

Active recovery vs sodium bicarbonate: impact on lactic acid removal following a specific judo effort

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Abstract

Background and Study Aim:

Combat sports such as judo are known to be extremely high demanding which can result with high level of lactic acid. Because of that recovery is crucial part of preparation for competitive judo. The aim of this study was the effectiveness of active recovery and sodium bicarbonate to removal of lactic acid after a judo match simulation (JMS) and Specific Judo Fitness Test (SJF).

Material and Methods:

Participants were 10 judo athletes (6 male and 4 female), age 18-20 years, from Judo Club Samobor, Croatia. In this study, the SJFT was used as well as JMS with a duration of 4 minutes.

Results:

There are significant differences on all lactate levels between the active recovery and baking soda variables during SJFT and JMS. In all measurements, lactate levels were significantly higher ($p < 0.001$) when athletes used baking soda intake versus active recovery.

Conclusions:

Overall results in this research suggest that levels of lactic acid were significantly lower when athletes used active recovery versus sodium bicarbonate intake. This may be due to the difference in effectiveness of the aerobic system during active recovery and the system in which soda bicarbonate removes the excess hydrogen ions.

Key words:

HR • *ippon-seoi-nage* • judo match simulation • randori • Specific Judo Fitness Test

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Lactic acid – *noun* a sugar that forms in cells and tissue, and also in sour milk, cheese and yoghurt [43].

Active recovery – *noun* rehabilitation from an injury in which gentle exercise is taken to maintain flexibility [43].

Sodium – *noun* a chemical element that is the basic substance in salt (NOTE: The chemical symbol is **Na**.) [43].

Combat sports – are a competitive contact sports with one-on-one combat. Determining the winner depends on the particular contest's rules. In many combat sports, a contestant wins by scoring more points than the opponent or by disabling opponent [45].

Tori – the person who applies a technique in *judo* training. The receiver of the technique is referred to as *uke* [44].

Hajime (jap.) – begin.

Mate (jap.) – stop (wait).

Ippon-seoi-nage – single back throw (belong to *te-waza* : hand throwing techniques, sub group judo techniques in vertical posture).

Randori – sparring in judo in which both participants practice attacking and defending [44].

Judogi – is the formal Japanese name for the traditional uniform used for judo practice and competition [Wikipedia see also 46].

Fatigue – *noun* very great tiredness [43].

HR – heart rate.

Supramaximal efforts – can be defined as efforts with oxygen demand exceeding VO_{2max} [47].

INTRODUCTION

Although techniques and tactics play an important role in judo match [1], it is also very physiologically [2] and psychologically demanding [3] sport. Franchini et al. [4] concluded that high level competitive judo athletes usually show highly developed dynamic strength, muscular endurance, anaerobic power and capacity as well as aerobic power. Judo belongs to intermittent, high-intensity activities, intervalled by brief recovery periods [5, 6]. Thus, Franchini [7] concluded that judo combats rely on all three metabolic energy systems. Artioli et al. [8] stated that anaerobic glycolytic pathway is strongly associated with judo efforts, which is influenced by short recovery periods. Moreover, this short recovery periods could lead to high lactate concentration following judo matches [9]. It can be argued that judo performance by fatigue as a limiting factor which is due the intensity of effort, the duration of matches, and the high number of matches during one day [8]. Some authors [10, 11] stated that fatigue in short-term activities such as judo is educed due to accumulation of H^+ ions and consequent intramuscular acidosis. During training sessions, *randori* is the exercise that most closely mimics competitive matches [12] and this is why it is chosen as one of the tests in this study. Aforementioned test is usually consisted of several high-intensity combat sessions periods which lead to high post-exercise blood lactate concentrations [7]. Because of high physiological demands during judo fights it is important to have and use specific tests to evaluate judo athletes physical fitness which can help improve their training routine and contribute to a higher level of performance.

One of the most used specific judo tests is the Special Judo Fitness Test (SJFT). SJFT has shown high reliability [13], highly correlated to performance in well controlled laboratory tests [14, 15] and correlated to attacks during a judo match [16]. Franchini and Sterkowicz [4] in their research on 14 male judo athletes who performed the SJFT found that higher alactic contribution seems to be a consequence of the high intensity efforts performed during the test, and its intermittent nature. They suggested that, when using the SJFT, coaches are evaluating mainly their athletes' anaerobic alactic system, which is considered to be the most predominant system contributing to the actions performed during the match.

Differences between active and passive recovery have been researched in several studies conducted on judo athletes. One research on 17 male judokas of different competitive levels tried to verify the effects of active and passive recovery after a judo match on blood lactate removal [9]. Aforementioned authors found that the lactate removal was improved with active recovery when compared to passive. However, active recovery did not produced improvements in performance in a subsequent intermittent anaerobic exercise. Furthermore, Franchini et al. [17] compared the effects of active and passive recovery on performance in judo. They found that the minimal recovery time reported in judo competitions (15 min) is long enough for sufficient recovery, showed through a specific high-intensity test (SJFT). However, the possibility of winning a match significantly increased when judo athlete performed active recovery and his opponent performed passive recovery.

There were numerous studies that investigated influence of sodium bicarbonate to athletes' performances in different sports. Recent studies suggested that sodium bicarbonate intake improves the performance of the athletes. In their study, Mc Naughton and Thompson [18] found that ingestion of sodium bicarbonate, over a period of six days significantly improved work output two days after bicarbonate ingestion ceased. Artioli et al. [8] concluded that sodium bicarbonate improves judo-related performance and increases blood lactate concentration but has no effect on perceived exertion. Artioli et al. [19] investigated the effect of the $NaHCO_3$ ingestion on the judo performance. Aforementioned authors concluded that the ergogenic effects of $NaHCO_3$ are not enough to contribute to the improvement of the performance in judo fights and suggested that future studies should be made in order to investigate this concept further. This is why we used the similar protocol in our study.

Elite judokas must achieve an excellent level of physical fitness and physical condition during training in order to be successful. Knowledge on the physiological response to judo-specific modalities and training sessions can help coaches to improve their training prescription and, consequently, maximize their athlete's performance [20]. Although there are numerous studies investigating the influence of different ways of recovery on numerous performance variables, some of which suggest that active recovery as

well as sodium bicarbonate intake may be beneficial to athlete's recovery, there are no studies which investigated and compared these two ways.

The aim of this study was the effectiveness of active recovery and sodium bicarbonate to removal of lactic acid after a judo match simulation (JMS) and Specific Judo Fitness Test (SJFT). Due to differences in the way those two recovery methods work, it is expected that the levels of lactic acid will be higher when athletes use baking soda than when they use active recovery. Furthermore, it is expected that the numbers of throws in SJFT will be higher when athletes use baking soda as a recovery method.

MATERIALS AND METHODS

Participants

Participants were 10 well trained judokas, (19.2 ±1.4 age; Height 176.4 ±4.9; Weight 78.9 ±10.2), from Judo Club Samobor, Croatia). Participants were required to refrain from exercise 24 h prior to each trial and not to ingest any food 2 h prior the test sessions. All participants were familiarised with the procedures adopted and had performed the tests previously at least once in training. All competitors were international athletes. Two months prior to testing VO₂max was measured with all subjects on the testing that took place at the University of Sport in Zagreb. From a total of 10 participants there were 6 men and 4 women. They all signed a Written Participant Consent form prior to testing.

The protocol of the study was approved by the Ethical Committee of the Faculty of Kinesiology, University of Zagreb, according to the revised Declaration of Helsinki.

Procedures

Protocol 1: judo match simulation (JMS) with a duration of 4 minutes (*randori* including *hajime* and *mate*) was used. Each participant was assessed on two different days, with 4 days recovery between trials and was randomly assigned with 0.3 g/kg body weight of NaHCO₃ 120 min before the beginning of sodium recovery trial and prescribed active recovery in the other trial.

Protocol 2: The Special Judo Fitness Test (SJFT) is proposed by Sterkowicz [21]. In this test, two

judokas (*ukes*) with similar height and body mass of the judo athlete (*tori*) performing the test are positioned at 6m distance from one another, while the *tori* is 3m from the judokas that will be thrown. The measurement procedure is divided into three time periods: 15 s (A), 30 s (B), and 30 s (C) with 10 s intervals between them. During each measurement period, *tori* throws the partners using the *ippon-seoi-nage* technique as many times as he can. In original procedure, immediately after 1 minute as the test is completed the athlete's heart rate is checked. Throws are also counted and the index is calculated:

Index = final HR(bpm) + HR 1min after the end of the test (bpm)/total number of throws.

The higher test performance means the index value will be lower. In this research, only the levels of lactic acid were measured in the different times after competition of SJFT. Each volunteer was assessed on two different days, with 4 days recovery between trials and was randomly assigned 0.3 g/kg body weight of NaHCO₃ 120 min before the beginning of one trial and prescribed active recovery in the other. For lactate measure device Accutrend PLUS SYSTEM was used, while POLAR M400 was used for heart rate monitoring.

Testing took place in competition's post season, during two weeks in July 2016. During testing, all subjects were wearing judogi and belt. The first day, starting at 18:00, the participants first access SJFT lasting 95 seconds after which was administered active recovery (10 minutes running at 50% VO₂ peak ~ 130 HR) and measured their blood lactate. During the active recovery participants wore POLAR M400 in order to measure their heart rate during running. Four days after the first test the same participants worked simulated JMS (*randori*) with a duration of 4 minutes (including *hajime* and *mate*) with referee, and based on action points were awarded. If some of the participants achieved *ippon* (end of the match) fight would be continued until the expiry of 4 minutes. After a JMS active recovery (10 minutes running at 50% VO₂ peak ~ 130 HR) was applied and their blood lactate measured. The following week at 18:00 the same participants again have accessed SFJT. Two hours prior to this test they all took the baking soda into the body orally at a dose of 0.3 g/kg body mass. After the test, which lasted 95 seconds lactate levels were measured and subjects were just standing

by and did not use any method of recovery.

On the fourth day of second week of testing, the same participants at 18:00 hours worked simulated JMS (*randori*) with duration of 4 minutes (including *hajime* and *matte*) with referee, and based on action points were awarded. If some of the participants achieved *ippon* (end of the match) fight would be continued until the expiry of 4 minutes. After finishing, the fight blood samples were taken and the participants watched from the side-lines and did not use any methods of recovery. Again they took the baking soda 2 hours before the fight into the body orally at a dose of 0.3 g/kg body mass. All subjects blood samples were taken from a finger before the test, immediately after the end of the test, then after 3 minutes of rest and finally after 10 minutes of rest. The tests was conducted with a minimal time interval of 24 h and a maximum of 1 week between the first and last test session. All tests were conducted at the same time of day.

Statistical analysis

All statistical analyses were performed with SPSS, version 9.0. Descriptive statistics and Kolmogorov–Smirnov tests (normality of the distribution) were calculated for all experimental data before inferential testing. Data were expressed as mean values \pm standard deviation. Sample t-test was used where significant variations occurred. The level of significance was set at $p < 0.05$.

RESULTS

All five variables showed normally distributed data. According to the results of t test there are significant differences on all lactate levels between active recovery and baking soda intake in SJFT (Table 1). In all measurements, levels

of lactate were significantly higher ($p < 0.001$) when athletes used baking soda intake versus active recovery. Also, there is significant difference between two measurements at basic levels of lactate which can limit further conclusions about differences in other measurements after that. Furthermore, there were no significant differences in the number of throws between two measurements.

The Kolmogorov–Smirnov test for distribution normality showed that all five variables have normally distributed data. The t test showed significant differences between the active recovery and baking soda variables during JMS. There were significant differences on all the lactate measurements except on basic levels (L1) which were the same in both situations. In all other measurements, levels of lactate were significantly higher ($p < 0.001$) when athletes used baking soda intake versus active recovery.

DISCUSSION

Results in the present study show significant differences on all lactate levels between active recovery and sodium bicarbonate intake in SJFT. In all measurements, levels of lactic acid were significantly higher ($p < 0.001$) when athletes used sodium bicarbonate intake versus active recovery. Some previous studies also showed increases in blood lactate concentration after sodium bicarbonate intake [22, 23]. On the other hand, there are some studies that showed no significant changes in blood lactate [24, 25]. Artioli et al. [8] argued that the possible reason for this increase in lactate concentration after sodium bicarbonate intake can be found due to the fact that the sarcolemma is not permeable to bicarbonate [26]. Accordingly, hydrogen ions are not buffered inside muscle cells. When there is greater extracellular sodium bicarbonate

Table 1. Basic descriptive statistics and differences in lactate level between active recovery and baking soda during Special Judo Fitness Test 10 judo athletes.

Variables	Active recovery mean \pm SD	Baking soda mean \pm SD	t-value	p-value
Number of throws	22.70 \pm 1.34	24.30 \pm 2.00	-0.21	0.050
L1 start	2.18 \pm 0.33	2.54 \pm 0.41	-2.13	0.047
L2 end	11.25 \pm 0.93	17.10 \pm 1.30	-11.54	<0.001
L3(+3 min)	15.8 \pm 0.80	18.60 \pm 1.28	-5.87	<0.001
L4(+10min)	8.76 \pm 1.13	17.21 \pm 0.99	-17.73	<0.001

Table 2. Basic descriptive statistics and differences in lactate level between active recovery and baking soda during judo match simulation 10 judo athletes.

Variables	Active recovery mean ±SD	Baking soda mean ±SD	t-value	p-value
L1 start	2.35 ±0.40	2.65 ±0.32	-1.83	0.083
L2 end	16.33 ±2.04	19.13 ±0.73	-4.09	<0.001
L3(+3 min)	14.53 ±1.59	18.79 ±1.53	-6.10	<0.001
L4(+10 min)	11.87 ±1.38	15.12 ±1.44	-5.15	<0.001

concentration there is also greater hydrogen ions efflux to the blood [27], where it can be buffered. Consequently, this reduces intramuscular acidosis and can delay the onset of fatigue [22].

When we analyse the mean values of the results (Table 1) for the protocol including sodium bicarbonate, we can see that the values of lactic acid in the blood increased immediately after performing SJFT (L2; M= 17.10) and continued to increase 3 minutes after that (L3; M=18.60). Furthermore, 10 minutes after the test the values still remained very high (L4; M= 17.21). In the protocol where active recovery was used, levels of lactic acid in the blood were significantly lower compared to protocol when sodium bicarbonate was used, and this happened through all the measurements: immediately after SJFT (L2; M = 11.25), 3 minutes later (L3; M = 15.8) and 10 minutes after the test (L4; M = 8.76). We can see from statistically significant differences (Table 1) that the lactic acid concentrations in the blood were much higher in the sodium bicarbonate protocol and they stayed that way even 10 min after the test. Values after active recovery were significantly lower and also dropped further 10 minutes after performing the test, finishing at significantly lower value than in sodium bicarbonate protocol. Here it is also important to note that the levels of lactic acid in the blood were significantly different in the first measurement, before performing the test. (L1; p = 0.047). This means that any differences in further measurements may be influenced by this significant difference at the beginning of the testing. This can further limit our conclusions about results.

When comparing the acid lactate levels of judo athletes in this study to the previous studies which used SJFT, we can see that their values 3 minutes after conducting the test are somewhat different than ours. On male judo athletes, Franchini et al. [16] measured 10.9 mmol/l of lactic acid

and Detanico et al. [28] got the similar values (10.2 mmol/l). For non- elite female judo athletes, Drid et al. [29] got the value of 6.2 mmol/l. In our study, 3 min after the test, our athletes had M = 18.60 mmol/l when using the sodium bicarbonate and M = 15.8 when using active recovery. Considering that, we can conclude that athletes in this study had significantly different levels of lactic acid between protocol in which they used active recovery and protocol where sodium bicarbonate intake was used in all time points (immediately after the test, 3 and 10 minutes after the test). On every measurement, the active recovery resulted in lower levels of lactic acid than sodium bicarbonate intake. Also, results in our study on measurements conducted 3 minutes after the test are higher than those in other similar studies in both situations. The reason behind that can be the fact that competitors in this study were all cadets and juniors while majority of the other studies used high level seniors due to the seniors having higher fitness and technical levels.

Furthermore, there were no significant differences in number of throws (Table 1) between two measurements. This means that, in our study, there were no differences in performance between trials when athletes used active recovery versus trials when they used sodium bicarbonate intake. Several previous studies [8, 24, 30] indicated that induced alkalosis can be especially efficient in intermittent, high-intensity, short-term bouts of exercise, such as judo. Results in our study did not confirm significant differences in performance in relation to active recovery but some other studies suggested that the impact of sodium bicarbonate is particularly apparent after the onset of fatigue; after several bouts of SJFT [8]. In our study, we used only one trial on SJFT for each protocol (active recovery and sodium bicarbonate intake) and this may be the reason why significant differences in number of throws didn't occur. However, if we analyse the

arithmetic means (M) of the results in number of throws, we can see that the athletes did perform more throws (M = 24.30) when they used sodium bicarbonate intake as opposite to protocol when they used active recovery (M = 22.70).

Other similar studies which used SJFT got similar results considering the number of throws during the test. Franchini et al. [16] on non-elite judo athletes got the average of 25, similar to Sterkowicz and Franchini, [31] who got the average of 25.8 on junior male judo athletes. On the female judo athletes, Jagiello et. al [32] as well as Wolska-Paczoska [33] got the mean of 22.1 throws, while Wolska et. al [34] and Smulski et. al [35] got slightly higher number of throws (24.3). These values are similar to ours when athletes used sodium bicarbonate intake (M = 24.3) as well as when they used active recovery (M = 22.70). On the other hand, there are some studies which concluded that intake of sodium bicarbonate didn't influence performance nor blood lactate concentration [25, 36].

Results from this study also show a significant difference on all the lactic acid levels between active recovery and sodium bicarbonate intake after the judo match simulation. In all measurements after the end of the fight the lactic acid levels were significantly higher ($p < 0.001$) when the athletes used sodium bicarbonate intake versus active recovery. The differences were not found on initial measurement, before the fight ($p = 0.083$), suggesting that any further differences were consequences of intervention in the study. In support of this Franchini et al. [37] found that the likelihood of winning a match increased 10 times when a judoka performed active recovery following the previous bout. This may have been due to the increased removal of lactic acid as a result of the active recovery.

However, the results from the SJFT show a slight increase in the number of throws when the athletes ingested soda bicarbonate. Although this was not measured during the JMS, it could be assumed that the effects would be similar. In support of this Siegler et al. [38] had 6 male and 8 female swimmers and implemented randomized placebo and sodium bicarbonate treatments. They found that swim time decreased significantly for the athletes who ingested sodium bicarbonate 2.5 hours before they swam. In addition, McNaughton et al. [39] assumed that chronically intake of sodium bicarbonate ($0.5 \text{ g} \cdot \text{kg}^{-1}$ body mass) for a period of 5 days would improve

the performance during 60s of high-intensity exercise on an electrically braked cycle ergometer. They found that the addition of sodium bicarbonate to a normal diet proved to be of ergogenic benefit in the performance of short-term, high-intensity work. Costil et al [24] conducted a study on 11 participants who have used 0.2 g/kg body mass and concluded that supplementing with bicarbonate does improve performance. The athletes in their study performed five successive 60 second sprints on a stationary bike, with the last sprint lasting until the athlete reached exhaustion. The bicarbonate improved time until exhaustion thus directly influencing the performance. Results of those studies, as well as ours, suggest that intake of sodium bicarbonate can result in higher performances of the athletes.

On the other hand, Artioli et al. [8] in their study on judo athletes concluded that the administration of alkaline substances was not capable of improving performance in judo fights. They suggested further investigation in this area because of great quantity of variables related to performance in a judo fight. In sports such as judo, the high H^+ ions concentration can be one of the main causes of muscular fatigue [40]. This can further harm the muscular contraction-relaxation and energy obtaining processes [40]. Although there are some studies that failed to prove its efficiency [25, 36], the ergogenic action of alkaline substances (such as sodium bicarbonate) was the topic in many different studies using different high intensity and short duration exercises. It is been argued that alkaline substances can be especially efficient in improving the performance in intermittent series of supra maximal exercises or in a series of them with duration from 60 s to 5 minutes [8, 41]. Considering that judo fights can last from few seconds to 5 or more minutes, judo is a very interesting area of study considering these influences. Furthermore, judo fighters predominantly use their upper limbs in numerous different grip fights where alkalosis can, according to Artioli et. al [8], have a special effects. Therefore, judo fights can be an especially interesting area of study for influences of sodium bicarbonate on performance as well as lactic acid removal.

When we analyse the mean values of the results on judo match simulation (Table 2) for the protocol including sodium bicarbonate, we can see that the values of lactic acid in the blood increased immediately after the fight (L2; M = 19.13) but started to decrease 3 minutes after that (L3; M = 18.79). This

is somewhat different than in SJFT when the levels of lactic acid continued to increase in this time. Furthermore, 10 minutes after the test the values still remained very high (L4; M = 15.12) but still little lower than when using the SJFT (M = 17.12). In the protocol where active recovery was used, levels of lactic acid in the blood were significantly lower compared to protocol when sodium bicarbonate was used, and this happened through all the measurements: immediately after JMS (L2; M = 16.33), 3 minutes later (L3; M = 14.53) and 10 min after the test (L4; M = 11.87). Compared to active recovery in the SJFT, these results are much higher in all measurements. Furthermore, we can see that the lactic acid concentrations in the blood were much higher in the sodium bicarbonate protocol and they stayed that way even 10 min after the test (Table 2). Values after active recovery were significantly lower and also dropped further 10 minutes after performing the test, finishing at a significantly lower value than in sodium bicarbonate protocol.

Overall results in this research suggest that levels of lactic acid were significantly lower when athletes used active recovery versus sodium bicarbonate intake. This may be due to the difference in effectiveness of the aerobic system during active recovery and the system in which soda bicarbonate removes the excess hydrogen ions. Although active recovery resulted in significantly lower levels of lactic acid in both tests used in this study (SJFT and *randori* test) it may not be appropriate at competition as athletes also need to rest and cannot be constantly exercising between contests. Therefore, soda bicarbonate might be a better alternative. Future studies would be able to confirm which would be more suitable in specific judo situations.

In this research we used a relatively small number of participants at a similar level. Future studies need to include more participants who of a different age and level of involvement in sport. Furthermore, in this study we didn't have any performance variable during JMS (such as number of attacks, throws etc.) which should be included in future studies. Klinzing and Karpowicz [42] stated that one of

the main limitations of their research on wrestling was numerous differences between activities performed in a real match and in the laboratory. Similar difficulties can be transformed to research on judo [8]. In order to avoid that and improve the ecological validity of our study, we used 2 different tests to evaluate performances related to a judo match (SJFT and JMS). Both of these tests confirmed their validity in numerous studies conducted on judo athletes [12, 16]. However, it is still not clear whether those tests provide a good enough measure to generalize conclusions to actual judo competition. Further investigations using different durations of the fight as well as different groups of participants (male vs. female, younger vs. older, elite vs. non-elite) should be conducted in order to further investigate differences observed in this study.

CONCLUSIONS

The results of our study revealed that levels of lactic acid are significantly lower when athletes use active recovery versus sodium bicarbonate intake. Furthermore, lactic acid levels after an actual competition performance could be measured in order to conclude about real differences and usefulness of different recovery types in real situations. Also, more relevant performances should be measured during judo match simulation or actual competition performances such as: number of attacks, number and types of throws etc. These results can show possible differences in different recovery types used between the fights. However, it is somewhat difficult to choose which measures are good enough to represent performance in actual judo competition.

The question is open: Do we need to count number of attacks not scores, which scores and do we count as false attacks?

In our opinion much more detailed researches should be made across different age categories to ensure that general conclusions about the influence of different recovery types to performance can be made.

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