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Effect of anaerobic and aerobic exercises using organic nutritional supplements on the lactate threshold, energy expenditure during effort, and endurance performance in handball players

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ABSTRACT

The aim of this study was to identify the extent to which energy systems (anaerobic or aerobic) contribute to the development of lactate threshold, energy expenditure during effort, and endurance performance, when using organic nutritional supplements for handball players. An experimental design with two equal experimental groups was utilized. A sample of 14 players of the Karbala Youth Club in Karbala Governorate was randomly and equally divided into two experimental groups, with 7 players in each group. The first group did lactic energy system exercises, using organic nutritional supplements (curcumin and ginseng), while the second group did aerobic energy system exercises using the same organic supplements. Exercising in both the lactic and aerobic energy systems while using organic nutritional supplements had a positive effect on the development of the lactate threshold, energy expenditure during effort, and endurance performance of young handball players ($p<0.05$). Training with the anaerobic energy system yielded better results than with the aerobic energy system in the development of the lactate threshold, energy expenditure during effort, and endurance performance of young handball players ($p<0.05$). The use of organic nutritional supplements played an important role in the development of the lactate threshold, energy expenditure during effort, and endurance performance of young handball players.

KEYWORDS

Energy Systems; Lactic-Aerobic; Organic Food Supplement; Lactate Threshold; Handball Players

1. INTRODUCTION

Through the examination of the improvements in players' results and team performance, and reviewing relevant studies and research, it was noted that there is a growing interest in advancing the science of sports training and integrating other scientific disciplines, particularly physiology, to enhance the science of training. One significant factor from said field are the physiological changes that occur in the functional organs of the body, such as changes in the anaerobic and aerobic energy systems. These systems are responsible for producing the energy required for athletic performance, as well as physical and skill duties. Such changes occur in muscle fibres — muscles in the human body are fundamental for the performance of physical activity and stability in different positions, as they are responsible for converting chemical energy into mechanical energy. The proper functioning of these systems requires the cooperation of all body systems and organs, which ultimately determine motor, physical, and skill competence (Hassan & Mosleh, 2002).

Likewise, nutritional supplements play a vital role in the training process, in particular the organically extracted ones, by compensating for the deficiency that occurs due to continuous training. Such deficiencies may take an extended period for the body to recover naturally. Nutritional supplements, therefore, provide a means to fill this gap and reach the required level. The organic system is one of the modern systems used in the production of animal and vegetable food products, which have been grown or produced without the use of genetically modified hormones or chemicals. Organic food, such as curcumin and ginseng, has numerous health benefits, including a greater amount of nutrients compared to inorganic food.

After reviewing scientific literature related to sports training, conducting interviews with academics, and observing various past and recent training processes by coaches, it was noted that there is a significant weakness in the manifestations of special endurance, which stems from the insufficiency of development in some physiological variables such as lactic threshold, energy expenditure during effort, and endurance performance. Furthermore, there is a lack of information on the effect of lactic-aerobic exercises using organic nutritional supplements. Therefore, the purpose of this study is to examine the effect of energy system exercises (lactic and aerobic), when using organic nutritional supplements, on the lactate threshold, energy expenditure during effort, and endurance performance of handball players. Ultimately, the goal is to provide useful information to coaches and specialists in developing effective training programs for players. The research hypothesis were: 1) Exercises of the two experimental groups using organic nutritional supplements will have a positive effect on the development of the lactate threshold, energy expenditure during effort, and endurance

performance for handball players. 2) The first experimental group that used the lactic exercise energy system with organic nutritional supplements will show better development of the lactate threshold, energy expenditure during effort, and endurance performance, when compared to the second experimental group that used the aerobic energy system with organic nutritional supplements.

2. METHODS

2.1. Design and participants

The researchers used an experimental design with two equal experimental groups to suit the nature of the studied problem. The study population for this research was the players of the players of the Karbala Youth Club in Karbala Governorate, consisting of 16 young handball players without goalkeepers. For the purpose of this study, a sample of 14 players was randomly and equally divided into two experimental groups, with 7 players in each group. The first group did lactic energy system exercises, using organic nutritional supplements (curcumin and ginseng), while the second group did aerobic energy system exercises using the same organic supplements.

2.2. Instruments and procedures

Tools and equipment used

The tools and equipment used were: 2 Fox whistles, 12 hand balls, 3 Sewan type stopwatch, sticky tape, 1 measuring tape, medical supplies, 1 Sony camera, treadmills, 1 Fitmate device, 1 height and weight scale, 1 Lenovo laptop calculator.

First test: Blood lactate level

The tactical threshold was measured for each member of the sample after performing a high-effort exercise, which consisted of four stages of running on a treadmill. Each stage lasted four minutes without stopping between them. A second-generation hand-held lactic acid measurement device (Lactate Pro2) was used to measure the lactic threshold. The measurement process involved pricking one of the fingers, and wiping away the first drop of blood. Once the second drop of blood appeared, the measuring tape (cut), connected to the device, was placed on the finger to draw the blood towards the tape. The finger was held on the tape until the result of the lactic acid proportion appeared, which took approximately 15 seconds (Huwaiber, 2016)

Second test: Energy expenditure during activity

Purpose of the test: To measure the energy expenditure during the effort and the endurance performance. Equipment and tools: Fitmate device, Treadmills, Cotton, Disinfectant (alcohol). Procedures and performance specifications: Prior to starting the energy expenditure test, the test-taker sanitized the breathing mask of the device (Fitmate PRO) using a disinfectant solution. Then the test-taker connected the parts of the device system to each other, placed the pulse belt on the chest of the participant, and attached the pulse signal receiver (Bluetooth) to the Fitmate PRO device. After entering the laboratory information into the device — which included the name, date of birth, gender, height, and weight — the type of test to be performed — energy spent during effort — was selected. Next, the breathing mask was tightly secured with the specialized belts to prevent any air leakage. The participant climbed onto a treadmill and gradually started running with added speed, and the Bruce protocol was followed. The test-taker controlled the speed, using the button on the treadmill, from 2.7 km/h to 11.6 km/h. The Fitmate PRO device had a small screen that displayed a square graph, with rectifier monitoring. Conditions: 1) The laboratory must be in a normal state before the test begins. 2) Attention should be paid to gradually increasing the load gradient on the treadmill, while monitoring the participant when they are reaching the state of exhaustion or requesting to stop the test. 3) The treadmills should be stopped by gradually reducing the speed. Registration: The device generates a comprehensive measurement report.

Third test: Endurance performance (Handball players' endurance test)

Purpose of the test: To measure the endurance performance of handball players. Description of the test: The test began at the first square, located 6 metres away from the end line of the playing field and 1 metre from the side line. At the sound of the whistle, the player dribbled the ball in a straight line for a distance of 19 metres at maximum speed, and then proceeded following a zigzag pattern among five cacti. The first person was 5 metres away from the half-court line, and there was a 1-metre distance between the posts. Next, the player moved 10.5 metres to a square located 3 metres away from a flat wall to handle and receive five balls. After completing this task, the player moved to a square with the same measurements as the first square, where a ball was placed for the participant to catch it and then make a long pass towards a vertical goalpost, located 30 metres diagonally away. Following this exercise, the player performed defensive moves by advancing and reversing diagonally around six bars placed near a line (6 metres and 9 metres) with a 2-metre gap between the bars laterally and a 3-metre gap front and back. The player then moved to a square located 3 metres away from a flat wall, but from the other side of the goalpost, to pick up five balls, handling and

receiving one at a time. Next, the participant moved to a square with the same measurements as the first square, where a ball is placed for the participant to catch it and then make a long pass towards a vertical net, located 30 metres diagonally, near a 9-metre line after it bounces off the ground. Finally, the player runs as quickly as possible to the finish line, which is 25 metres away from the shooting area. Notes: The test is conducted in a handball environment. Aiming and handling must be performed with accuracy and high concentration. The test must be carried out as quickly as possible. Registration: Each participant is given one attempt, and the total time for completion is recorded in seconds and in stages. If the ball falls or any of the beacons placed for the test is moved, 5 seconds shall be added to the player's total time.

Exploratory experience

The researchers conducted an exploratory experiment on Sunday, November 7, 2021, on a group of six sample members, at the Karbala gymnasium stadium and the physiology laboratory.

Pre-test

The pre-test was conducted on the research sample on Sunday, December 12, 2021, at the Karbala gymnasium stadium and the physiology laboratory of the University of Kerbala, College of Physical Education and Sports Sciences.

Main experience

Upon completion of the pre-tests, the researchers introduced exercises for both active and aerobic energy systems using organic food supplements. These exercises were part of the training program designated to the research sample at the beginning of the main section of the training unit. The main part was completed along with the same trainer’s exercises, performed as follows:

- The start date of the exercises was on Thursday, December 16, 2021.
- The exercises were applied during the special preparation stage.
- The experiment lasted 8 weeks, consisting of 24 training units (three units per week).
- A special trainer was assigned to each group, provided with a specific exercise program at the beginning of the main part. The groups trained at the Karbala gymnasium on Saturdays, Mondays, and Thursdays at the same time, where they first completed the special exercises and were then merged again to complete the group training unit, under the supervision of their coach.
- The researchers determined the intensity of the exercises to be between 80-90% for the tactical system.

- The researchers determined the intensity of exercises to be between 70-80% for the aerobic system.
- The training volume of the exercises was set to 40-60 minutes per training unit.
- The researchers used the high- and medium-intensity interval training method.
- The end date of the experiment was on Monday, February 7, 2022.

Post-test

The post-test was conducted on the research sample on Thursday, February 10, 2022, at the Karbala gymnasium stadium and the physiology laboratory, under the same conditions as during the pre-test.

2.3. Statistical analyses

The researchers used the SPSS statistical package with the following statistical methods: arithmetic mean, standard deviation, t-test for symmetric and independent samples, Pearson correlation coefficient, skewness coefficient, median, and the K^2 test

3. RESULTS AND DISCUSSION

3.1. Results and analysis of the pre- and post-test scores for the two research groups

To examine the second hypothesis, the researchers used the *t* test for the corresponding samples, as shown in Tables 1 and 2. Table 1 shows means, standard deviations, calculated *t* value, level and type of significance for the first experimental group in the pre- and post-tests. These are the statistical indicators of the results of the tests in the pre- and post-measurement of the research variables that the members of the first experimental group underwent.

Table 1. Comparison between pre- and post-tests for the first group

Variables	Tests	Mean	Std. deviation	Mean difference	Std. deviation difference	*t* value	*p*
Lactate threshold	Pre-	4.8429	.08864	.65857	.03888	16.939	.000
	Post-	4.1843	.03359				
Energy expenditure during effort	Pre-	1215.2143	8.64994	90.50000	4.09849	22.081	.000
	Post-	1124.7143	4.27061				
Endurance performance	Pre-	83.8167	.07416	3.01143	.05087	59.201	.000
	Post-	80.8053	.09256				

Note. Below significance level (0.05) and sample size (6)

With regard to the studied variables (lactate threshold, energy expenditure during effort, and endurance performance), the results showed that the mean values were lower in the post-test compared to those in the pre-test. Moreover, a significant difference was observed between the two tests, favouring the post-test, as the lower the mean, the better the level. That is, the results in the post-test indicated better performance levels than those in the pre-test. The levels of significance were found to be less than the 0.05 significance level, which indicates the existence of significant differences between the two tests.

Table 2 shows means, standard deviations, calculated *t* value, level and type of significance for the second experimental research group in the pre- and post-tests. Like Table 1, these are the statistical indicators for the research variables in the second experimental group.

Table 2. Comparison between pre- and post-tests for the second group

Variables	Tests	Mean	Std. deviation	Mean difference	Std. deviation difference	*t* value	*p*
Lactate threshold	Pre-	4.7857	.11073	.30857	.04728	6.527	.001
	Post-	4.4771	.04786				
Energy expenditure during effort	Pre-	1212.2857	7.93125	66.85714	4.37214	15.292	.000
	Post-	1145.4286	9.28901				
Endurance performance	Pre-	83.8493	.09168	1.68886	.10082	16.751	.000
	Post-	82.1604	.19560				

Note. Below significance level (0.05) and sample size (6)

With regard to the studied variables (lactate threshold, energy expenditure during effort, and endurance performance), the results showed that the mean values were lower in the post-test compared to those in the pre-test. Furthermore, a significant difference was observed between the two tests, favouring the post-test, as the lower the arithmetic mean, the better the level. The levels of significance were less than the 0.05 significance level, which indicates that there are significant differences between the two tests. This is consistent with what was stated in the second hypothesis of the research.

The development observed in both experimental groups can be attributed to the regularity in the training process and adherence to a method prepared and organized by the researchers, which relied upon the use of training methods to enhance performance. Moreover, it can be attributed to the nature of the exercises used in the training units, which were like the variables investigated — similar to the motor paths of skills to some extent — as well as the intensity and volumes applied, which

were equal and higher than the intensity and volumes used in the actual performance of those skills. It is well established that organized sports training leads to an increase in the efficiency of functional organs, especially the nervous and muscular systems, which in turn results in an improved ability of the muscles to produce strength and an increased muscular contraction speed, ultimately enhancing skilled performance (Allawi & Abdel-Fattah, 1984).

Additionally, the researchers regulated the training loads to minimize the risks associated with this type of exercise, with appropriate rest during the training exercises and the use of supplements to ensure participant safety. Likewise, as some exercises are often undesirable by the players — because of the strict requirements that may lead to boredom, rejection and a lack of seriousness in performance — the researchers diversified the exercises to cause desire and suspense to perform, and enhance engagement. This counteracted boredom that may result from monotonous and unvaried training methods (Bean, 2004).

As for endurance performance, the observed difference between pre- and post-test is attributed by the researchers to the semi-maximum intensity exercises used, which were organized according to scientific principles of intensity, size, and rest intervals. Insufficient rest between repetitions and totals led to an improvement in the level of performance effectiveness and endurance. During the exercises, energy was primarily gained through the anaerobic system, which functions in the presence lactic acid accumulation in the blood, resulting in an increased adaptation and energy production. The resistance exercises were performed with and without the ball throughout the test. Wilmore (1978) also confirmed the concept of adaptation, as he claimed that “as a result of long periods of training continuously and regularly, functional changes occur to the organs called functional adaptation”.

Physical fitness and motor skills are among the general requirements of handball. Endurance is especially important, as it enables the player to move continuously and be in the right position offensively or defensively, as well as to continuously engage with opponents and score effectively. According to Abul-Ela Abdel-Fattah (1997), the main part of the sports preparation process comes after the special physical process, which focuses on developing the various abilities necessary for the athlete to achieve the highest possible level in a particular type of sports activities. The changing situations in handball, such as quick attacks and quick returns to defence, require players to possess great endurance performance. Darwish et al. (1998) have confirmed that the same element of endurance in its various types contributes to mastering defensive and offensive skill work.

3.2. Presentation and analysis of the post-test results for the two research groups

Table 3 shows means, standard deviations, calculated *t* value, level and type of significance for the post-test results of the two experimental research groups. This allows to compare the differences in results of the studied variables (lactate threshold, energy expenditure during effort, and endurance performance.

Table 3. Comparison of post-test results between groups

Variables	Experimental groups	Mean	Std. deviation	*t* value	*p*
Lactate threshold	First	4.1843	.03359	13.251	.000
	Second	4.4771	.04786		
Energy expenditure during effort	First	1124.7143	4.27061	5.361	.000
	Second	1145.4286	9.28901		
Endurance performance	First	80.8053	.09256	16.569	.000
	Second	82.1604	.19560		

Below the significance level (0.05), sample size (6)

Upon reviewing the results of the tests, it is evident that there are significant differences between the post-test measurements of the two experimental groups in the studied variables (lactate threshold, energy expenditure during effort, and endurance performance). The first experimental group, which utilized the lactic energy system, demonstrated a higher level of performance, as indicated by a significance level lower than the error level (0.05).

The researchers attribute the superiority of the first experimental group over the second to its use of exercises with the lactic energy system. The anaerobic exercises performed by the members of the second group enhanced their abilities to resist fatigue through the improvement of anaerobic energy production. Additionally, the mechanism to remove lactic acid accumulation from muscle fibres into the bloodstream was developed, reducing its negative impact on impeding the continuation of motor performance and delaying the appearance of symptoms of fatigue.

Based on the results, the researchers believe that the high-intensity exercises used for an appropriate amount of time contributed to an increased ability to tolerate accumulated lactic acid in the muscles, which made the members of the first experimental group able to perform faster while bearing the accumulation of lactic acid caused by this type of exercises. The ability to maintain high performance during more competitions, despite the increase in the accumulation of lactic acid in the muscles, is a positive outcome. Zaki & Muhammad (2002) confirmed that the increase in the lactic acid concentration in the blood of athletes after performance indicates their ability to tolerate the pain caused by such accumulation, allowing them to perform at a faster rate and for a longer time.

Physical activities characterized by high intensity and long duration indeed result in a high percentage of energy expenditure (Al-Hindawi, 2011).

As for the development of endurance sports performance, Nassif (1987) states, "the programmed aerobic exercise has a significant impact on developing performance". This was supported by Hammad (1988), who declared that "the closer the training circumstance is to the competition (the match), the more useful and effective the exercise will be for the player and achieve the goals of reaching the level of endurance to perform the match".

Handball players require physical abilities and endurance to carry out skill and tactical duties during matches, as well as technical performance for jumping power to defend against shots or repetition of attack-defence processes, among other activities (Oreibi, 1998). In that sense, the use of anaerobic exercises for handball players was effective in the development of their l performance and endurance levels, which contributed to economizing consumed energy and maintaining a constant level of performance for the special physical load during shorter intervals (Abdul-Jabbar, 2001).

Furthermore, the use of ginseng plant components has been shown to improve the circulatory and nervous systems, thus leading to a better sports performance and endurance. Scientific sources suggest that the ginseng plant can be used for a variety of health purposes, such as stress relief and improved cardiovascular and central nervous system function, and it also contains antioxidants that help to boost immunity. Likewise, ginseng and curcumin are particularly beneficial for athletes, as they contain ginsenosides, which improve the muscles ability to remove lactic acid more quickly and delay the onset of fatigue, increasing endurance and energy levels, as well helping athletes to use oxygen more effectively and recover faster between repetitions. These also regulate blood circulation and metabolism, and activate the heart muscle, enhancing its efficiency during physical activity. (Pengelly Tomy, 2011; Al-Maliki, 2013). Besides ginsenosides, ginseng contains iron, which enhances the work of blood vessels and increase haemoglobin in the blood. This supports the work of the central nervous system as well, incrementing the percentage of oxygen in the muscles during physical activity. (Humphreys, 2001; Manati, 2015). Ginseng and curcumin may also improve memory and concentration, but most importantly they contribute to building strength and resistance during exercise and sports competitions.

4. CONCLUSIONS

In conclusion, exercising in both the lactic and aerobic energy systems while using organic nutritional supplements had a positive effect on the development of the lactate threshold, energy

expenditure during effort, and endurance performance of young handball players. Training with the anaerobic energy system yielded better results than with the aerobic energy system in the development of the lactate threshold, energy expenditure during effort, and endurance performance of young handball players. The use of organic nutritional supplements played a significant role in the development of the lactate threshold, energy expenditure during effort, and endurance performance of young handball players.

5. RECOMMENDATIONS

It is highly recommended in training the two energy systems (lactic-aerobic) to use organic nutritional supplements for all age groups, especially young handball players. The combination of training with the two energy systems (lactic-aerobic) and using organic food supplements is useful to enhance the lactate threshold, energy expenditure during effort, and endurance performance. Further studies should be conducted on different age groups and for other sports to expand the knowledge of the impact of organic supplements on athletic performance.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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