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The effect of high-intensity interval training (HIIT) on some functional indicators, speed endurance, and skill performance in advanced boxers in the 69-75 kg weight category

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Abstract
High Intensity Interval Training (HIIT) is a modern and effective method for developing the physical and skill performance of athletes. It is characterized by intense load and varied time intervals, commensurate with the requirements of specialized activity. The importance of this research lies in its presentation of a practical application of the HIIT method to improve functional indicators, speed endurance, and skill efficiency in advanced boxers in the weight category (69-75 kg). This is achieved by designing a training program based on the components of motor and functional performance related to the requirements of the fight. The research aims to develop a HIIT training program to develop some functional abilities and speed endurance, as well as improve skill performance in boxers. It also aims to identify the impact of the training program compared to traditional methods. The main hypothesis was based on the existence of There were statistically significant differences between the experimental groups between the pre-and post-measurements in all variables examined. The researcher followed the experimental method uses two equal groups (experimental group and control group) to conduct pre-and post-test measurements sample was selected from the players of the Al-Ittihad, Al-Arabi, and Al-Hussein clubs in Baghdad Governorate for the advanced category with a weight of (69-75 kg) for the 2023-2024 sports season. The research community amounted to (20) boxers from the advanced category in the Al-Ittihad, Al-Arabi, Al-Hussein, and Al-Shorta clubs in Baghdad Governorate. (16) boxers were selected from them randomly to represent the basic research sample and divided equally into two groups (experimental group and control group), while (4) other boxers were allocated as a survey sample. The proposed training program was implemented using the HIIT method during the special preparation period, with an intensity ranging from 80-95% of maximum effort, taking into account the gradual progression of intervals and active rest periods. After implementing the program on the experimental group, post-tests were conducted, and the results were analyzed using the SPSS statistical program. The results: The researcher concluded that HIIT training effectively contributed to improving functional indicators (the efficiency of the circulatory and respiratory systems), increasing speed endurance, and developing the skill performance of advanced boxers in the 69-75 kg weight category, compared to traditional training. This reflects the importance of this method in preparing boxers physically, functionally, and skillfully. The researcher recommends adopting the High Intensity Interval Training (HIIT) method within boxer preparation programs during the special preparation phase, taking into account the gradual progression of intensity and time intervals to suit the requirements of the fight. Similar studies should be conducted on different weight categories and age groups to expand the scope of the research findings.

Keywords: High-intensity interval training (HIIT), functional indicators, skill performance

Introduction
Sports training is one of the fundamental pillars upon which the physical and technical development of athletes is based. It represents an organized activity aimed at bringing about positive changes In terms of physical and motor skill levels, developing skills and expanding the base of experience, leading to optimal performance in competitions. Boxing is a competitive sport that requires a high degree of integration between physical, functional, and skill abilities, given its nature, which relies on speed, endurance, reaction time, and precision in split-second decision-making within highly intense and complex movement contexts.

Recent trends in sports science indicate the importance of focusing on developing functional abilities and speed endurance, as they are key determinants of a boxer's performance during successive rounds. A noticeable decline in performance in the second and third rounds of a bout is an indicator of a deficiency in specific endurance and functional adaptation to the demands of the match, which negatively impacts the accuracy of strikes, timing of decision-making, and the ability to resolve situations. Based on the above, high-intensity interval training (HIIT) stands out as a modern and effective training method, due to its direct impact on enhancing the efficiency of functional systems, raising specific endurance, and improving motor and skill performance in sports that require intermittent, high-intensity effort, such as boxing. This type of training relies on short, intense bursts of work interspersed with active or passive rest periods, contributing to effective physiological and functional adaptations commensurate with the nature of the effort expended in boxing.

Through the researchers' observation field reality of local tournaments, it became clear that there was a clear disparity in the ability to maintain technical and physical performance throughout the fight. He observed a decline in performance speed and concentration after the first round, indicating a weakness in speed endurance and functional ability, which hinders skill performance and affects the chances of winning. Therefore, the research problem arose in the need to adopt specific training programs aimed at developing speed endurance, functional abilities, and skill proficiency for advanced boxers, particularly in the weight category (69-75 kg). Based on this, the researcher sought to design a training program using the high-intensity interval training (HIIT) method, with the aim of identifying its impact on developing some functional indicators, speed endurance, and skill efficiency of advanced boxers within the target sample. He also hypothesized the existence of There is a statistically significant difference between the pre-test and post-test results, in favor of the experimental group, in these variables.

The research sample included (16) advanced boxers with previous training experience, representing the Al-Ittihad, Al-Arabi, Al-Hussein, and Al-Shorta clubs in Baghdad Governorate. The exploratory and main experiment was implemented in the Al-Shorta Sports Club hall during the 2023-2024 sports season, from January 10, 2023 to March 10, 2024. Methods and Procedures: The researcher adopted the experimental approach, designing two groups (experimental and control) with pre-and post-measurements, given its suitability for the nature of the phenomenon under study and the research objectives. This design is considered the most appropriate for testing hypotheses and revealing the effect of the independent variable on the dependent variable. Zhou *et al*. (2021) also indicated that the choice of approach is linked to the nature of the data and the phenomenon to ensure accurate scientific results, as shown in Table 1.

Table 1: Shows the distribution of clubs and the number of boxers participating in the study, in addition to the number of individuals in the exploratory experiment

Number of Clubs	Number of boxers	Exploratory Experimental sample
Etisalat	5	1
Al-Arabi	5	1
Al-Shorta	5	1
Al-Hussein	5	1
Total	20	4

The researcher defined his research community as a category of advanced boxing clubs in Baghdad Governorate (Etisalat, Al-Arabi, Al-Hussein, and Al-Shorta) within the weight category (69-75 kg). The number of active boxers reached (20) representing the original community. A research sample of (16) boxers was selected using a stratified random method at a rate of (80%). They were randomly distributed into two equal groups (experimental and control), with (8) boxers per group, with (4) of them allocated to the exploratory experiment. To ensure equivalence between the two groups, the researcher used the mean, standard deviation, and the (t) test for independent samples, as shown in Table (2).

Table 2: Shows the extent of equivalence between the two groups in the variables under study

Variables	Unit of measurement	Experimental group		Control group		T-Value calculated	Level Sig	Type Sig
		Mean	STD	Mean	STD			
energy index	E1	114.03	2.471	115.797	1.291	1.123	0.739	Non sig
Maximum Capacity	mm/min	39.192	2.244	40.938	1.213	0.609	0.192	Non sig
Speed Endurance	count	155.7	2.304	155.137	4.976	1.362	0.892	Non sig
Skill Performance	count	41.536	1.199	43.637	0.925	0.378	0.286	Non sig

Significant at a significance level of ≤ (0.05), a t-value of 1.761, and a degree of freedom of n-2=14.

Methods, devices, and tools used in the research: Internet, tests and measurements, observation, a weighing device, a device for measuring punch speed endurance, (6) special masks for training boxers, a Chinese (HP) laptop, (2) Korean-made Sony video cameras, (1) Chinese-made stopwatch, (1) Chinese-made whistle, a boxing ring with legal specifications and dimensions, (10) ounce boxing gloves for competition, (12) ounce boxing gloves for training, (16) bladder protectors, and (16) mouth guards.

Research Tests

Test Name: Cooper's VO_2max Test

- **Test Objective:** This test aims to indirectly estimate the maximum oxygen consumption (VO_2max) by calculating the total distance covered by an individual during a 15-minute continuous run, reflecting the individual's maximum aerobic capacity during physical exertion.
- **Equipment Used**
  - A standard running track (400 meters).
  - An accurate stopwatch.
  - Individual scoring forms.
  - A measuring tape to calculate final distance differences.
- **Performance Description:** The test is administered to all participants simultaneously to enhance the competitive element. Upon receiving the "Take your place" command, participants stand in a ready position. After hearing the start signal, they begin running continuously around the track for 15 minutes without stopping.
- **Standard Conditions and Procedures**
  - Each participant is required to run continuously around a 400-meter track for 15 minutes.
  - When the time is up, an audible signal (whistle) is given

and the participants stop in their seats.
- The distance covered by each participant is accurately recorded, with partial differences being accounted for using a measuring tape if necessary.
- The total distance covered by each participant is calculated in meters.

How to Calculate VO_2max:

The following equation is used to estimate VO_2max based on distance covered:

$VO_2max\(ml/kg/min)=\left(\frac{distance\(m) \times 60}{time\performance\(sec)} \right) \times 3.5$

Or, in a simplified way, as in the updated Cooper equation:

$VO_2max=\left(\frac{distance\(m)-504.9}{44.73} \right)$

This equation is used to estimate maximum oxygen consumption based on the 12-15-minute Cooper test.

Interpretation of Results: The greater the distance covered by the participant during the test, the higher the aerobic capacity, reflecting a good level of cardiorespiratory fitness.

Test Name: Parash Test for Cardiac Energy Index

- **Purpose:** This test measures the energy index, which expresses the effort the heart exerts to pump blood through the circulatory system per minute. This index is known as the Cardiac Output Index (CEI). This index relies on blood pressure and heart rate to estimate cardiac energy levels.
- **Equipment Used**
  - Mercury sphygmomanometer.
  - Stethoscope.
  - Accurate stopwatch.
  - Comfortable seat.
- **Test Procedure**
  - The patient sits quietly on a chair for 3-5 minutes to ensure cardiac stability.
  - The pulse is measured for 30 seconds using the fingers or a stethoscope, then the result is multiplied by 2 to obtain the heart rate per minute (bpm).
  - Systolic and diastolic blood pressures are measured using a mercury cuff in the conventional manner.
  - The energy index is determined using the following formula.

Cardiac energy index=(systolic pressure + diastolic pressure)×pulserate100\frac{(systolic pressure + diastolic pressure) \times pulse rate}{100}

Interpretation: The "energy index" estimates how much energy the heart uses each minute to circulate blood. A higher index indicates increased cardiac workload.

This index is used as an indirect measure of the heart's functional status, particularly in physiological studies related to stress or exertion.

Fig 1: Show the energy index test

Test Name: Punch Speed-Endurance Test

- **Purpose:** This test aims to measure a boxer's ability to maintain the speed of punches for the maximum possible period of time, reflecting the speed endurance of the arm and shoulder muscles during repeated combat.
- **Equipment Used**
  - An electronic device equipped with sensitive punch counter pads.
  - A digital display to count punches.
  - A stopwatch or timer built into the device.
- **Performance Procedure**
  - The boxer stands in a ready position in front of the device at an appropriate distance that allows him to throw punches without bending his torso.
  - Upon hearing the start signal, the boxer begins to throw consecutive straight punches with both hands toward the sensitive pads.
  - The continuous performance continues for (40) seconds without interruption.
- **Recording:** The total number of punches recorded by the device over a (40)-second period is calculated, and this number is considered an indicator of the boxer's speed endurance level.

Interpretation of results: The greater the number of punches executed within the specified time, the higher the level of muscle efficiency and speed endurance in the upper body muscles, which is crucial to the competitive performance of boxers.

Fig 2: Speed Endurance Test

Test Name: Skill Performance Test in Partnered Boxing

- **Test Objective:** This test aims to assess a boxer's skill performance level in a competitive environment that simulates real-life match conditions, by executing legal punches and defenses within a specified time frame.
- **Equipment Used**
  - Manual stopwatch to time rounds.
  - Boxing gloves (4 pieces-one pair for each boxer).
  - Legal boxing ring.
  - Referee forms to record points.
  - Whistle to start and end rounds.
  - Two corner markers (red and blue).
- **Performance Description**
  - Each boxer stands in their designated corner inside the ring. Upon hearing the signal to start from the center referee, the competition begins between the boxers with an exchange of legal punches and defenses for three rounds, each lasting three minutes, followed by a one-minute rest period between rounds. The use of various punches (straight, hook, uppercut) and defenses (blocking, retreating, covering) is permitted in accordance with the official rules of the game.
- **Requirements**
  - The boxer must adhere to the legal offensive and defensive skills approved in the Boxing Laws.
  - Points are awarded only for punches that are recorded as clear and effective hits, at the discretion of the judging committee.

Recording: Points are scored using judging forms by three side judges. A boxer is awarded a point for each effective and effective hit, according to established technical standards. The total points scored are used to determine each boxer's skill performance level.

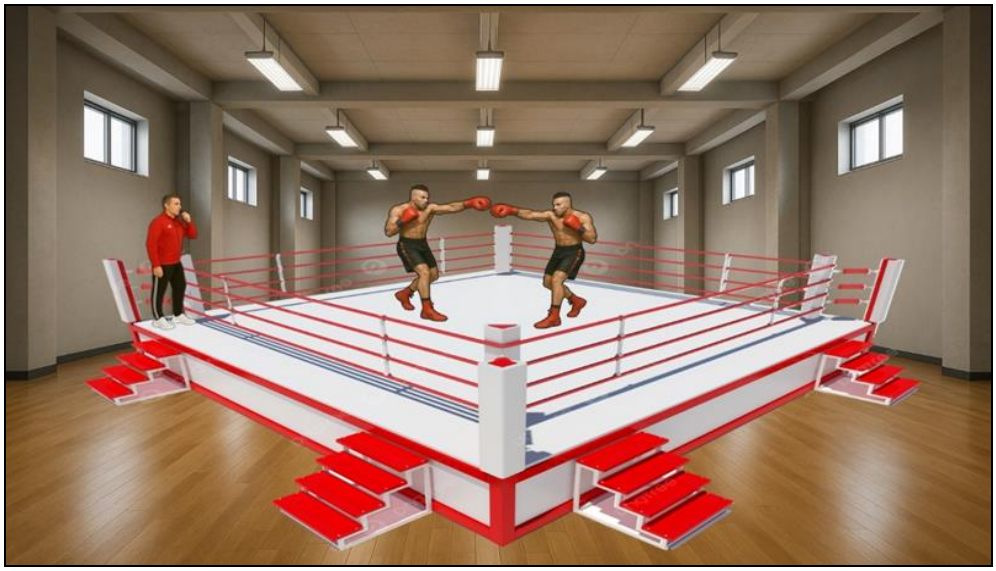

Fig 3: Show the skill performance test

Exploratory Experiment

The researcher, with the assistance of the research team, conducted his exploratory experiment on Wednesday, January 5, 2023, at 4:00 PM, in the Police Sports Club Boxing Hall in Baghdad. He conducted some training with the help of a group of (4) boxers from outside the research sample. This constituted a mini-experiment similar to the main experiment. Pre-tests were conducted on January 16, 2023, in the Police

Sports Club Hall in Baghdad, in cooperation with the support team. The first day included a VO_2max test on the track, followed by the energy index and speed endurance tests. After a warm-up and ensuring the sample's readiness, the results were documented on special forms. On the second day, a skill performance test was conducted inside the hall, using a legal ring and under the supervision of certified referees to ensure accuracy.

Special exercises prepared by the researcher

After completing the pre-tests, the researcher began implementing the special exercises that had been prepared in advance, with the aim of developing speed endurance, functional abilities, and skill performance among the members of the experimental group of boxers. The training program began on Sunday, January 22, 2023, and continued for ten weeks, with three training units per week on Sundays, Tuesdays, and Thursdays. It concluded on Thursday, March 2, 2023, as part of the main section of the special phase of the daily training unit, under the direct supervision of the researcher.

In preparing these exercises, the researcher considered gradual progression in intensity and volume, according to the training level and age group of the participants, based on approved scientific principles in sports training and physiology, and supported by the opinions of boxing experts. Special training masks were used in the exercises, due to their impact on improving the efficiency of functional systems.

Implementation Details

Intensity

High-intensity interval training at a rate ranging from 80-95% of the maximum individual performance capacity, developed based on preliminary tests to determine performance level. Size: The number of sets and repetitions was determined according to the nature of each exercise and the players' development level.

Post-tests

After completing the specific exercises previously prepared by the researcher on the boxers' sample, the post-tests were conducted on February 16, 2023, at 4:00 PM. The researcher ensured that these tests were conducted under the same conditions as the pre-tests, in terms of timing, location, and method. He also utilized the same support staff to ensure the consistency of the results and achieve the highest degree of accuracy in measurement and comparison.

Statistical methods

The researchers used the statistical program SPSS for data processing and result extraction, and used the following statistical methods: (percentage, mean, standard deviation, chi-square test, simple correlation coefficient (Pearson), t-test for related samples, t-test for independent samples.

Table 3: Displays the mean and standard deviation of the pre-and post-tests for the experimental group, the mean difference, the standard error of the mean, the calculated t-value, and the significance level of the studied variable

Variables	Units	Pre-test		Post-test		T-Value calculated	Level Sig	Type Sig
		Mean	STD	Mean	STD			
energy index	E1	123.530	1.354	116.297	2.361	6.591	0.0412	Sig
Maximum Capacity	mm/min	39.192	2.244	48.635	2.185	3.574	0.0175	Sig
Significant at a significance level of ≤ (0.05) and at a degree of freedom of 8-1=7								

Table 3 shows the pre-test and post-test results of the experimental group completing the training program using the high-intensity interval training (HIIT) method, analyzing two basic physiological variables.

Energy index (E1): The results showed a clear decrease in the mean from 123.530 in the pre-test to 116.297 in the post-test, with a calculated t-value of 6.591, which is statistically significant at the 0.05 level, with a P value of 0.0412. This indicates an improvement in the efficiency of energy use during performance, reflecting the development of the cardiorespiratory and neuromuscular systems. "This supports the outcomes of recent studies, such as Kinnunen *et al*. (2020) [1], which found that HIIT training enhances oxygen uptake (VO_2max) and improves both aerobic and anaerobic energy systems. Participants' top running speed increased from 39.192 to 48.635 m/s after completing the program, showing a clear boost in speed endurance. This change is statistically significant, as indicated by a t-value of 3.574 and a p-value of 0.0175.

These findings indicate that HIIT helps boxers maintain peak speed for longer periods, which can lead to better performance in matches. This conclusion is consistent with the work of Buchheit & Laursen (2013) [2], who observed that HIIT allows athletes to better perform repeated high-intensity actions by raising their lactate threshold and improving their recovery between efforts.

The study's author concluded that HIIT training has a notably positive effect on building both physical efficiency and speed endurance, which in turn enhances the execution of skills. This type of training fits boxing especially well, as the sport requires explosive movements in short bursts, followed by quick recovery-just like the structure of a HIIT workout".

Table 4: The table shows the average scores and standard deviations for the experimental groups' pre-test and post-test results, as well as the differences in these averages, the standard errors of the means, the calculated t-values, and the significance levels for the studied variables

Variables	Units	Pre-test		Post-test		T-Value calculated	Level Sig	Type Sig
		Mean	STD	Mean	STD			
Punch speed endurance	count	155.7	2.304	193.137	3.926	30.614	0.0012	Sig
Skill performance	count	41.536	1.199	50.97	1.711	16.732	0.0015	Sig
Significant at a significance level of ≤ (0.05) and at a degree of freedom of 8-1=7								

Table 4 outlines the statistical results for variables such as punch speed, endurance, and dexterity among participants in the experimental group after undergoing a high-intensity interval training (HIIT) program. The data show a statistically significant difference between pre-test and post-test outcomes at the 0.05 level, confirming the program's positive impact.

First: Punch Speed Endurance, there was a notable increase in the average punch speed endurance, with the mean improving from 155.7 to 193.137 following the training. This was accompanied by a small standard error, a t-value of 30.614, and a highly significant p-value of 0.0012. These statistics suggest a substantial enhancement in the athletes' anaerobic performance and muscular endurance-critical factors in assessing boxing efficiency.

This improvement is attributed to HIIT's ability to activate fast-twitch (Type II) muscle fibers and boost neuromuscular efficiency. Research by Laursen & Buchheit (2019) [3] supports this, indicating that HIIT enhances the capacity for repeated maximal effort-an essential trait in combat sports.

Second: Skill Performance, The skill performance metric also improved, with the average increasing from 41.536 to 50.97. This result was statistically significant (P=0.0015, t=16.732), indicating marked progress in the precision and fluidity of technical movements. The improvement reflects HIIT's impact not just on physical capabilities but also on motor and technical performance, driven by the blend of intense training and repeated technical execution under pressure. These findings align with studies like that of Slimani *et al*. (2017) [4], which demonstrate that incorporating technical drills into high-intensity workouts enhances motor learning and boosts performance under realistic competitive conditions. Franchini *et al*. (2021) [5] also found that HIIT can improve skill performance by increasing an athlete's ability to execute skills effectively, even when fatigued.

The researcher concluded that the training program led to notable and statistically significant improvements in the examined variables, validating the effectiveness of HIIT in developing both the physical and technical aspects of boxing. He recommends incorporating this type of training into preparation programs for combat sports athletes.

Table 5: Shows the means and standard deviations of the pre-and post-tests for the control group, the differences between the means and the standard errors of the means, the calculated t-values, and the significance levels of the studied variables

Variables	Units	Pre-test		Post-test		T-Value calculated	Level Sig	Type Sig
		Mean	STD	Mean	STD			
energy index	E1	118.53	1.02	117.797	1.291	12.317	0.0012	Sig
Maximum Capacity	mm/min	38.671	1.324	43.876	1.74	2.479	0.0155	Sig
Significant at a significance level of ≤ (0.05) and at a degree of freedom of 8-1=7								

Table 5 shows that there were statistically significant differences between the pre-test and post-test in the control group in terms of energy index and maximum energy. The differences were significant at the 0.05 level, indicating limited but statistically significant progress, which may be due to the influence of regular training or time repetition factors.

First: Energy index (E1), Despite the small difference between the pre-test mean (118.53) and the post-test mean (117.797), the value (t=12.317) and significance (P=0.0012) indicate a slight but significant improvement. This is due to the relative adherence to the traditional training style, which contributes to maintaining general physical efficiency without significant improvement, as confirmed by the study by (Gentil *et al*., 2021) [6], which demonstrated that traditional training protocols may maintain fitness but lack the profound physiological impact of HIIT programs. Second: Maximum: The variable recorded a slight improvement from (38.671) to (43.876), with a significant significance (P=0.0155) and a value (t=2.479). This indicates a limited response to the usual training program, which is consistent with the results of (Murawska-Ciałowicz *et al*. 2020) [7], which demonstrated that intense stimulation is necessary to achieve noticeable progress in maximum abilities such as strength or maximum energy. The researcher concluded that there were significant differences, but with limited practical impact, which reinforces the need to introduce more adaptive training programs, such as HIIT, to obtain clear and effective improvements in physical and functional indicators.

Table 6: Shows the means and standard deviations of the pre-test and post-test, the differences between the means and the standard errors of the means, the calculated t-values, and the significance levels of the studied variables for the control group

Variables	Units	Pre-test		Post-test		T-Value calculated	Level Sig	Type Sig
		Mean	Std	Mean	Std			
Punch speed endurance	count	152.87	5.087	178.967	3.897	16.836	0.0012	Sig
Skill performance	count	41.37	1.036	46.803	1.738	4.147	0.0035	Sig
Significant at a significance level of ≤ (0.05) and at a degree of freedom of 8-1=7								

Table 6 shows the statistical analysis results of the control group before and after the test. In addition to the paired sample t-test, we also used a variety of statistical methods, such as mean and standard deviation, to determine the degree of change in the research variables between the pre-test and post-test.

First, for the variable "stroke speed endurance": the mean increased from 152.87 in the pre-test to 178.967 in the post-test, while the standard deviation decreased significantly from 5.087 to 3.897. This reflects an enhancement in performance and consistency in the results. The calculated t-value was 16.836 with a significance level of 0.0012, which is below 0.05, indicating a statistically significant difference between the two measurements. This suggests that the observed improvement in "punch speed endurance" in the control group might be attributed to natural progression or repeated exposure to the test rather than a specific experimental factor. As noted by Thomas, Nelson, & Silverman (2020), such improvement in a control group could stem from learning effects or familiarity with the test procedure rather than a training intervention.

Second, regarding the "skill performance" variable, the mean increased from 41.37 to 46.803, while the standard deviation rose from 1.036 to 1.738, potentially indicating minor variability in participant responses. The calculated t-value was 4.147 at a significance level of 0.0035, which is also below 0.05, confirming statistically significant differences.

Although the differences are significant, (Field, 2021) [9] indicates that the statistical change in the control group should be interpreted with caution, especially if it is not accompanied by a directed experimental change. This means that the change may be due to uncontrolled environmental or psychological factors. The results reflect significant differences in some variables, even within the control group. This necessitates monitoring external factors and ensuring the stability of testing conditions. Recent studies, such as (Cumming & Calin-Jageman 2017) [10], emphasize the importance of verifying effect size, along with statistical significance, to ensure that the change has actual practical value.

The researcher concluded that the results of this table demonstrate the importance of controlling experimental conditions and interpreting results in context, especially in sports performance studies, where environmental factors or self-learning can influence results even without direct experimental intervention. Therefore, it is recommended that additional tests and supporting qualitative analysis be used to interpret the results of the control groups more accurately.

Table 7: Displays the mean and standard deviation of the posttest, the calculated t-value, the significance level, and the significance of the difference between the experimental and control groups on the studied variable

Variables	Units	Experimental group		Control group		T-Value calculated	Level Sig	Type Sig
		Mean	STD	Mean	STD			
energy index	E1	114.03	2.471	117.797	1.291	6.028	0.0005	Sig
Maximum Capacity	mm/min	46.368	2.296	43.876	1.74	2.806	0.0036	Sig
Significant at a significance level of ≤ (0.05) and at a degree of freedom of n-2 = 14								

- **First:** The "Energy Index" variable (E1), the experimental group achieved a mean of (114.03) compared to (117.797) for the control group, with clear differences in the standard deviation. The calculated (t) value was (6.028) at a significance level of (0.0005), reflecting a statistically significant difference between the two groups. The decrease in the energy index in the experimental group indicates an increase in energy efficiency during performance, which is consistent with what (Bompa & Haff, 2018) [11] explained, which is that improving energy efficiency is a key indicator of the effectiveness of specialized training programs.
- **Second:** Maximum Capacity (mm/min), the experimental group showed an increase in the mean to (46.368) compared to (43.876) in the control group. The calculated t-value was 2.806 at a significance level of 0.0036, indicating a significant difference in maximum physical capacity favoring the experimental group. This result indicates an improvement in aerobic fitness and overall endurance, consistent with recent research like Joyner & Coyle (2022) [12], which demonstrated that structured training effectively boosts cardiorespiratory performance.

The experimental group's training program was successful, outperforming the control group across all measured variables. This advantage is likely attributed to the use of contemporary training strategies that focus on progressive overload and varied training sessions, which help enhance both physical and functional performance markers (Stone *et al*., 2021) [13].

The researcher concluded that the notable differences between the experimental and control groups across the three variables highlight the training program's effectiveness. This underlines the importance of comparative assessments conducted after interventions to uncover the true impact of training programs. The results also support the use of objective tools to measure training success, especially in the context of competitive sports.

Table 8: Displays the posttest mean and standard deviation, the calculated t-value, the level of significance, and whether the difference between the experimental and control groups for the studied variable is statistically significant

Variables	Units	Experimental group		Control group		T-Value calculated	Level Sig	Type Sig
		Mean	STD	Mean	STD			
Punch speed endurance	count	190.87	4.037	178.967	3.897	6.204	0.0017	Sig
Skill performance	count	48.703	1.822	46.803	1.738	4.027	0.0035	Sig
Significant at a significance level of ≤ (0.05) and at a degree of freedom of n-2 = 14								

Table (8) presents a comparison of the mean, standard deviation, and the computed t-value for the variables "Speed Endurance" and "Skill Performance" between the experimental and control groups after the proposed training program was implemented. An independent sample t-test with a significance level of 0.05 and a degree of freedom of 14 (n-2) was used to test the significance of the difference between the two groups. First, the variable "Speed Endurance": the mean of the experimental group is (190.87) and the standard deviation is (4.037), while the mean of the control group is (178.967) and the standard deviation is close to (3.897). The calculated (t) value is (6.204), which is statistically significant at the (0.0017) level, indicating a clear significant difference in favor of the experimental group. This significant improvement in "speed endurance" in the experimental group reflects the effectiveness of the training program used, which likely focused on intermittent speed exercises and progressive physiological loading. According to (Reilly, Bangsbo, & Franks, 2020) [14], training programs designed to enhance anaerobic endurance and speed lead to improved performance in high-intensity intermittent activities, a key feature of sports such as boxing. Second: Skill Performance Variable: The experimental group recorded a mean of 48.703 points compared to 46.803 points for the control group, with slight differences in standard deviations (1.822 and 1.738 points, respectively). The calculated t-value was 4.027 at a significance level of 0.0035, indicating statistically significant differences in favor of the experimental group. The training program proved effective not only in developing physical abilities but also in refining the technical skills associated with performance. According to Schmidt & Lee (2020) [15], integrating skill drills with physical elements like speed and endurance enhances skill performance through repetitive practice and neuromotor adaptation. The notable

improvements in both speed endurance and skill execution among the experimental group indicate that the training approach was well-rounded and scientifically sound. This reinforces the significance of blending physical and technical elements to elevate athletic performance. Supporting this, Bompa & Carrera (2021) [16] emphasized the importance of crafting training sessions that combine general fitness with sport-specific techniques to boost overall performance.

The researcher concluded that the training regimen significantly improved both skill proficiency and speed endurance in the experimental group when compared to the control group. This emphasizes the importance of basing training strategies on scientific principles that address the physiological and technical needs of athletes, especially in sports that demand a synergy of physical and skill-based responses.

Conclusions

- The researcher concluded that HIIT training effectively contributed to improving functional indicators (the efficiency of the circulatory and respiratory systems), increasing speed endurance.
- Improving skill performance in elite boxers in the 69-75 kg weight class compared to conventional training techniques. This underscores the importance of this method in developing boxers' physical, functional, and technical abilities.

Recommendations

- Integrate high-intensity interval training (HIIT) into boxing training routines during the specific preparation stage, progressively increasing both intensity and duration to align with competitive demands.
- Conduct additional research on various weight divisions and age brackets to broaden the applicability of the study's conclusions.

References

1. Kinnunen H, Rantanen A, Kenttä T, Koskimäki H. HIIT improves cardiorespiratory performance and metabolic responses. Front Physiol. 2020;11:567.
2. Buchheit M, Laursen PB. High-intensity interval training, solutions to the programming puzzle. Sports Med. 2013;43(5):313-338.
3. Laursen PB, Buchheit M. Science and application of high-intensity interval training. Human Kinetics, 2019.
4. Slimani M, *et al*. Effects of high-intensity interval training on technical and tactical performance in combat sports. J Strength Cond Res. 2017;31(4):1121-1129.
5. Franchini E, *et al*. Combining HIIT with skill-based training improves performance in combat sports athletes. Front Sports Act Liv. 2021;3:665721.
6. Gentil P, *et al*. Traditional vs. high-intensity interval training: Effects on aerobic and anaerobic capacity. J Sports Sci. 2021;39(3):319-326.
7. Ciałowicz ME, *et al*. Effect of traditional and high-intensity functional training on aerobic capacity and muscle strength. Biol Sport. 2020;37(4):389-396.
8. Thomas JR, Nelson JK, Silverman SJ. Research methods in physical activity. Human Kinetics, 2020.
9. Field A. Discovering statistics using IBM SPSS statistics. 6th ed. SAGE Publications, 2021.
10. Cumming G, Jageman CR. Introduction to the new statistics: Estimation, open science, and beyond. Routledge, 2017.
11. Bompa TO, Haff GG. Periodization: Theory and methodology of training. Human Kinetics, 2018.
12. Joyner MJ, Coyle EF. Endurance exercise performance: the physiology of champions. J Physiol, 2022.
13. Stone MH, Sands WA, Stone ME. Principles and practice of resistance training. Human Kinetics, 2021.
14. Reilly T, Bangsbo J, Franks A. Anthropometric and physiological predispositions for elite soccer. J Sports Sci, 2020.
15. Schmidt RA, Lee TD. Motor learning and performance: from principles to application. 6th Ed. Human Kinetics, 2020.
16. Bompa TO, Carrera MC. Periodization of strength training for sports. Human Kinetics, 2021.