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Research Article

Comparing the Recovery of Blood Lactate to Uchi- Komi Training in Male and Female judoka

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Abstract

Background: One of the reasons in judo fight is the accumulation of muscle lactate; therefore, searching for suitable method to reduce recovery time during competitions and comparing the recovery of male and female judo players is the aim of this research.

Materials and Methods: 17 judokas including nine men (age: 19.94±1.68, weight: 68.57±10.03 and height: 176.77±7.44) and eight women (age: 25.62±3.48, weight: 62.70±40.0 and height: 160.7±87.31), voluntarily participated in semi-experimental study. Subjects performed Uchi-kumi training until exhaustion in two separate sessions as two active and passive recoveries with a time interval of 48 hours. Blood lactate was measured before, immediately, 5 and 10 minutes after exercise. In passive recovery, subjects sat on a chair, and in active recovery, uchi-kumi training was performed without a training opponent. Data were analyzed by analysis of variance with repeated Measures and t-test.

Results: After 5 minutes, lactate reduction was significant only in active recovery for men (P=0.001) and women (P=0.001); But in 10th minute of recovery, lactate reduction in both active states for men (P=0.001) and women (P=0.048) and passive states for men (P=0.001) and women (P=0.001) It was significant. In addition, the changes between men and women were similar in both cases.

Conclusion: An increase in blood lactate after uchi kumi training was expected; however, passive recycling required at least 10 minutes. Therfore, 5 minutes of Uchi Kumi training without a training opponent, regardless of the effect of gender, accelerated the recovery and prepared the judokas to participate in the next competition.

Keywords:
Recovery, Blood lactate, Uchi-kumi, Judoka

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1. Introduction

Judo is an olympic sport; each match can last up to 4 minutes. A judoka can win full Ipon points in the first seconds of a fight by performing a fast and perfect technique and finish the match. However, reaching the peak of performance in judo requires the development of physiological capabilities that are the result of general and specific exercises of this sport (1). Measuring blood lactate is one of the predictive methods for reaching peak endurance and sports performance (2). In the research on elite taekwondo athletes, Janoski et al. (2021) stated that adaptation to high-intensity training reduces lactate concentration and fatigue (3). In a systematic study, Franchini et al. (2019) reported that high-intensity interval training (HIIT) leads to the improvement of the aerobic and anaerobic systems of martial arts athletes, including judokas, while maintaining their body weight (4). He showed in another article in 2021 under the title basics and practical recommendations of high-intensity interval exercises in judo, that performing the uchi kumi technique (turning and lifting the opponent without throwing) and repeating it in judo training sessions, which is one of the most used exercises of judo players, can be considered as HIIT training specifically for judo players (5). Azevido et al. (2007) showed in their study that the Ochi Kumi test can be used instead of the running test to evaluate the endurance performance of judokas using lactate threshold and heart rate (6). The study of physiological responses during fights of female judokas showed that fight-based exercises might be effective in preparing athletes to cope with the physiological and technical demands of fighting by improving the performance of energy systems required in official competitions (1). A judo fight consists of a series of quick attacks, defenses, and counterattacks that the judo player mainly uses the anaerobic glycolysis system to provide enough energy during a match (5). However, in case of win or lose, the match must continue in the winners or losers table. Therefore, in order to return to the original state and renew the energy sources, it should also develop aerobic metabolism (7).

One of the most important reasons for the loss of performance due to fatigue is the increase in the concentration of lactic acid in muscle cells, which causes a decrease in blood pH and a decrease in the speed of catabolic reactions, and ultimately reduces the ability to produce ATP (8). The methods of removing lactic acid in the body are of interest to coaches and researchers, considering the need of athletes to reach normal conditions and prepare for the next competition, especially in combat sports where the athlete has to compete several times in one day. Lactic acid is a product of anaerobic metabolism that results from the incomplete breakdown of glucose without the presence of oxygen and the Krebs cycle and the electron transfer chain not being effective (9). During exercise, many stimulating messages are transmitted to the corresponding nerve cells in the motor cortex of the brain, and their stimulating impulses lead to an increase in muscle contractions and an increase in the need for energy and the consumption of fuel resources. This process continues until the inhibitory and energy-conserving nerve cells are stimulated and the movement stops. Due to high consumption of energy and increasing lactic acid, glycogen reduction, central fatigue and ultimately loss of sports performance occur (10). Therefore, the recovery period is very important. In 2012, Laskoski et al investigated blood lactate accumulation during one day of boys' judo competition.

The results showed that the peak of blood lactate was obtained on the day of the competition and after the fourth fight (25 mmol/l) out of five fights, which was higher than the first fight (9.8 mmol/l) and even the Wingate test (13.3 mmol/l) before the competition (11). In Borger et al.'s study (2015), it was found that with the increase of lactate after the first, second and third fight in simulated karate competitions, the speed of lactate excretion increased, which indicated the improvement of recycling ability (12). Koko et al. (2018) showed in their study on 270 male and female judo players with at least 5 years of training experience, there was a significant difference between blood lactate in three conditions before the match, immediately after the match and 10 minutes after the end of the match. However, after 10 minutes of passive recovery, lactate levels were close to pre-race levels (13). The researchers found that the frequent participation of combat sports athletes in the competitions moderates the physiological and hormonal responses to the next rounds and improves the performance. In fact, the metabolic changes related to the fight program and the acceleration of recovery between two fights can be effective in the championship process (14).

Considering the importance of removing lactate from the blood of combat sports athletes, after an intense competition and preparing for the next fight, it seems necessary to find a method that can lead to its faster removal. In fact, it is very important to pay attention to the recovery phase in creating the physiological adaptations of athletes and to find out how and when the athlete can start the next activity after a high-pressure activity (9). In this regard, the specific time when the relative recovery of judokar can be obtained has not been fully determined.

In addition, considering the physiological differences in terms of gender, the comparison of blood lactate excretion between male and female judo players will also be interesting for trainers, so the present research, in addition to comparing passive and active recovery methods with uchi kumi training, compares male and female genders and possible differences in lactate recovery.

2. Materials and Methods

Material and methods

Subjects

The statistical population of this study included 17 female and male judoka athletes who were members of the judo team of Bandar Anzali city, Gilan province, Iran. Among them were male and female judokas who were in the age groups of 13 to 40 years and had between 1 and 3 years of sports experience and were well familiar with Uchi Kumi training. The subjects were chosen voluntarily and were placed in two groups of women (8 people) and men (9 people) in a non-random way.

Test

After explaining the research objectives and receiving written consent, the subjects were asked not to do any physical activity two days before the main exercise. It should be noted that after the approval of the Research Council of the Islamic Azad University, Rasht Branch and according to the Declaration of Helsinki Research Ethics, the subjects participated in the research after completing the health questionnaire and the researchers' confidence in the entry criteria. To eliminate the influence of the time of day on the physiological responses, all measurements were made between 5 and 7 in the evening on two separate days with an interval of 48 hours (15).

First, blood lactate was measured at rest and before the start of training. Then, the subjects did stretching and softening exercises for 5 minutes before starting the uchi kumi exercise to warm up. After that, the subjects performed Uchi Kumi with an opponent of the same weight until exhaustion. This exercise was done by beating the song 30 times per minute while listening to the sound of the metronome. The interruption of the activity was done when two consecutive errors were made by the subjects, which indicated the laziness of the subjects. Immediately after exercise, blood lactate was measured again and the subjects were asked to sit on a chair and do no activity. Then, in 5 and 10 minutes, blood lactate was measured for passive recovery (16). After 48 hours, the same procedures were repeated again, with the difference that the subjects were asked to do the same Uchi Kumi exercise without the training opponent (shadowing) in sync with the sound of the metronome (30 times per minute) instead of sitting on a chair, for active recovery. Also, the intensity of activity in active recovery was in the range of 60 to 70% of the maximum heart rate, which was controlled using a polar heart rate monitor (17).

Blood lactate measurement

The blood lactate measurement of the subjects was done before the uchi kumi training, immediately and 5 and 10 minutes after the training on two separate days (with an interval of 48 hours). To measure the amount of blood lactate, an hp/cosmos lactometer made in Germany was used. This hand-held device shows the lactate concentration in millimoles per liter through enzymatic spectrophotometry. The way to use it was that first, a special kit was placed in the hole of the device, then the place where the blood was taken, i.e. the index finger of the right hand, was disinfected with cotton soaked in alcohol, and a drop of blood was placed on the kit, after a few seconds, the device displayed the blood lactate concentration in millimoles per liter on the screen.

Statistical analysis

After data collection, descriptive statistics were used to determine dispersion indices (mean and standard deviation). The Shapiro-Wilk test was used to determine the normality of data distribution. Analysis of variance tests with repeated design as well as dependent t and independent t tests were used for inferential data analysis. Statistical analysis was

3. Results

The subjects' characteristics including age, height, body mass index weight, fat percentage, and body fat mass are presented in Table 1.

Table 1. training protocol

Variable	Man (n=9)	Woman (n=8)
Age (year)	19.94 ± 1.86	25.62 ± 3.8
Height (cm)	176.7 ± 77.44	160.7 ± 87.31
Weight (Kg)	68.1 ± 3.57	62.7 ± 16.40
BMI (kg/m2)	21.2 ± 3.887	24.4 ± 3.15
Fat (%)	10.8 ± 9.56	22.6 ± 19.67
Free fat mass (kg)	60.6 ± 19.53	48.3 ± 23.66

Based on the results of the Shapiro-Wilk test, the distribution of data in all variables in both control and experimental groups was normal (P<0.05). In figure 1, the intra-group changes of lactate in the active and inactive state of men were shown using analysis of variance with repeated design. Intragroup changes of lactate in the active state of men showed that there is a significant difference between the four stages (pre-test, post-test, 5 minutes and 10 minutes after recovery) (P=0.001).

Using Tukey's post hoc test, it was determined that there were differences between pre-test-post-test (P=0.001), pre-test-5 minutes' recovery (P=0.001), pre-test-10 minutes' recovery (P=0.001), post-test-5 minutes' recovery (P=0.001) and post-test-10 minutes' recovery (P=0.001).

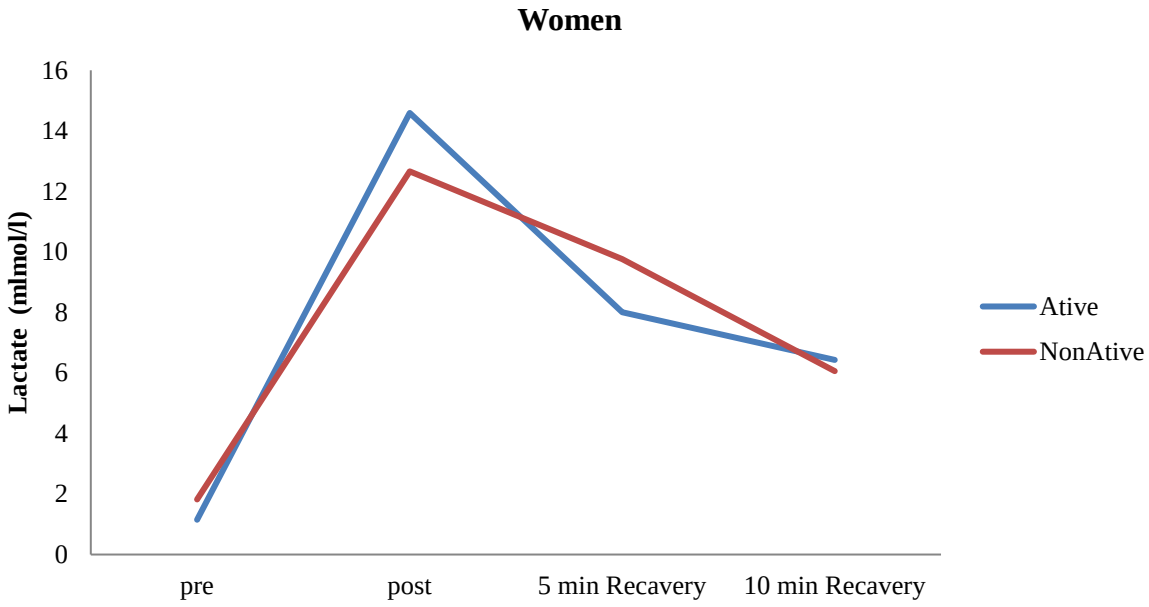

Figure 1. Comparison of within-group changes of recycling in two active and inactive states in men.

Also, the lactate changes within the group in the inactive state of men showed that there is a significant difference between the four stages (pre-test, post-test, 5 minutes and 10 minutes after recovery) (P=0.02). Using Tukey's post hoc test, it was determined that the differences were between pre-test-post-test (P=0.001), pre-test-5 minutes' recovery (P=0.001), pre-test-10 minutes' recovery (P=0.82), post-test-10 minutes' recovery (P=0.001) and 5 minutes' recovery-10 minutes' recovery (P=0.001).

In figure 2, intra-group changes of lactate in active and inactive state of women were shown using analysis of variance with repeated design.

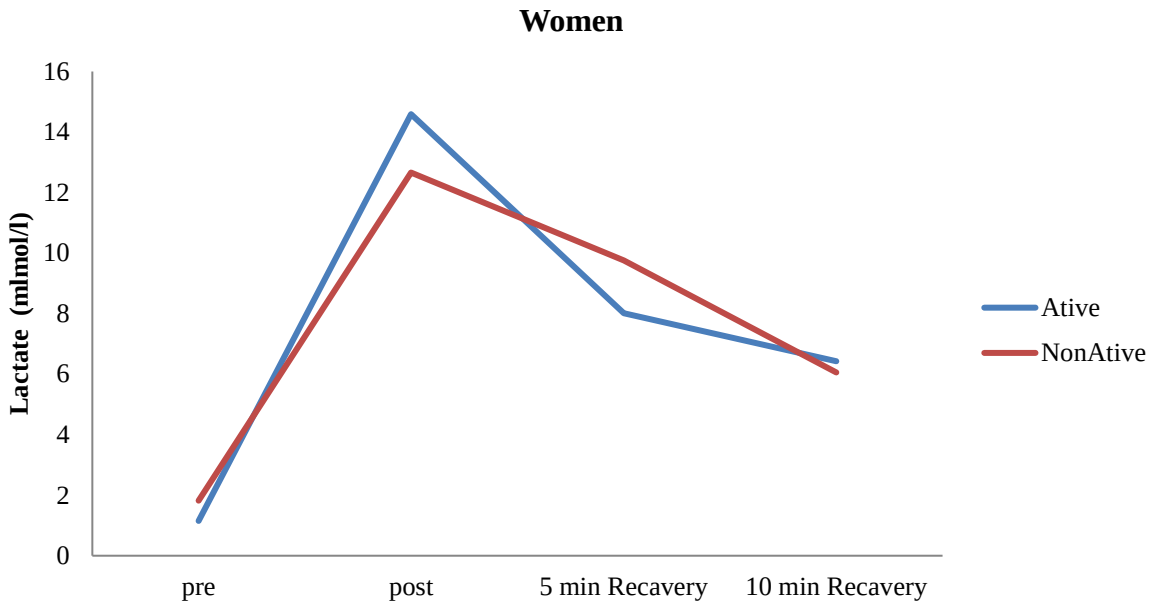

Figure 2. Comparison of within-group changes of recycling in two active and inactive states in women.

Intragroup changes of lactate in the active state of women showed that there is a significant difference between the four stages (pre-test, post-test, 5 minutes and 10 minutes after recovery) (P=0.001). Using Tukey's post hoc test, it was determined that there were differences between pre-test-post-test (P=0.001), pre-test-5 minutes' recovery (P=0.001), pre-test-10 minutes' recovery (P=0.001), post-test-5 minutes' recovery (P=0.001) and post-test-10 minutes' recovery (P=0.048).

Also, lactate changes within the group in the inactive state of women showed that there is a significant difference between the four stages (pre-test, post-test, 5 minutes and 10 minutes after recovery) (P=0.004).

Using Tukey's post-hoc test, it was determined that there were differences between pre-test-post-test (P=0.001), pre-test-5 minutes' recovery (P=0.001), pre-test-10 minutes' recovery (P=0.65), post-test-10 minutes' recovery (P=0.001) and 5 minutes' recovery-10 minutes' recovery (P=0.001). In figure 3. Percentage changes of lactate recycling are shown in both active and inactive states of men and women.

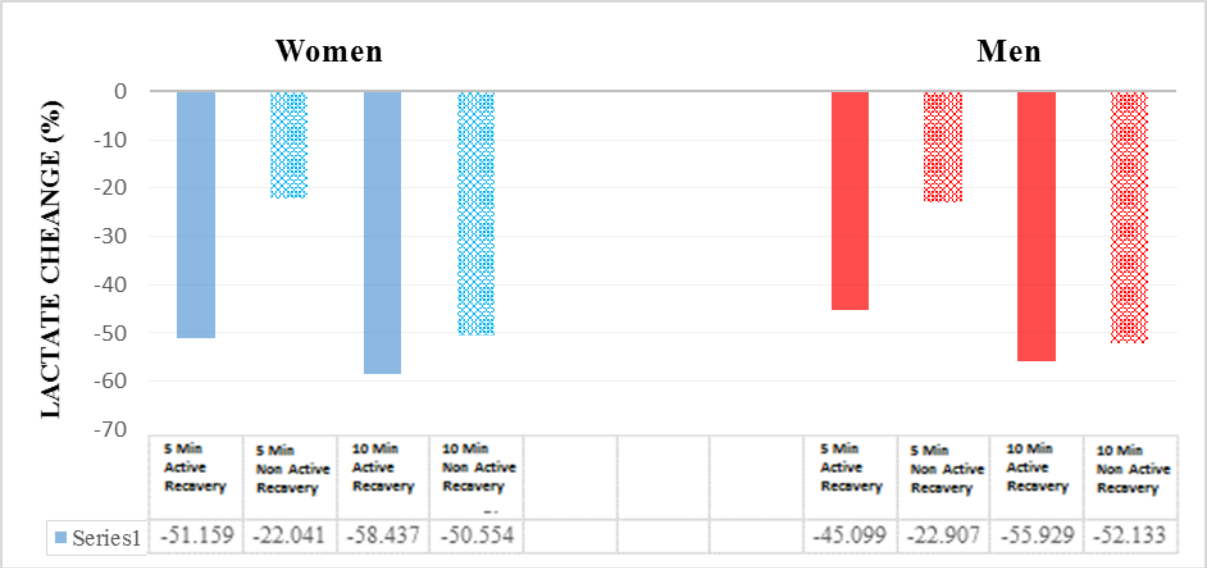

Figure 3. Comparison of active and passive lactate recycling percentage changes in men and women.

Comparison of lactate changes using independent t-test between active and inactive state in men showed that there was a significant difference between the two types of recovery after 5 minutes (P = 0.004); But after 10 minutes (P=0.46) there was no significant difference. In the case of women, there was a significant difference between the lactate changes of the two types of recovery after 5 minutes (P=0.03); But after 10 minutes (P=0.45) there was no significant difference. Comparison of lactate changes using independent t-test in active state between men and women showed that there is no significant difference between the two sexes (P=0.99). In addition, the comparison of changes in lactate recycling in the inactive state between men and women showed that there is no significant difference between the two sexes (P=0.44).

4. Discussion

When performing intense sports activities, one of the factors that prevents the continuation of the activity continuously is the fatigue caused by the increase in muscle lactate concentration. Fatigue has an adverse effect on the continuation of sports activity and reduces the quality of sports performance. Judo is no exception to this rule. Faster elimination of fatigue caused by sports is considered the secret of athletes' success for the next competition. In this regard, the period of returning to the initial state or recycling becomes especially important (9). Considering the role of recycling in physiological adaptations, it is important to find out when judo players can perform better and less tired for the next fight on the same day of the competition and what is the difference between blood lactate recycling in men and women. Many studies have been conducted to investigate the effect of different training models on physiological adaptation, which are directly related to success in judo competitions (18, 19). Increasing muscle mass and increasing lactate tolerance are among the desirable adaptations in this sport.

Many studies have been conducted to investigate the effect of different training models on physiological adaptation, which are directly related to success in judo competitions (18, 19). Increasing muscle mass and increasing lactate tolerance are among the desirable adaptations in this sport. In fact, a higher peak lactate is a sign of a higher capacity of the athlete to use the anaerobic glycolysis system in energy production. In 2021, Franchini et al. showed that the implementation of the Uchi-Kumi technique in the form of high-intensity interval training in training sessions leads to an increase in glycolytic capacity and an improvement in the performance of judokas. Emphasis on the implementation of this type of exercise, which is somewhat similar to a real judo competition, led to an increase in blood lactate levels (5).

The findings of the present research indicate that Uchi-Kumi training to the point of exhaustion with a training opponent of the same weight caused a significant increase in the blood lactate level of male and female judo fighters. In previous studies (1, 3, 20) it was also shown that blood lactate increases with increasing exercise intensity (21). Accumulated lactate is the result of an imbalance between its production and its entry into the blood versus its excretion. In fact, increasing the production of lactic acid and decreasing its excretion are the two causes of the increase in blood lactate concentration during anaerobic training (22). During the competition, despite the production of energy through the aerobic system in conditions where the intensity of activity is very high, the anaerobic system prevails and ATP is produced due to the breakdown of muscle glycogen in the glycolysis pathway under conditions of lack of oxygen. In fact, the release of hydrogen at the end of the respiratory chain precedes its oxidation and pyruvic acid turns into lactic acid, causing the accumulation of hydrogen ions in muscle cells and finally entering the blood (8). In this condition, the acid-alkaline balance of the muscle fibers is disrupted and causes acidosis, the result of which is a disturbance in the process of energy production and muscle contraction. In fact, by inhibiting the enzyme activity in the glycolysis pathway, ATP production is stopped anaerobically, fatigue, stagnation, and finally, a drop in sports performance occurs (23).

Another finding of the current research was the comparison of blood lactate response of men and women to Uchi-Kumi training with the opponent training to the limit. As expected, the implementation of this exercise increased blood lactate in men (about 18 mmol/liter) compared to women (about 14 mmol/liter). The higher anaerobic capacity of men compared to women is primarily dependent on a higher fat-free mass (60.53 kg vs. 48.23 kg) and secondly on the higher ability of the anaerobic glycolysis system to produce ATP (24).

After completing the Uchi-Kumi training, the phase of returning to the initial state or recycling began. The reduction of blood lactate in men after 5 minutes was 51% in active recovery mode and 22% in passive recovery mode. This difference in changes was significant. In women, such a significant difference was seen in lactate reduction after 5 minutes of active recovery (45%) versus passive recovery (22%), which was a sign of the effect of performing high-intensity training with an equal-weight training opponent for faster lactate recovery. However, after 10 minutes, active vs. inactive recovery was similar for men (58% vs. 50%) and for women (56% vs. 52%). That is, after 10 minutes, there was not much difference between the two types of recycling. In most of the past studies, it has been mentioned that blood lactate decreases

faster in active versus passive recovery (25-27). During active recovery, the metabolism of physical activity is maintained with more blood flow and higher muscle tissue temperature (28). This condition is facilitated in the cycle of energy production through the aerobic system by the recirculation of lactate in different tissues of the body (29).

In the Cori cycle, the liver tissue helps return glucose to the active muscle tissue by harvesting lactate and converting it to glucose through the process of gluconeogenesis. In addition, the kidneys and brain take the produced lactate as a source of energy. The heart muscle is also one of the target tissues for the consumption of blood lactate in active recycling because in this state the heart rate and stroke volume are still higher than in the inactive state (30). In active recovery with Uchi-Kumi training without a training opponent, the maximum call of muscle fibers is not necessary to produce force, so the slow twitch fibers are involved in the activity and probably the motor units containing the fast twitch fibers that participated in the maximal activity are resting (23).

Therefore, despite the higher energy consumption during active recovery, which is lower than the anaerobic threshold, its positive effects were realized for faster relief of fatigue and higher readiness to start the next match in a short period of time for male and female judo players. Considering the increase in blood lactate levels after Uchi-Kumi training with an equal weight-training opponent, it is suggested to use this training to strengthen the anaerobic system in judo training. In addition, as blood lactate decreases more quickly after 5 minutes of active recovery, the unopposed Uchi-Kumi exercise, which requires little space to perform, can be used by judokas between matches for faster recovery.

Conclusion

As expected, blood lactate increased significantly after Uchi-Kumi training with a training opponent; but recycling it passively required at least 10 minutes to return to the base state. Considering that faster recovery is of great importance to prepare judokas to participate in the next competition, performing 5 minutes of Uchi-Kumi training without a training opponent led to an acceleration of recovery time. The interesting thing is that the decrease in blood lactate after Uchi-Kumi training was independent of gender; This means that women judo players, like men, can use the technique of Uchi-Kumi in the shadowing method (without a training opponent) - which can be done in a small space in the competition hall - to relieve fatigue caused by lactate faster.

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Compliance with ethical standards

Conflict of interest None declared.

Ethical approval the research was conducted with regard to the ethical principles.

Informed consent Informed consent was obtained from all participants.

Author contributions

Conceptualization: F.S, M.R.F.C; Methodology: F.S, M.R.F.C; Software: F.S, M.R.F.C; Validation: F.S, M.R.F.C; Formal analysis: F.S, M.R.F.C; Investigation: F.S, M.R.F.C; Resources: F.S, M.R.F.C; Data curation F.S, M.R.F.C; Writing - original draft: F.S, M.R.F.C; Writing - review & editing: F.S, M.R.F.C; Visualization: F.S, M.R.F.C; Supervision: F.S, M.R.F.C; Project administration: F.S, M.R.F.C; Funding acquisition: F.S, M.R.F.C;

References

1. Ouergui I, Kamzi S, Houcine N, Abedelmalek S, Bouassida A, Bouhlel E, Franchini E. Physiological Responses During Female Judo Combats: Impact of Combat Area Size and Effort to Pause Ratio Variations. J Strength Cond Res. 2021 Jul 1;35(7):1987-1991. doi: 10.1519/JSC.0000000000003307. PMID: 31343555.

2. Ghoochani, S., Riyahi Malayeri, S., Daneshjo, A. Short-term effect of Citrulline Malate supplement on LDH and Lactate levels and Resistance Exercise Performance. Journal of Military Medicine, 2022; 22(4): 154-162. https://militarymedj.bmsu.ac.ir/article_1000921.html?lang=en.

3. Janowski M, Zieliński J, Kusy K. Exercise Response to Real Combat in Elite Taekwondo Athletes Before and After Competition Rule Changes. J Strength Cond Res. 2021 Aug 1;35(8):2222-2229. doi: 10.1519/JSC.0000000000003110. PMID: 30844985.

4. Franchini E, Cormack S, Takito MY. Effects of High-Intensity Interval Training on Olympic Combat Sports Athletes' Performance and Physiological Adaptation: A Systematic Review. J Strength Cond Res. 2019 Jan;33(1):242-252. doi: 10.1519/JSC.0000000000002957. PMID: 30431531.

5. Franchini E. High-Intensity Interval Training in Judo Uchi-komi Fundamentals and Practical Recommendations. The Arts and Sciences of Judo. 2021;1(1):35-45. https://78884ca60822a34fb0e6-082b8fd5551e97bc65e327988b444396.ssl.cf3.rackcdn.com/up/2021/04/IJF-Journal-FINAL-web-16189163-1618916315.pdf

6. Azevedo PH, Drigo AJ, Carvalho MC, Oliveira JC, Nunes JE, Baldissera V, Perez SE. Determination of judo endurance performance using the uchi - komi technique and an adapted lactate minimum test. J Sports Sci Med. 2007 Oct 1;6(CSSI-2):10-4. PMID: 24198697; PMCID: PMC3809042.

7. Julio UF, Panissa VLG, Esteves JV, Cury RL, Agostinho MF, Franchini E. Energy-System Contributions to Simulated Judo Matches. Int J Sports Physiol Perform. 2017 May;12(5):676-683. doi: 10.1123/ijspp.2015-0750. Epub 2016 Oct 13. PMID: 27736247.

8. Rusdiawan A, Sholikhah AM, Prihatiningsih S. The Changes in pH Levels, Blood Lactic Acid and Fatigue Index to Anaerobic Exercise on Athlete After NaHCO 3 Administration. Malaysian Journal of Medicine & Health Sciences. 2020 Dec 5; 16.

9. Jafari M, Pouryamehr E, Fathi M. The effect of eight weeks high intensity interval training (HIIT) on E-selection and P-selection in young obese females. International journal of sport studies for health. 2018 Jan 31;1(1). doi: https://doi.org/10.5812/intjssh.64336.

10. Yu X. Fatigue and recovery of Wushu athletes based on fatigue damage model. InIOP Conference Series: Materials Science and Engineering 2020 Sep 1 (Vol. 914, No. 1, p. 012016). IOP Publishing. doi: 10.1088/1757-899X/914/1/012016.

11. Laskowski R, Kujach S, Smaruj M, Grzywacz T, Łuszczyk M, Marek A, Ziemann E. Lactate concentration during one-day male judo competition: A case study. Archives of Budo. 2012 Mar 31;8(1):51-7. doi: 10.12659/AOB.882651.

12. Bürger-Mendonça M, de Oliveira JC, Cardoso JR, Bielavsky M, Azevedo P. Changes in blood lactate concentrations during taekwondo combat simulation. J Exerc Rehabil. 2015 Oct 30;11(5):255-8. doi: 10.12965/jer.150218. PMID: 26535215; PMCID: PMC4625653.

13. Coco M, Platania S, Castellano S, Sagone E, Ramaci T, Petralia MC, Agati M, Massimino S, Di Corrado D, Guarnera M, Pirrone C. Memory, personality and blood lactate during a judo competition. Sport Sciences for Health. 2018 Dec;14:547-53. https://doi.org/10.1007/s11332-018-0458-x

14. Bridge CA, Sparks AS, McNaughton LR, Close GL, Hausen M, Gurgel J, Drust B. Repeated Exposure to Taekwondo Combat Modulates the Physiological and Hormonal Responses to Subsequent Bouts and Recovery Periods. J Strength Cond Res. 2018 Sep;32(9):2529-2541. doi: 10.1519/JSC.0000000000002591. PMID: 29781933.

15. Molaei A, Hosseinpour Delavar S, Mehran G, Jabbari R, Jalilvand M. The Effect of Water Immersion and Transcranial Direct Current Stimulation (TDCS) during Recovery Period on Changes in Blood Lactate and Subsequent Performance of Swimmers. Research in Sport Medicine and Technology. 2020 Nov 10;18(20):49-58. URL: http://jsmt.khu.ac.ir/article-1-419-fa.html

16. Rodríguez-Marroyo JA, González B, Foster C, Belén Carballo-Leyenda A, Villa JG. Effect of the Cooldown Type on Session Rating of Perceived Exertion. Int J Sports Physiol Perform. 2021 Apr 1;16(4):573-577. doi: 10.1123/ijspp.2020-0225. Epub 2021 Jan 21. PMID: 33477106.

17. Barros TAR, do Prado WL, Tenório TRS, Ritti-Dias RM, Germano-Soares AH, Balagopal BP, Hill JO, Freitas-Dias R. Cardiovascular Effects of Aerobic Exercise With Self-Selected or Predetermined Intensity in Adolescents With Obesity. Pediatr Exerc Sci. 2021 May 19;33(3):125-131. doi: 10.1123/pes.2020-0104. PMID: 34010805.

18. Saanijoki T, Nummenmaa L, Eskelinen JJ, Savolainen AM, Vahlberg T, Kalliokoski KK, Hannukainen JC. Affective Responses to Repeated Sessions of High-Intensity Interval Training. Med Sci Sports Exerc. 2015 Dec;47(12):2604-11. doi: 10.1249/MSS.0000000000000721. PMID: 26110694.

19. Selmi O, Gonçalves B, Ouergui I, Levitt DE, Sampaio J, Bouassida A. Influence of Well-Being Indices and Recovery State on the Technical and Physiological Aspects of Play During Small-Sided Games. J Strength Cond Res. 2021 Oct 1;35(10):2802-2809. doi: 10.1519/JSC.0000000000003228. PMID: 31403575.

20. Branco BH, Massuça LM, Andreato LV, Marinho BF, Miarka B, Monteiro L, Franchini E. Association between the Rating Perceived Exertion, Heart Rate and Blood Lactate in Successive Judo Fights (Randori). Asian J Sports Med. 2013 Jun;4(2):125-30. doi: 10.5812/asjsm.34494. Epub 2013 Feb 23. PMID: 23802054; PMCID: PMC3690732.

21. Riyahi Malayeri, S., Mirakhorli, M. The Effect of 8 Weeks of Moderate Intensity Interval Training on Omentin Levels and Insulin Resistance Index in Obese Adolescent Girls. Sport Physiology & Management Investigations, 2018; 10(2): 59-68. https://www.sportrc.ir/article_67070.html?lang=en.

22. Poole DC, Rossiter HB, Brooks GA, Gladden LB. The anaerobic threshold: 50+ years of controversy. J Physiol. 2021 Feb;599(3):737-767. doi: 10.1113/JP279963. Epub 2020 Nov 19. PMID: 33112439.

23. Brooks GA. Lactate as a fulcrum of metabolism. Redox Biol. 2020 Aug;35:101454. doi: 10.1016/j.redox.2020.101454. Epub 2020 Feb 9. PMID: 32113910; PMCID: PMC7284908.

24. Mochizuki Y, Saito M, Homma H, Inoguchi T, Naito T, Sakamaki-Sunaga M, Kikuchi N. Sex differences in lifting velocity and blood lactate concentration during resistance exercise using different rest intervals. https://doi.org/10.21203/rs.3.rs-1288068/v1

25. Ilbeigi S, Moazani H, Saghbejoo M, Yousefi M. The effect of recovery methods after a session of exhaustive activity on some performance indicators and muscle damage in teenage soccer players. Journal of Sport and Exercise Physiology. 2021 Sep 23;14(2):127-36.doi: 10.52547/JOEPPA.14.2.127

26. Obmiński Z, Ładyga M, Borkowski L, Wiśniewska K. The effect on 4-month judo training period on anaerobic capacity, blood lactate changes during the post Wingate test recovery, and resting plasma cortisol, and testosterone levels in male senior judokas. Journal of Combat Sports and Martial Arts. 2013 Aug 1;4:119-23. doi: 10.5604/20815735.1090655

27. Draper N, Bird EL, Coleman I, Hodgson C. Effects of Active Recovery on Lactate Concentration, Heart Rate and RPE in Climbing. J Sports Sci Med. 2006 Mar 1;5(1):97-105. PMID: 24198686; PMCID: PMC3818679.

28. Galaz-Campos D, Olivares-Arancibia J, Solis-Urra P, Suarez-Cadenas E, Santos-Lozano A, Rodríguez-Rodríguez F, et al. Effect of High-Intensity whole body vibration on blood lactate removal and heart rate after an all-out test in active young men (Efecto de las vibraciones de alta intensidad de cuerpo completo sobre la remoción del lactato sanguíneo y la frecuencia cardia. Retos. 2020(39):471-6. doi: 10.47197/retos.v0i39.78441

29. Hall MM, Rajasekaran S, Thomsen TW, Peterson AR. Lactate: Friend or Foe. PM R. 2016 Mar;8(3 Suppl):S8-S15. doi: 10.1016/j.pmrj.2015.10.018. PMID: 26972271.

30. Philp A, Macdonald AL, Watt PW. Lactate--a signal coordinating cell and systemic function. J Exp Biol. 2005 Dec;208(Pt 24):4561-75. doi: 10.1242/jeb.01961. PMID: 16326938.