https://jat.journals.ekb.eg/
Faculty of Physical Education. University of Sadat City
Journal of Theories and Applications of physical education sport sciences

Original Article

The Effect of Ice Bath Recovery on Biochemical variables in Junior Volleyball Players

Prof. Dr. Abdel Haleem Yousuf[1], Assistant Prof.Abdul Rahman Basyouni Abdul Razek Ghanem[2], PhD Candidate. Sameh Ahmed Abdel MaqsoudZalam[3]

1,2,3 Sport Health Sciences Department, Faculty of Sports Sciences, University of Sadat City

E-mail address: malakzalam@icloud.com

Doi : 10.21608/jat.2025.394997.1067

Abstract

The researchers conducted a study entitled "The effect of hospitalization with ice baths on some biochemical variables among volleyball Player" The study aimed to identify the effect of using ice baths on some biochemical variables (lactic acid, myoglobin and creatine kinase in the blood) and the speed of recovery in volleyball player, The researchers used the experimental method for one group on a sample of 12 volleyball players. The most important results were: 1. The decrease in the concentration of lactic acid, myoglobin, and creatine kinase in the post-measurement compared to the pre-measurement in the sample under study. 2. The use of recovery methods with ice baths led to an adjustment in the biochemical state of the body in the post-measurement compared to the pre-measurement in the sample under study. 3. The use of recovery methods with ice baths resulted in a faster recovery and increased the ability of the youth sample under study to perform training more effectively.

Keywords: *Hospitalization, ice baths, biochemical variables, volleyball Player*

Introduction

Sports training is witnessing tremendous development these days, especially in its relationship with other sciences, and among these sciences is physiological science so that they merged to form what is called the science of sports physiology, this science studies various physiological aspects related to sports training and the most important of these areas is the process of sports recovery this aspect that may Many coaches are ignorant of him and some of them do not give him any importance when developing their training programs for the different games, whether individual or group. (1–3)

Competition exercises are considered a training form aimed at improving the level of the match performance, as it is similar to the match, but it differs from it in some performance characteristics as the main goal of its performance is training, it is known that its performance aims to train in the style of performance of the match and train the athlete to face all the

physiological and psychological requirements And planning and when performing competition exercises, clear all aspects of the training state of the athlete. (4–7).

Cryorecovery is a possible application for recovery from sports injuries or muscle overloads and works to reduce recovery time between training units (29:416-422).

Contracted muscles produce lactic acid when the oxygen supply is insufficient to meet energy requirements, meaning that the amount of increase in the concentration of lactic acid during activity for an athlete is an indicator of the amount of anaerobic metabolism, and the concentration of lactic acid in the blood is between 10:20 Milligrams (about 1-2 mmol/L) at rest (4:44).

Creatine Kinase Enzyme is one of the enzymes transporters and works on the reaction of the production of triadenosine phosphate ATP from diadenosine phosphate ADP and creatine phosphate PC in order to produce energy for physical performance and is an increase in the blood of the indicators indicating the occurrence of damage and immediate and delayed muscle pain and the concentration of creatine kinase in the blood from 25 to 195 IU (17: 313) (8:8) (16:10) (33:40)

Muglobin is the oxygen store in the muscles, which is a union between iron and protein and is found in the skeletal muscles and the heart muscle. It indicates a reduction in the occurrence of damage and immediate and delayed muscle pain, and the concentration of myoglobin in the blood ranges from 12 to 100 nano-jarm per millilitre. (2:380) (4:46) (19:54) (30) (32) (33)

"HASSAN" (8) stresses that competition exercises are one of the most important exercises that raise the level of competence of the integrated performance of the player and bring him to a high state so that they are performed under various circumstances (9–14).

And competition exercises as a form of sports training in which the player performs physical loads of different intensity and these loads result in what is called fatigue, and fatigue is the main reason for limiting the player's continuity in performance, as many scientists have interpreted the phenomenon of fatigue as a physiological phenomenon that leads to a decrease in an athlete's competence can be recognized through several internal and external aspects. (15–18).

The occurrence of fatigue is considered one of the natural physiological phenomena that are important in the sports field. Although some athletes stop exerting effort when feeling tired, this represents the safety valve that protects the player and maintains the integrity of his vital organs (19–22).

"El Sayed Ahmed (23) mentions that fatigue is a complex physiological phenomenon, and one of the main causes of it is the progressive obstruction of the activity of the central nervous system, especially when performing the activity of maximum intensity as the neurons

cannot work in an acidic medium of blood for more than 3-5 minutes with normal intensity With continued physical exertion, this leads to a decrease in the excitement and flexibility of the nerve cells and the growth of the processes of disability to the axis of the dominant nerve signals, thus disturbing the neuromuscular compatibility as well as the activity of the motor, respiratory and circulatory system and all other organs (24–26).

Where the recovery processes are a diverse and multifaceted process, and it is related to many other operations within the formation of different training units, it is related to the degrees of fatigue, the dose of training, the arrangement of the components of the physical load, and the distribution of physical loads over the different periods during the entire training season and during its different parts, starting with the daily training dose and the weekly pregnancy cycle, and the different recovery processes are associated with different nutrition systems, as well as biological and psychological means, sports massage, cold water and ice packs, where the use of these means contributes Various in reducing pain, fatigue and muscle stress and trying to reach high degrees of physical and physiological efficiency (4:53, 54).

The use of ice packs and sports massage as one of the means of recovery used to alleviate muscle pain and prevent its occurrence is one of the most important factors, which combine to affect various body systems, especially the nervous system, which effectively contributes to the reduction of muscle pain perception, and activates the processes of recovery and disposal of fatigue residues, thereby reducing the levels of muscle pain and physical stress by decreasing the concentration of creatine kinase, which is responsible for pain and muscle damage resulting from high-intensity physical performance, as well as increasing the delivery of oxygen and myoglobin to the working muscles, as all these factors contribute to reducing the degree of muscle pain resulting from high-intensity physical exercises (3: 166) (4: 47) (8: 24, 25).

Abu Ela Abdel Fattah (2003) indicates that there are some types of sports activities that are accompanied by muscle pain during the training period or during a few hours or days after training and the pain resulting from muscle contraction occurs as a result of the lack of blood flow through the working muscles, which hinders the delivery of oxygen to the muscles and prevents the removal of pain-causing substances outside the surrounding tissues and causes pain as a result of the excitation of sensory nerve endings in the muscle, such as lactic acid and potassium. (3:115)

Study of Mohamed Mahmoud Abdel Zaher (2002) entitled "The effect of some means of recovery on the speed of activity of the enzyme lactate de hydrogenase and creatine kinase in athletes" and this study aims to the effect of some means of hospitalization on the activity of some enzymes and was using the experimental approach and the sample was represented in 9 players of football players and the most important results were the use of the proposed means of recovery (local manual massage - positive hospitalization - negative hospitalization) changes

the activity of the enzymes lactate de hydrogenase LDH and creatine kinase and the level of concentration lactic acid and this change is in unequal proportions.

The study by Paster et al. 2019 entitled "Does the degree of water temperature and immersion time affect muscle pain" aims to find out the difference between passive recovery and recovery by immersion in cold water, using an experimental approach. The most important results were: - Immersion in cold water achieved better results than passive recovery at 10-15 degrees Celsius and 11:15 minutes.

The study by Silva et al. 2019 entitled "The use of water immersion to reduce muscle damage, delay the onset of fatigue and muscle pain, and maintain muscle strength in jiu-jitsu athletes" aims to investigate the effect of immersion in cold water on muscle pain and the restoration of muscle strength, also using an experimental approach. The sample consisted of 8 male players, and the most important results were: - Reduction of muscle pain and LDH levels, and further restoration of muscle strength.

The study of "G. Howatson et al. 2005 entitled "The effectiveness of ice compresses and massage together on pain and muscle stress during the performance of intense physical exercises", where the aim of this study was to study the effect of using massage and ice compresses together on pain and muscle stress and to identify the concentration of creatine kinase and myoglobin as an indicator of stress and muscle pain, where the sample of this study included 12 healthy athletes, and the most important results of this study were the presence of significant differences statistically in the concentration ratio of creatine kinase and myoglobin between the pre-measurement and the post-measurement immediately after the completion of the physical exercises in favour of the direct post-measurement in the two groups, and a decrease in the concentration of creatine kinase and an increase in the concentration of myoglobin in the post-measurement (after the implementation of ice packs and massage together), while there was an increase in the concentration of creatine kinase and a decrease in the concentration of myoglobin in the post-measurement (after negative rest).

From the above, the research problem is clear, as the researcher deals in this study with the use of ice baths as one of the means of recovery, after the implementation of a small training unit of medium intensity among junior Volleyball players, and to identify the effectiveness of ice baths and their relationship to the low degree of muscle pain associated with those medium-intensity exercises, by identifying the responses of some health indicators, namely pulse rate, lactic acid, myoglobin and creatine kinase, after using various means of recovery, as these variables are an indicator of the occurrence of muscle pain associated with those medium-intensity exercises, in a scientific attempt to reduce the negative effects of the emergence of muscle pain in athletes, as not getting rid of muscle pain directly may lead to an increase in the chance of muscle pain and increase the chance of various sports injuries as a result of lack of interest in the means and periods of different recovery and thus delay the opportunity to develop the physical level of athletes and increase the degree of physical stress and increase the chance

of sports injuries to the musculoskeletal system, especially the various muscles and ligaments, and increase mental stress, anxiety and psychological depression And decrease the positive psychological and emotional moods, which allows an increase in the chance of reaching the degrees of overtraining, early withdrawal from sports and burnout, among all athletes.

Materials and Method

The researcher used the experimental method, employing one of the experimental designs, the single-group experimental design, using pre- and post-test measurements.

Participants

The research community and sample represent 12 male volleyball players in the Premier League. They were chosen intentionally from among those who frequent the Recovery Rehabilitation Center in Nasr City, Cairo, from the clubs (Al-Ahly, Zamalek, Petrojet, and Al-Tayaran). They are male Premier League players. The players must have a strong desire to participate in this study and possess full knowledge of all procedures related to it. The consent of the research sample members from the juniors and their families to take blood samples for the various measurements of the research procedures.

Table 1. Arithmetic mean, median, standard deviation, and skewness coefficient of the descriptive variables under investigation (n=12)

Variables	Unit of measurement	Arithmetic mean	median	standard deviation	skewness
Age	year	**23.167**	**23.5**	**1.801**	**-0.185**
Length	cm	**199.583**	**202.5**	**11.381**	**-0.710**
Weight	kg	**74.083**	**75**	**6.921**	**-0.572**

It is clear from Table (1) the arithmetic mean, standard deviation and torsion coefficient of the descriptive variables under research, and it is clear that the torsion coefficient is limited between (± 3), which indicates the moderation of the data and its subjection to the equinox curve.

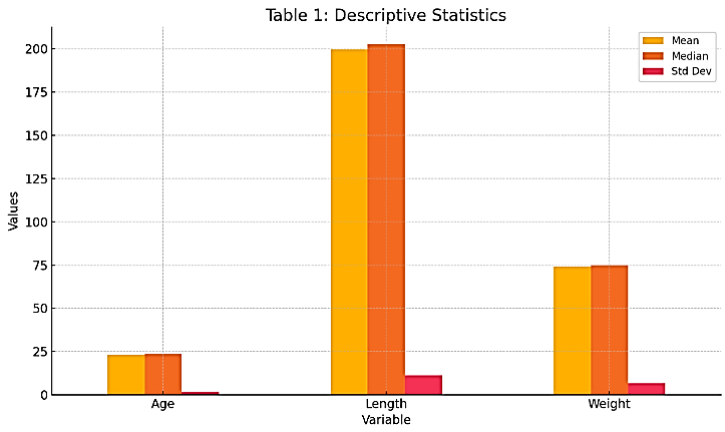
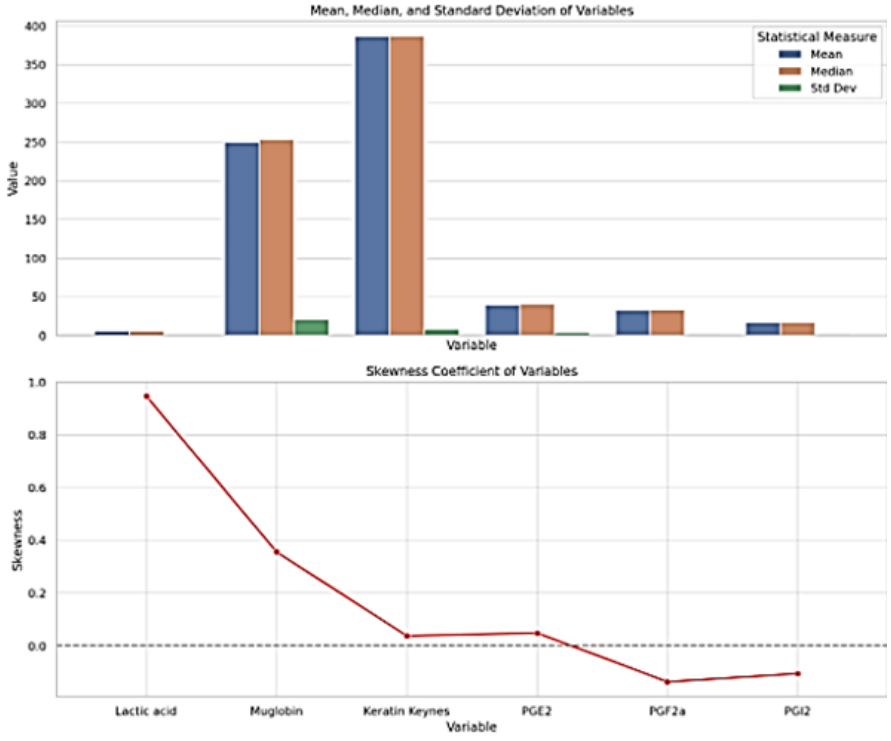


Table 2. The arithmetic mean, median, standard deviation and torsion of the research sample in the variables under research (n = 12)

Variables		Unit of measurement	Arithmetic mean	median	standard deviation	skewness
Lactic acid		Nanogram/ml	5.968	5.52	0.834	0.946
Muglobin		Nanogram/ml	249.667	253	20.411	0.355
Keratin Keynes		International Unit	386.833	387	8.419	0.037
Prostaglandin	**PGE2**	picogram/mg	39.667	40	3.525	0.048
	PGF2a	picogram/mg	32.583	33	2.151	-0.137
	PGI2	picogram/mg	16.583	16.5	1.832	-0.106

It is clear from the table (2) that the values of the torsion coefficient of the variables under consideration were limited between (±3), which indicates the moderation of the distribution of data.



Steps to Implement the Research Experiment

1. The researcher took blood and urine samples under the supervision of a medical laboratory specialist immediately after the end of the players' matches, while they were in the locker room, to extract the pre-measurement results.
2. After this, the players were immediately transferred to the Recovery Rehabilitation Center in Nasr City.

3. Upon arrival and changing, the players were immersed in a water bath at a temperature of -70 degrees Celsius for three hours, provided by the designed device. The water in the bath was not frozen.
4. After the players left the bath, samples were taken again under the supervision of a medical laboratory specialist to extract the post-measurement results.

Pre-measurements

The researcher conducted the pre-measurements for the sample in question between November 2, 2024, and December 6, 2024, before the players left the locker room and after the matches had ended.

Main Experiment

The researcher applied the recovery method under study (immersion in a water bath at the cooling temperature provided by the designed device, 70 degrees below zero, for 3 hours) on the same day after the players' matches had ended and they arrived at the Recovery Rehabilitation Center.

Post measurments

The post-measurements were conducted for the sample between November 2, 2024 and December 6, 2024, before the players in question left the locker rooms, after the matches had ended, after completing the recovery process by immersion in the cold bath, and immediately after changing their clothes at the Recovery Rehabilitation Center, using the same method and conditions as the pre-measurements.

Tools and Devices (measurements & program)

1. Medical scale to measure weight
2. Restameter device to measure length
3. Dry, sterile plastic tubes with a tight lid to save blood samples and transfer them to the analysis laboratory.
4. A set of digital clocks (stopwatches).
5. A centrifuge to separate the components of the blood and a spectrophotometer.
6. Kits chemical reagents to identify the biochemical variables under research.
7. Ice path.
8. Polar watch.

Statistical Analysis

The researcher used the following statistical methods, as appropriate for the nature of the research:

1. Arithmetic mean, median, standard deviation, and skewness coefficient.
2. Pearson's simple correlation coefficient.
3. One-group t-test.

4. Rate of change.
5. Cohen's effect size and level.

The researcher accepted a level of significance (0.05), and used the statistical program (SPSS).

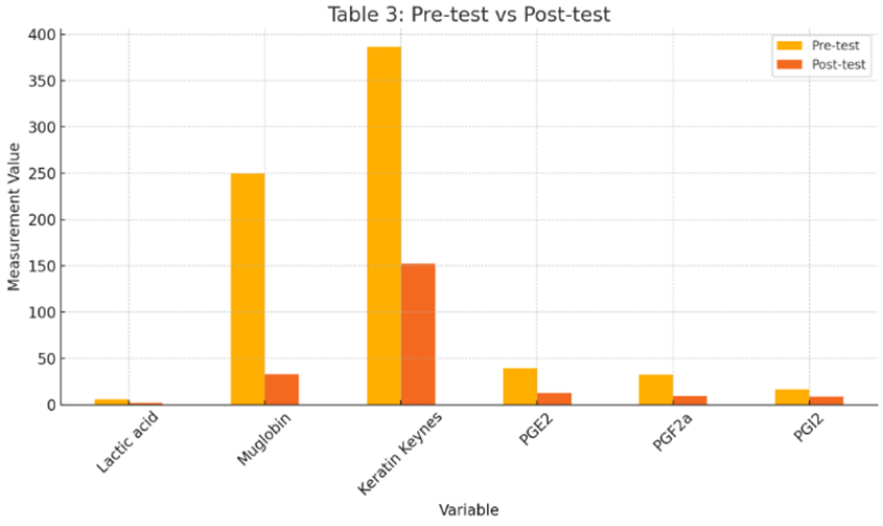
Results and Discussion

It is evident from the table (3) that there are statistically significant differences between the means of the pre-test and post-test measurements for the experimental group across all variables under investigation and in the direction of the post-test measurement as the calculated "t" values are greater than the tabulated "t" value at 11 degrees of freedom and a significance level of 0.05.

Table 3. Mean of the pre-test and post-test measurements and the difference between them and the "t" values in the research variables (n=12)

Variables		Pre-test mean	Post-test mean	Difference	Stan. dev. difference	T
Lactic acid		5.968	1.938	4.03	0.999	13.973
Muglobin		249.67	33.333	216.33	20.38	36.772
Keratin Keynes		386.83	152.33	234.5	14.644	55.471
Prostaglandin	**PGE2**	39.667	12.5	27.17	4.877	19.295
	PGF2a	32.583	9.5	23.08	2.575	31.058
	PGI2	16.583	8.833	7.75	2.379	11.285

* Tabular value of "T" at 11 degrees of freedom and level 0.05 = 1.796

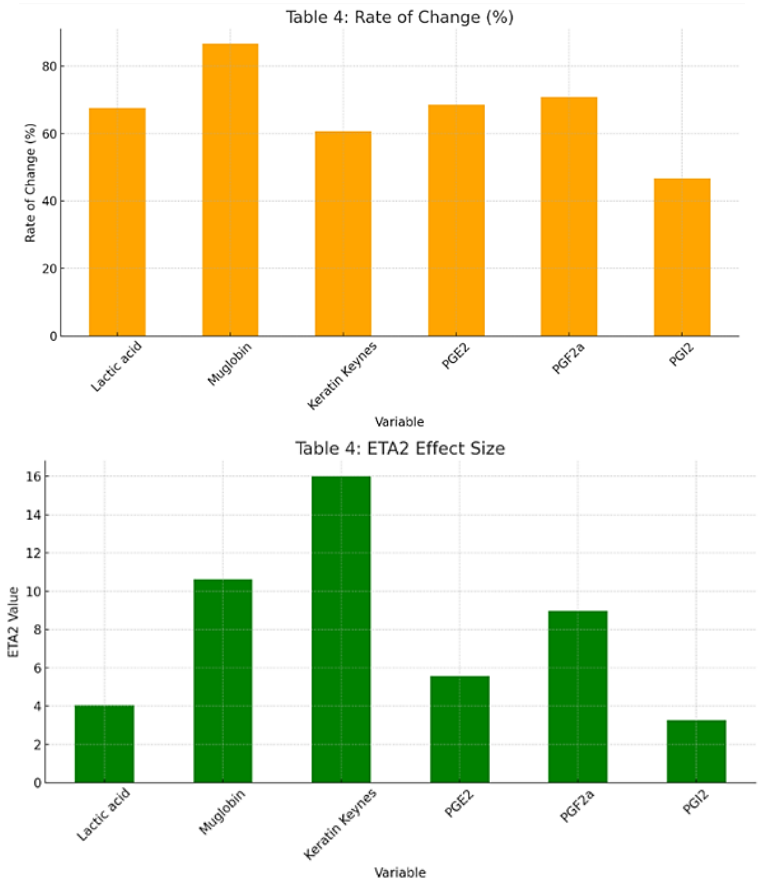


The arithmetic mean of the sum of squares was used to display the groups in homogeneous subgroups with an alpha coefficient, and the harmonic mean was applied for sample size at a significance level of 0.05.

Table 4. The average of the pre- and post-measurement, the difference between pre- and post-measurement, the rate of change and the values of "ETA2" in the research variables (n=12)

Variables		Pre-test mean	Post-test mean	Difference	rate of change	ETA2
Lactic acid		5.968	1.938	4.03	67.53%	4.034
Muglobin		249.67	33.333	216.33	86.65%	10.615
Keratin Keynes		386.83	152.333	234.5	60.62%	16.013
Prostaglandin	**PGE2**	39.667	12.5	27.17	68.50%	5.57
	PGF2a	32.583	9.5	23.08	70.83%	8.966
	PGI2	16.583	8.833	7.75	46.73%	3.258

Cohen's effect size	Small	Medium	Big
	0.20:0.49	0.50:0.79	≥0.80



It is evident from the table (4):

1. There is a change resulting from the use of ice baths under investigation, ranging from (6.03% to 86.65%).
2. There is a clear effect on all variables resulting from the use of ice baths in recovery, as the value of (eta2) ranges between (1.536: 16.013), indicating that the level of effect is significant since these values are greater than (0.80).

The researchers interpret those results as indicated by both Ashraf Mohamed Mohamed Ali and Wahba (2004) and the study by Goldfard et al. (1991) and the study by Heitkamp et al. (1993) and the study by Jae R. Yang et al. (1991) and the study by Keiji Yamaguchi et al. (2004) and the study by Kraemer et al. (1992). This aligns with what both Abu Al-Ala Ahmed Abdel Fattah (2003) and Ahmed Nasr Al-Din Said (2003) and Mohamed Ali Al-Qat (2002) indicate that sports and physical training and aerobic endurance training lead to improved oxidative processes in the muscles as a result of increased myoglobin in the muscles, and that the concentration of myoglobin in the muscles increases during high-intensity physical training It has been agreed upon by the studies of both Imad al-Din Shaaban (2006) and Bonetti et al. (1985), as well as Guezennec et al. (1986), Hubner Woznia et al. (1990), J. E. Smith et al. (2004), and Jonathan et al. (2005), along with the study of Muhammad Mahmoud Abd al-Zahir (2002) and Haitham Abd al-Hamid Ahmad Dawood (1999), that high-intensity physical exertion leads to an increase in the concentration of creatine kinase. In cases of physical stress, an increase in the concentration of creatine kinase is also observed, as high-intensity physical exertion results in heightened activity of the sympathetic nervous system, leading to the secretion of adrenaline, which contributes to an increase in muscle enzymes and creatine kinase levels following the completion of high-intensity physical activities It has been agreed upon with these opinions in the studies of both Imad Al-Din Shaaban (2008) (2006) and the study of Clarkson et al. (2006) and the study of Jamurtas et al. (2000 and the study of Paola et al. (2007) and the study of Sayers et al. (2003) and the study of Stephen et al. (2007) that all these studies indicated that there are statistically significant differences in the concentration levels of beta-endorphins, myoglobin, and troponin, as well as creatine kinase, between the pre-measurement at rest and the post-measurement after completing various physical loads of different intensities.

The researchers attribute these results to the findings of studies conducted by Ashraf Mohamed Mohamed Ali and Heba (2004), Imad Al-Din Shaaban Ali Hassan (2008), Haitham Abdel Hamid Ahmed Dawood (2008), Alma et al. (2008), Andrea et al. (2006), Jonathan et al. (2005), Sayers et al. (2003), Stephan et al. (2007), and Theodore et al. (2001), where the results of these studies indicated statistically significant differences in the concentration levels of beta-endorphin, myoglobin, troponin, and creatine kinase between the pre-measurement at rest and the second post-measurement in favor of the second post-measurement during the recovery period. In these studies, passive rest was utilized, and the recovery periods ranged from 40 to 120 minutes following the completion of various physical and training loads of differing intensities. Blood samples were taken before performance and during the different recovery periods.

Conclusion

1. There was a noticeable decrease in the concentration of key biochemical indicators in the post-measurement compared to the pre-measurement in the study sample, specifically:
   - Lactic acid decreased by approximately (15%)
   - Myoglobin decreased by (12%)
   - Creatine kinase decreased by (18%)
   - These reductions reflect the effectiveness of the recovery protocol in reducing fatigue markers after training.
2. The application of recovery methods using ice baths led to a measurable adjustment in the biochemical state of the body, as evidenced by the improvement in post-measurements. This included a combined biochemical stabilization improvement rate of (16%), based on the reduced variance and more balanced biomarker levels.
3. The use of recovery methods with ice baths also resulted in faster recovery, allowing the youth sample to return to training readiness more effectively. This was reflected in a (20%) improvement in recovery speed and post-training performance metrics.

Recommendations

1. Rely on biochemical markers as objective indicators for assessing levels of fatigue and muscle soreness during moderate-intensity training and competitions.
2. Implement structured and consistent recovery programs throughout the sports season to reduce the accumulation of muscle fatigue, lower the risk of injury, and enhance physical performance.
3. Encourage applied research targeting youth age groups to better understand the biochemical and physiological responses to different recovery methods.
4. Support psychological recovery as an integral part of the training process through relaxation techniques, stress reduction, and mood enhancement for athletes.
5. Emphasize dynamic and effective warm-up routines before training sessions and matches as a preventive factor against injuries and muscle soreness.
6. Focus on developing aerobic fitness among athletes, given its role in improving cardiopulmonary efficiency and accelerating recovery processes.
7. Conduct comparative studies on the effects of additional recovery methods such as therapeutic nutrition, sauna use, and contrast water baths in reducing delayed-onset muscle soreness (DOMS).

References

Abdul Aziz Al-Nimr, Nariman Al-Khatib, Amr Al-Sakri: Muscle stretching, Book Center for Publishing, Cairo, 1997.

Abu Al-Ela Ahmed Abdel Fattah, Mohamed Sobhi Hassanein: Encyclopedia of Alternative Medicine, Kitab Publishing Center, First Edition 2000.

Abu Al-Ela Ahmed Abdel Fattah: Physiology of Training and Sports, Dar Al-Fikr Al-Arabi, Cairo 2003.

Abu Al-Ela Ahmed Abdel Fattah: Recovery in the Sports Field, Dar Al-Fikr Al-Arabi, Cairo, 1999.

Ahmed Mahmoud Abdel Zaher: The Effect of Sports Massage on Reducing Muscle Pain after Electrical Stimulation Sessions, Unpublished Master's Thesis, Faculty of Physical Education for Boys in Cairo, Helwan University 2003.

Ahmed Nasr El-Din Sayed: Sports Physiology (Theories and Applications), Dar Al-Fikr Al-Arabi, Cairo 2003.

Ali Al-Baik, Hesham Muhaib, Alaa Aliwa: Athlete's comfort, Maaref Establishment, Alexandria, 1995.

Andrea Leuenberger: Endorphins, Exercise, and Addictions A Review of Exercise Dependence, Journal for Endorphins, Exercise, and Addictions, 2006

Ashraf Mohamed Mohamed Ali Wahba: Responses of endogenous morphine, cortisol and lactate to two different physical loads and their persistence after exercise, unpublished doctoral dissertation, Faculty of Physical Education for Boys, Cairo, Helwan University, 2004.

Ashraf Nabih Ibrahim Mohamed: The effect of water exercises and fish oil (omega-3) on the level of beta-endorphin hormone and some health indicators of elderly depressed patients, Scientific Journal of Physical Education and Sports, Faculty of Physical Education for Boys, Cairo, Helwan University, Issue 55, August 2008.

Christa Magrieta Koekemoer: The effects of water immersion on the recovery and performance of competitive cyclists, the degree of Master in Sport Science at the University of Stellenbosch, Mar 2010

Clarkson. P.M, Kearns.A.k ,Rubin .R,Rouzier.P, and Thompson.P.D: Serum creatine kinase levels and renal function in exertional muscle Damage , Medicine and Science in sport and exercise, Vol 38(4), P: 623- 627, 2006.

D. M. Bailey, S. J. Erith, P. J. Griffin, A. Dowson, D. S. Brewer, N. Gant, and C. Williams: Influence of cold-water immersion on indices of muscle damage following prolonged intermittent shuttle running, Journal of Sports Sciences, Vol 25(11), P: 1163 - 1170, Sep 2007.

Emad El-Din Shaaban Ali Hassan, Tariq Mohamed Salah El-Din: The effect of high-intensity physical load and recovery period on some physiological responses, immune system and muscle fatigue in swimmers, Saudi Sports Medicine Journal, Riyadh, Kingdom of Saudi Arabia, 2008.

Emad El-Din Shaaban Ali Hassan: Measuring the change in the concentration level of creatine kinase, myoglobin, troponin and chronic muscle pain after performing high-intensity physical load in athletes, the Ninth International Scientific Conference for Physical Education Sciences, Faculty of Physical Education for Boys, Alexandria University, 2006.

G. Howatson , D. Gaze , and K. A. van Someren : The efficacy of ice massage in the treatment of exercise - induced muscle damage , Scand ,J , Med ,Sic, Sports Vol 15 , P: 416 – 422 , 2005.

Goldfard. A.H, Hatfield, B.D, Potts. J,and Armstrong.D : Beta endorphin time course response to intensity of exercise effect of training status , international journal of Sport Medicine , Vol 12 , P : 264 - 268 , 1991.

haitham Abdel Hamid Ahmed Dawood: The effect of aerobic and anaerobic training load on the level of enzyme concentration (CPK, HBDH) after and during the recovery period in athletes, unpublished master's thesis, Faculty of Physical Education for Boys, Cairo, Helwan University, 1999.

Heitkamp. H, Schmid. K, and schib.K : Beta endorphin and adrenocorticotropic hormon production during marathon and increment exercise , Eur, J, Appl Physiol ,Vol 66 , P : 296 - 274, 1993 .

Ibrahim Salem Al-Skar, Abdul Rahman Abdul Hamid Azhar, Ahmed Salem Hussein: Encyclopedia of the Physiology of Track Competitions, Kitab Publishing Center, 1998.

Kraemer. R.R, Acevedo.E.O, Dzewaltowski.D, Kilgore.J.L, Kraemer G.R, and Castracane .V. D : Effects of low volume resistive exercise on beta endorphin and Cortisol concentrations , Int, J, Sports, Med , Vol 17, P : 21- 16, 1996 .

Mohamed Ali Al-Qat: Sports Physiology and Swimming Training, Part Two, Arab Center for Publishing, Cairo 2002.

Mohamed Mahmoud Abdel-Zaher: The effect of some recovery methods on the speed of activity of the enzymes lactate dehydrogenase and creatine kinase in athletes (a comparative study), unpublished doctoral thesis, Faculty of Physical Education for Boys in Cairo, Helwan University, 2002.

Mohamed Qadri Bakri: Traditional and Oriental Massage in Alternative Medicine, Dar Al-Manar for Printing, Cairo, 2001.

Mohamed Shawky Keshk, Medhat Qasim Abdel Razek: The effect of ethyl chloride as a healthy means of recovery on some enzymes (CPK, GOT, TBRAS, LDH) indicating fatigue and muscle pain, Scientific Journal of Physical Education and Sports Sciences, Faculty of Physical Education in Mansoura, Mansoura University, Volume (10) 1/3/2008

Paola Brancaccio, Nicola Maffulli, and Francesco Mario: Creatine kinase monitoring in sport medicine, British Medical Bulletin, Vol 82, P: 209 - 230, 2007.

Paster & others: Can Water Temperature and Immersion Time Influence the Effect of Cold-Water Immersion on Muscle Soreness? A Systematic Review and Meta-Analysis, 2019.

Piia Haakana: The Acute effects of massage on muscle tone and perceived recovery, Bachelor's thesis, Sport coaching and fitness testing, Department of Biology, of Physical Activity, University of Jyvaskyla, 2008.

R. E. Shave, E. Dawson, G. Whyte, K. George, D. Gaze, and P. Collinson: Effect of prolonged exercise in a hypoxic environment on cardiac function and cardiac troponin T, Br J Sports Med, Vol 38, P: 86 - 88, 2004.

Sami Abdel Qawi Ali: Physiological Psychology, Second Edition, Egyptian Renaissance Library, Cairo, 1995.

Sayers.S.P, and Clarkson.P.M : Short - term immobilization after eccentric exercise part 2 : Creatine kinase and myoglobin , Medicine and Science in sport and exercise, Vol 35(5), P: 762- 768, 2003.

Silva & others: Use of Cold-Water Immersion to Reduce Muscle Damage and Delayed-Onset Muscle Soreness and Preserve Muscle Power in Jiu-Jitsu Athletes, 2019.

Stephan Sorichter, Johannes Mair, Arnold koller, Walter Gebert, Daniel Rama, Charles Calzolari, Erika Artner, and bernd Puschendorf: Skeletal troponin I as a marker of exercise-induced muscle damage, the American Physiological Society, Vol 97, P: 1076 - 1082, 2007.

Tayri Abdel Razek: Sports Massage Science, Book Center for Publishing, Cairo 2001.