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STUDYING THE EFFECT OF LACTIC ANAEROBIC TRAINING ON SOME PHYSIOLOGICAL AND BIOCHEMICAL RESPONSES OF BOYS DURING ADOLESCENCE

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Abstract
This study examines the physiological and biochemical effects of lactic anaerobic endurance training on male adolescents aged 12 to 16. While there is a growing interest in youth athletic training, concerns persist regarding the potential health risks associated with intensive lactic anaerobic training in this age group. The research problem arises from the limited data on how such training affects children's physiological development and overall health, emphasizing the need for evidence-based guidelines for coaches and trainers. The study involved 12 athletes, categorized into two age groups: 12–14 years and 14–16 years. Both groups participated in an eight-week lactic anaerobic endurance training program. Physiological and biochemical parameters—including vital capacity, maximal oxygen consumption (VO_2 max), blood pH levels, lactic acid concentration, creatine kinase (CK), lactate dehydrogenase (LDH), and running performance at 300 and 500 meters—were measured pre- and post-training.

The findings indicate a significant increase in lactic acid, CK, and LDH levels in both groups following the training program, though the degree of change varied depending on the specific test and training protocol. Additionally, both groups demonstrated improvements in vital capacity, VO_2 max, and running performance. However, notable differences in physiological responses were observed between the two age groups.

Based on these results, the study advises against lactic anaerobic endurance training for the 12–14 age group due to heightened risks of muscle damage and overstrain. The findings suggest that the high intensity of such training may exceed the metabolic capacity of younger adolescents, given their limited energy reserves (glycogen and PCr-ATP). For the 14–16 age group, the study recommends implementing lactic anaerobic training with caution and moderation to mitigate muscle damage and ensure safe physiological adaptation. The research underscores the importance of age-appropriate training regimens to prevent injuries and optimize athletic development. Furthermore, it highlights the need for additional studies exploring the effects of lactic anaerobic training on female adolescents to determine the most suitable age for such training interventions.

Keywords:
Lactic anaerobic endurance training, adolescent athletes (12–16 years old), physiological and biochemical responses, age-appropriate training, muscle damage, health risks, female adolescent athletes, future research on girls.

Introduction and Problem Statement

In recent years, the training of children and adolescents has gained considerable attention from researchers interested in sports science. This interest has increased due to the rising intensity of training loads that young athletes are subjected to in order to meet the demands of competitive sports, which consequently leads to significant physical strain and stress. A major debate has emerged among researchers regarding the effects of

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training on the health of young athletes, particularly concerning anaerobic endurance training. This is due to the limited anaerobic capacity in children compared to adults.

Mohamed Shawky Kashk (2010) highlights the inappropriateness of exposing children and adolescents to physical loads that exceed their developmental capacities prematurely. Excessive and intense training, particularly that which emphasizes anaerobic lactic capacity, is not suitable for these early stages of growth. This is primarily because the development rate of anaerobic enzyme activity in young individuals is significantly lower compared to that of adults.

The problem addressed by this study arose from the researcher's observation of a lack of available information and studies on the impact of anaerobic lactate training on children. Moreover, the absence of clear guidelines regarding the appropriate age to begin such training is evident. The researcher, having 18 years of experience as an athlete and coach in athletics, noticed a decline in performance levels among adult athletes in Egypt, despite young athletes achieving high performance levels that sometimes exceed those of their counterparts in other countries. However, these athletes often fail to maintain their achievements as they enter senior levels of competition. The researcher believes this might be attributed to the lack of information available to coaches about the effects of training on young athletes, particularly regarding anaerobic lactate training and its impact on their health and performance, both in the short and long term.

Thus, the research aims to explore one of the critical issues in training children and adolescents by investigating the effect of anaerobic lactate training on physiological and biochemical responses in boys between the ages of 12 and 16. As this paper seeks to analyze how these responses are related to training and their impact on child health.

Research Significance

The significance of this study lies in its attempt to recognize the impact of anaerobic lactate training on boys aged 12-16, through the measurement of specific physiological and biochemical responses resulting from this type of training. Furthermore, the study seeks to examine the potential risks associated with excessive use of such training at this evolving stage, and answer critical questions regarding the appropriate age for beginning such training by assessing the concentration of the enzymes creatine kinase (CK) and lactate dehydrogenase (LDH) in the blood. Elevated levels of these enzymes are indicative of muscle damage, stress, and potential overtraining injuries.

Research Objectives

The primary objective of this research is to study the effects of lactic anaerobic training on the physiological and biochemical responses in adolescent boys, focusing on the following goals:

1. To identify the effect of anaerobic lactate endurance training on the physiological and biochemical responses being investigated (lactic acid, creatine kinase (CK), lactate dehydrogenase (LDH), pH level, vital capacity, and maximal oxygen consumption) in boys aged 12-14 years.
2. To examine the effect of anaerobic lactate endurance training on the physiological and biochemical responses being investigated. These responses include lactic acid levels, creatine kinase (CK) enzyme activity, lactate dehydrogenase (LDH) enzyme activity, pH levels, vital capacity, and maximal oxygen uptake (VO_2 max) in adolescents aged 14 to 16 years.
3. To compare the effect of anaerobic lactic endurance training on physiological and biochemical responses under investigation (lactic acid – creatine kinase (CK) – lactate dehydrogenase (LDH) – pH Level – vital capacity – maximum oxygen consumption) in two age groups (12–14) and (14–16) Years

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Research Questions:

1. What is the effect of anaerobic lactate endurance training on the physiological and biochemical responses being studied (lactic acid, creatine kinase (CK) enzyme, lactate dehydrogenase (LDH) enzyme, pH level, vital capacity, and maximum oxygen consumption) in the age group of 12-14 years?
2. What is the effect of anaerobic lactate endurance training on the physiological and biochemical responses being studied (lactic acid, creatine kinase (CK) enzyme, lactate dehydrogenase (LDH) enzyme, pH level, vital capacity, and maximum oxygen consumption) in the age group of 14-16 years?
3. What is the significance of the differences in the physiological and biochemical responses being studied (lactic acid, creatine kinase (CK) enzyme, lactate dehydrogenase (LDH) enzyme, pH level, vital capacity, and maximum oxygen consumption) between the age groups of 12-14 years and 14-16 years as a result of anaerobic lactate endurance training?

Research Methodology:

The researcher employed an experimental design using a pre-post measurement approach with two experimental groups.

Research Sample:

The sample consisted of 12 male athletes, aged between 12 and 16 years, divided into two groups: Group 1 consisted of 6 players aged 12-14 years, and Group 2 included 6 players aged 14-16 years.

Duration of the Training Program:

The training program lasted 8 weeks for both research groups, with 4 training sessions per week. Each training session lasted between 75 and 120 minutes.

Research Variables:

- Maximum oxygen consumption (VO2 max) - Vital capacity
- pH level- Lactic acid concentration
- Lactate dehydrogenase (LDH) enzyme
- Creatine kinase (CK) enzyme
- Performance times in 300m and 500m running

Statistical Analysis:

The researcher used the following statistical methods for data analysis:

- *Arithmetic mean* - Standard deviation
- Coefficient of Skewness - t-test for significant differences
- Percentage of change

Measurement Methods for Research Variables:

- **Vital Capacity Measurement:** The researcher used an electronic spirometer to measure vital capacity, which records multiple variables simultaneously and prints them on a tape showing the measured variables. Appendix (3)
- **Maximum Oxygen Consumption (VO2 max) Measurement:** The researcher applied the Queens College step test to measure maximum oxygen consumption. Appendix (3)

Measurement of pH Level -

The researcher employed rapid-reacting urine test strips to measure urinary variables. A urine sample was collected from the athlete two hours after completing physical exertion (running 300m and 500m sprints). The test strip was then immersed in the urine sample for 60 seconds before being removed. The resulting color change was compared against the provided reference scale on the test strip container to determine the pH level accurately.

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Measurement of Blood Lactic Acid Concentration

The researcher utilized the Accusport device to measure blood lactic acid concentration, ensuring high accuracy and efficiency while requiring only a minimal blood sample (one drop). Measurements were conducted at rest (before training) and three minutes post-exertion (after a 300m sprint), following standardized protocols outlined in multiple scientific studies. This procedure was repeated at rest before a 500m sprint and again three minutes after completing the 500m sprint. Consequently, four lactic acid concentration readings were obtained for each athlete. Appendix (3)

Measurement of LDH and CK Enzyme Concentrations in Blood

To assess the concentration of lactate dehydrogenase (LDH) and creatine kinase (CK) enzymes in the blood, a 2 cm^3 blood sample was collected from the athletes while at rest, prior to engaging in physical exertion (a 300-meter sprint). The blood was collected by a trained laboratory technician using sterile plastic syringes. After collection, the blood was carefully transferred into pre-labeled test tubes, ensuring that the syringe needle was removed beforehand to preserve the integrity of blood components during transfer. The samples were then stored in an ice box to maintain their stability.

Subsequent blood samples were obtained immediately after completing the 300-meter sprint and again two hours post-exercise. The same procedure was repeated on a different day for a 500-meter sprint. Blood samples were collected at rest before the sprint, immediately after the sprint, and two hours post-exercise.

After all samples were collected, they were transported in the ice box to the Heliopolis Center for Medical Analysis and Hormonal Research. The enzyme concentrations of LDH and CK in the blood were analyzed under the supervision of Associate Professor Dr. Khaled Raafat, a faculty member specializing in medical analysis at the Faculty of Medicine, Ain Shams University.

The normal reference range for creatine kinase (CK) concentration in blood is between **24 and 195 IU (International Units)**, while the normal range for lactate dehydrogenase (LDH) concentration is between **230 and 460 IU**.

Measurement of Digital Level (Running Distance Used):

The researcher employed measurements for running distances of 300m and 500m. The procedure involved starting from a high point, activating the stopwatch upon signaling the player to begin, and stopping it once the player crossed the finish line. The performance time was recorded using a stopwatch to the nearest 1/10th of a second. The 300m and 500m runs were conducted on separate days, with blood samples collected to measure lactate levels and the enzymatic activities of (-CKLDH) in the blood, as well as pH levels in the urine. Measurements were taken before and after the 300m run at predetermined times. The same sampling procedure was repeated before and after the 500m run on a different day.

Design of Player Data Registration Form:

The researcher designed a registration form to record the data and measurements for each player in the sample. This form was used to collect and organize data efficiently (Appendix 1).

Preliminary Research Procedures:

Before beginning the core research procedures, the researcher carried out several preliminary steps to determine how the experiment would proceed and avoid potential obstacles that could negatively affect the research process. These preliminary actions included:

- Clarifying the importance of the research and the nature of the measurements to be conducted with the players and their guardians.
- Obtaining consent from the players and their guardians to participate in the study and agree to blood sample collection for measurements.

- Establishing the necessary timeframe for implementing the training program, along with determining the schedules for pre- and post-measurements and notifying players to ensure their punctuality for measurements and training.
- Preparing and testing the equipment and tools used in the research. Some equipment was borrowed from the scientific laboratory at the Faculty of Physical Education for Boys, Mansoura University, while other tools were obtained from the Sports Medicine Unit at the Benha Sports Stadium in Qalyubia Governorate.
- Ensuring the functionality and readiness of the tools and equipment, including testing them to confirm their suitability and to avoid any technical issues that could arise from malfunctioning equipment.
- Organizing the measurement procedures and their timing to ensure efficiency and accuracy.
- Designing a form to record player data and research variables.
- Selecting two assistants from the youth leaders of the athletics team at Shams Club, who were graduates of the Faculty of Physical Education. The researcher trained them on how to carry out the necessary measurements for the variables under study and on how to use the measurement tools and record data on the designed forms.

Design and Standardization of the Training Program:

- The researcher conducted a review of scientific references on training and athletics, utilizing several modern sources to design a training program aimed at developing anaerobic lactate endurance.
- The objective of the program was to examine the effect of anaerobic lactate endurance training on the physiological and biochemical variables under study, including vital capacity, maximum oxygen consumption, lactate concentration in the blood, levels of LDH and CK enzymes in the blood, pH levels in urine, and performance times for the 300m and 500m sprints.

Duration of the Training Program:

The training program, focused on anaerobic lactate endurance, was applied over 8 weeks for both groups in the study. The program included 4 training sessions per week, distributed as follows:

- 2 sessions per week focused on anaerobic lactate endurance training.
- 1 session per week focused on aerobic endurance training.
- 1 session per week focused on general fitness and circuit training.

An initial 6-week period of general preparation preceded the implementation of the anaerobic lactate endurance training program.

- Each training session lasted between 75 and 120 minutes.

Foundations for Developing the Training Program:

The training program was designed based on the following principles:

- Prioritization and sequence of the main training tasks.
- Adherence to fundamental training principles.
- Setting realistic and appropriate goals for each group based on the players' abilities.
- Ensuring the proposed loads were suitable for the players' capabilities.
- The proposed training methods (loads and techniques) were aligned with the program's goals.
- Ensuring flexibility in the program to allow for practical application.
- Determining and adjusting the training loads using several modern scientific references, both Arab and international (e.g., sources 2, 34, 51, 57, 60, 61, 73, 74, 87).

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The researcher conducted measurements of the running distances used in the training program to determine the maximum intensity (100%) for each player. These measurements helped to define the appropriate training loads for the experimental program.
The researcher standardized the components of the training load using a training schedule ( ).

Table (1): Methods for Developing Anaerobic Lactate Endurance

	Speed Endurance	Specific Endurance 1	Specific Endurance 2
Intensity	95 – 100%	90 – 100%	90 – 100%
Distance	80 – 150 meters	150 – 300 meters	300 – 600 meters
Repetitions per Group	2 – 5	1 – 5	1 – 4
Number of Sets	2 – 3	1	1
Rest Between Repetitions	5 – 6 minutes	10 – 15 minutes	15 – 20 minutes
Rest Between Sets	6 – 10 minutes	-	-
Total Distance per Session	300 – 1200 meters	300 – 1200 meters	300 – 1200 meters
Example	3 × (60, 80, 100) meters	2 × 150 + 2 × 200 meters	3 × 400 meters

Training Program Contents:

Research Implementation Steps:

Pretests:

The preliminary measurements for both research groups were conducted from August 16, 2003, to August 22, 2024, at the athletics track at Shams Club Stadium. The measurements were divided over three days as follows:

- **Saturday, August 16th , 2024**:
- Measurement of height and weight.
- 300m running test, followed by blood and urine samples before and after the 300m run to measure variables (LDH-CK) and lactate levels in the blood, as well as pH levels in the urine.
- **Wednesday, August 20, 2024**:
- 500m running test, followed by blood and urine samples before and after the 500m run.
- **Friday, August 22, 2024**:
- Measurement of Vital Capacity.
- Measurement of maximum oxygen consumption (VO2 max).

Training Program Implementation:

The training program using anaerobic lactate endurance exercises was implemented over 8 weeks for both groups from August 23rd , 2024, to October 17th , 2024, under the supervision of the researcher at the athletics track at Shams Club Stadium.

Post-Training Measurements:

The post-training measurements for both groups were conducted from October 18, 2024, to October 24, 2024, with measurements distributed over three days as follows:

- Measurement of height and weight.
- **Saturday, October 18th , 2024**:
- 300m running test, followed by blood and urine samples.
- **Wednesday, October 22nd , 2024**:
- 500m running test, followed by blood and urine samples.
- **Friday, October 24th , 2024**:

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- Measurement of Vital Capacity.
- Measurement of maximum oxygen consumption (VO2 max).

Problems and Challenges Encountered by the Researcher:

- Difficulty in obtaining the required number of participants, as the researcher intended each group to consist of 10 players, but only 6 players were available.
- The high costs of the study, with a total of 144 blood samples collected from players for the analysis of (LDH-CK) enzymes in both pre- and post-test measurements (288 analyses in total). Additionally, 96 blood samples were required for lactate analysis, which significantly increased the financial burden of the study.
- The challenge of collecting multiple blood samples from players, which caused some players to feel apprehensive, making it difficult to obtain the required blood samples at times.

Statistical Processes (3/9):

The researcher employed the following statistical methods to analyze the data:

- Arithmetic Mean
- Standard Deviation
- Coefficient of Skewness
- T-test for the significance of differences (T-test)
- Percentage Change

Presentation and Discussion of Results

Table (2): Statistical Significance of Differences Between Groups (12-14) and (14-16) Years in Pre-Test Variables

N = 6

Variables	Group	Mean	Standard Deviation	Difference	T-Value
PH after 300m	(12-14)	5.67	0.52	0.16	0.41
	(14-16)	5.83	0.75		
PH after 500m	(12-14)	5.83	0.41	0.17	0.42
	(14-16)	6.00	0.63		

- **Critical T-value at 0.05 significance level**: 2.33

At a significance level of 0.05, the tabulated **t**-value is **2.33**.

Table (28) presents the **mean** and **standard deviation** of the pre-test measurements for the two research groups (ages **12–14 years** and **14–16 years**), along with the difference between the means. The results in Table (28) indicate the following:

- There are no statistically significant differences in **urinary pH measurements** after **300 meters** and after **500 meters** in the pre-test phase for both research groups.

Table (3)

Statistical Significance of Differences Between Groups (12-14) and (14-16) Years in Post-Test Variables

N = 6

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Variables	Group	Mean	Standard Deviation	Difference	T-Value
PH after 300m	(12-14)	5.50	0.55	0.17	0.35
	(14-16)	5.67	0.82		
PH after 500m	(12-14)	5.83	0.41	0.17	0.42
	(14-16)	6.00	0.63		

The tabulated "T" value at a significance level of 0.05 is 2.33.
Table No. (29) presents the mean and standard deviation of the post-test measurements for the two research groups (ages 12–14 and 14–16), along with the difference between their means. The findings in Table No. (29) indicate the following:

- There are no statistically significant differences in the **urine pH measurements** (pH after 300m – pH after 500m) between the two research groups in the post-test measurement..

Table (4):
Rates of Change for the 12–14 Age Group

Variable	Pre-Test Mean	Post-Test Mean	Rate of Change (%)
Max Oxygen Consumption (VO2 max)	40.18	41.57	3.46
Vital Capacity	2300	2350	2.17
300m Running Time	51.67	48.08	-6.95
500m Running Time	92.33	86.62	-6.18
Lactate at Rest before 300m	2.2	2.27	3.18
Lactate after 300m	8.35	8.92	6.83
Lactate at Rest before 500m	2.23	2.3	3.14
Lactate after 500m	8.12	8.63	6.28
LDH at Rest before 300m	263.33	270.33	2.66
LDH after 300m (immediate)	373.83	378.5	1.25
LDH after 300m (2 hours)	415.5	427	2.77
LDH at Rest before 500m	265.83	270.33	1.69
LDH after 500m (immediate)	359.5	361	0.42
LDH after 500m (2 hours)	390.33	404.17	3.55
CK at Rest before 300m	124.67	122.5	-1.74
CK after 300m (immediate)	207	212.83	2.82
CK after 300m (2 hours)	240	250.33	4.30
CK at Rest before 500m	126.67	120.17	-5.13
CK after 500m (immediate)	202.33	207.5	2.56
CK after 500m (2 hours)	228.17	243.17	6.57

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Variable	Pre-Test Mean	Post-Test Mean	Rate of Change (%)
PH after 300m	5.67	5.5	-3.00
PH after 500m	5.83	5.83	0.00

It is evident from Table (30) that the percentage of changes in the measurements for the research group (ages 12–14) were as follows:

- **Lactic Acid:** The post-test average exceeded the pre-test average. The highest increase was observed in lactic acid levels after running 300 meters, with a percentage change of **6.83%**, followed by lactic acid levels after 500 meters (**6.28%**). Lactic acid levels during rest before running 300 meters increased by **3.18%**, while those before 500 meters increased by **3.14%** respectively.
- **LDH (Lactate Dehydrogenase):** The highest increase in LDH levels was recorded two hours after running 500 meters (**3.55%**), followed by two hours after 300 meters (**2.77%**). LDH levels during rest before 300 meters increased by **2.66%**, while those before 500 meters rose by **1.69%**. Immediately after 300 meters, LDH increased by **1.25%**, and the lowest increase was recorded immediately after 500 meters (**0.42%**).
- **CK (Creatine Kinase):** The highest increase in CK levels occurred two hours after running 500 meters (**6.57%**), followed by two hours after 300 meters (**4.30%**). Immediately after 300 meters, CK levels increased by **2.82%**, while immediately after 500 meters, they rose by **2.56%**. Conversely, CK levels showed a **decrease** during rest before 500 meters (**-13.5%**) and before 300 meters (**-1.74%**).
- **Urine pH:** A **decrease** of **-0.3%** was recorded in pH levels after 300 meters, while no change was observed after 500 meters.
- **Maximum Oxygen Consumption (VO_2 max):** An **increase** of **3.46%** was observed.
- **Vital Capacity:** An **increase** of **2.17%** was recorded.
- **300-Meter Running Time:** A **decrease** in time (**-6.95%**) indicated an improvement in performance.
- **500-Meter Running Time:** A **decrease** in time (**-6.18%**) also indicated an improvement in performance.

Table (5)
Rates of Change for the 14-16 Year-Age Group

Variable	Pre-test Mean	Post-test Mean	Rate of Change (%)
Maximum Oxygen Consumption	45.67	46.47	1.75
Vital Capacity	3541.67	3608.33	1.88
300m Run Time	43.7	42.03	-3.82
500m Run Time	82.88	79.32	-4.30
Lactic Acid at Rest Before 300m	2.48	2.63	6.05
Lactic Acid After 300m	11.33	12.45	9.89
Lactic Acid at Rest Before 500m	2.53	2.7	6.72
Lactic Acid After 500m	10.65	11.93	12.02
LDH at Rest Before 300m	302.33	308.33	1.98

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Variable	Pre-test Mean	Post-test Mean	Rate of Change (%)
LDH Immediately After 300m	397.83	406.33	2.14
LDH Two Hours After 300m	451.83	482.83	6.86
LDH at Rest Before 500m	276.5	335	21.16
LDH Immediately After 500m	392.33	390.5	-0.47
LDH Two Hours After 500m	423.5	454.5	7.32
CK at Rest Before 300m	118.5	128.67	8.58
CK Immediately After 300m	159.5	203.17	27.38
CK Two Hours After 300m	186.33	236.17	26.75
CK at Rest Before 500m	120.5	128.17	6.37
CK Immediately After 500m	156.5	193.33	23.53
CK Two Hours After 500m	178.5	227.17	27.27
pH After 300m	5.83	5.67	-2.74
pH After 500m	6	6	0.00

The data presented in Table No. (31) illustrates the percentage of changes in measurement rates for the research group (aged 14–16 years) as follows:

- **Lactic Acid**: An increase was observed in the post-test mean compared to the pre-test mean. The highest increase was recorded after 500 meters, with a percentage change of **12.02%**, followed by lactic acid levels after 300 meters (**9.89%**), at rest before 500 meters (**6.72%**), and at rest before 300 meters (**6.05%**).
- **Lactate Dehydrogenase (LDH)**: The highest increase in LDH levels was recorded at rest before 500 meters (**21.16%**), followed by LDH levels two hours after 500 meters (**6.86%**), immediately after 300 meters (**2.14%**), and at rest before 300 meters (**1.98%**). In contrast, a **47.0%** decrease was observed immediately after 500 meters.
- **Creatine Kinase (CK)**: The highest increase in CK levels was recorded immediately after 300 meters (**27.38%**), followed by two hours after 500 meters (**27.27%**), two hours after 300 meters (**26.75%**), immediately after 500 meters (**23.53%**), at rest before 300 meters (**8.58%**), and at rest before 500 meters (**6.37%**).
- **Urine pH**: A decrease of **74.2%** was recorded after 300 meters, whereas no change was observed after 500 meters.
- **Maximum Oxygen Consumption (VO_2 max)**: An increase of **1.75%** was recorded.
- **Vital Capacity**: An increase of **1.88%** was observed.
- **300-Meter Running Time**: A decrease of **82.3%** was recorded, indicating improved performance.
- **500-Meter Running Time**: A decrease of **30.4%** was recorded, reflecting improved performance.

Conclusions:

Based on the results of the study conducted by the researcher, and in light of the statistical analysis of the data within the scope of the research objectives and sample limits, the following conclusions were drawn:

1. The use of anaerobic lactate endurance training for the age group of 12-14 years leads to an increase in blood lactate concentration and an increase in the activity of enzymes (LDH, CK). These increases

vary depending on the timing of blood sample collection and the type and nature of the physical performance used. Additionally, improvements were observed in vital capacity, maximum oxygen consumption, and the performance levels for the 300m and 500m running distances, while a decrease in urine pH levels occurred.

2. The use of anaerobic lactate endurance training for the age group of 14-16 years results in an increase in blood lactate concentration and an increase in the activity of enzymes (LDH, CK), with these increases varying according to the timing of blood sample collection and the type of physical performance employed. Moreover, there was an improvement in vital capacity, maximum oxygen consumption, and performance in the 300m and 500m running distances, while urine pH levels decreased.
3. Differences were found in the average measurement results of the research variables between the two study groups (12-14 years and 14-16 years) as a result of applying anaerobic lactate endurance training to both groups.

Recommendations:

In light of the research objectives and results, and within the confines of the sample, the researcher recommends the following:

1. Avoid using anaerobic lactate endurance training for the age group of 12-14 years due to its negative effects on young individuals, which include muscle damage and fatigue as a result of the excessive physical strain caused by these training exercises. The training is unsuitable for the physical capabilities of children at this age due to their limited muscle energy reserves (glycogen, PC-ATP), leading to a limited anaerobic capacity.
2. Avoid using anaerobic lactate endurance training for the age group of 14-16 years due to its negative impact on young individuals, which can lead to muscle damage from the excessive physical effort. If this training is employed, it should be done cautiously and in very small amounts relative to other training requirements.
3. Do not excessively increase the training loads for children and adolescents to prevent the risk of injury. It is essential to ensure that physical loads are appropriate for their developmental capacities and consistent with their growth stages.
4. Conduct similar studies with female participants to measure the impact of anaerobic lactate training on them and determine the most appropriate age for its application.
5. When assigning physical loads to children and adolescents, consider their biological age rather than chronological age in order to avoid exposing them to potential harm and to respect the stages of growth they are undergoing.

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Maximum Oxygen Consumption Based on Heart Rate During Recovery After the Queens College Step Test for Males and Females

Heart Rate (Females)	VO2 Max (ml/kg/min)	Heart Rate (Males)	VO2 Max (ml/kg/min)
128	42.2	120	60.9
140	40.0	124	59.3
148	38.5	128	57.6
152	37.7	136	54.2
156	37.0	140	52.5
158	36.6	144	50.9
160	36.3	148	49.2
162	35.9	149	48.8
163	35.7	152	47.5
164	35.5	154	46.7
166	35.1	156	45.8
168	34.8	160	44.1
170	34.4	162	43.3
171	34.2	164	42.5
172	34.0	166	41.6
176	33.3	168	40.8

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Heart Rate (Females)	VO2 Max (ml/kg/min)	Heart Rate (Males)	VO2 Max (ml/kg/min)
180	32.6	172	39.1
182	32.2	176	37.4
184	31.8	178	36.6
196	29.6	184	34.1

Weekly Training Cycle Model

Weeks / Units	First Week	Second Week	Third Week	Fourth Week
Unit 1 (Saturday)	**Goal**	Anaerobic Lactic	Anaerobic Lactic	Anaerobic Lactic
Components	- 3 × 300 m. - Intensity: 90%. - Rest: 15 min.	- 150 m, rest 10 min. - 200 m, rest 10 min. - 250 m, rest 10 min. - 300 m. - Intensity: 90%.	- 2 × 500 m. - Intensity: 90%. - Rest: 20 min.	- 3 × 80 m, rest 5 min. - 2 × 100 m, rest 6 min. - 2 × 150 m, rest 8 min. - Intensity: 95%. - Rest between sets: 10 min.
Unit 2 (Monday)	**Goal**	General Fitness	General Fitness	General Fitness
Components	- Circuit training. - (6 stations) × 3 sets. - Stations include bodyweight exercises.	- Circuit training. - (7 stations) × 3 sets. - Stations include bodyweight exercises.	- Circuit training. - (6 stations) × 4 sets. - Stations include bodyweight exercises.	- Circuit training. - (6 stations) × 3 sets. - Stations include bodyweight exercises.
Unit 3 (Wednesday)	**Goal**	Anaerobic Lactic	Anaerobic Lactic	Anaerobic Lactic
Components	- 1 × 400 m. - 1 × 500 m. - Intensity: 90%. - Rest: 20 min.	- 300 m, rest 15 min. - 400 m, rest 20 min. - 300 m. - Intensity: 90%.	- 4 × 150 m. - Intensity: 95%. - Rest: 8 min.	- 3 × (4 × 200 m). - Intensity: 70%. - Rest between repetitions: 1 min. - Rest between sets: 3 min.
Unit 4 (Thursday)	**Goal**	Aerobic	Aerobic	Aerobic
Components	- 2 × 12 min. - Rest: 5 min.	- 30 min running.	- 3 × (4 × 300 m). - Intensity: 70%. - Rest between repetitions: 1 min. - Rest between sets: 3 min.	- 25 min light running.

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