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The Effect of Artificial Intelligence (AI) Lactic Threshold Training Design on Some Neurotransmitters, Hydrogen Circuits and Performance Tolerance in Young Boxers

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Abstract

Objectives: To examine the effects of training exercises prescribed according to the lactate-threshold load on selected neurotransmitters, biochemical indicators, and physical and motor performance among young boxers.

Materials and Methods: A one-group experimental pretest–posttest design was employed with a sample of young boxers. Participants completed a structured exercise program in which the training load was prescribed according to their lactate threshold and supported by artificial intelligence–based methods. Acetylcholine, serotonin, carbonic acid, haemoglobin, and selected physical and motor performance variables were assessed before and after the intervention. The pretest and posttest data were classified, analysed, and compared to determine changes following the program.

Results: Significant differences were observed between the pretest and posttest measurements across all investigated variables, with the posttest results consistently favouring improved neurotransmitter responses, biochemical indicators, and physical and motor performance.

Conclusions: Lactate-threshold–based training was associated with favourable changes in the measured physiological, physical, and motor variables among young boxers. Incorporating artificial intelligence–supported methods into training-load prescription may assist coaches in individualising exercise intensity and optimising athletic development. Further controlled studies with larger samples are needed to confirm these findings.

Keywords : Training, Lactic Threshold, BArtificial Intelligence , Neurotransmitters, Hydrogen Circuits, Performance Endurance, Young Boxers.

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Introduction

The domain of modern sports training is experiencing significant advancement propelled by a technological and cognitive transformation (Sangwan, Rathee & Chahal, 2023), which has facilitated the implementation of artificial intelligence tools for the assessment and interpretation of athletes' physiological and physical data, as well as the creation of highly accurate adaptive training regimens (Reis et al., 2024). Boxing is developing into a sports paradigm that necessitates superior motor and physiological skills for rapid reactions and exceptional performance amidst intense competition (Mahlangu et al., 2024). Classification of novice boxers is an important aspect in this sport, and for this purpose modern technologies are used to improve their physical and physiological indicators according to the criteria of international championships (Adil & Kasim, 2026; Ilhomovich, 2022). Boxing is basically a combination of physical and physiological capabilities with skills and motor functions which are essential for maintaining high-complexity performance throughout combat rounds (Subkhh & Kadhim, 2025). Investigating the relationship between lactic threshold training and critical physiological factors such as neurotransmitters and hydrogen pathways and their effect on the endurance of complex skill execution in adolescent boxers (Lee et al., 2023). allows us to form a trustworthy scientific perspective that aids in creating effective training programs that improve athletic performance (Kraemer, Ratamess & Newman, 2024). Lactic threshold training is one of the most effective methods of improving the operation of vital systems and delaying the onset of physical fatigue (Ahmed et al., 2026). However, determining the best size, intensity and frequency of these workouts is a challenge for trainers, especially when considering the unique physiological differences across athletes (Kenney, Wilmore & Costill, 2022). AI is a significant instrument for the evaluation of biological markers and the precise forecasting of lactic performance thresholds, which guarantees that personalised training is adapted to the unique requirements of each boxer (Grivas & Safari, 2025). These activities enable the achievement of optimal physiological adaptation within safe thresholds for physical exertion (Travers et al., 2022). Physiologically and biologically, the application of AI in developing accurate training contributes to a notable enhancement of muscular and neurological capabilities (Mateus et al., 2024). This involves modulating neurotransmitters such as dopamine, serotonin, and acetylcholine, which improve the nervous system's ability to transmit signals efficiently, maintain mental focus, and promote faster motor response during high-intensity anaerobic exercises (Gharakhanlou & Fasihi, 2023). Additionally, the adaptations that are caused by lactic threshold training are a major player in biochemical efficiency as it improves the effectiveness of circulatory hydrogen compounds like bicarbonate and protein elements which are a primary defence mechanism in maintaining pH equilibrium within muscle cells (Fleming, 2023). This balance helps prevent the deterioration of neuromuscular transmission and enhances performance in high-stress situations (Hussein & Kasim, 2022; Zemková & Zapletalová, 2022). The interaction between optimisation of neurotransmitter activity and increase in efficacy of blood hydrogen regulation system is crucial for increase in physical endurance of young boxers (Przewłócka et al., 2024). This integration allows boxers to

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sustain high-intensity, accurate skill execution throughout the fight time without a significant decline of motor efficiency, thus improving technical dominance in the sport (Nakamura & Kodama, 2024). In view of these empirical and practical considerations, it is important to conduct a targeted investigation into the effects of artificial intelligence-assisted lactic threshold training on the regulation of neurotransmitter responses and the optimisation of hydrogen circuits. This study aims to demonstrate the effect of this physiological and biochemical integration on the endurance of physical and technical performance in adolescent boxers. The expected results contribute to the development of a new training paradigm, which combines the technical progress and scientific rigour in the field of sport training for the benefit of the future of this unique sport.

Research Problem

Boxing is an ever-evolving sport due to the modern understanding of scientific concepts that apply to the demands of performance. There are many factors that influence boxing skill performance (Basyzbek, 2024). Boxing is a physically and physiologically demanding sport in which athletes need to have high levels of concentration, strength and speed during intense competition and anaerobic exhaustion (Finlay et al., 2023). The researcher notes a significant decrease in endurance, a delay in motor reaction times, and a loss of concentration during the match, as the inexperienced boxers have a great difficulty in keeping their skill and physical capabilities at the same level in the late rounds of the fights (Omelyanchik et al., 2023). The physiological and biochemical decline is due to two main reasons: the most important is the disruption of neurotransmitter secretion and balance caused by increased central nervous stress during high-intensity anaerobic exercise, which decreases the efficiency of neuromuscular transmission and the fidelity of signals to the working muscles (Kasim, 2022; King, 2025). The second factor is the rise of hydrogen ions (H+) that comes with the buildup of lactic acid, which causes the decrease of pH in the muscle cells and blood. When the buffers for hydrogen do not work enough to fight the acidity, then chemical muscle exhaustion happens (Yas, 2025). While trainers are aware of the need for "lactic threshold training" to deal with this issue, conventional methods of exercise load assessment and administration are characterised by a lack of precision and the absence of immediate individual customisation (Casado ET AL., 2023). The disconnect between scientific research and real-world application is highlighted by the use of artificial intelligence (AI) tools to analyse a boxer's physiological data and develop lactate threshold training loads that are extremely specific to the individual capabilities of each young fighter. The researcher conducted a review of numerous references and scientific sources, coupled with field observations, to explore whether lactic threshold training, formulated with artificial intelligence, affected certain neurotransmitters, hydrogen circuits, and the endurance performance of young boxers. Therefore, the research problem is focused on empirically investigating the effects of utilising artificial intelligence (AI) strategies in the formulation of lactic threshold training on neurotransmitter responses and the effectiveness of hydrogen circuits, as well as the degree to which this biochemical physiological adaptation translates into enhanced endurance performance in young

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boxers, with the objective of developing an intelligent training model that connects technological progress with the advancement of specialised athletic performance.

Research Objectives

1. Identify the size of the lactic threshold training in some neurotransmitters ((stylcholine, serotonin) and hydrogen cycles (carbonic acid, hemoglobin) and performance tolerance of young boxers in the experimental group.

Research hypotheses

1. There are positive differences between pre- and post-tests in neurotransmitters (stylcholine, serotonin) and hydrogen diarrhes (carbonic acid, hemoglobin) and performance tolerance for young boxers in the experimental group.

Methodology

Research Methodology

The investigator employed the experimental approach by establishing a single experimental group with both pre- and post-tests tailored to the problem's nature and the research aims.

Research Population and Sample:

The research population coincided with the research sample, utilising a detailed inventory procedure, comprising 10 novice boxers from Hilla Sports Club. Homogenisation was conducted among the boxers to commence the search protocols, given that the data exhibited a moderate distribution, particularly since the torsion coefficient was null.

Table 1: Sample distribution shows the research.

Variables	Units of Measuremer	M	SD	Torsion
Weight	Kg	60.1	1.18	0.29
Length	Cm	162.3	5.77	0.78
Age	Year	17.3	0.11	0.16
Training Age	Year	2	0.21	0.22

Devices, tools used and means of information collection:

Observation. Citations and Bibliography. A carton of medical syringes manufactured in China. Cotton bags manufactured in China. German-manufactured sterilisation alcohol (1) German-manufactured stopwatch case (1). Blood storage tubes incorporating anticoagulant agents (edit). Device for spinning blood specimens. German-manufactured medical weighing device (1). German electric medical apparatus for the refrigeration and preservation of blood specimens (1). Punching bag (numbered sleeve apparatus). Ten-ounce boxing gloves.

Steps to conduct the research:

Determining the research variables: After analysing several sources and references, and as a consequence of the research's nature, hydrogen cytotoxics (carbonic acid, haemoglobin) were discerned

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in addition to the examination of neurotransmitters (stylcholine, serotonin) and performance tolerance in boxing.

Determining the tests of research variables: The assessments of hydrogen cycles (carbonic acid, haemoglobin) and the analysis of neurotransmitters (stylcholine, serotonin) were performed in a laboratory environment, whereas the composite skill performance in boxing relied on a standardised field test established in a prior study.

Exploratory Experiment: To evaluate the efficacy of the composite skill performance endurance test and to guarantee the fidelity of the experimental procedures and the competence of the assisting team, the researchers executed an exploratory experiment on 28/2/2026 involving 5 boxers from the same research community at Al-Hilla Club at 3 p.m., with a follow-up on 1/3/2026. Verify the appropriateness of the instruments and apparatus employed. Determining the degree to which the sample participants can execute the test. Understand the duration required for execution, testing, and appropriateness. Assessment of the appropriateness of the forms designated for registration. Effectiveness of the support team. Ascertain the suitable time of day for doing the necessary measurements and assessments, which was 3 p.m. Validate the empirical basis of the boxing performance endurance assessment. Appropriateness of the exercises for the research cohort.

Scientific Foundations of Tests:

First: Validity of the tests and measurements used: All the tests were honest because they were conducted in the laboratory, but the composite skill performance was codified.

Second: Consistency of the tests and measurements used: The researchers retested it 3 days after the reconnaissance experiment and on the same boxers. It was conducted on the same sample of the exploratory experiment and under the same conditions, and the stability coefficient between the two tests was extracted by Spearman's law of 0.92 and the results showed that there is a high correlation between the tests.

Third: The Objectivity of the Tests and Measurements Used: The researchers extracted the Pearson correlation coefficient for the test and the results came out with a high objectivity for the judges with an estimate of 0.89, as the higher level of consistency means a function of the high level of objectivity.

Main experience

Pre-Tests:

The pre-test took place at three PM on Friday and Saturday, 4/3/2026, focusing on neurotransmitters, hydrogen circuits, and performance tolerance, all held at Hilla Sports Club. The examinations were carried out under the oversight of the researchers and with the assistance of the support staff.

Main research experience:

The investigators formulated a cohesive training approach utilising artificial intelligence methods to enhance neurotransmitter production, hydrogen circuitry, and performance thresholds, emphasising

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anaerobic threshold while considering the fluctuations and gradations in training load intensity across weeks and modules. This program comprises several fundamental elements, specifically:

1. **Exercise Diversity Principle :** To ensure that players remain motivated and avoid boredom, the researchers were keen to apply the diversity principle. Different drills will be used, including balls and ballless drills.
2. **Application Schedule:** The training program period extends to 12 weeks, with 3 training doses per week, bringing the total number of training doses to 36 doses.

Training Dosage Structure: Each training dose consists of three main sections:

1. **Preparatory Section (Warm-Up):** It aims to physically prepare the player to bear the burdens of the main section. This section also features variety to avoid boredom.
2. **Main section**: It is the primary part in which anaerobic threshold exercises will be applied.
3. **Concluding section:** It aims to speed up the recovery process by reducing metabolic accumulations resulting from training. This is done through jogging and stretching exercises for major muscle groups.

Training Load Components: The training load components have been precisely defined to ensure that the desired objectives are achieved:

1. **Training intensity:** Between 80% and 90% of a player's maximum capacity, which is an intensity suitable for stimulating lactic acid buildup, which is the basis of anaerobic threshold training. The maximum intensity of each player will be determined through a reconnaissance experiment.
2. **Training Size:** It will be determined based on the number of repetitions of the exercise in one group or the time it takes to perform the exercise, taking into account the intensity of the training unit.
3. **Rest periods:** Rest between repetitions: It will be a positive rest (Active Rest), so that it does not allow the player to fully recover. It is determined based on the return of the pulse rate to between 120-130 beats/minute. The pulse rate of the carotid artery will be measured for 10 seconds and multiply the output by 6. Rest between sets: 3 to 5 minutes, which is enough time for the player to effectively perform the exercises in the next set.

Post-Tests:

After the training modules were fully implemented on April 6, 2026, the post-tests were executed, with researchers committed to replicating the same methodologies employed in the pre-tests by overseeing the research activities alongside the assistant team, while ensuring consistent conditions in terms of timing, setting, and tools.

Statistical Methods

(Median. for spring deviation, Wilcoxon test, Mann test, Tenney test, Spearman)

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Results

Present, analyze and discuss the results

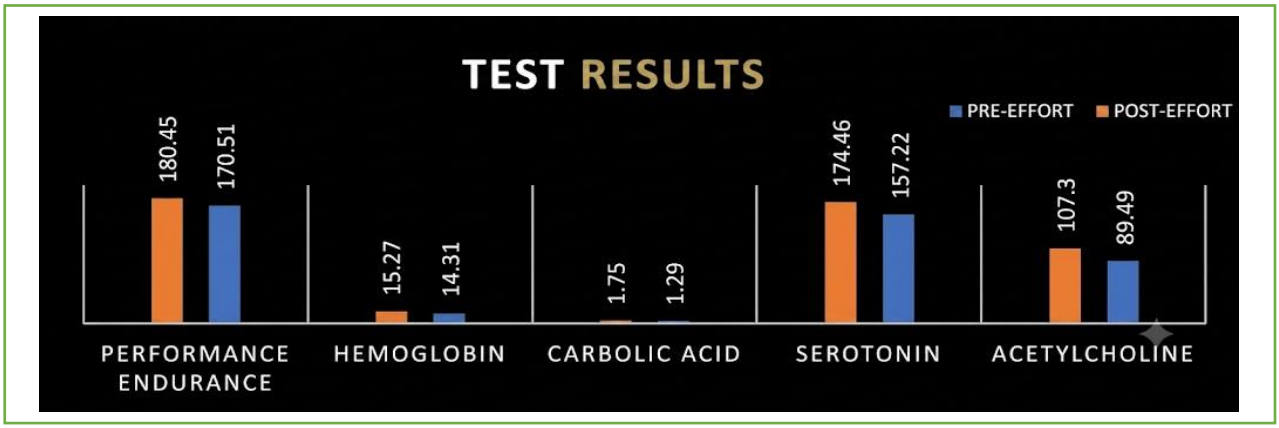
Table 2: Shows the pre-post-test of the experimental group

Variable	Pre-test		Post-test		Wilcoxon Test	Sig
	M	SD	M	SD		
Acetylcholine	89.49	4.71	107.30	0.87	2.07	0.000
Serotonin	157.22	13.51	174.46	12.69	2.08	0.000
Sour Carbonic	1.29	0.044	1.75	0.087	2.23	0.000
Hemoglobin	14.13	0.33	15.27	0.58	2.07	0.000
Performance Tolerance	170.51	9.46	180.45	12.12	2,08	0.000

Table (2) indicates that there are statistically significant disparities between the pre- and post-assessments of the experimental group across all examined variables. These factors comprise:

- **Neurotransmitters**: Acetylcholine and serotonin.
- **Hydrogen cycles**: carbonic acid and hemoglobin.
- **Withstand composite skill performance**.

The findings indicated that the "p-value" from the Wilcoxon test was below (0.05). This indicates that the variations observed between the pre and post-test outcomes were not coincidental, but rather a definitive consequence of the training program. These disparities were also advantageous for the post-tests, suggesting an enhancement in the performance of the experimental group following the implementation of the exercises, as illustrated in Figure (1).



Discussion of the results

The analysed data indicate that there are statistically significant disparities between the measurements recorded prior to and following the implementation of the training loads, with the latter yielding superior dimensional outcomes. The researchers credit this enhancement to the influence of enzymes and neurotransmitters, which are naturally occurring molecules at rest, when the body undergoes physical activity. This endeavour causes a change in their ratios as a natural physiological response to ensure ongoing muscle function and delay exhaustion (Bestwick-

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Stevenson et al., 2022). These neurotransmitters are essential for the activation of motor neurones which then stimulate skeletal muscles, thus acting as stimulatory transporters. Muscles are excitable, contract rapidly, can change, and can move voluntarily and involuntarily. Neurotransmitters are released with every movement. Of these transporters, acetylcholine is a neurotransmitter in synaptic vesicles that carries nerve impulses from the neurone to the receptors on the target cell. This compound has many functions, including the contraction of striated muscles and the dilation of capillaries. Conversely, serotonin has a widespread distribution in tissues, including the platelets. It has a vasodilatory effect on blood vessels, depending on blood circulation conditions. The study showed that the exertion from anaerobic training intensities (80-90%) had a beneficial effect on these biochemical markers. The researchers wanted to look at what happens when you apply load and adjustments. The investigators state that a temporary increase in carbonic acid (H2CO3) in the study group causes increased blood acidity (pH). The body has regulatory mechanisms that keep things in balance to fix this . When physical activity ceases and the body enters a resting state, carbon dioxide levels return to normal due to an increased rate of respiration, which allows for the removal of carbon dioxide (Thomas et al., 2023). This process occurs in the pulmonary alveoli where carbonaceous dehydes, which accelerate the reaction, convert H2CO3 to CO2 and water (H2O). Studies have shown that the lungs can eliminate large amounts of carbonic acid daily without producing significant changes in the pH of the blood. Besides its function with oxygen, it serves as a pH diminisher (Tambalis & Arnaoutis, 2022). Many factors increase the concentration of haemoglobin in the blood, especially in the experimental group, say the researchers. One of these is proper nutrition, including large amounts of iron. This is a small increase but the higher concentration of Hb means an increased blood oxygen saturation as 1 gram of haemoglobin can bind 1.34mL of oxygen (Webb et al., 2022). The investigators argue that blood pH is a marker of the body's regulatory efficiency, because any deviation in blood pH can adversely affect the operation of all other bodily systems. This is why controlled mechanisms work to keep the blood's pH at a normal level. An increase in lactic acid will lead to the blood's pH decreasing, which affects the interaction of myosin with actin, affecting the contraction of the muscle (MacLaren & Morton, 2024). Lowered blood pH also impairs the function of enzymes essential for energy production and affects the transmission of nerve impulses through nerve terminals. Athletic training conducted at appropriately structured loads can facilitate adaptations that mitigate pH fluctuations and postpone muscle acid accumulation, hence enhancing endurance.

Conclusions

1. AI-engineered anaerobic threshold training resulted in a notable transformation in the levels of specific neurotransmitters (acetylcholine, serotonin) among the boxing partners in the study cohort.
2. Anaerobic threshold workouts resulted in a noticeable enhancement in the endurance of the overall skill execution of the young boxers in the experimental cohort.

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3. The AI-generated training program significantly influenced the process of hydrogen prevention through carbonic acid and haemoglobin, hence impacting the endurance performance of young boxers.
4. The Influence of Neurotransmitter Function and Hydrogen Circuits on Enhanced Endurance in Skill Execution Among Young Boxers.

Recommendations

1. The scholars suggest that trainers adopt scientific strategies rooted in artificial intelligence techniques to emphasise the traits of boxers and ascertain their strengths and weaknesses throughout training days, which aids in tailoring the intensity and type of training to foster the development of boxers' capabilities.
2. The scholars propose the establishment of a training syllabus focused on the lactic threshold to cultivate comprehensive physical talents and skills in boxing.
3. The scholars advocate for comparable research to explore other physical competencies in addition to the unique skills of boxers.
4. The researchers advocate for the organization of specialised programs in all modern coaching methodologies for boxing instructors in Iraq.

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Appendix (1) Training Module Template

Section	Section Time	Daily Training Unit Details	Single Exercise	Number of Repetitions	Exercise Intensity	Exercise Heart Rate	Rest Between	Rest Between Sets	Total Work Time	Total Rest Time	Total Work & Rest Time	General Notes for Daily Training Unit
Preparatory	20 min											
	10 min	General Warm-up	---	---	---	---	---	---	---	---	---	Pulse reaches **110 - 120 bpm**

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Appendix (2)

Teat Boxing Composite Skill Performance **: Name**

.Measuring the endurance of composite skill performance in boxing **:Purpose of the test•**

The test duration is100 seconds .

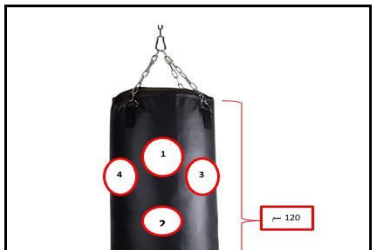
Tools Used: 10 oz boxing gloves, 35 cm diameter and 120 cm high, numbered stopwatch, camera type canon.

Test Description:

a. The boxer stands in front of the boxing bag in standby mode and when pronouncing a performance, the boxer performs straight punches left and right of the boxing bag at the number 1 or 2 located on the front of the bag for 20 seconds.
b. After the first 20 seconds, the trainer gives an instruction to the boxer to perform the right straight punches with the right snatch, as the left straight will be on the number 1 or 2 on the front of the bag and the right snatch on the number 3 next to the bag for 20 seconds.
c. After 20 seconds, the trainer instructs the boxer to perform the right straight punches with the left snatch, where the right straight will be on the number 1 or 2 on the front of the bag and the left snatch on the number 4 next to the bag for 20 seconds.
d. After 20 seconds of the third, the trainer instructs the boxer to perform the left snatch punches with the right take-off, as the left snatch will be on the number 4 on the front of the bag, while the right snatch will be on the number 5 at the bottom of the bag for 20 seconds.
e. After the first 20 seconds, the trainer instructs the boxer to perform the right snatch punches with the left take-off, as the right snatch will be on the number 3 on the side of the bag, while the left take-off will be on the number 5 under the bag for 20 seconds.
f. Immediately after the tested player finishes performing the test, a sample of the is drawn and the blood is placed in a special tube for the purpose of player's blood taking the blood to the laboratory for the purpose of conducting laboratory tests for .the studied physiological variables

How to calculate the result:

The laboratory executes the aforementioned intricate tasks continuously, tallying the number of accurate punches (to be positioned at the grip's forefront, impacted, and correctly aligned with the designated number on the bag), awarding one point for each correct punch during a span of 100 seconds. Any entries that do not conform to the definition of "correct punch" as previously stated are eliminated. The boxer's performance is recorded and evaluated by skilled and knowledgeable judges.



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