol Nutr Metab. 2015;40(11):1116-22.

17. Miarka B, Del Vecchio FB, Franchini E. Acute effects and postactivation potentiation in the Special Judo Fitness Test. J Strength Cond Res. 2011;25(2):427-31.

18. de Andrade Kratz C, de Salles Painelli V, de Andrade Nemezio KM, da Silva RP, Franchini E, Zagatto AM, et al. Beta-alanine supplementation enhances judo-related performance in highly-trained athletes. J Sci Med Sport. 2017;20(4):403-8.

19. Souza DB, Del Coso J, Casonatto J, Polito MD. Acute effects of caffeine-containing energy drinks on physical performance: a systematic review and meta-analysis. Eur J Nutr. 2017;56(1):13-27.

20. Souissi M, Abedelmalek S, Chtourou H, Atheymen R, Hakim A, Sahnoun Z. Effects of morning caffeine' ingestion on mood states, simple reaction time, and short-term maximal performance on elite judoists. Asian J Sports Med. 2012;3(3):161-8.

21. Souissi M, Aloui A, Chtourou H, Aouicha HB, Atheymen R, Sahnoun Z. Caffeine ingestion does not affect afternoon muscle power and fatigue during the Wingate test in elite judo players. Biol Rhythm Res. 2015;46(2):291-8.

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BIBLID.0025-8105:(2023):LXXVI:1-2:5-9.

22. Kreider RB, Kalman DS, Antonio J, Ziegenfuss TN, Wildman R, Collins R, et al. International Society of Sports Nutrition position stand: safety and efficacy of creatine supplementation in exercise, sport, and medicine. J Int Soc Sports Nutr. 2017;14:18.

23. Artioli GG, Coelho DF, Benatti FB, Gailey AC, Gualano B, Lancha AH Jr. A ingestão de bicarbonato de sódio pode contribuir para o desempenho em lutas de judô? Revista Brasileira de Medicina do Esporte. 2006;12(6):371-5.

24. Artioli GG, Gualano B, Coelho DF, Benatti FB, Gailey AW, Lancha AH Jr. Does sodium-bicarbonate ingestion improve simulated judo performance? Int J Sport Nutr Exerc Metab. 2007;17(2):206-17.

25. Šančić J, Scruton A, Prosoli R, Štefan L, Sporiš G, Madić D, et al. Active recovery vs sodium bicarbonate: impact on lactic acid removal following a specific judo effort. Archives of Budo. 2017;13:315-22.

26. Casals C, Huertas JR, Franchini E, Sterkowicz-Przybycień K, Sterkowicz S, Gutiérrez-García C, et al. Special judo fitness test level and anthropometric profile of elite Spanish judo athletes. J Strength Cond Res. 2017;31(5):1229-35.

27. Bishop PA, Jones E, Woods AK. Recovery from training: a brief review: brief review. J Strength Cond Res. 2008;22(3):1015-24.

28. Kellmann M. Preventing overtraining in athletes in high-intensity sports and stress/recovery monitoring. Scand J Med Sci Sports. 2010;20(Suppl 2):95-102.

29. Morales J, Alamo JM, García-Massó X, Buscà B, López JL, Serra-Añó P, et al. Use of heart rate variability in monitoring stress and recovery in judo athletes. J Strength Cond Res. 2014;28(7):1896-905.

30. Robergs RA, Ghiasvand F, Parker D. Biochemistry of exercise-induced metabolic acidosis. Am J Physiol Regul Integr Comp Physiol. 2004;287(3):R502-16.

31. Mueller SM, Gehrig SM, Frese S, Wagner CA, Boutellier U, Toigo M. Multiday acute sodium bicarbonate intake improves endurance capacity and reduces acidosis in men J Int Soc Sports Nutr. 2013;10(1):16.

32. Felippe LC, Lopes-Silva JP, Bertuzzi R, McGinley C, Lima-Silva AE. Separate and combined effects of caffeine and sodium-bicarbonate intake on judo performance. Int J Sports Physiol Perform. 2016;11(2):221-6.

33. Saunders B, Elliott-Sale K, Artioli GG, Swinton PA, Dolan E, Roschel H, et al. β-alanine supplementation to improve exercise capacity and performance: a systematic review and meta-analysis. Br J Sports Med. 2017;51(8):658-69.

34. Detanico D, Dal Pupo J, Franchini E, Dos Santos SG. Effects of successive judo matches on fatigue and muscle damage markers. J Strength Cond Res. 2015;29(4):1010-6.

35. Brown SJ, Child RB, Day SH, Donnelly AE. Exercise-induced skeletal muscle damage and adaptation following repeated bouts of eccentric muscle contractions. J Sports Sci. 1997;15(2):215-22.

36. Dankovic G. Effects of sodium bicarbonate supplementation in martial arts. Serbian Journal of Experimental and Clinical Research. Forthcoming 2022. Doi: 10.2478/sjecr-2022-0016

37. Ponorac N, Matavulj A, Rajkovača Z, Kovačević P. The assessment of anaerobic capacity in athletes of various sports. Med Pregl. 2007;60(9-10):427-30.