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The Effect of Lactate Resistance Training on Hemoglobin Concentration Performance Endurance and Some Offensive Skills of Under-21 Football Players

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Abstract

Enhancing the functional efficiency of vital components (hemoglobin) to cope with the substantial accumulation of lactate, and improving the efficiency of muscle fibers during high-intensity exertion and pronounced intramuscular lactate buildup—along with increasing these fibers' capacity to generate the required energy through lactate removal and breakdown during high-intensity training—constitutes a key factor in developing performance endurance. Among the most effective exercises that create these conditions are lactate-resistance training methods. The first aims to elevate lactate to maximal levels without excessive accumulation within muscle fibers, while the second seeks to raise intensity with increased accumulation in order to improve blood hemoglobin concentration and enhance performance endurance, which is strongly associated with the muscles' tolerance to lactate levels and accumulation. The research problem lies in the reduced ability to maintain speed during the advanced stages of matches and the weak linkage between high physical effort and the accurate and effective execution of complex offensive skills, which may be attributed to insufficient physiological adaptations resulting from the training methods used. The study aimed to identify the effect of lactate-resistance training on hemoglobin concentration, performance endurance, and certain offensive skills among under-21 football players. The research hypothesis posited that lactate-resistance training would have a significant effect on hemoglobin concentration, performance endurance, and selected offensive skills in

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under-21 football players.ةThe researchers adopted the experimental approach due to its suitability for addressing the nature of the proposed problem. The research sample consisted of under-21 players from Karbala Football Club. The researchers concluded that the scientifically planned and systematically implemented training program applied to the study sample contributed positively to the development of the study variables.

Keywords: Lactate Resistance Training, Hemoglobin Concentration, Endurance Performance, Offensive Soccer Skills.

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Introduction and Significance of the Study

Football is one of the most widely practiced sports worldwide, characterized by excitement, suspense, and intense competition among players. Performance in football relies heavily on energy production through the anaerobic lactic system. The specific demands of the game place a considerable burden on various functional systems of the body due to increased accumulation of lactate and hydrogen ions within muscle fibers during training and competition. Consequently, players experience muscle pain, a reduction in speed, and may ultimately cease activity when excessive amounts of lactic acid/lactate and hydrogen ions accumulate in the blood.

However, the body possesses regulatory systems that help restore internal homeostasis, including biological buffers—chemical substances that reduce hydrogen ion concentration when it increases (acidosis) and counteract alkalinity when it decreases—thereby maintaining blood pH balance. Among the most important chemical biological buffers is hemoglobin.

With the significant advancements in modern training methods and approaches, and the scientific additions introduced through rigorous research and experimentation, developing the function of biological buffers (hemoglobin) to cope with high lactate accumulation, improving the efficiency of muscle fibers under high-intensity conditions, and enhancing these fibers' capacity to generate energy through lactate removal and breakdown during intense training have become key factors in improving performance endurance. The most important exercises that provide these adaptations are lactate-resistance training methods. The first aims to elevate lactate to maximal levels without excessive accumulation within muscle fibers, while the second seeks to raise intensity with increased accumulation to improve blood hemoglobin concentration and enhance performance endurance, which is strongly associated with increased muscular tolerance to lactate levels and accumulation.

Football has been profoundly influenced by modern sports sciences, as training science has witnessed remarkable development, particularly in lactate-resistance training, which enhances the efficiency and activity of various body systems and organs. This is positively reflected in general and specific abilities, as well as physiological and skill-related capacities, through optimal use of training techniques and methods to achieve positive outcomes. In line with this development, there is a need to design varied and well-regulated training programs based on scientific principles that align with competition demands and players' age categories to achieve the desired objectives in modern football. Hence, the importance of the present study lies in designing lactate-resistance training to develop the investigated variables, as a scientific contribution to training programs adopted by coaches.

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Research Problem

The accumulation of lactic acid is considered one of the physiological factors that negatively affect the continuity of effective performance due to its association with muscular fatigue, decreased performance endurance, and reduced accuracy in executing complex skills, particularly in demanding offensive situations. Although many training programs focus on developing endurance and speed separately, there is a clear deficiency in the scientific application of lactate-resistance training aimed at physiological adaptations related to oxygen transport, such as hemoglobin, and their effect on performance endurance and its direct reflection on the quality of complex offensive skill performance.

Through observing the training reality and competitions of this age group, a decline in the ability to maintain speed during the advanced stages of matches and a weak linkage between high physical effort and the accurate and effective execution of complex offensive skills have been noted. This may be attributed to insufficient physiological adaptations resulting from the training methods employed. Accordingly, the research problem is defined as the need to examine the effect of lactate-resistance training on selected physiological, physical, and skill variables to determine its contribution to improving hemoglobin concentration, performance endurance, and the development of complex offensive skills among under-21 football players, thereby contributing to the design of more efficient training programs aligned with the requirements of modern performance.

Research Objectives

1. To identify the effect of lactate-resistance training on hemoglobin concentration, performance endurance, and selected offensive skills among under-21 football players.

Research Hypothesis

1. Lactate-resistance training has a positive effect on hemoglobin concentration, performance endurance, and selected offensive skills among under-21 football players.

Research Scope

1. **Human Scope:** Under-21 players of Karbala Football Club.
2. **Temporal Scope:** 15/08/2025 – 01/12/2025.
3. **Spatial Scope:** Karbala International Stadium.

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Research Methodology and Field Procedures

Research Methodology

The researchers employed the experimental method due to its suitability for the nature of the problem under investigation. An experimental design with two equivalent groups—experimental and control—was adopted.

Research Population and Sample

The research population is defined as "all individuals, events, or objects that constitute the subject of the research problem" (Mohammed Abdul Fattah Al-Sarafi, 2002, p. 185). The research population consisted of under-21 football players from Karbala Football Club. The researchers selected a sample of 20 players using the comprehensive enumeration method. The sample was randomly divided into two groups: an experimental group and a control group, with each group comprising 10 players.

Homogeneity

The researchers identified the measurements that influence the study variables—namely height, body mass, and training age—due to their relevance to the research variables under investigation. Homogeneity among the sample participants with respect to these measurements was examined using Levene's test.

Table1. Results of Levene's Test for Homogeneity of the Research Groups

Variables	Unit of Measurement	Group	Mean ($\bar{X}$)	SD	df Between Groups	df Within Groups	Levene's Value	Sig. Level	Type of Significance
Height	cm	Control	171.4400	3.77689	1	18	0.128	0.725	Not significant
		Experimental	173.2100	3.65922					
Body mass	kg	Control	64.6900	4.45856	1	18	0.331	0.572	Not significant
		Experimental	63.9000	3.90640					
Training age	months	Control	52.2000	4.62990	1	18	0.257	0.618	Not significant
		Experimental	53.9000	5.31489					

It is evident from Table (1) that the significance levels of Levene's test for homogeneity across all variables were greater than the significance level (0.05), indicating that the two research groups were homogeneous with respect to the extraneous variables.

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Instruments, Devices, and Tools Used in the Study

- Observation.
- Personal interviews.
- Tests and measurements.
- Electronic device for measuring height and body mass.
- Two (2) SONY cameras (Japanese-made).
- One (1) ACER electronic calculator/computer.
- Medical cotton.
- Disinfectant solution.
- Two (2) whistles (Chinese-made).
- Four (4) cones with a height of 30 cm.
- Twenty (20) medical syringes with a capacity of 5 ml.
- Cooling box (cool box).

Field Research Procedures

Determination of Research Variable Measurements

ϖ Blood Hemoglobin Measurement (Hb):

Hemoglobin concentration was measured using a 2 ml blood sample analyzed with a Complete Blood Count (CBC) device.

First: Performance Endurance Test

- Test Name: Circular Performance Test.
- Purpose of the Test: To measure circular performance endurance of the players.
- Test Requirements: Football field, 10 footballs, 6 markers, whistle, stopwatch, timer, and recorder.
- **Performance Description:**
  This test is performed in a circular sequence. The player starts at the midfield line on the right side and performs 30 ball touches (ball control). The player then runs along the touchline while dribbling the ball until reaching the corner area, where a high cross is delivered into the penalty area. The player then runs to the edge of the penalty area facing the goal and shoots five (5) balls at the goal. Subsequently, the player moves to the left touchline to perform a throw-in to a teammate, receives the ball back, and dribbles the ball in a zigzag pattern between plastic markers (cones). Finally, the player sprints for a distance of 30 meters.
- **Scoring:**
  The total time taken to complete the performance is recorded.

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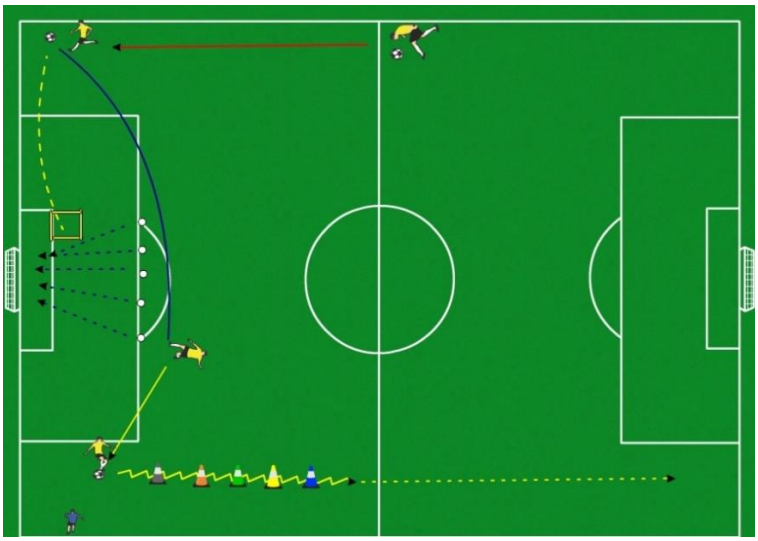

Figure (1) Illustrates the **Circular Performance Endurance Test**.

Second: Dribbling Test

- Test Name: Dribbling the ball between ten (10) markers, back and forth (Saleh Radi, 1998, p. 120).
- Purpose of the Test: To measure dribbling skill.
- Equipment Used: Football, stopwatch, ten (10) markers of appropriate height.
- Test Area: The test area is defined so that the distance between each marker is 1.5 m.
- Performance Description: Upon hearing the starting whistle, the player dribbles the ball between the markers while maintaining proper dribbling technique.
- Number of Attempts: Each player is given one attempt; if the attempt is unsuccessful, a second attempt may be allowed.
- Scoring: The time taken to complete the test back and forth is recorded to the nearest tenth of a second.

Third: Passing Test

- Test Name: Passing test (Raad Hussein Hamza, 1999, p. 14).
- Purpose of the Test: To measure passing accuracy.
- Equipment Used: Ten (10) footballs and a small goal with dimensions (110 cm × 63 cm).
- **Performance Description:**
  A line of 1 m in length is drawn at a distance of 20 m from the small goal. A stationary ball is placed on the starting line, and the player stands behind the line facing the small

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goal. Upon the signal, the player passes the ball toward the goal. Each player is given five (5) consecutive attempts.

- **Scoring:** The total score is calculated based on the five passes, as follows:
  - Two points for each successful pass that enters the small goal.
  - One point if the ball hits the post or crossbar without entering the goal.
  - Zero points if the ball misses the small goal.
  - **Maximum score:** 10 points.

Fourth: Ball Reception Test

- **Test Name:** Ball reception (inside of the foot) test (Hanafi Mahmoud Al-Mukhtar, 1997, p. 63).
- **Purpose of the Test:** To measure the player's ability to control the ball within a defined area in football players.
- **Equipment Used:** Footballs, cones, rope.
- **Performance Description:**
  The player stands inside a circle with a diameter of 2 m. A teammate passes three (3) ground balls into the circle, and the player must receive and control each ball without allowing it to leave the circle.
- **Scoring:** One point is awarded for each successful reception in which the ball remains within the circle.
- **Maximum score:** 3 points.

Pilot Study

A pilot study is defined as a small-scale experiment or preliminary procedure conducted by the researchers to identify the strengths and weaknesses that may accompany the implementation of the main experiment (Nouri Al-Shouk & Rafi' Al-Kubaisi, 2004, p. 77). The objectives of the pilot study were as follows:

- The pilot study was conducted on Saturday, 16/08/2025.
- To determine the extent to which the research sample responds to and interacts with the tests.
- To identify the appropriate time required for administering the tests.
- To verify the adequacy of the assisting research team in conducting the tests.
- To determine the time duration of each test.
- To establish the scientific bases of the tests.
- To identify the time required for the training unit.
- To familiarize with the exercises and their methods of execution.
- To determine the duration and intensity of the exercises.

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Scientific Bases of the Tests

- **Test Validity:**
  Validity is one of the essential scientific bases of a good test and refers to "the extent to which the test actually measures the ability, trait, attitude, or readiness it was designed to measure; that is, it measures what it is intended to measure" (Mohammed Jassim Al-Yasiri, 2010, p. 72).
- **Test Reliability:**
  Reliability is the second essential characteristic that researchers must verify, referring to "the degree of accuracy with which the test measures the trait it assesses. In other words, a test is considered reliable if it measures the trait accurately and consistently from one occasion to another under similar conditions" (Ahmed Mohammed Abdulrahman, 2010, p. 94).
- **Test Objectivity:**
  Objectivity refers to "freedom from bias or prejudice and the exclusion of the examiner's personal factors, such as opinions, tendencies, or personal inclinations, including any form of bias" (Ali Samoom Al-Fartousi et al., 2015, p. 229).

Pretests

Prior to implementing the training exercises prepared by the researchers, pretests were conducted on Friday, 15/08/2025, for the research sample on the study variables under investigation. The researchers ensured that all temporal and spatial conditions, as well as the procedures for administering the tests, were standardized as much as possible.

Equivalence

The researchers carried out equivalence testing for the research sample based on dependent variables, including hemoglobin concentration, performance endurance and selected complex offensive skills (see Table 2).

Table2. Equivalence of the Two Research Groups

Variables	Group	Mean ($\bar{X}$)	SD	Calculated t-value	Sig. Level	Type of Significance
Hemoglobin before exertion	Control	14.3	1.24	0.151	0.487	Not significant
	Experimental	14.2	1.56			
Hemoglobin after exertion	Control	15.6	2.12	0.086	0.745	Not significant
	Experimental	15.5	2.78			
Performance endurance	Control	67.55	3.54	0.120	0.598	Not significant
	Experimental	67.77	4.23			

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Dribbling	Control	19.22	0.57	0.488	0.354	Not significant
	Experimental	19.12	0.23			
Passing	Control	3.50	0.88	0.017	0.932	Not significant
	Experimental	3.00	0.69			
Ball reception	Control	4.00	0.71	1.256	0.134	Not significant

Main Experiment

The researchers designed lactate-resistance training exercises to develop the investigated research variables for the experimental group. This was based on the analysis and review of a large number of specialized scientific sources and references, while taking into account the training level and physical capacity of the research sample.

The training program was implemented as follows:

- The training units were applied during the special preparation phase.
- Implementation of the exercises began on Sunday, 17/08/2025.
- The training program lasted for eight (8) weeks.
- Three training units were conducted per week, resulting in a total of twenty-four (24) training units.
- The duration of each training unit ranged from 45 to 55 minutes.
- The exercises were applied only in the main part of the training unit.
- The researchers considered the individual differences and performance levels of the players when designing the exercises.
- The training consisted of a combination of physical exercises integrated with ball-based drills, all directed toward lactate-resistance training.
- Training days were Sunday, Tuesday, and Thursday.
- A high-intensity interval training method was used.
- Training intensity ranged between 80% and 90% of the target time for each participant, based on the results of the pretests.
- The implementation of the training program concluded on Thursday, 16/10/2025.

Posttests

Upon completion of the training exercises included in the training program, the researchers re-administered the same tests used in the pretests to both research groups, under the same temporal and spatial conditions and following the same procedures as closely as possible for the research variables under investigation.

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Statistical Methods

The researchers used the Statistical Package for the Social Sciences (SPSS) employing the following statistical techniques:

- Arithmetic mean.
- Standard deviation.
- Levene's test.
- t-test for paired samples.
- t-test for independent samples.

Presentation, Analysis, and Discussion of Results

Presentation and Analysis of the Pre- and Posttest Results of Hemoglobin, Performance Endurance, and Offensive Skills for the Two Research Groups and Their Discussion

Presentation and Analysis of the Pre- and Posttest Results of Hemoglobin, Performance Endurance, and Offensive Skills for the Control Group

Table3. Shows the arithmetic means, standard deviations, mean differences, standard error of the differences, calculated *t*-values, significance levels, and type of statistical significance for the pre- and posttests of the research variables for the control group.

Variables	Test	Mean ($\bar{X}$)	SD	Mean Difference	SE of Difference	Calculated t-value	Sig. Level	Type of Significance
Hemoglobin before exertion	Pretest	14.3	1.24	0.400	0.124	3.225	0.003	Significant
	Posttest	14.7	0.43					
Hemoglobin after exertion	Pretest	15.6	2.12	0.600	0.167	3.592	0.001	Significant
	Posttest	16.2	0.29					
Performance endurance	Pretest	67.55	3.54	10.05	1.612	6.234	0.000	Significant
	Posttest	57.5	2.54					
Dribbling	Pretest	19.22	0.57	1.72	0.322	5.341	0.000	Significant
	Posttest	17.5	0.76					
Passing	Pretest	3.5	0.88	2.500	0.715	3.496	0.002	Significant
	Posttest	6.0	0.96					
Ball reception	Pretest	4.00	0.71	1.00	0.263	3.802	0.001	Significan

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Table (3) presents the statistical indicators of the pre- and posttest results for the physical and skill variables of the control group. The results revealed statistically significant differences between the pre- and posttests for the variables of hemoglobin, performance endurance, ball reception, dribbling, and passing. This was clearly demonstrated through the use of the t-test. The mean values obtained in the pre- and posttests for the variables of performance endurance and dribbling showed lower mean values in the posttests compared with the pretests. This is expected, as these variables are measured inversely by time; that is, a lower mean value indicates a better performance level. In contrast, the results showed that the mean values in the posttests for the passing and ball reception variables were higher than those of the pretests, which is a normal outcome, since the results of these tests depend on an increase in the number of successful repetitions or scores.

Presentation and Analysis of the Pre- and Posttest Results of Hemoglobin, Performance Endurance, and Offensive Skills for the Experimental Group

Table4. Shows the arithmetic means, standard deviations, mean differences, standard error of the differences, calculated *t*-values, significance levels, and type of statistical significance for the pre- and posttests of the research variables for the experimental group.

Variables	Test	Mean ($\bar{X}$)	SD	Mean Difference	SE of Difference	Calculated t-value	Sig. Level	Type of Significance
Hemoglobin before exertion	Pretest	14.2	1.56	1.20	0.154	7.792	0.000	Significant
	Posttest	15.4	0.35					
Hemoglobin after exertion	Pretest	15.5	2.78	1.10	0.215	5.116	0.000	Significant
	Posttest	16.6	0.27					
Performance endurance	Pretest	67.77	4.23	13.54	1.764	7.676	0.000	Significant
	Posttest	54.23	1.89					
Dribbling	Pretest	19.12	0.23	2.77	0.369	7.507	0.000	Significant
	Posttest	16.33	0.52					
Passing	Pretest	3.00	0.69	5.00	0.532	9.398	0.000	Significant
	Posttest	8.00	0.71					
Ball reception	Pretest	3.50	0.96	5.50	0.489	11.247	0.000	Significant
	Posttest	9.00	0.75					

Table (4) presents the statistical indicators of the pre- and posttest results for the variables of hemoglobin, performance endurance, ball reception, dribbling, and passing for the experimental group. The results revealed statistically significant differences between the pre- and posttests in favor of the posttests, as clearly demonstrated by the use of the t-test.

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The mean values for performance endurance and dribbling were lower in the posttests than in the pretests, since these variables are inversely measured by time; that is, a lower mean value in the posttest indicates a better performance level. In addition, the results showed statistically significant differences between the pre- and posttests in favor of the posttests for hemoglobin concentration, passing, and ball reception. The mean values of these variables were higher in the posttests than in the pretests, which is a normal and expected outcome, as the results of these tests depend on an increase in the number of successful repetitions or scores.

Presentation and Analysis of the Posttest Results of Hemoglobin, Performance Endurance, and Offensive Skills for the Control and Experimental Groups

Table5. Shows the arithmetic means, standard deviations, calculated *t*-values, significance levels, and type of statistical significance for the posttest comparisons between the control and experimental groups for the research variables.

Variables	Group	Mean ($\bar{X}$)	SD	Calculated t-value	Sig. Level	Type of Significance
Hemoglobin before exertion	Control	14.7	0.43	3.788	0.001	Significant
	Experimental	15.4	0.35			
Hemoglobin after exertion	Control	16.2	0.29	3.029	0.002	Significant
	Experimental	16.6	0.27			
Performance endurance	Control	57.5	2.54	3.099	0.002	Significant
	Experimental	54.23	1.89			
Dribbling	Control	17.5	0.76	3.812	0.001	Significant
	Experimental	16.33	0.52			
Passing	Control	6.0	0.96	5.025	0.000	Significant
	Experimental	8.0	0.71			
Ball reception	Control	5.0	0.83	10.727	0.000	Significant

Table (5) presents the statistical indicators of the posttest results for the variables of hemoglobin, performance endurance, ball reception, dribbling, and passing for the control and experimental groups. The results revealed statistically significant differences between the posttests of the control and experimental groups for these variables, in favor of the experimental group, as clearly demonstrated by the use of the *t*-test.

The mean values of the experimental group for the variables of dribbling and performance endurance were lower than those of the control group, since these variables are inversely measured by time; that is, the lower the mean value, the better the performance level. In addition, the results showed that the mean values of the experimental group for hemoglobin, passing, and

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ball reception were higher than those of the control group, which is a normal and expected outcome, as the results of these tests depend on an increase in the number of repetitions or scores.

Discussion

After presenting and analyzing the results of the pre- and postmeasurements of hemoglobin (Hb) concentration before and after exertion for the research sample, it was found that all participants demonstrated improvements in this variable before exertion. The researchers attribute the increase in blood hemoglobin concentration to several contributing factors, including proper nutrition rich in iron and other amino acids that play a role in elevating hemoglobin levels. Although the observed increase was relatively small, even a slight rise in hemoglobin (Hb) leads to an increase in blood oxygen saturation, as one gram of hemoglobin can bind with approximately 1.34 ml of oxygen. An increase during rest indicates an enhancement in the oxygen-carrying capacity of the blood, which represents a positive physiological adaptation. Risan Khuraibat and Ali Turki indicated that amino acids and iron ions are essential components in the formation of red blood cells and hemoglobin molecules, and that iron deficiency in daily nutrition leads to anemia, with the estimated daily iron requirement being approximately 1 mg; therefore, daily dietary intake must contain an adequate amount to meet the body's needs of this important compound (Risan Khuraibat & Ali Turki, 2002, p. 59).

On the other hand, the researchers note that the exercises applied to the experimental group had a clear effect on increasing blood volume. These exercises contributed to an increase in plasma volume and subsequently red blood cell count, which positively influenced cardiac efficiency and enhanced oxygen transport to body systems and muscles.

The researchers also attribute the improvement in performance endurance to the proposed training exercises, which enhanced the players' ability to sustain performance during play by working at high but submaximal intensity for longer durations and resisting fatigue resulting from exertion. This led to the development of physiological adaptations among the players. This finding is consistent with what was stated by Amr Allah Al-Bassati, who noted that directed physical exercises or efforts lead to functional adaptations in the body's internal systems to achieve a high level of sports performance (Amr Allah Al-Bassati, 1998, p. 3). Furthermore, the exercises prepared by the researchers were carefully selected according to a scientific perspective in terms of intensity and distances that match the specificity of the game. Mohammed Othman (1987) emphasized that when a coach is able to determine the appropriate timing for recovery phases,

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gradual increases in training load can be achieved within the training rhythm of physical performance (Mohammed Othman, 1987, p. 70).

The results also demonstrated statistically significant differences in offensive skills (dribbling, passing, and ball reception) in the posttests between the experimental and control groups, in favor of the experimental group. The researchers attribute this improvement to the effectiveness of lactate-resistance training applied to the experimental group, as these exercises possess distinctive characteristics and closely resemble real game situations due to their continuous use of the ball. This similarity enhances motivation and encourages players to exert maximum effort during training. Alfred Kunze (1980) emphasized that proper football training requires the ball to be the central focus of training, and that acquiring technical performance and playing ability necessitates precise observation and gradual physical conditioning within integrated technical and tactical training (Alfred Kunze, 1980, p. 22).

Moreover, the nature of the lactate-resistance exercises included in the training program was designed according to precise scientific principles, taking into account training load components such as progression and gradual increase in intensity in a manner suitable for the age group and performance level of the players. Adherence to the principles of sports training science leads to positive outcomes, as the success of training programs is measured by the extent of progress achieved by the athlete in skill, physical, and functional performance, which depends on the level of adaptation achieved through the applied training program. Abu Al-Ala and Ahmed Al-Nasr (1993) indicated that scientifically programmed training based on the principles of progression and gradual overload has positive effects on trainees, and that endurance training, in particular, produces tangible athletic development and creates favorable conditions for tactical understanding according to the type of sport practiced (Abu Al-Ala Ahmed & Nasr Al-Din Sayed, 1993, p. 192).

Offensive skills are considered fundamental skills in football, as players cannot perform their assigned duties without mastering them. The researchers believe that the observed development in these skills is attributed to their intensive use within the proposed training exercises, which led to significant improvements. Lactate-resistance training enhanced players' ball feel and passing distance perception, enabling accurate passing under pressure and improving decision-making in confined training areas. Ron Greenwood emphasized that training within limited spaces develops and teaches players passing accuracy (Ron Greenwood et al., 1989, p. 24). Therefore, coaches play a crucial role in guiding players toward mastering passing skills in all their forms.

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Furthermore, the development of football, whether in playing styles or tactical approaches, largely depends on players' mastery of basic skills, particularly offensive skills, which require precise timing and high sensitivity of all body parts to maintain ball possession. Ball reception skill involves bringing the ball under control and acting according to the team's tactical needs. The improvement in this skill can be attributed to the integration of skills with correct performance and quick decision-making at the appropriate time within training areas under real competitive pressure during ball possession. Hassan Abdul Jawad (1980) stated that the success of a player in executing any task depends on proper ball reception from any direction (Hassan Abdul Jawad, 1980, pp. 28–29). In addition, the adaptation of the experimental group players to the training program, which employed high-intensity interval training with appropriate intensity levels and suitable rest intervals, led to the development of specific endurance capacities that positively reflected on offensive skill performance.

Enhancing physical capacities is of great importance for football players and represents one of the fundamental characteristics of modern football. The ultimate goal of training is to enable athletes to reach optimal performance levels by creating harmony between their abilities and capacities and the applied training program.

Conclusions and Recommendations

Conclusions

The researchers concluded the following:

- The scientifically planned and systematically designed training exercises applied to the research sample contributed positively to the development of the study variables (hemoglobin concentration, performance endurance, and complex offensive skills).
- The training exercises significantly enhanced the efficiency of hemoglobin as a biological buffer through increased binding with hydrogen ions.
- Lactate-resistance training had a positive effect on improving performance endurance and selected offensive skills among under-21 football players.

Recommendations

- Rely on physiological measurements whenever possible, such as hemoglobin concentration, at regular intervals to scientifically monitor the development of athletes' capacities.
- Coaches are encouraged to benefit from these training exercises and incorporate them into their training programs in a manner consistent with preparation phases.
- It is recommended to examine the effects of these training exercises on other research variables in future studies.

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