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The Effect of High-Intensity Interval Training (HIIT) at Race Pace on Certain Structural and Physiological Abilities and 1500-Meter Running Performance

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Abstract: *The 1500-meter race is considered a middle-distance running event, and this event is characterized by special specifications related to physical fitness elements and physiological indicators to achieve functional adaptation of the organic systems to perform the effort during the race and endure it to achieve the best possible time. This event is characterized by an increase in the effort used (rate of speed) at the beginning of the race and sometimes in the middle of the race, as well as the fast end, which requires the runner to change the specifications of the intensity used. Hence came the importance of research in preparing high-intensity interval training (HIIT) according to the pace of the race in some structural and physiological abilities and the achievement of running the 1500 meters. Hence, The study preparation oriented high-intensity training (HIIT) based on the pace of the race in running the (1500m) and identifying their effecton the study variables. This search is an experimental method on Al-Diwaniyah clubs' players of athletics, specifically middle-distance running for youth, in whose number reached (10) competitors who participated in the sports season (2025). They were randomly assigned to the experimental and control group, with (5) competitors in each group. Study variables did not differ between groups. Those trainings were done in the special preparation phase for both groups for a period of (8) weeks, (3) training units per week. The results after applying high-intensity training (HIIT) according to the pace of the race and the traditional coach training, the researcher concluded that there is an advantage for the experimental group using high-intensity training (HIIT) according to the pace of the race in: Special endurance, maximum oxygen consumption (ml. Per min/kg), lung capacity (L) and achievement of running 1500 meters.*

Keywords: High-Intensity Interval Training (HIIT); Race Pace; VO_2max; Middle-Distance Running; 1500-Meter Performance

Introduction

Enhancement of athletic performance in order to achieve a high level of achievement in certain sports disciplines is the aim of modern methods of sports training. Such a variety of these methods and their various effects have stimulated experts and coaches in sports training to take advantages of the most effective methods which contribute substantially to performance improvement and enhancement.

Athletics is one of the sports disciplines that has been the subject of intensive scientific research and studies. Such focus has inspired significant advances in training techniques and has fostered greater successes in recorded achievements across international and world competitions.

One of the events that has become fertile ground for sports training physiology researchers, and which provides studies that may help to enhance and improve performance in the event itself is the 1500-meter run. In 1500 m, the most important variables are special endurance and maximal oxygen uptake (VO_2max). Coaches must know exactly how the desired training methods and styles can be applied to get the athletes performing at and taking up these training loads as they increase. Sometimes, in addition to a fast finish, this event is marked by an early increase in effort — in terms of running speed — and sometimes in the middle of the race, too, as well as at the end. These types of things demand a runner to change the integrated speed characteristics utilized in the race. This changeover helps the aerobic to anaerobic energy systems which are the key determinants of race outcome.

The second suggests that the way pacing interacts with physical and physiological capacity variables, and therefore the level of performance, can only be addressed in the context of the different phases of a race. In view of this, the present study is pertinent regarding the design of high-intensity interval training (HIIT) sessions in reference to race pace and in accordance with an athlete's predetermined competition itinerary for passing competitors at each stage of the race. It also emphasizes the fact that the coach is the one creating these strategies, with the work coming in determining the strengths and weaknesses each runner has in order to counter the negative effects.

Research Problem

Over the last 30 years, sport has rapidly evolved, as developed countries have placed considerable investment effort into enhancing athletic performances through scientifically informed methods promoting optimal exploitation of athlete capacity combining technical, physical and physiological modalities. From analyzing many training plans employed by most middle- and long-distance coaches, I noticed that much of the training consists of large training volumes aimed at achieving special endurance over the lengthen distances, and little of the training intensity is extracted from race phases or segments—pacing consideration. None of these exercises replicate game speed.

When considering the champion of the 1500-meter event, a distance that also comprises one of the international and Olympic athletics events, over more than 100 years, the evolution of performance levels as opposed to the Iraqi performance level is readily apparent. Thus, the researcher considered it is necessary to conduct this study by designing HIIT involving a structured race pace based on the pace rates of race phases or segments in the 1500m event.

Research Objectives

The study aims to achieve the following:

1. To design high-intensity interval training (HIIT) exercises based on race pace for the 1500-meter run.
2. To identify the effect of these exercises on special endurance, maximal oxygen uptake, vital capacity, and 1500-meter running performance.

Research Hypothesis

The researcher hypothesizes that the applied training program will have a positive effect on the physical and physiological variables of the study, as well as on 1500-meter running performance.

Scope of the Study

1. Human Scope: Youth runners of Al-Diwaniyah clubs specializing in the 1500-meter event, totaling ten athletes.
2. Time Scope: From 20 May 2025 to 7 August 2025.
3. Spatial Scope: Afak Olympic Club Stadium, the College of Physical Education and Sports Sciences stadium at Al-Qadisiyah University, and the Physiology Laboratory at the College of Physical Education and Sports Sciences, Al-Qadisiyah University.

Methodology

Research Method

The researcher employed the experimental method using the equivalent groups design, as it is appropriate for the nature of the study. This method enables the researcher to obtain accurate results, as experimentation is considered one of the most efficient means of reaching reliable knowledge. It is also regarded as the only method that allows for the true testing of hypotheses related to cause-and-effect relationships.

Population and Sample of the Study

The research population consisted of youth athletes from athletics clubs in Al-Diwaniyah Governorate specializing in long-distance running, aged 18–19 years, totaling twelve athletes who participated in the 2025 sports season. After excluding two athletes due to lack of training commitment, the final sample comprised ten athletes. These athletes were randomly divided into two groups: an experimental group and a control group, with five athletes in each group. The two groups were matched in the study variables, as shown in Table (1).

Equivalence of the Experimental and Control Groups in Study Variables and 1500-Meter Performance

To determine the status of the study variables and performance levels of the experimental and control groups, the researcher measured these variables and calculated the median and quartile deviation, which indicate variations across different variables, as shown in Table (1).

Table (1) Median and quartile deviation of the variables used to establish equivalence between the two research groups

No.	Variable	Unit	Experimental Group Median	Quartile Deviation	Control Group Median	Quartile Deviation
1	Speed endurance (600 m run)	min/sec	1.35	2.16	1.34	3.97
2	Strength endurance (jump	meter	280	1.50	277	1.80

	running for 1 min)					
3	Maximal oxygen uptake (VO_2max)	ml/kg/min	47.60	2.5	46.40	1.5
4	Vital capacity	liter	3.33	0.77	3.15	0.38
5	1500 m performance	min/sec	4:30.20	2.16	4:31.02	3.975

Table (2) Calculated and tabulated Mann–Whitney values and significance of differences for equivalence variables

No.	**Variable**	**Calculated Value**	**Tabulated Value**	**Significance**
1	600 m run	15	0.130	Non-significant
2	Strength endurance (jump running)	19	0.267	Non-significant
3	VO_2max	11	0.049	Non-significant
4	Vital capacity	17	0.090	Non-significant
5	1500 m performance	25	0.549	Non-significant

At a significance level of 0.05 and a sample size of five athletes per group.

Devices, Tools, and Instruments Used

- Data recording forms.
- Electronic handheld stopwatches (8 units).
- Electronic calculator (Sharp, Japanese-made).
- FIT MAT PRO device for measuring maximal oxygen uptake (Italian-made).

Experimental Design

The experimental design involved both the experimental and control groups undergoing pre-tests to determine their initial status before the introduction of the experimental variable. The experimental group performed training based on a regulated pacing method, with training intensity determined according to the exertion required in the phases or segments of the 1500-meter race. The control group followed the training program designed by their supervising coach. The training was applied during the specific preparation phase for a period of eight weeks, with three training units per week. Post-tests were then conducted, and the differences between pre- and post-test results were attributed to the effect of the experimental variable.

Pilot Study

In this context, a pilot study serves as practical training for the researcher to find out difficulties experienced while testing and to dodge them. The pilot study aimed to evaluate

the tests for fitness within the research sample, the response of the sample to these tests, and the time needed to conduct them.

Specifications of Measurements and Tests Used

1. Physical Tests First: 600-meter run test
   Purpose: To measure speed endurance.
2. Second: One-minute jump running test
   Purpose: To measure strength endurance.
3. Physiological Measurements
4. Bruce treadmill test for measuring maximal oxygen uptake
   Purpose: To measure maximal oxygen uptake. Procedures: The test is conducted on a treadmill for 21 minutes, divided into seven stages. In each stage, running speed and treadmill incline are increased, as illustrated in the figure below, which shows the details of the test stages.

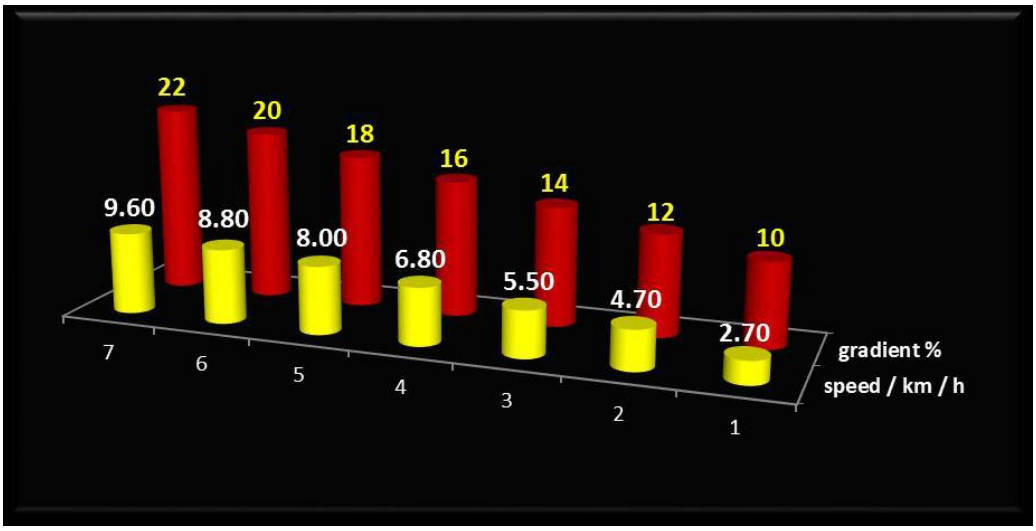

Figure (1). Illustrates the stages of the Bruce test for measuring VO_2max.

Second: Measurement of Vital Capacity (VC): Vital capacity is measured using a spirometer. The participant sits on a chair facing the device after body weight, height, and age are measured. These data are entered into the device. The participant places the mouthpiece in the mouth and performs 1–3 preparatory inhalation and exhalation cycles in a normal, moderately deep manner. After that, the participant inhales the maximum possible amount of air, followed by a maximal exhalation into the device tube. Three trials are performed, and the best result is recorded.

1500-Meter Run Test (Performance): Purpose: To assess 1500-meter running performance.

Pre-Tests and Measurements

Pre-tests and measurements were conducted from 24 to 27 June 2025, as follows:

1. Day 1: Speed endurance test and strength endurance test.
2. Day 2: Vital capacity measurement and maximal oxygen uptake (VO_2max) test.
3. Day 3: 1500-meter run performance test.

Implementation of the Specialized Exercises

After completing the pre-tests, the implementation of the specialized high-intensity interval training (HIIT) exercises based on race pace began. The training program lasted eight weeks, with three training units per week during the specific preparation phase. Training intensity was determined according to the speed rates of race segments. A total of 24 training units were implemented, as shown in Appendix (1). The program started on 30 June 2025 and ended on 30 August 2025.

Post-Tests and Measurements

Post-tests and measurements were conducted for both the experimental and control groups after completing the training program on 2 September 2025, using the same procedures applied in the pre-tests.

Statistical Methods

The Statistical Package for the Social Sciences (SPSS) was used for data analysis

Result and Discussion

Presentation of Pre- and Post-Test Results for Speed Endurance in the Experimental and Control Groups

Table (3). Shows the median, quartile deviation, calculated and tabulated Wilcoxon values, and significance of differences between pre- and post-tests for speed endurance in the experimental and control groups.

Group	Statistical Values	Sample Size	Significance of Differences
	Wilcoxon Test Value		
	Pre-test Median (min:s)	Quartile Deviation	Post-test Median (min:s)
Experimental	3:05.33	2.16	2:56.88
Control	3:06.50	3.97	3:01.40

Presentation of Pre- and Post-Test Results for Strength Endurance

Table (4). Shows the median, quartile deviation, calculated and tabulated Wilcoxon values, and significance of differences between pre- and post-tests for strength endurance in the experimental and control groups.

Group	Statistical Values	Sample Size	Significance of Differences
	Wilcoxon Test Value		
	Pre-test Median (m)	Quartile Deviation	Post-test Median (m)
Experimental	180	1.30	220
Control	185	1.33	200

Comparison Between Experimental and Control Groups in Speed and Strength Endurance

Table (5). Shows the significance of differences in medians and the calculated and tabulated Mann–Whitney values for the post-test speed endurance results between the experimental and control groups.

Group	Statistical Values	Significance of Differences

	Mann–Whitney Test Value	
	Post-test Median (min:s)	Quartile Deviation
Experimental	2:56.88	2.86
Control	3:01.40	4.28

Table (6). Shows the significance of differences in medians and the calculated and tabulated Mann–Whitney values for the post-test strength endurance results between the experimental and control groups.

Group	**Statistical Values**	**Significance of Differences**
	Mann–Whitney Test Value	
	Post-test Median	Quartile Deviation
Experimental	220	2.44
Control	200	2.70

Discussion of Speed Endurance and Strength Endurance Results

Tables (3) and (4) indicate statistically significant differences between the pre- and post-tests in favor of the post-test for both the experimental and control groups in speed endurance and strength endurance tests. The researcher attributes this improvement to the application of specialized high-intensity interval training (HIIT) exercises based on race pace for the experimental group, and to the traditional coach-designed training for the control group. Both programs included training loads based on scientific principles of volume, intensity, and appropriate recovery periods suited to the capabilities of the research sample.

The right type of training, focus on managing intensity stresses, and efficient recovery between repetitions — all of this translates into better performance, according to Hussein Al-Ali. The Mann–Whitney values for comparing the post-test between the experimental and control groups are shown in Table 4, with significant differences in the favor of the experimental group. This implies that the training program implemented on the experimental group was better than that of the control group.

The training was prescription by running more specific to race pace to better replicate the demands of actually running the 1500-meter to help his pacing awareness, how to distribute effort and intensify the 1500-Meter performance. According to Salman, athletes must be skilled at managing speed and power for a good result — no one can keep the same speed over an entire race. When you sustain high speed in the short span duration more lactic acid is produced in the muscles which affects performance. As such, effort allocation varies in each race. It is the same combination of high speed early, speed endurance in the middle, and the finishing speed needed in the 1500-meter event.

The large effects of speed endurance (Table 3) on 1500-m performance as post-tests is consistent with previous findings that speed endurance is one of the most important determinants of 1500-m performance (17). According to Thiodorisco, for strength- and speed-dominated sports, the level of special endurance has a strong impact on performance, in particular for middle- and long-distance races such as 1500 m and 5000–10,000 m, where fatigue is extreme during the second half of the race. With improvements

in the area of special endurance, an athlete is better equipped to handle the demands of training and competition.

Presentation of Maximal Oxygen Uptake (VO_2max) Results

Table (7). Shows the median, quartile deviation, calculated and tabulated Wilcoxon values, and significance of differences between pre- and post-tests for VO_2max in the experimental and control groups.

Group	Statistical Values	Significance of Differences
	Wilcoxon Test Value	
	Pre-test Median (ml/kg/min)	Quartile Deviation
Experimental	47.60	2.5
Control	46.40	1.5

Table (8). Shows the significance of differences in medians and the calculated and tabulated Mann–Whitney values for the post-test VO_2max results between the experimental and control groups.

Group	Statistical Values	Significance of Differences
	Mann–Whitney Test Value	
	Post-test Median (ml/kg/min)	Quartile Deviation
Experimental	52.50	1.5
Control	48.30	2.0

Discussion of VO_2max Results

The results of the VO_2max test revealed statistically significant differences between pre- and post-tests in both the experimental and control groups, in favor of the post-test. The researcher attributes these differences to the effect of the HIIT program based on race pace with regulated intensity for the experimental group, and to the traditional training program applied to the control group. Both programs contributed to improvements in the respiratory and circulatory systems and blood function.

According to Bastawisi Ahmed, muscular work efficiency is associated with the availability and transport of oxygen from the lungs to the working muscles through aerobic and anaerobic processes. Numerous studies have confirmed that VO_2max increases with physical training lasting no less than eight weeks.

In the post-test comparison between the experimental and control groups, statistically significant differences in VO_2max were found in favor of the experimental group. This indicates that oxygen consumption during exertion was more efficient in the experimental group, which the researcher attributes to the nature of the specialized high-intensity exercises based on the race pace of the 1500-meter event. Heart rate increases during physical training in proportion to training intensity, and this increase supports higher oxygen consumption. Physiological training load intensity can be determined by the amount of oxygen consumed during exercise. As training intensity increases, oxygen consumption increases accordingly. Oxygen consumption ranges from approximately 4–5

liters per minute in middle-distance running and may reach its maximum after a 1500-meter run, reaching approximately 30 liters per minute or more.

Presentation and Analysis of Vital Capacity Results

Table (9). Shows the median, quartile deviation, calculated and tabulated Wilcoxon values, and significance of differences between pre- and post-tests for lung vital capacity in the experimental groups.

Groups Measurement of Lung Vital Capacity Significance of Differences

Group	Pre-test Median (L)	Quartile Deviation	Post-test Median (L)	Quartile Deviation	Calculated Wilcoxon	Tabulated Value	Significance
Experimental Group	3.33	0.77	4.17	0.42	0	3	Significant
Control Group	3.15	0.38	3.85	0.08	0	3	Significant

Table (10). Shows the significance of median differences and the calculated and tabulated Mann–Whitney values in the post-test for measuring lung vital capacity in the two groups.

Group	Post-test Median	Calculated Mann–Whitney	Tabulated Value	Significance
Experimental Group	4.175	0	0	Significant
Control Group	3.85	—	—	—

Table (11). Shows the percentage of median improvement for both groups in the pre- and post-tests of lung vital capacity.

Group	Pre-test	Post-test	Improvement (%)
Experimental Group	3.33	4.17	25.22
Control Group	3.15	3.85	22.22

Discussion of Lung Vital Capacity Results for the Two Groups

The results of the lung vital capacity test revealed statistically significant differences between the pre- and post-tests in both the experimental and control groups, in favor of the post-test. The researcher attributes these differences to the effect of the training programs applied to both groups, namely high-intensity interval training (HIIT) for the experimental group and traditional training for the control group. These programs produced clear physiological adaptations in pulmonary variables, particularly vital capacity, which is considered one of the most important indicators of respiratory system efficiency.

In the post-test comparison between the two groups, statistically significant differences were observed in favor of the experimental group. This improvement is attributed to the effects of external physical workload, which induced clear adaptations through regular training sessions, progressive loading, and appropriate manipulation of training volume and intensity. Organized and continuous training has been reported to increase vital capacity to approximately 6000–7000 cm^3. Vital capacity is closely associated with training that requires efficient cardiorespiratory interaction, which depends on the

integrity of both the circulatory and respiratory systems. It also increases during high-intensity training due to the opening of a large number of pulmonary capillaries and an increase in blood volume surrounding the alveoli as a result of increased cardiac output. An increase in lung surface area allows the blood to absorb a greater amount of oxygen. Pulmonary ventilation increases during physical exertion in direct proportion to the body's metabolic demands. Under maximal physical load, this increase occurs through a higher breathing rate, accompanied by functional adaptations in the respiratory system resulting from regular engagement in aerobic training activities.

Presentation and Analysis of 1500-Meter Running Performance Results

Table (12). Shows the median, quartile deviation, calculated and tabulated Wilcoxon values, and significance of differences between pre- and post-tests for 1500-meter running performance in the two groups.

Group	Pre-test Median (min:s)	Quartile Deviation	Post-test Median (min:s)	Quartile Deviation	Calculated Wilcoxon	Tabulated Value	Significance
Experimental Group	4:30.20	2.16	4:23.66	2.86	0	3	Significant
Control Group	4:31.02	3.975	4:29.35	4.28	0	3	Significant

Table (13). Shows the significance of median differences and the calculated and tabulated Mann–Whitney values in the post-test for 1500-meter performance.

Group	Post-test Median (min:s)	Calculated Mann–Whitney	Tabulated Value	Significance
Experimental Group	4:23.66	0	0	Significant
Control Group	4:29.35	—	—	—

Table (14). Shows the percentage of median improvement for both groups in the pre- and post-tests of 1500-meter running performance.

Group	Pre-test (min:s)	Post-test (min:s)	Time Difference (s)	Improvement (%)
Experimental Group	4:30.20	4:23.66	6.54	2.42
Control Group	4:31.02	4:29.35	1.67	0.62

Discussion of 1500-Meter Performance Results

The results of 1500 m run time in table (12) indicate that the improvement was also observed in experimental and control groups. HIIT was the prescribed training for the experimental group, with the control group following traditional training protocols. There were statistically significant differences between the pre- and post-test in favor of post-test in both groups.

The researcher believes that analysis of the results indicated improvements were due to the implementation of specific training programs that utilized scientific principles of volume, intensity and recovery of training load beyond the mathematical formulae

associated with those in the study, which were specific to physical, physiological and performance characteristics. On comparing the results of the control group and the experimental group from the post-test, significant differences were shown in favor of the experimental group that used HIIT based on race pace.

An additional percentage analysis of the improvements verified that the experimental group outperformed the control group. This result suggests that the intervention delivered to the experimental group, was more effective in augmenting 1500-meter performance.

Conclusion

Based on the results, the researcher concluded the following:

1. High-intensity interval training (HIIT) based on race pace positively affects speed endurance, strength endurance, physiological variables, and 1500-meter performance.
2. Statistically significant differences were observed between pre- and post-tests for all study variables in favor of the post-test.
3. Statistically significant differences were found between the two groups in the post-test for all study variables in favor of the experimental group.
4. Race-pace-based HIIT has a clear and direct effect on improving 1500-meter running performance.
5. HIIT is the most effective training method for increasing aerobic capacity (VO_2max) and vital capacity, particularly during the specific preparation phase for 1500-meter runners.

Recommendations

The researcher recommends the following:

1. Coaches of middle- and long-distance running should emphasize race-intensity training based on pacing strategies to enhance cardiorespiratory efficiency and lactic acid tolerance during prolonged performance.
2. Coaches should prioritize functional measurements as indicators of physiological adaptation and training status.
3. Particular attention should be given to heart rate, blood lactate concentration, VO_2max, and blood pressure.
4. Further studies should be conducted to determine different intensity levels across various preparation phases and their effects on physiological variables.
5. Greater emphasis should be placed on developing athletes' ability to control running speed across different race segments, particularly maintaining pace consistency between the first and second halves of the race.
6. Analytical tools and modern assessment devices should be employed for national athletics team athletes to compare their tactical approaches with international performance standards

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