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THE EFFECT OF SWIMMING ON BLOOD LACTATE LEVELS AFTER INTENSE PHYSICAL EFFORT IN CONTACT SPORTS

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Abstract. *In combat sports, physical recovery is an essential factor for optimizing performance, as it is conditioned both by the development of the functional capacity necessary to sustain prolonged effort and by the improvement of motor skills and offensive and defensive technical-tactical strategies, applied in order to obtain a decisive competitive advantage. The efficiency of functional recovery after intense effort allows athletes to sustain a higher training volume, which leads to improved training levels and higher competitive performance. Swimming, although established as a performance sport, is also recognized for its recreational benefits and its role in improving quality of life, an effect facilitated to a large extent by the horizontal position of the body during activity. The objective of this study is to investigate the effectiveness of aquatic movement in post-exercise recovery among combat athletes. The sample comprised 22 athletes practicing judo and taekwondo, aged between 20 and 30 years, equally divided into two groups. The experimental group underwent an active swimming recovery session (20 minutes at 55-65% of maximum heart rate), while the control group underwent passive recovery. The research protocol included lactic acid testing at three key time points: before exercise, immediately after intense exercise and after an aquatic recovery session. The results indicate a significant decrease in lactic acid levels following aquatic recovery, highlighting the effectiveness of this method. The study supports the integration of aquatic movement into the recovery strategies of performance athletes.*

Keywords: *aquatic recovery; combat sports; lactic acid; taekwondo; judo.*

Introduction

Combat sports exert a significant positive influence on the health and vitality levels of participants. The physical training specific to these disciplines involves the development of high functional capacity for sustained effort and the development of combined motor skills. The technical-tactical activities, whether offensive (attack/counter-attack) or defensive, are carried out over one or more rounds and, depending on the specific nature of the sport and the competition rules, are aimed at scoring as many points as possible or bringing the match to a rapid end by clearly showing superiority (Coelho-E-Silva et al., 2020). Especially taekwondo depends on far more dynamical movements than any other sports do, for example, not only defending, punching, kicking and thrusting but also body-turning attack, jumped-up breaking and defending, attacking the target by moving the body in the air attacking mobile targets, breaking with a strong impact of bodily members, and numerous others (Kukkiwon, 2014, p.68). In judo, the fundamental principles formulated by Kano (2013, p.176) - Seiryoku-Zenyo (efficient use of energy) and Jita-Kyoei (mutual benefit and common prosperity) - form the basis of the philosophy and practice of this discipline, with the emphasis on the optimal use of physical and mental resources, through the integration of technique, strategy and self-control, with the aim of achieving competitive success. Although combat simulations during training have certain similarities with official competitions, their physiological demands are significantly lower, thus, as a consequence, the intensity of training effort should be adjusted accordingly in order to maximize physiological adaptations and the effectiveness of training

(Franchini et al., 2014). Generally, in the context of a competition, the athlete usually analyzes his opponent's strengths and vulnerabilities, exploiting any weaknesses in order to gain a decisive advantage. Thus, contact sports such as judo and taekwondo involve high physical and mental demands, requiring the development of effort capacities and effective recovery strategies. It has also been shown that short-term, high-intensity exercise can generate significant arterial lactate concentrations, reaching up to 25 mmol-l-^{1} in highly motivated subjects (McLoughlin et al., 1991). Excessive lactate accumulation is recognized as one of the main contributors to the onset of muscle fatigue (Gladden, 2004). Efficient post-exercise recovery is a fundamental element in optimizing sports performance and reducing the risk of injury (Li et al., 2024; Bieuzen et al., 2014). Numerous studies have shown a significant correlation between the onset of muscle fatigue and lactic acid accumulation in the body (Allen et al., 2008). Moreover, rapid restoration of optimal performance in athletes is closely associated with efficient and early elimination of lactic acid post-exercise (Monedero & Donne, 2000). However, achieving success in such a context requires not only intensive training, but also rigorous scientific training coordinated by a highly competent instructor (Kukkiwon, 2014, p.72). In this regard many researchers, recommend the removal of lactic acid as a primary indicator of recovery (Sahlin, 1986). It has also been shown that blood lactate concentrations decrease more rapidly during active recovery performed at below average exercise intensity (Dodd et al., 1984). Lactate removal is recognized as an essential factor in the post-exercise recovery process, and the literature highlights that active recovery is considerably more effective than massage in facilitating this removal, especially in the immediate recovery phase (Hemmings et al., 2000). In this context, aquatic exercise stands out for a number of relevant physiological and psychological benefits (Buitrago-Restrepo et al., 2024) gaining more and more ground in the recovery of elite athlete (Sharma et al., 2017).

Research Methods

The aim of the current study is to evaluate the effectiveness of aquatic recovery in reducing lactic acid concentration after intense physical exertion in combat sports. It was hypothesized that in combat sports, such as judo and taekwondo, active recovery by post-exercise swimming would lead to a significantly faster reduction in blood lactate concentration compared to passive recovery.

Participants

The study was conducted on a sample of 22 students, members of the combat sports representative team of the “Carol Davila” University of Medicine and Pharmacy “Carol Davila” in Bucharest, aged between 20 and 30 years. The participants were divided into two equal groups, each composed of 11 athletes (4 judo and 7 taekwondo). The morphological and physiological characteristics of the subjects are presented in Table 1. Before the start of the study, all participants were informed of the possible associated risks and benefits, and their participation was voluntarily consented by signing an informed consent form. All subjects were declared clinically healthy. The research was conducted in accordance with institutional and international ethical principles, guaranteeing anonymity of participants and confidentiality of the data obtained.

Table 1. *(Mean ±SD) values of the subjects' characteristics*

Variables	Group experimental (1)	Group control (2)
Age (years)	24.3±3.07	24.1±3.05
Height (m)	170.8±6.69	171.2±6.22
Body mass (kg)	72.4±8.42	73.8±9.38
Lactates (mmol/l)	1.80±0.073	1.79±0.064

Materials

For the determination of blood lactate concentration, the handheld Lactate Pro 2 device (Arkray, Japan), an enzyme analyzer validated for its accuracy and reliability in the context of physiological assessments in sports, was used. It allows on-the-spot testing, providing results in approximately 15 seconds, based on a minimum capillary volume of 0.3 µl of blood obtained by pricking the finger or earlobe. The device has an internal storage capacity of up to 330 values and is commonly used in applied research to monitor metabolic response to exercise. Its reliability has been demonstrated by significant correlations with standard laboratory methods for lactate analysis.

Study design and procedure

The study was conducted on two groups of 11 students, tested in parallel and under similar conditions, day and hour, with a 1-2 minutes variation between participants. Ethical principles were strictly adhered to throughout the study according to institutional and international standards. Initial blood lactate concentration testing was performed at rest before exercise for both groups. Subsequently, after specific intense exercise, the experimental group underwent an active recovery protocol by swimming for 20 minutes at an intensity of 55-65% of maximum heart rate (HRmax), using crawl and backstroke styles, administered in randomized order. The control group received a passive recovery period during the same interval. At the end of the 20 min recovery, blood lactate concentration was retested for both groups. Blood samples were collected by pricking the tip of the index finger, after disinfection with isopropyl alcohol, using an automatic spring lancet device.

Statistical analysis

The data obtained were analyzed using IBM SPSS Statistics software (version 25) and Microsoft Excel software (kutools). To verify the homogeneity of lactate values at rest and after exercise for the two groups of subjects, the Levene SPSS test was applied. Also, in order to compare the mean values of lactate concentration between the two groups (experiment and control), before and after the recovery protocol, the t test for independent samples and kutools software were used.

Results

We present below the analysis of lactate values for the two groups providing the basis for the statistical validity of further comparisons.

Table 2. *Test Levene of Homogeneity of Variances*

	Levene Statistic	df1	df2	Sig.
Resting Test	1.023	2	22	.324
Post exercise Test	2.264	2	22	.148

The analysis of homogeneity of variances, performed by Levene's test in SPSS (table 2), revealed no significant differences between the experimental and control groups in terms of resting lactic acid values (Levene's Statistic = 1.023, $p = 0.324$). Similarly, the results for lactate values after exercise (Levene Statistic = 2.264, $p = 0.148$) confirm the lack of significant differences between the two groups. In both cases, the statistical significance values ($p = 0.324$ for fasting and $p = 0.148$ after exercise) are greater than the 0.05 threshold, indicating that the analyzed groups show equal variances both before and after exercise, therefore the data are suitable for further comparative parametric tests.

The comparison of the results between the two groups of students, according to the type of recovery applied (active swimming versus passive), reveals statistically significant differences, which indicates the major influence of the recovery strategy on the process of lactic acid elimination after intense exercise.

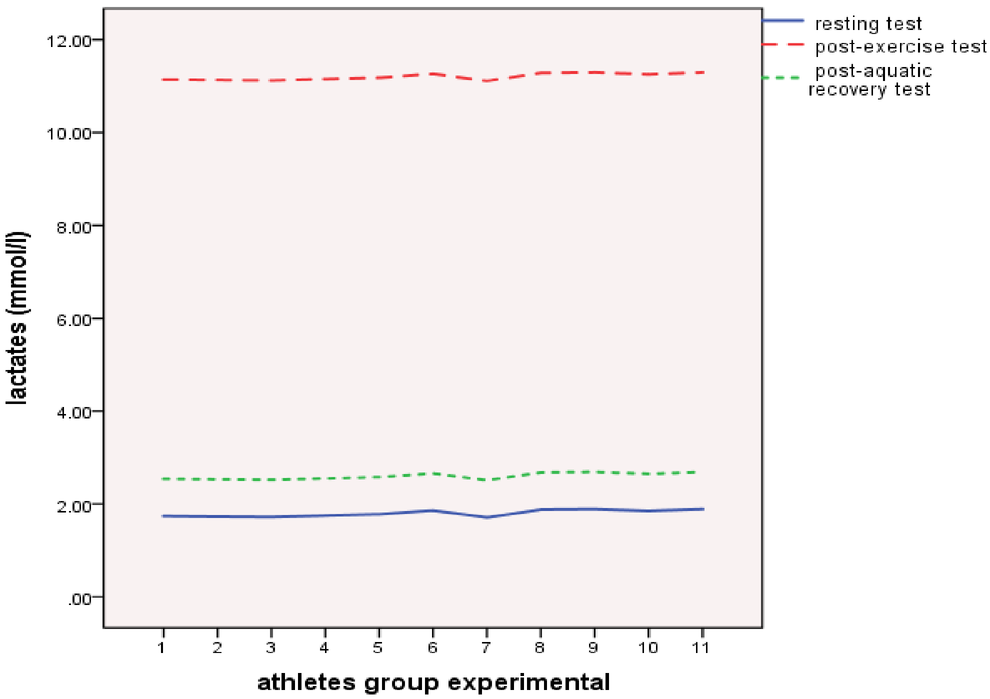

Figure 1. The change in blood lactate levels for the three tests in the experimental group

Figure 1 illustrates the significant impact of active aquatic recovery on blood lactate concentration after intense exercise. Graphical and data analysis shows a substantial reduction in lactate levels, with an average decrease from 11.2 mmol/l immediately after exercise to 2.6 mmol/l following active swimming recovery.

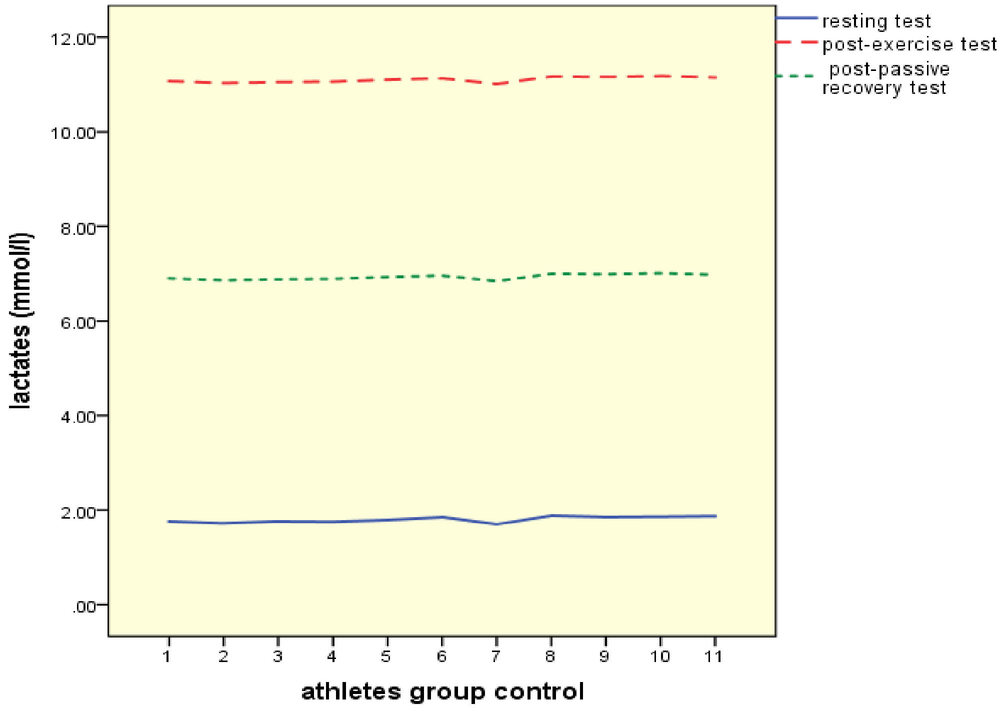

Figure 2. Change in blood lactate levels for the three control group tests

According to the data shown in Figure 2 and Figure 3, passive recovery after strenuous exercise results in a moderate reduction in blood lactate concentration. Thus, the lactate level decreased from 11.1 mmol/l, measured immediately after exercise, to 6.93 mmol/l after a 20-minute period of passive recovery in the training room.

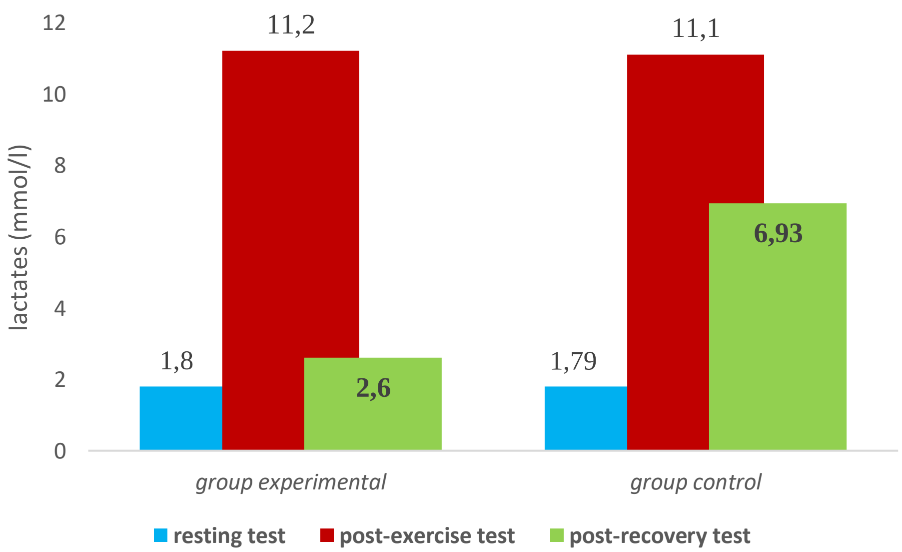

Figure 3. Comparative evolution of blood lactate concentration in the three tests for the two groups

Table 3. *Descriptive post - recovery statistics of the two groups*

Test administered post-recovery	N	Mean	Std. Deviation	Std. Error Mean	Skewness	Kurtosis
Group experimental	11	2.6	0.73	.022	0.115	-2.068
Group control	11	6.93	0.06	.018	-0.092	-1.596

In table 3, the descriptive statistical analysis of the blood lactate concentration measured after the recovery process for the experimental group (active recovery by swimming) and the control group (passive recovery) shows a mean blood lactate for the experimental group at 2.6 mmol/l (SD = 0.73), while in the control group the mean was 6.93 mmol/l (SD = 0.06). The relatively low standard errors of the mean (.022 for the experimental group and .018 for the control group) indicate a high precision of the mean estimation. The data distribution shows a slight positive skewness for the experimental group (Skewness = 0.115) and a negative skewness for the control group (Skewness = -0.092), both values being close to zero, suggesting an approximately normal distribution of the data. The kurtosis values (-2.068 for the experimental group and -1.596 for the control group) indicate a flatter than normal (flat kurtic) distribution in both cases.

Table 4. *T-test for independent samples. Post -recovery Test*

	t-test for Equality of Means						
	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
						Lower	Upper
Equal variances assumed	-150.66	20	0.000	-4.33	.028	-4.390	-4.2709
Equal variances not assumed	-150.66	19.22	0.000	-4.33	.028	-4.391	-4.2707

In order to identify the differences between the experimental and control groups in post-recovery blood lactate levels, an independent samples t-test was used (table 4). The results showed a statistically significant difference between the two groups, $t(20) = -150.66$, $p < 0.001$. The mean difference between the groups was -4.33 mmol/l, with a 95% confidence interval for the mean difference ranging from -4.390 to -4.2709 mmol/l. These results suggest that active recovery (by swimming) leads to a significantly greater reduction in blood lactate concentration compared to passive recovery, highlighting the effectiveness of using aquatic exercise in the recovery process after intense physical exertion.

Discussion and Conclusions

The researchers from the Department of Kinesiology at Kyungwoon University in South Korea found a significant increase in blood lactic acid concentration during taekwondo matches; reported values indicate a concentration of 1.57 ± 0.58 mmol/l at rest, which progressively increased to 5.29 ± 1.6 mmol/l after the first round, 6.11 ± 1.79 mmol/l after the second round and 8.37 ± 1.86 mmol/l at the end of the third round (Seo et al., 2011). In a previous study, Kim (1998) found that lactic acid levels can increase up to 496% from resting values after the three rounds of combat. These data support the intense activation of anaerobic lactic metabolism during taekwondo match-specific exertion, a phenomenon associated with the onset of muscle fatigue, decreased performance and increased risk of injury.

In the context of judo matches, Bonitch-Góngora et al. (2012) showed a clear association between decreased maximal isometric endurance and increased post-exercise lactic acid concentrations, with values reaching 18.12 ± 4.40 mmol-L-¹, especially in the dominant hand, which considerably influences the degree of muscle fatigue. Previous studies involving competitive athletes have reported similar levels of blood lactate concentration during judo competition, ranging from 13 to 18 mmol-L-¹ (Callister et al., 1990; Callister et al., 1991), supporting the predominantly anaerobic nature of judo. In addition, the significant increase in lactate concentration is correlated with important disturbances in the acid-base balance of the post-competition organism (Bonitch-Domínguez et al., 2010), with lactate values reaching up to 14 mmol-L-¹ after each bout (Bonitch-Góngora et al., 2012). This has been shown to affect the contractile capacity of the muscles and, thus. muscle response (Bielenichev et al., 2025).

The analysis of all the data obtained in this study supports the fact that the intervention based on active recovery in an aquatic environment leads to a significant reduction in blood lactate levels compared to traditional passive recovery methods, thus underlining the essential role of water exercise in optimizing physiological recovery after intense exertion in contact sports. These results support the hypothesis that active recovery through swimming contributes to a more efficient removal of lactate from the blood. Finally, we can say that aquatic post-exercise recovery in contact sports is an effective, safe and easy to implement strategy. The study recommends the regular use of this method during periods of intense training, with the potential for wider application in other sports.

References

Allen, D. G., Lamb, G. D., & Westerblad, H. (2008). Skeletal muscle fatigue: cellular mechanisms. *Physiological Reviews*, *88*(1), 287-332. https://doi.org/10.1152/physrev.00015.2007

Bielenichev, I. F., Gunina, L. M., Orlov, O. I., Samura, I. B., Doroshenko, E. Y., Danylchenko, S. I., & Skoryna, D. Y. (2025). The role of lactate in the body of martial artists during physical activity: a new look at the problem. *Modern Medical Technology*, *17*(1), 51–59. https://doi.org/10.14739/mmt.2025.1.314534

Bieuzen, F., Borne, R., Toussaint, J. F., & Hausswirth, C. (2014). Positive effect of specific low-frequency electrical stimulation during short-term recovery on subsequent high-intensity exercise. *Applied Physiology, Nutrition, and Metabolism*, *39*(2), 202-210. https://doi.org/10.1139/apnm-2013-0185

Buitrago-Restrepo, C. M., Patiño-Villada, F. A., & Arango-Paternina, C. M. (2024). Effects of Aquatic Exercise on Physical Performance in Older Adults: A Systematic Review and Meta-Analysis. *Journal of Aging and Physical Activity*, *32*(5), 651-667. https://doi.org/10.1123/japa.2023-0192

Bonitch-Domínguez, J., Bonitch-Góngora, J., Padial, P., & Feriche, B. (2010). Changes in peak leg power induced by successive judo bouts and their relationship to lactate production. *Journal of Sports Sciences*, *28*(14), 1527–1534. https://doi.org/10.1080/02640414.2010.512641

Bonitch-Góngora, J. G., Bonitch-Domínguez, J. G., Padial, P., & Feriche, B. (2012). The effect of lactate concentration on the handgrip strength during judo bouts. *Journal of Strength and Conditioning Research*, *26*(7), 1863–1871. https://doi.org/10.1519/JSC.0b013e318238ebac

Callister, R., Callister, R. J., Fleck, S. J., & Dudley, G. A. (1990). Physiological and performance responses to overtraining in elite judo athletes. *Medicine and Science in Sports and Exercise*, *22*(6), 816–824. https://doi.org/10.1249/00005768-199012000-00014

Callister, R., Callister, R. J., Staron, R. S., Fleck, S. J., Tesch, P., & Dudley, G. A. (1991). Physiological characteristics of elite judo athletes. *International Journal of Sports Medicine*, *12*(2), 196–203. https://doi.org/10.1055/s-2007-1024667

Coelho-E-Silva, M. J., Sousa-E-Silva, P., Morato, V. S., Costa, D. C., Martinho, D. V., Rama, L. M., Valente-Dos-Santos, J., Werneck, A. O., Tavares, Ó. M., Conde, J., Castanheira, J. M., Soles-Gonçalves, R., & Duarte, J. P. (2020). Allometric Modeling of Wingate Test among Adult Male Athletes from Combat Sports. *Medicina (Kaunas, Lithuania)*, *56*(9): 480. https://doi.org/10.3390/medicina56090480

Dodd, S., Powers, S. K., Callender, T., & Brooks, E. (1984). Blood lactate disappearance at various intensities of recovery exercise. *Journal of Applied Physiology: Respiratory, Environmental and Exercise Physiology*, *57*(5), 1462–1465. https://doi.org/10.1152/jappl.1984.57.5.1462

Franchini, E., Brito, C. J., Fukuda, D. H., & Artioli, G. G. (2014). The physiology of judo-specific training modalities. *Journal of Strength and Conditioning Research*, *28*(5), 1474–1481. https://doi.org/10.1519/JSC.0000000000000281

Gladden L. B. (2004). Lactate metabolism: a new paradigm for the third millennium. *The Journal of Physiology*, *558*(1), 5–30. https://doi.org/10.1113/jphysiol.2003.058701

Hemmings, B., Smith, M., Graydon, J., & Dyson, R. (2000). Effects of massage on physiological restoration, perceived recovery, and repeated sports performance. *British Journal of Sports Medicine*, *34*(2), 109-114. https://doi.org/10.1136/bjsm.34.2.109

Kano, J., (2013). *Kodokan Judo: The Essential Guide to Judo by its Founder Jigoro Kano*. Kodansh International. https://www.amazon.com/Kodokan-Judo-Essential-Founder-Jigoro/dp/156836539X

Kim, W.K. (1998). Study on the distribution of% VO2max and changes of blood lactate, LDH and CPK in Taekwondo competition. *Do-A University, Dissertation of Graduate School*. https://cir.nii.ac.jp/crid/1573387450649435776

Kukkiwon. (2014). *Taekwondo Textbook*. OSUNG Publishing Company, Korea.

Li, S., Kempe, M., Brink, M., & Lemmink, K. (2024). Effectiveness of Recovery Strategies After Training and Competition in Endurance Athletes: An Umbrella Review. *Sports Medicine - Open*, *10*(1): 55. https://doi.org/10.1186/s40798-024-00724-6

McLoughlin, P., McCaffrey, N., & Moynihan, J. B. (1991). Gentle exercise with a previously inactive muscle group hastens the decline of blood lactate concentration after strenuous exercise. *European Journal of Applied Physiology and Occupational Physiology*, *62*(4), 274–278. https://doi.org/10.1007/BF00571552

Monedero, J., & Donne, B. (2000). Effect of recovery interventions on lactate removal and subsequent performance. *International Journal of Sports Medicine*, *21*(8), 593–597. https://doi.org/10.1055/s-2000-8488

Sahlin, K. (1986). Muscle fatigue and lactic acid accumulation. *Acta Physiologica Scandinavica. Supplementum*, *556*, 83–91. https://europepmc.org/article/med/3471061

Seo, B., Kim, D., Choi, D., Kwon, C., & Shin, H. (2011). The effect of electrical stimulation on blood lactate after anaerobic muscle fatigue induced in taekwondo athletes. *Journal of Physical Therapy Science*, *23*(2), 271-275. https://doi.org/10.1589/jpts.23.271

Sharma, L., Hussain, M. E., & Verma, S. (2017). Effect of recovery modalities on blood lactate clearance. *Saudi Journal of Sports Medicine*, *17*(2), 65-69. https://doi.org/10.4103/1319-6308.207577