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ORIGINAL

THE EFFECT OF SOME MODERN TRAINING METHODS ON THE TEMPORAL AND TECHNICAL PERFORMANCE IN THE 100-METER FREESTYLE SWIMMING RACE

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ABSTRACT

The research aims to identify the effect of some modern training methods on the temporal and technical performance in the 100-meter freestyle swimming race through the following methods: (interval training, training on swimming techniques including breathing and streamline improvement exercises, maximum speed training, and resistance training involving strength exercises). The researcher used the experimental method due to its suitability for the nature of the research, and adopted a quasi-experimental design with pre- and post-measurements for four experimental groups. The researcher selected a random sample of (40) students from the University of Kirkuk for the academic year 2024–2025. One of the most important conclusions was the presence of statistically significant differences at the level of (0.05) between the means of the pre- and post-tests for the experimental groups using (interval training, training on swimming techniques including breathing and streamline improvement exercises, maximum speed training, and resistance training involving strength exercises) in favor of the post-test mean in both the technical and temporal levels in the 100-meter freestyle swimming race. Interval training significantly outperformed (training on swimming techniques, maximum speed training, and resistance training) in the numerical level of the 100-meter freestyle swimming. Among the most important recommendations was relying on interval training within short-distance swimming programs due to its positive effect on developing anaerobic endurance and improving temporal

performance during race phases. It also recommended the use of maximum speed training to enhance swimmers' starts and increase the ability to finish the race at the highest possible speed, especially in the last 25 meters.

KEYWORDS: Modern Training Methods, 100-Meter Freestyle Swimming

1. INTRODUCTION

Swimming holds significant and distinctive importance among other sports due to the physical, psychological, and social benefits it provides to individuals. It also occupies a prominent position in international and Olympic rankings. The essential capabilities that a swimmer must possess include general and specific endurance, speed-strength, maximum speed, and flexibility considered among the most important physical attributes for swimmers. Swimming is also one of the leading individual sports characterized by a high level of competitiveness and requires advanced levels of physical and technical performance to achieve athletic excellence. The 100-meter freestyle race is considered one of the short-distance races that rely on maximum speed and technical control, making it one of the most demanding races in terms of training efficiency. Regular athletic training enhances the efficiency and adaptation of the body's various systems. This efficiency appears most directly in the muscular system's ability to generate muscular force, whether dynamic or static. This functional efficiency of the muscle is achieved through physiological changes resulting from training (Mohamed & Abou, 2004). Swimming training relies on a variety of training methods, and each coach selects the method that best suits the nature of the swimmers they train and the type of swimming they master. These methods aim to develop motor skills and physical components to the highest possible level. It is well-known that effective training for swimmers leads to the development and improvement of physiological variables that contribute to enhancing the physical and skillful competence of swimmers. Sports training depends on energy production systems; therefore, training methods appropriate for swimmers must be designed to elicit the correct physiological responses for these systems (Samira, 2016). All the objectives that the teacher wishes to achieve when giving educational lessons through the use of various teaching strategies and methods (Hussein et al., 2024). Hassan El-Din Bardan (Hassan, 2017) indicates that the optimal selection of suitable training methods and understanding the approaches and variables involved in each method, along with the ability to apply them in line with training directions, is essential. In recent years, sports training methods have witnessed significant development, supported by advances in motor sciences, sports physiology, and performance analysis. Relying solely on traditional programs is no longer sufficient to reach highly competitive levels. Instead, it has become necessary to employ modern training methods based on precise scientific foundations (Hassan, 2017). The old traditional methods adopted by the trainers do not induce appropriate

learning among students (Majed, 2022). In this research, the researcher has studied some modern training methods that can improve the temporal and technical performance of 100-meter freestyle swimmers, including:

- Interval Training: A training method that involves alternating between high-intensity effort periods and rest or low-intensity periods. It is used to develop aerobic and anaerobic capacities and aims to improve cardiovascular function, increase endurance and speed, and strengthen muscular endurance over short distances (Bompa & Buzzichelli, 2019).

- Maximum Speed Training: A type of training that focuses on performing at maximum possible speed in short repetitions. It targets the development of start speed, turns, and race finishes in swimming. It aims to improve wall push-off power, increase the efficiency of arm and leg movements at maximum speed, and strengthen the central nervous system's control over high-speed performance (Maglischo, 2003).

- Technique Training (Breathing and Streamline Improvement Drills): A training method that focuses on enhancing technical aspects of performance, such as coordinating breathing with movement, reducing water resistance, and increasing streamline, to improve mechanical efficiency in swimming. It aims to raise the swimmer’s breathing efficiency and timing, reduce energy consumption by improving body position in water, and enhance entry, pull, and glide techniques (Counsilman, 1968).

- Resistance Training (Strength Exercises): A type of training used to improve muscular strength and the ability to pull and push, through resistance exercises in or out of water. It aims to increase muscular strength in the arms and legs, enhance resistance against water, and achieve stronger propulsion, as well as strengthen trunk muscles to improve balance and streamline (Tanaka & Swensen, 1998).

1.1 Research Problem

Swimming is a sport that requires a high level of coordination between physical, motor, and technical abilities, especially in sprint races like the 100-meter freestyle, which is one of the main events in local and international championships. This race is characterized by its short duration and high intensity, making it heavily dependent on precision in motor performance, speed of completion, and technical efficiency simultaneously. Despite the continuous development in sports training methods, many coaches still rely on traditional training programs that focus on repetitive performance without taking into account the specific characteristics and physiological and technical requirements of modern races. This leads to slower-than-expected improvements in swimmers’ time performance or the emergence of technical errors that negatively impact performance efficiency. Additionally, the diversity

and variety of modern training methods—such as interval training, maximum speed training, resistance training, and technical training (breathing and streamline improvement) raise questions about the effectiveness of each and the impact of using them within integrated programs to improve real swimmer performance, particularly in short sprint races.

Through his practical experience, the researcher has observed that many students display weaknesses in precise technical aspects despite possessing physical capability, leading to a noticeable discrepancy between their time and technical performance. This indicates a flaw in the training method used and highlights the need to adopt modern and precisely targeted training methods according to the nature of the race.

These methods vary between interval training, which develops anaerobic endurance and sustained speed; maximum speed training, which enhances neuromuscular efficiency; technique training, which focuses on improving streamline and breathing timing; and resistance training, which contributes to increased muscle strength linked to motor performance in water. In light of this, the importance of this research lies in testing the effect of some of these modern methods on two fundamental variables in competitive swimming:

- Temporal performance (total time to finish the race)

- Technical performance (basic technical skills such as the start, streamline, motor coordination, breathing, etc.) This is to be achieved through an integrated training program directed at short-distance swimmers.

1.2 Research Objectives

The research aims to identify the effect of some modern training methods on the temporal and technical performance in the 100-meter freestyle swimming race through the following methods:

- Interval Training
- Technique Training (Breathing and Streamline Improvement Drills)
- Maximum Speed Training
- Resistance Training (Strength Exercises)

1.3 Research Hypotheses

- There are statistically significant differences between the pre- and post-tests for the first experimental group (using interval training) in the temporal and technical performance in the 100-meter freestyle race in favor of the post-test.

- There are statistically significant differences between the pre- and post-tests for the second experimental group (using technique training) in the

temporal and technical performance in the 100-meter freestyle race in favor of the post-test.

- There are statistically significant differences between the pre- and post-tests for the third experimental group (using maximum speed training) in the temporal and technical performance in the 100-meter freestyle race in favor of the post-test.

- There are statistically significant differences between the pre- and post-tests for the fourth experimental group (using resistance training) in the temporal and technical performance in the 100-meter freestyle race in favor of the post-test.

- There are statistically significant differences between the four groups (interval training, technique training, maximum speed training, resistance training) in the technical and temporal performance in the 100-meter freestyle race in the post-test.

2. Research Procedures

2.1 Research Methodology

The researcher used the experimental method due to its suitability for the nature of the research. The researcher adopted the experimental design with both pre- and post-measurements for four experimental groups.

2.1.1 Research Population and Sample

2.1.1.1 Research Population

The research population consists of students from the University of Kirkuk for the academic year 2024–2025.

2.1.1.2 Research Sample

The researcher randomly selected a sample of (40) students from the University of Kirkuk for the academic year 2024–2025. The sample was divided as follows:

- First Experimental Group: Composed of (10) students on whom the interval training method was applied.

- Second Experimental Group: Composed of (10) students on whom the training on swimming techniques (breathing and streamline improvement exercises) was applied.

- Third Experimental Group: Composed of (10) students on whom the maximum speed training method was applied.

• Fourth Experimental Group: Composed of (10) students on whom the resistance training (strength exercises) method was applied This is illustrated in Table (1).

Table 1: Description of the Research Sample.

CLASSIFICATION	NUMBER OF STUDENTS	PERCENTAGE
FIRST EXPERIMENTAL GROUP	10	%25
SECOND EXPERIMENTAL GROUP	10	%25
THIRD EXPERIMENTAL GROUP	10	%25
FOURTH EXPERIMENTAL GROUP	10	%25
TOTAL	40	%100

2.2 Statistical Description of the Research Sample

The basic variables of the sample (under study) were measured in terms of (age, weight, and height) in order to control the variables that might affect the research procedures. Table (2) below illustrates this.

Table 2: Statistical Significance of the Research Sample in the Basic Variables Before the Experiment (N = 40).

VARIABLE	UNIT OF MEASUREMENT	MEAN	MEDIAN	STANDARD DEVIATION	SKEWNESS	KURTOSIS
AGE	Years	17.63	17.00	0.56	0.94	0.93
WEIGHT	Kg	72.40	71.00	1.98	1.25	1.02
HEIGHT	cm	175.94	176.00	1.14	0.78	-0.63

It is clear from Table (2), which relates to the homogeneity of the research sample's data in the basic initial measurements, that the data of the overall research sample are moderate, non-dispersed, and characterized by a normal distribution. The skewness values range between (0.78 to 1.25), which are close to zero, and the kurtosis values range between (-0.63 to 1.02), indicating that the fluctuation of the normal curve is acceptable and average not skewed upward or downward. This confirms the similarity of the research sample members in the basic variables before the experiment.

2.2.1 Measurements and Tests Used in the Research

A. Measurement of Temporal Performance in the 100m Freestyle Swimming Race: This is the time the swimmer takes from the start until touching the pool wall at the end.

B. Measurement of Technical Performance in the 100m Freestyle Swimming Race (Under Study): The researcher measured the level of technical performance through a committee of experts consisting of three professors in swimming training. A technical performance evaluation form for the 100m

freestyle race was used, which includes the following phases:

- Start
- Streamlining
- Arm movement
- Leg movement
- Balance in the water
- Breathing timing
- Motor coordination

Each element was rated out of (10) points based on the experts' opinions. The researcher then calculated the arithmetic mean of the experts' scores for each stage of technical performance evaluation in the 100m freestyle race under study.

2.3 Training Program Using Modern Training Methods

2.3.1 Program Objective

To identify the impact of four modern training methods (Interval Training – Maximum Speed Training – Resistance Training – Technique Training) on improving the temporal and technical performance of swimmers in the 100-meter freestyle race, through applying specialized training programs based on each method to equivalent samples and comparing the results to determine the most effective methods.

2.3.2 Foundations for Designing the Program

- The program content should suit the students' level.
- Individual differences among students must be considered.
- The program content should challenge the students' abilities.
- The program should align with its objectives.
- The program must avoid boredom and attract students' interest in the learning process.
- Safety and security factors must be taken into account.
- Students should receive immediate feedback to support their correct or incorrect responses.

2.3.3 Time Distribution of the Proposed Training Program

Table 3(a): Time Distribution of Training Units in the Proposed Training Program

NO	ITEM DESCRIPTION	TIME DISTRIBUTION
1	Number of Weeks	(8) weeks
2	Number of Units in the Program	(16) units
3	Number of Units Per Week	(2) units

Table 3(b): Time Distribution of Training Units in the Proposed Training Program

NO	ITEM DESCRIPTION	TIME DISTRIBUTION
4	Duration of Each Training Unit	(90) minutes
5	Weekly Training Duration	(180) minutes
6	Total Duration of Program Implementation	(1440) minutes

It is evident from Table (3) that the duration of the program implemented in this study was eight (8) weeks, comprising sixteen (16) training units, at a rate of two units per week, with each unit lasting (90) minutes. Consequently, the total duration of the program amounted to (1440) minutes.

2.3.4 Method of Program Implementation

The researcher divided the research sample into four equal groups, each consisting of (10) students. Modern training methods were applied, with each group implementing a specific modern training method as follows:

- The first experimental group applied the program (using interval training).
- The second experimental group applied the program (using training on swimming techniques).
- The third experimental group applied the program (using maximum speed training).
- The fourth experimental group applied the program (using resistance training – strength exercises).

The researcher implemented the program at the following times:

- Academic year (2024–2025)
- The program was implemented during the period from 17/02/2025 to 27/04/2025
- The pre-measurements were conducted on 17/02/2025
- The program was applied from 25/02/2025 to 25/04/2025
- The post-measurements were conducted on 27/04/2025

2.4 Main Study

The main study was conducted during the period from 17/02/2025 to 27/04/2025, and the researcher will clarify that as follows:

Pre-measurement: The pre-measurements were conducted on 17/02/2025 for the variables under study on the research sample consisting of (40) students. They were divided into: (10) students in the first experimental group, (10) students in the second experimental group, (10) students in the third experimental group, and (10) students in the fourth experimental group. The measurements were carried out at the swimming pool of the University of Kirkuk for the pre-measurement phase.

2.4.1 Equivalence between the Four Experimental Groups:

Table 4: Equivalence between the Four Groups (Interval Training, Training on Swimming Techniques, Maximum Speed Training, Resistance Training) in Technical Performance in the 100-Meter Freestyle Race During the Pre-Measurement Before the Experiment.

TECHNICAL PERFORMANCE	SOURCE OF VARIANCE	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	F-VALUE	SIGNIFICANCE LEVEL
START	Between Groups	3	.675	.225	.448	.721
	Within Groups	36	18.100	.503		
	Total	39	18.775			
GLIDE	Between Groups	3	1.475	.492	.683	.568
	Within Groups	36	25.900	.719		
	Total	39	27.375			
ARM MOVEMENT	Between Groups	3	.500	.167	.145	.932
	Within Groups	36	41.400	1.150		
	Total	39	41.900			
LEG MOVEMENT	Between Groups	3	1.875	.625	.705	.555
	Within Groups	36	31.900	.886		
	Total	39	33.775			
BALANCE IN WATER	Between Groups	3	2.600	.867	1.139	.347
	Within Groups	36	27.400	.761		
	Total	39	30.000			
BREATHING TIMING	Between Groups	3	1.000	.333	.237	.870
	Within Groups	36	50.600	1.406		
	Total	39	51.600			
MOTOR ALTERNATION	Between Groups	3	2.475	.825	2.077	.120
	Within Groups	36	14.300	.397		
	Total	39	16.775			

Significant at the 0.05 level – Tabulated (F) value at the 0.05 level = 2.886

It is clear from Table (4), which presents the ANOVA analysis between the four groups (interval training, swimming technique training, maximum speed training, and resistance training) in the technical performance in the 100-meter freestyle swim for the pre-test measurement of the research sample, that there are no statistically significant differences between the four groups in technical performance in the 100-meter freestyle swim. The F-values ranged between (0.145 to 2.077), which are all lower than the tabulated (F) value at the 0.05 level, indicating the equivalence of the four groups in technical performance in the 100-meter freestyle swim before the experiment.

Table 5: Equivalence between the Four Groups (Interval Training, Swimming Technique Training, Maximum Speed Training, Resistance Training) in Time Performance in the 100-Meter Freestyle Swim for the Pre-Test Measurement Before the Experiment.

VARIABLE	SOURCE OF VARIANCE	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	F-VALUE	SIGNIFICANCE LEVEL
100M FREESTYLE SWIMMING TIME	Between groups	3	3.800	1.267	.591	.625
	Within groups	36	77.100	2.142		
	Total	39	80.900			

Significant at the 0.05 level – Tabulated (F) value at the 0.05 level = 2.886

It is clear from Table (5), which presents the analysis of variance (ANOVA) between the four groups (interval training, swimming techniques training, maximum speed training, resistance training) in the numerical level of the 100m freestyle swimming in the pre-test for the research sample, that there are no statistically significant differences between the four groups in the numerical level of the 100m freestyle swimming.

The F value reached (0.591), which is less than the tabulated F value at the 0.05 significance level, indicating that the four groups are equivalent in the numerical level of 100m freestyle swimming before the experiment.

Program Implementation: The proposed program was applied to the four groups, consisting of (40) students with (10) students in each group. The proposed training program was implemented over a period of 8 weeks, from February 25, 2025, to April 24, 2025, at a rate of (2) units per week on the main sample (the four experimental groups).

Post-Test Measurement: Post-test measurements of the variables under study were conducted on the members of the research sample on April 27, 2025, and the measurements were carried out at the University of Kirkuk swimming pool.

Statistical Treatments Used in the Research:

- Arithmetic Mean
- Standard Deviation
- Median
- Skewness Coefficient
- Kurtosis Coefficient
- T-test
- One-Way Analysis of Variance (ANOVA)

3. Presentation and Discussion of Results

First: Presentation and discussion of the results of the first hypothesis: There are statistically significant differences between the pre-test and post-test measurements of the first experimental group (using interval training) in the level of time performance and technical performance in the 100m freestyle swim, in favor of the post-test.

Table 6: Statistical Significance of the (T) Test Differences between Pre-test and Post-Test in Technical and Time Performance in the 100m Freestyle Swim and Percentage of Improvement for the First Experimental Group Using Interval Training (n = 10).

VARIABLES	UNIT OF MEASUREMENT	EXPERIMENTAL GROUP (INTERVAL TRAINING)				T VALUE	SIGNIFICANCE LEVEL	IMPROVEMENT PERCENTAGE
		Pre-Test		Post-Test				
		Mean	SD	Mean	SD			
START	Degree	4.00	0.67	8.00	0.82	15.49	0.00	100%
STREAMLINING	Degree	3.50	0.71	7.60	0.84	11.78	0.00	117.14%
ARM MOVEMENT	Degree	3.40	1.17	6.90	1.10	8.17	0.00	102.94%
LEG MOVEMENT	Degree	3.80	1.03	8.10	0.88	9.59	0.00	113.16%
WATER BALANCE	Degree	3.20	0.92	6.90	0.74	12.33	0.00	115.63%
BREATHING TIMING	Degree	2.90	1.20	6.20	1.32	5.91	0.00	113.79%
MOTOR ALTERNATION	Degree	3.40	0.52	7.30	1.25	9.00	0.00	114.71%
NUMERICAL LEVEL OF 100M FREESTYLE	Seconds	70.55	1.42	62.00	1.25	24.21	0.00	12.12%

The (T) value at a significance level (0.05) = 2.262

It is clear from the results of Table (6) that there are statistically significant differences at the level of (0.05) between the mean scores of the pre-test and post-test measurements for the first experimental group using interval training, in favor of the post-test mean in the technical and time levels in the 100m freestyle swimming race. The calculated "T" value ranged between (5.91: 24.21), with an improvement percentage ranging between (12.12%: 117.14%). The results indicate that interval training led to comprehensive improvement in all variables, both technical and time-related, with high statistical significance. This is confirmed by most studies, which emphasize that interval training is one of the effective training methods for developing performance components in swimming, especially for short distances like the 100-meter freestyle. This aligns with the study by Hassan Al-Wudayan and Amjad Al-Mudannat (Hassan & Amjad, 2011), which showed differences in the level of performance improvement in the 100m freestyle crawl stroke post-test, attributed to the effect of both interval and continuoustraining methods, in favor of interval training. It also agrees with the results of the study by Zaid Ahmed Al-Lubani (Zaid, 2017), which showed differences between pre- and post-test results in favor of the post-test for the 100m freestyle swimming test. It is also consistent with the findings of the study by Hatem Hosni Youssef (Hatem, 2019), which demonstrated the positive impact of the proposed program on improving swimmers' numerical level. The researcher believes that the high improvement percentages (exceeding 100% in some variables) indicate that the trainees were not in peak physical or technical readiness at the beginning, which allowed ample room for improvement when a scientific program was applied.

Second: Presentation and Discussion of the Results of the Second Hypothesis: There are statistically significant differences between the pre- and post-test measurements of the second experimental group (using training on swimming techniques) in the time and technical performance level in the 100m freestyle swimming race, in favor of the post-test.

Table 7(a): Statistical significance of (T) Test Differences Between Pre- and Post-Test in the Technical and Time Levels in the 100m Freestyle Swimming Race and Improvement Percentage for the Second Experimental Group Using Training on Swimming Techniques (n = 10).

VARIABLES	UNIT OF MEASUREMENT	THE EXPERIMENTAL GROUP (TRAINING ON SWIMMING TECHNIQUES)				T VALUE	SIGNIFICANCE LEVEL	IMPROVEMENT PERCENTAGE
		Pre-test		Post-test				
		Mean	SD	Mean	SD			
START	Degree	4.00	0.47	7.20	1.14	9.80	0.00	80%
STREAMLINING	Degree	3.60	0.70	6.80	0.92	8.23	0.00	88.89%

Table 7(b): Statistical significance of (T) Test Differences Between Pre- and Post-Test in the Technical and Time Levels in the 100m Freestyle Swimming Race and Improvement Percentage for the Second Experimental Group Using Training on Swimming Techniques (n = 10).

VARIABLES	UNIT OF MEASUREMENT	THE EXPERIMENTAL GROUP (TRAINING ON SWIMMING TECHNIQUES)				T VALUE	SIGNIFICANCE LEVEL	IMPROVEMENT PERCENTAGE
		Pre-test		Post-test				
		Mean	SD	Mean	SD			
ARM MOVEMENT	Degree	3.50	1.18	5.90	0.74	5.31	0.00	68.57%
LEG MOVEMENT	Degree	3.90	0.99	7.10	0.99	9.80	0.00	82.05%
WATER BALANCE	Degree	3.30	0.95	6.40	0.52	9.86	0.00	93.94%
BREATHING TIMING	Degree	3.20	1.32	5.60	0.84	5.62	0.00	75%
MOTOR ALTERNATION	Degree	3.70	0.48	6.50	0.97	6.73	0.00	75.68%
NUMERICAL LEVEL OF 100M FREESTYLE	Seconds	70.35	1.63	63.40	1.07	11.44	0.00	9.88%

The (T) value at a significance level (0.05) = 2.262

It is evident from the results of Table (7) that there are statistically significant differences at the (0.05) level between the mean scores of the pre-test and post-test for the second experimental group that used swim technique training, in favor of the post-test average in the technical and time performance levels in the 100m freestyle swim. The calculated "t" value ranged between (5.31: 11.44), with an improvement percentage ranging between (9.88%: 93.64%). In this regard, McMaster & Osborne (McMaster & Osborne, 2021) indicated in their study that improving the start can provide a critical time advantage in sprint races, which confirms the importance of technical training for race starts. Additionally, the results of the study by Trowbridge et al. (Trowbridge et al., 2022) stated that technical training improves swimming efficiency and reduces the overall time. The researcher believes that the swim technique training method is one of the most effective approaches in developing the fine aspects of motor performance, and it also contributes to improving mechanical and motor elements that cannot be developed by endurance or speed training alone.

Third: Presentation and discussion of the results of the third hypothesis: There are statistically significant differences between the pre-test and post-test for the third experimental group (using maximum speed training) in the technical and time performance levels in the 100m freestyle swim, in favor of the post-test.

Table 8: Statistical Significance of the Differences Using The (T) Test Between the Pre-Test and Post-Test in the Technical and Time Performance Levels in the 100m Freestyle Swim and the Improvement Percentage for the Third Experimental Group That Used Maximum Speed Training (n = 10).

VARIABLES	UNIT OF MEASUREMENT	THE EXPERIMENTAL GROUP (MAXIMUM SPEED TRAINING)				T VALUE	SIGNIFICANCE LEVEL	IMPROVEMENT PERCENTAGE
		Pre-Test		Post-Test				
		Mean	SD	Mean	SD			
START	Degree	4.00	0.94	6.50	0.97	5.84	0.00	62.50%
STREAMLINING	Degree	3.30	0.95	6.10	0.74	7.20	0.00	84.85%
ARM MOVEMENT	Degree	3.30	0.95	5.70	0.48	7.06	0.00	72.73%
LEG MOVEMENT	Degree	4.10	0.74	6.30	0.67	6.13	0.00	53.66%
WATER BALANCE	Degree	2.80	0.92	5.60	0.52	11.22	0.00	100%
BREATHING TIMING	Degree	3.00	1.05	5.20	0.92	6.13	0.00	73.33%
MOTOR ALTERNATION	Degree	3.10	0.57	5.80	0.79	12.65	0.00	87.10%
NUMERICAL LEVEL OF 100M FREESTYLE	Seconds	71.05	1.38	64.00	0.94	13.59	0.00	9.92%

The (T) value at a significance level (0.05) = 2.262

It is evident from the results of Table (8) that there are statistically significant differences at the level (0.05) between the means of the pre- and post-test scores for the third experimental group using maximum speed training, in favor of the post-test mean in the technical and temporal performance in the 100m freestyle swimming event. The calculated "t" value ranged between (5.84: 13.59), with an improvement percentage ranging from (9.92%: 100%). In this regard, the results of the study by Barbosa (Barbosa, 2010) confirmed that the strong improvement reflects the technical-motor adaptation resulting from the high repetition of movements at maximum speed, and that maximum speed training contributed to the development of motor coordination and movement speed during underwater performance. The researcher believes that maximum speed training has proven highly effective in improving the technical aspects of swimmers, especially balance, motor alternation, and streamlining, while its impact was relatively less on the digital time and leg movements.

Fourth: Presentation and Discussion of the Fourth Hypothesis Results: There are statistically significant differences

between the pre- and post-tests for the fourth experimental group (using resistance training - strength exercises) in the technical and temporal performance in the 100m freestyle swimming event, in favor of the post-test.

Table 9: (a) Statistical Significance of the (T) Test Between the Pre- and Post-Tests in the Technical and Temporal Performance in the 100m Freestyle Swimming Event and the Improvement Percentage for the Fourth Experimental Group Using Resistance Training - Strength Exercises (n = 10)

VARIABLES	UNIT OF MEASUREMENT	THE EXPERIMENTAL GROUP (RESISTANCE TRAINING)				T VALUE	SIGNIFICANCE LEVEL	IMPROVEMENT PERCENTAGE
		Pre-test		Post-test				
		Mean	SD	Mean	SD			
START	Degree	3.70	0.67	6.40	1.07	8.06	0.00	72.97%
STREAMLINING	Degree	3.10	0.99	6.20	0.42	9.86	0.00	100%
ARM MOVEMENT	Degree	3.60	0.97	5.50	0.53	6.04	0.00	52.78%
LEG MOVEMENT	Degree	3.50	0.97	5.70	0.67	8.82	0.00	62.86%
WATER BALANCE	Degree	2.70	0.67	5.90	0.74	24.00	0.00	118.52%
BREATHING TIMING	Degree	3.30	1.16	5.50	0.97	5.28	0.00	66.67%
MOTOR ALTERNATION	Degree	3.10	0.88	6.00	0.94	8.33	0.00	93.55%

Table 9: (b) Statistical Significance of the (T) Test Between the Pre- and Post-Tests in the Technical and Temporal Performance in the 100m Freestyle Swimming Event and the Improvement Percentage for the Fourth Experimental Group Using Resistance Training - Strength Exercises (n = 10)

VARIABLES	UNIT OF MEASUREMENT	THE EXPERIMENTAL GROUP (RESISTANCE TRAINING)				T VALUE	SIGNIFICANCE LEVEL	IMPROVEMENT PERCENTAGE
NUMERICAL LEVEL OF 100M FREESTYLE	Seconds	70.25	1.40	64.10	0.74	14.57	0.00	8.75%

The (T) value at a significance level (0.05) = 2.262

It is evident from the results of Table (9) that there are statistically significant differences at the (0.05) level between the means of the pre-test and post-test scores for the fourth experimental group that used resistance training (strength exercises), in favor of the post-test mean in both the technical and time performance levels in the 100m freestyle swimming race. The

calculated "T" values ranged between (5.28: 24.00), with an improvement percentage ranging between (8.75%: 118.52%). Water balance represents the greatest improvement in this table, reflecting the significant effect of strengthening the core and back muscles, which play a key role in stability in water. This is confirmed by the results of Willardson's study (Willardson, 2007), which stated that resistance exercises enhance the efficiency of the deep muscles responsible for dynamic stability. The researcher believes that resistance training has an effective impact on improving technical aspects related to balance, coordination, and streamlining. However, it needs to be integrated with technical training to improve arm movements and breathing timing. Additionally, the positive effect on time performance reflects the importance of this type of training as a supportive element within combined programs.

Fifth: Presentation and Discussion of the Fifth Hypothesis Results: There are statistically significant differences between the four groups (interval training, swimming techniques training, maximum speed training, and resistance training) in the technical and time performance levels in the 100m freestyle swimming race in the post-test measurement.

Table 10(a): ANOVA analysis Between the Four Groups (Interval Training, Swimming Techniques Training, Maximum Speed Training, Resistance Training) in the Technical Performance of the 100m Freestyle Swimming Race in the Post-Test Measurement.

TECHNICAL PERFORMANCE	SOURCE OF VARIANCE	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	F-VALUE	SIGNIFICANCE LEVEL
START	Between Groups	3	16.475	5.492	5.416*	.004
	Within Groups	36	36.500	1.014		
	Total	39	52.975			
GLIDE	Between Groups	3	14.275	4.758	8.356*	.000
	Within Groups	36	20.500	.569		
	Total	39	34.775			
ARM MOVEMENT	Between Groups	3	11.600	3.867	*6.824	.001
	Within Groups	36	20.400	.567		
	Total	39	32.000			
LEG MOVEMENT	Between Groups	3	32.400	10.800	16.200*	.000
	Within Groups	36	24.000	.667		
	Total	39	56.400			

Table 10(b): ANOVA analysis Between the Four Groups (Interval Training, Swimming Techniques Training, Maximum Speed Training, Resistance Training) in the Technical Performance of the 100m Freestyle Swimming Race in the Post-Test Measurement.

TECHNICAL PERFORMANCE	SOURCE OF VARIANCE	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	F-VALUE	SIGNIFICANCE LEVEL
BALANCE IN WATER	Between Groups	3	9.800	3.267	8.055*	.000
	Within Groups	36	14.600	.406		
	Total	39	24.400			
BREATHING TIMING	Between Groups	3	5.275	1.758	1.661	.193
	Within Groups	36	38.100	1.058		
	Total	39	43.375			
MOTOR ALTERNATION	Between Groups	3	13.400	4.467	*4.442	.009
	Within Groups	36	36.200	1.006		
	Total	39	49.600			

Significant at the 0.05 level – Tabulated (F) value at the 0.05 level = 2.886

It is clear from Table (10), which presents the Analysis of Variance (ANOVA) between the four groups (interval training, swimming techniques training, maximum speed training, resistance training) in technical performance in the 100-meter freestyle swimming event for the post-test measurement of the research sample, that there are statistically significant differences between the four groups in technical performance. The F values ranged between (4.442 to 16.200), which is greater than the tabulated F value at the 0.05 significance level, except for (breathing timing), where the F value reached (1.661). To determine the significance of the differences between the four groups (interval training, swimming techniques training, maximum speed training, resistance training) in technical performance in the 100-meter freestyle swimming event, the Least Significant Difference (LSD) test was used, as shown in Table (11).

Table 11: (a) Significance of the Differences Between the Four Groups (Interval Training, Swimming Techniques Training, Maximum Speed Training, Resistance Training) in Technical Performance in the 100-Meter Freestyle Swimming Event Using the LSD Test

TECHNICAL PERFORMANCE	GROUPS	MEAN	STANDARD DEVIATION	SIGNIFICANCE OF DIFFERENCES BETWEEN MEANS				LSD VALUE
				Interval	Swimming Techniques	Maximum Speed	Resistance Training	
START	Interval Training	8.00	0.82		0.80	1.50*	1.60*	0.234
	Swimming Techniques	7.20	1.14			0.70	0.80	
	Maximum Speed	6.50	0.97				0.10	
	Resistance Training	6.40	1.07					
GLIDE	Interval Training	7.60	0.84		.80*	1.50*	1.40*	0.277
	Swimming Techniques	6.80	0.92			.70*	0.60	
	Maximum Speed	6.10	0.74				-0.10	
	Resistance Training	6.20	0.42					
ARM MOVEMENT	Interval Training	6.90	1.10		1.00*	1.20*	1.40*	0.120
	Swimming Techniques	5.90	0.74			0.20	0.40	
	Maximum Speed	5.70	0.48				0.20	
	Resistance Training	5.50	0.53					
LEG MOVEMENT	Interval Training	8.10	0.88		1.00*	1.80*	2.40*	0.301
	Swimming Techniques	7.10	0.99			.80*	1.40*	
	Maximum Speed	6.30	0.67				0.60	
	Resistance Training	5.70	0.67					
BALANCE IN WATER	Interval Training	6.90	0.74		0.50	1.30*	1.00*	0.299
	Swimming Techniques	6.40	0.52			.80*	0.50	
	Maximum Speed	5.60	0.52				-0.30	
	Resistance Training	5.90	0.74					

Table 11: (b) Significance of the Differences Between the Four Groups (Interval Training, Swimming Techniques Training, Maximum Speed Training, Resistance Training) in Technical Performance in the 100-Meter Freestyle Swimming Event Using the LSD Test

TECHNICAL PERFORMANCE	GROUPS	MEAN	STANDARD DEVIATION	SIGNIFICANCE OF DIFFERENCES BETWEEN MEANS				LSD VALUE
				Interval	Swimming Techniques	Maximum Speed	Resistance Training	
BREATHING TIMING	Interval Training	6.20	1.32		0.60	1.00*	0.70	0.320
	Swimming Techniques	5.60	0.84			0.40	0.10	
	Maximum Speed	5.20	0.92				-0.30	
	Resistance Training	5.50	0.97					
MOTOR ALTERNATION	Interval Training	7.30	1.25		0.80	1.50*	1.30*	0.209
	Swimming Techniques	6.50	0.97			0.70	0.50	
	Maximum Speed	5.80	0.79				-0.20	
	Resistance Training	6.00	0.94					

It is evident from Table No. (11), which presents the significance of differences between the measurements of the four groups (interval training, swimming technique training, maximum speed training, resistance training) in the technical performance of the 100-meter freestyle race for the research sample using the Least Significant Difference (LSD) test, that:

- *Interval training* significantly outperformed *maximum speed training* and *resistance training* in the phases of (start, water balance, and motor alternation).
- *Interval training* significantly outperformed *swimming technique training*, *maximum speed training*, and *resistance training* in the phase of (streamlining).
- *Swimming technique training* significantly outperformed *maximum speed training* and *resistance training* in the phase of (streamlining).
- *Interval training* significantly outperformed *swimming technique training*, *maximum speed training*, and *resistance*

training in the phases of (arm movement and leg movement).

- *Swimming technique training* significantly outperformed *maximum speed training* and *resistance training* in the phase of (leg movement).
- *Swimming technique training* significantly outperformed *maximum speed training* in the phase of (water balance).

Through the analysis of the table, it is clear that *interval training* was the most effective training method in improving all indicators of technical performance, significantly surpassing the other methods, especially *resistance training*, which—despite contributing to strength development—did not achieve the same efficiency in the precise indicators of skill performance. This was confirmed by the results of Ahmed Mostafa's study (Ahmed, 2021). This can be explained by the fact that interval training provides a mix of intensity and rest, allowing the improvement of both aerobic and anaerobic capacity simultaneously, which directly reflects on performance in sprint events such as the 100m freestyle.

Table 12: Analysis of Variance (ANOVA) between the Four Groups (Interval Training, Swimming Technique Training, Maximum Speed Training, Resistance Training) in Time Performance in the 100-Meter Freestyle Race for the Post-Test Measurement.

VARIABLE	SOURCE OF VARIANCE	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	F-VALUE	SIGNIFICANCE LEVEL
100M FREESTYLE SWIMMING TIME	Between Groups	3	28.075	9.358	9.032*	.000
	Within Groups	36	37.300	1.036		
	Total	39	65.375			

Significant at the 0.05 level – Tabulated (F) value at the 0.05 level = 2.886

It is evident from Table (12), which presents the Analysis of Variance (ANOVA) between the four groups (interval training, swimming technique training, maximum speed training, resistance training) in the time performance of the 100-meter freestyle race for the post-test measurement of the research sample, that there are statistically significant differences between the four groups in the time performance of the 100-meter freestyle race. The calculated F-value was (9.032), which is greater than the critical F-value at the 0.05 significance level.

To determine the significance of the differences between the four groups (interval training, swimming technique training, maximum speed training, resistance training) in the time performance of the 100-meter freestyle race, the Least Significant Difference (LSD) test was used, as shown in Table (13):

Table 13: Significance of the Differences Between the Four Groups (Interval Training, Swimming Technique Training, Maximum Speed Training, Resistance Training) in the Numerical Level of the 100-Meter Freestyle Race Using the Least Significant Difference (LSD) test.

VARIABLE	GROUPS	MEAN	STANDARD DEVIATION	SIGNIFICANCE OF DIFFERENCES BETWEEN MEANS				LSD VALUE
				Interval	Swimming Techniques	Maximum Speed	Resistance Training	
NUMERICAL LEVEL OF 100M FREESTYLE SWIMMING	Interval Training	62.00	1.25		-1.40-*	-2.00-*	-2.10-*	0.351
	Swimming Techniques	63.40	1.07			-0.60	-0.70	
	Maximum Speed	64.00	0.94				-0.10	
	Resistance Training	64.10	0.74					

It is evident from Table No. (13), which addresses the significance of the differences between the four groups (interval training, technique-focused swimming training, maximum speed training, and resistance training) in the performance level of the 100-meter freestyle swimming event for the study sample using the Least Significant Difference (LSD) test, that:

- Interval training significantly outperformed technique-focused training, maximum speed training, and resistance training in the performance level of the 100m freestyle.

In this regard, the findings of the study by Hassan Al-Wadayan and Amjad Al-Mudannat (Hassan & Amjad, 2011) confirmed the presence of differences in performance improvement times in the 100m front crawl event in the post-measurement, attributed to the impact of both interval and continuous training methods, with a preference for interval training.

4. Conclusions

In light of the research objectives and hypotheses, and within the limits of the research sample and methodology used, and based on the statistical analysis and results, the researcher reached the following conclusions:

- There were statistically significant differences at the level of (0.05) between the pre- and post-test means for the first experimental group (interval training), in favor of the post-test average in both technical and time performance in the 100m freestyle event.

- Interval training contributed to the improvement of technical performance in the 100m freestyle by a percentage ranging from 100% to 117.14%.

- Interval training improved the numerical performance (timing) in the 100m freestyle by 12.12%.

- There were statistically significant differences at the level of (0.05) between the pre- and post-test means for the second experimental group (technique-focused training), in favor of the post-test in technical and time performance in the 100m freestyle.

- Technique-focused training helped improve technical performance by 68.57% to 93.64%.

- Technique-focused training improved the numerical performance of the 100m freestyle by 9.88%.

- There were statistically significant differences at the level of (0.05) between the pre- and post-test means for the third experimental group (maximum speed training), in favor of the post-test in technical and time performance in the 100m freestyle.

- Maximum speed training improved technical performance by 53.66% to 100%.

- Maximum speed training improved numerical performance by 9.92%.

- There were statistically significant differences at the level of (0.05) between the pre- and post-test means for the fourth experimental group (resistance training with strength exercises), in favor of the post-test in technical and time performance in the 100m freestyle.

- Resistance training with strength exercises improved technical performance by 52.78% to 118.52%.

- Resistance training with strength exercises improved numerical performance by 8.75%.

- Interval training significantly outperformed maximum speed training and resistance training in the stages of start, water balance, and motor coordination.

- Interval training significantly outperformed technique-focused training, maximum speed training, and resistance training in the streamlining phase.

- Technique-focused training significantly outperformed maximum speed training and resistance training in the streamlining phase.

- Interval training significantly outperformed all other groups in arm movement and leg movement phases.

- Technique-focused training significantly outperformed maximum speed training and resistance training in the leg movement phase.

- Technique-focused training significantly outperformed maximum speed training in water balance.

- Interval training significantly outperformed all other groups in numerical performance in the 100m freestyle.

5. Recommendations

Based on the results obtained and within the framework of the conclusions reached, the researcher recommends the following:

- Rely on interval training within short-distance swimming programs due to its positive impact on improving anaerobic endurance and performance time in race stages.

- Use maximum speed training to enhance swimmers' starts and increase their ability to finish the race at the highest possible speed, especially in the final 25 meters.

- Integrate resistance training (strength exercises) periodically within the training program to develop the muscle strength responsible for propulsion and gliding. It's important to use various resistance tools (e.g., resistance bands, aquatic resistance).

- Focus on technique training (streamlining, breathing, movement timing), due to its clear effect in improving technical performance and reducing race time by minimizing water resistance.

- Design integrated training programs that combine all four methods in a

scientifically progressive sequence to ensure comprehensive development of the swimmer's physical, technical, and timing aspects.

- Conduct regular technical performance analysis tests (e.g., slow-motion video, streamlining angle analysis) during the training program to monitor technical progress and allow for timely corrections.

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