HJSE 5 (2) (2026)

HOLISTIC JOURNAL OF SPORT EDUCATION

http://journal.uniga.ac.id/index.php/penjas

A COMPARATIVE STUDY OF EFFECT OF PLYOMETRIC, MAXIMAL STRENGTH, AND POWER TRAINING ON TEMPORAL AND TECHNICAL PERFORMANCE OF 50M FREESTYLE SWIMMERS

Maan Hasan Mahmood[1], Maad Abed Ibrahim[2]
[1,2] Faculty of Physical Education and Sports Sciences, University of Kirkuk, Iraq

Kata kunci:
Latihan Pliometrik, Kekuatan Maksimal, Daya, Renang.

ABSTRAK

Penelitian ini bertujuan untuk mengidentifikasi pengaruh tiga metode latihan kekuatan, yaitu latihan pliometrik, latihan kekuatan maksimal, dan latihan daya, terhadap performa teknis dan temporal perenang gaya bebas 50 meter muda. Peneliti menggunakan desain eksperimental dengan tiga tes pra dan pasca. Sampel terdiri dari 45 perenang yang dibagi secara acak menjadi tiga kelompok yang sama. Setiap kelompok mengikuti program latihan yang berbeda untuk durasi tertentu sambil melanjutkan latihan akuatik reguler mereka. Beberapa variabel teknis diukur, yaitu start, aliran, gerakan lengan dan kaki, menjaga keseimbangan di dalam air, mengatur waktu pernapasan, dan mengubah gerakan, selain performa perenang gaya bebas 50 meter. Hasil menunjukkan perbedaan yang signifikan secara statistik antara tes pra dan pasca, dengan skor tes pasca lebih tinggi di ketiga kelompok. Perbedaan signifikan juga ditemukan antar kelompok dalam skor tes pasca, dengan kelompok latihan daya lebih tinggi, diikuti oleh kelompok latihan pliometrik, dan kemudian kelompok latihan kekuatan maksimal. Penelitian menyimpulkan bahwa pengembangan kekuatan otot yang terkait dengan kecepatan produksi gaya merupakan faktor paling berpengaruh dalam meningkatkan performa dalam lomba sprint jarak pendek. Penelitian merekomendasikan perlunya memasukkan latihan kekuatan ke dalam program pelatihan untuk perenang gaya bebas 50 meter.

Keywords:
Plyometric, Maximum Strength, Power, Swimming

ABSTRACT

This research aimed to identify effect of three strength training methods plyometric training, maximal strength training, and power training on technical and temporal performance of young 50-meter freestyle swimmers. the researcher employed an experimental design with three pre- and post-tests. sample consisted of 45 swimmers randomly divided into three equal groups. Each group followed a different training program for a specific duration while continuing their regular aquatic training. Several technical variables were measured start, Flow, moving your arms and legs, staying balanced in water, timing your breathing, and changing your movement, in addition to

		swimmer's 50-meter freestyle performance. results showed statistically significant differences between pre- and post-tests, favoring post-test scores in all three groups. Significant differences were also found between groups in post-test scores, favoring power training group, followed by plyometric training group, and then maximal strength training group. research concluded that developing muscular power associated with speed of force production is most influential factor in improving performance in short-distance sprint races. research recommended need to incorporate power training into training programs for 50-meter freestyle swimmers.		
Article Information		Received: 27 March 2026	Accepted: 5 April 2026	Published: 6 April 2026

Korespondensi Penulis:
Maan Hasan Mahmood
Email: Maanhasan@uokirkuk.edu.iq

INTRODUCTION

Swimming is a competitive sport that has witnessed remarkable scientific development in recent decades, as achieving numerical success depends on integration of physical, skill, physiological and mechanical preparation Most swimming competitions, like the 50-meter freestyle, require physically demanding abilities., as it is characterized by a short performance time and high requirements for strength and speed, making it an ideal applied model for studying effect of different strength training patterns on numerical success (Ganchar et al., 2022; Matitaputty, 2020; Norberto et al., 2020). 50-meter freestyle represents pinnacle of anaerobic performance, with a duration ranging from approximately 23 to 35 seconds depending on age and competitive level. It relies primarily on explosive muscle power, rate of strength development, and technical proficiency during start, swim, and finish phases. Due to short race time, even a fraction of a second's improvement can significantly impact rankings, highlighting importance of selecting optimal training method for developing performance-related strength. (Arabi, 2016: 47)

Modern trends in sports training indicate that muscular strength is no longer measured solely by maximum force that can be produced, but also by athlete's ability to generate force in shortest possible time (Apriandi et al., 2023; Ivanov, 2025; Zulnadila et al., 2025). This has led to emergence of concepts such as power, rate of force development and plyometric training as strategies aimed at improving explosive power associated with rapid motor performance (Al-Wadiyan & Al-Madinat, 2011: 82). Maximum strength training is a traditional method for developing muscle strength. It relies on using high resistances ranging from 85–95% of one maximum repetition (1RM) to increase muscle cross-sectional area and improve neural recruitment of motor units. Although effective in raising baseline strength, extent to which its effect translates to rapid motor performance is still debated, especially in activities that require production of rapid force in a very short time, such as swimming 50 meters. (Sabah, 2010: 26)

Based on stretch-shortening cycle principle, where elastic energy stored in muscles and tendons is utilized to produce a rapid explosive movement. This type of training is widely used in sports that rely on jumping and starting, and many studies have indicated its effectiveness in improving explosive power and reaction time, two crucial elements in start and wall propulsion phases of swimming (Tarawneh, 2019: 41). Power training represents link between maximum strength and movement speed. It is performed using moderate resistances (30–60% of 1RM) while executing movement at maximum possible speed. This method aims to improve mechanical power output i.e., product of power and speed, which closely matches nature of performance in 50-meter freestyle race, which requires producing high power with a high contraction speed (Al-Hafnawi,

2005: 36). From a biomechanical perspective, performance in 50-meter freestyle depends on several technical indicators, such as stroke length, stroke rate, start time, time to complete first 15 meters, and efficiency of finish phase. Each of these variables is affected by swimmer's level of muscular strength and explosive power, which underscores importance of studying relationship between different strength training patterns and accompanying technical changes. (Al-Beek, 2005: 91)

Despite numerous studies that have examined impact of strength training on athletic performance in general, direct comparisons between plyometric training, maximal strength training, and power training in context of 50-meter freestyle swimming are still limited, especially with regard to simultaneous impact on time performance and technical indicators. From this standpoint, importance of conducting a comparative study aimed at identifying which of these training methods is most effective in improving It is clear how young 50-meter freestyle swimmers perform both technically and temporally. In order to guide training process on accurate scientific grounds and enhance efficiency of planning for future training programs. Second: research problem, Even though strength training methods have come a long way, many trainers still mostly use one kind of training.without relying on comparative scientific evidence that shows how effective each style is in improving performance in swimming speed races. This sometimes leads to limited improvements in numerical achievement, despite high volume of training load exerted.

It is also observed that some training programs focus on developing maximum strength without paying attention to speed at which it is produced, while others focus on explosive exercises without building a sufficient strength base, which may limit optimal utilization of available muscular capabilities. This problem is particularly evident in 50-meter freestyle race, which requires a delicate balance between strength, speed, and technical proficiency. By following results of youth swimmers in local championships, a great convergence in times is observed, so that difference between positions becomes fractions of a second, which indicates that traditional improvements may not be sufficient to achieve a leap in level. Hence, need arises to determine training method that is most influential on crucial variables in race, especially starting time, time of first 15 meters, and length of stroke. It is therefore unclear which of the three strength training techniques—power training, maximal strength training, and plyometric training—has the most impact on the technical and temporal performance of young 50-meter freestyle swimmers.It necessitates a methodical comparison analysis that helps produce reliable scientific data for training program planning.The purpose of this study is to compare how 50-meter freestyle swimmers' technical and time performance is affected by plyometric, maximum strength, and power training.

The comparison between the pre-test and post-test results of the first experimental group, which underwent plyometric training, showed statistically significant differences in both time performance and technical performance in the 50-meter freestyle swimming event, with the post-test results demonstrating superior outcomes. Regarding the 50-meter freestyle swimming event's time and technical performance, the second experimental group that underwent maximum strength training demonstrated a statistically significant difference between their pre- and post-test data. The measurement after the test was superior. The third experimental group's pre- and post-test results for the 50-meter freestyle swimming event differed dramatically, with the post-test result being superior. When it comes to technical proficiency and timing in the 50-meter freestyle swimming competition, Statistically significant differences were observed among the three groups that followed plyometric training, maximum strength training, and power training programs.

METHOD

The researcher used experimental method was chosen to suit nature of research, and the researcher used a pre- and post -test experimental design. For three experimental groups. It is community research for swimming players in Kirkuk Governorate clubs, youth category, for 2025-

2026 season. Forty-five swimmers from Kirkuk were selected at random by the researcher .Governorate clubs in the youth category for the 2025–2026 season were split into the following groups: the first experimental group, which consisted of 15 players and used the plyometric training approach. The maximum strength training strategy is applied to the second experimental group, which consists of fifteen players. The third experimental group, which consists of fifteen players, uses the power training strategy. According to Table (1), they are accountable.

Table 1. Research Sample Description

Classification	Players number	Percentage
First experimental Group	15	33.33 %
Second experimental Group	15	33.33 %
Third experimental Group	15	33.33 %
Total	45	100%

A statistical definition of the research sample: To minimize the potential impact of confounding variables on the research procedures, the fundamental characteristics of the study sample—namely age, height, and weight—were evaluated prior to conducting the experiment. The statistical description of these variables is presented in Table (2).

Table 2. Statistical Indicators Of The Research Sample For The Basic Variables Before The Experiment. N = 45

Variables	Measurement unit	Mean	Standard deviation	Torsion coefficient	squamous coefficient
Age	Year	16.89	0.26	0.12	0.27
Weight	Kg.	70.53	1.21	1.08	0.92
Height	cm.	174.92	0.97	0.14	-0.52

According to Table (2), the data for the entire research sample demonstrate moderate variability and are not widely dispersed, following a normal distribution. The skewness coefficients ranged from 0.14 to 1.08, indicating that the sample is homogeneous with respect to the main baseline variables., which is near zero. The normal curve's oscillation is within the usual range and is neither rising nor decreasing, according to the squaring-to-diastolic coefficient, which varied from -0.52 to 0.92 . This demonstrates that prior to the experiment, the members of the research group had similar basic characteristics.

Tests and Measurements Used in Research

A-Time performance level for the 50-meter freestyle swimming race: This is how long it takes the competitor to swim from the beginning to the finish.

B: Grading individuals' technical competence in the fifty-meter freestyle race: A panel of specialists including three professors of swimming instruction evaluated the researcher's technical performance. A form was used to assess a swimmer's performance in the 50-meter freestyle swimming sport. Start, flow, arm and leg movement, balancing in the water, timing your breathing, and modifying your movement are the steps in the form. Experts claim that on the evaluation form, each element receives ten points. The researcher then averaged the expert scores for each step of assessing the technical performance level in the 50-meter freestyle swimming competition under investigation. Plyometric, maximum strength, and power training are all part of the training program.

Goal Of Training Program

Proposed training program aims to identify impact of three different strength training patterns, namely: plyometric training, maximal strength trainingWith power training, on enhancing the youth category 50-meter freestyle swimmers' temporal and technical performance, through application of organized and standardized training programs for a specific period of time, and measuring changes that occur in physical and skill variables associated with performance. Program also aims to develop specific physical elements related to nature of 50-meter freestyle race, primarily muscular strength, explosive power, and rate of power development, which contributes to improving crucial performance phases in race, such as start phase, push off wall, acceleration of first 15 meters, and maintaining length and efficiency of stroke throughout race distance.

Program also seeks to determine which of three training methods is most effective in producing a tangible improvement in digital performance, by comparing pre- and post-test results for each group, and analyzing statistical differences between them, in order to draw practical recommendations that can be used as a guide in planning speed swimmer training programs.

Program Development Principles

Relying on principle of training specific to requirements of 50-meter freestyle race. Adhering to principle of gradual increase in load (intensity - volume - density). Applying principle of individual differences between players when regulating loads. Adherence to principle of appropriate load and adaptation while providing sufficient rest periods. Taking into account age group youth category and its physiological characteristics. Achieving integration between land training and water training. Variety in exercises within each training method to avoid negative adaptation. Adherence to principle of continuity and regularity throughout program period. Adherence to safety and security measures and injury prevention. Organizing relationship between work and rest within training unit. Relying on pre- and post-testing and evaluation to determine effectiveness of program. Consider progression from general preparation to specific preparation. Achieving a balance between developing strength and speed without compromising skill aspect.

Proposed Training Program's Time Schedule

Table 3. The Recommended Training Program's Training Session Schedule.

No.	Statement	Time distribution
1	Number of (weeks)	8 weeks
2	Number of units in program	16 sessions
3	Number of units per (week)	2 sessions
4	Application time in unit	(90) minutes
5	Application time per week	(180) minutes
6	Total time for program implementation	(1440) minutes

According to Table (3), the study's eight-week regimen had 16 training units, each lasting 90 minutes and occurring twice a week. This indicates that the entire duration of the program was 1440 minutes.

How to Apply Program

The research sample was split into three equal groups of fifteen players each by the researcher.Each group used a different training approach. The first experimental group used plyometric training. The experimental group underwent a regimen utilizing maximum strength training.

Experimental group was subjected to program using force characteristic of velocity. the researcher implemented program at following times season (2025-2026). program was implemented from 12/6/2025 to 15/8/2025. Pre-measurements were carried out on 12/6/2025. program was implemented from 14/6/2025 to 13/8/2025. Post measurements were carried out on 15/8/2025.

Basic Study

Main study was conducted from 12/6/2025 to 15/8/2025, and the researcher will explain this below:

Pre-measurement: On 12/6/2025, pre-measurements were done on the research sample of 45 players, who were split into three groups of 15 players eachthree experimental groups: the first, the second, and the third.Pre-measurements were conducted at the Kirkuk swimming pool.

Equivalence Among Three Experimental Groups

Table 4. Equivalency between three groups' technical performance in a 50-meter freestyle swimming pre-test before to the experiment: plyometric training, maximum strength training, and power training.

Technical performance	Variation source	Freedom degrees	Sum of squares	Mean of squares	F value	Sig. level
Start	Among groups	2	311	156	322	726
	Within groups	42	20.267	483		
	Total	44	20.578			
Flow	Among groups	2	1.378	689	1.365	267
	Within groups	42	21,200	505		
	Total	44	22.578			
Arm movement	Among groups	2	933	467	339	715
	Within groups	42	57.867	1.378		
	Total	44	58,800			
Leg movement	Among groups	2	1.733	867	1.062	355
	Within groups	42	34.267	816		
	Total	44	36,000			
Balance in water	Among groups	2	933	467	579	565
	Within groups	42	33.867	806		
	Total	44	34,800			
Breathing timing	Among groups	2	578	289	217	806
	Within groups	42	55.867	1.330		
	Total	44	56.444			
Alternating motion	Among groups	2	933	467	1.652	204
	Within groups	42	11,867	283		
	Total	44	12,800			

Significant at 0.05 level. Tabulated F-value at 0.05 level = 3.220

For the first evaluation of the research sample, Table (4) shows an analysis of variance (ANOVA) across three groups: Regarding technical performance in a 50-meter freestyle swimming competition, plyometric training, maximum strength training, and power training. With an F-value of (0.204) 0.806, the data indicate that there are no significant differences between the three

groups. These statistics indicate that the three groups swam similarly in the 50-meter freestyle competition before to the trial since they are less than the calculated (F) value at level 0.05.

Table 5. Plyometric training, maximum strength training, and power training are all the same.in timed performance of 50- meter freestyle swimming race for pre-test measurement

Time performance	Variation source	Freedom degrees	Sum of squares	Mean of squares	F value	Sig. level
Digital level for 100m freestyle swimming	Among groups	2	1,200	600	409	667
	Within groups	42	61,600	1.467		
	Total	44	62,800			

Significant at 0.05 level. Tabulated F-value at 0.05 level = 3.220

Table (5) displays the analysis of variance (ANOVA) for three groups related to the numerical level of 50-meter freestyle swimming: power training, maximal strength training, and plyometric training. The pre-test of the research sample showed no significant variations in the numerical level of 50-meter freestyle swimming between the three groups (plyometric training, maximal strength training, and power training) with a F value of 0.667. Before attempting it, the tabulated (F) value is less than 0.05, therefore the three groups' 50-meter freestyle swimming times are equal.

Program application: The proposed program was used with three groups of 15 players each, for a total of 45 players. The proposed training program was also put into action. For eight weeks, from June 14 to August 13, 2025, there were two units per week on the basic sample. three groups of people who were tested.

Data Analysis

Conducted on research sample on August 15, 2025, at Kirkuk swimming pool. Researchers employ statistical methods including mean calculation, standard deviation, mediator, torsion coefficient, and squamous coefficient. (t) test. ANOVA for one-way analysis.

RESULTS AND DISCUSSION

We will first present and discuss the findings of the first hypothesis: There are statistically The technical and temporal performance of the first experimental group in the 50-meter freestyle swimming race varied significantly between the pre- and post-measurements (using plyometric training), with the post-measurement being better.

Table 6. Displays The Differences Between Two Measures Taken Before And After The 50-Meter Freestyle Swimming Event, As Well As The Percentage Of Improvement For The First Experimental Group That Received Plyometric Training (N = 15).

Variables	Measurement unit	Experimental group (plyometric training)				(t) value	Sig. level	Improvement rate
		Pre-measurement		Post-measurement				
		M.	St.d	M.	St.d			
Start	Degree	3.933	0.704	8,000	0.845	19.717*	0.000	103.41%

Flow	Degree	3.467	0.640	7.733	0.799	15,025 *	0.000	123.05%
Arm movement	Degree	3.467	1.125	6.733	1.100	9.480 *	0.000	94.20%
Leg movement	Degree	3.533	0.990	8.133	0.915	12.689 *	0.000	130.20%
Water balance	Degree	3,400	0.910	7,000	0.655	16.837 *	0.000	105.88%
Breathing timing	Degree	3.067	1.163	6,400	1.298	6.877 *	0.000	108.67%
Kinetic alternation	Degree	3.333	0.488	7.333	1.113	12.358 *	0.000	120.01%
Digital level for 50m freestyle swimming	Sec.	31.733	1.335	28,800	0.941	6.205 *	0.000	10.18%

At the 0.05 level of significance, the tabulated t value was 2.145. As presented in Table (6), a statistically significant difference was found between the pre-test and post-test mean scores of the first experimental group that followed the plyometric training program. The post-test results showed higher mean values in both the technical and time performance of the 50-meter freestyle swimming event. The calculated t values ranged from 6.205 to 19.717, while the improvement percentages varied between 94.20% and 130.20%. These findings support the first research hypothesis, indicating the presence of statistically significant differences between the pre- and post-tests for the first experimental group. The post-test results revealed improvements across all technical performance variables, including the start, movement fluidity, arm and leg coordination, body balance, breathing timing, and motor alternation.

As well as numerical level, which is consistent with what results of Bishop's study (2009) concluded. study indicated that adding an eight-week ground plyometric training program for speed swimmers led to a statistically significant improvement in time of 50m freestyle race, and a clear improvement in start phase and time of first 15m. study attributed this to improving explosive power of lower limbs and increasing rate of power development, which was reflected positively in quality of start and push off wall, which are elements directly related to improving time and technical level in short speed races.

Potdevin indicated (2011) Ehab Sayed Ismail (2006) Their study demonstrated that a six-week plyometric training program improved 50-meter freestyle time and technical performance associated with start phase in young swimmers, compared to control group. researchers confirmed that improvement was not only temporal but also linked to improvements in mechanical variables such as start angle, flight time, and propulsion efficiency, which explains significant increase in improvement rates in technical variables.

The researcher believes that significant improvement in technical variables (ranging between 94.20% and 130.20%) is due to neurological nature of process. plyometric training of muscles improves speed of muscle contraction, increases efficiency of lengthening-shortening cycle, and raises level of neuromuscular coordination, which directly impacts quality of motor performance in water. 50-meter freestyle race depends largely on explosive power in start and initial acceleration phases, and therefore developing this quality leads to a tangible improvement in time. the researcher believes that integrating plyometric training into preparation programs for young speed swimmers is an effective method for improving both numerical and technical performance, especially when applied in a standardized and gradual manner that is appropriate to age characteristics of sample.

Second: The results of the second hypothesis show that the two measures differ statistically significantly prior to and subsequent to the second experimental group engaging in maximum strength training for the 50m freestyle swimming race.The post-measurement is better.

Table 7. Statistics (t) test showing the differences between two measurements before and after the 50m freestyle swimming event, as well as the percentage of improvement for the second experimental group, which did the most strength training (n = 15)

Variables	Measurement unit	Experimental group (Maximum strength training)				(t) value	Sig. level	Improvement rate
		Pre-measurement		Post-measurement				
		M.	St.d	M.	St.d			
Start	Degree	3,800	0.676	6.733	1.033	9.291 *	0.000	77.18%
Flow	Degree	3.533	0.640	6,000	1.195	6.345 *	0.000	69.83%
Arm movement	Degree	3,200	1.207	5.067	0.704	4.525 *	0.000	58.34%
Leg movement	Degree	3,400	0.828	5.133	1.302	3.926 *	0.002	50.97%
Water balance	Degree	3.333	0.816	4.933	1.163	6.287 *	0.000	48.00%
Breathing timing	Degree	3,000	1.134	4.467	0.516	3.898 *	0.002	48.90%
Kinetic alternation	Degree	3,400	0.632	5,600	1.242	5.782 *	0.000	64.71%
Digital level for 50m freestyle swimming	Sec.	31.533	1.187	29.667	0.976	4.802 *	0.000	6.29%

Value of (t) at a significance level of (0.05) = 2.145 The results in Table (7) demonstrate statistically significant differences at (0.05). The second experimental group that adopted maximum strength training demonstrated a higher level in the post-test mean in terms of technical level and time in the 50-meter freestyle swimming event. where the percentage of improvement varied from 6.29% to 77.18% and the computed "t" value ranged from 3.898 to 9.291. For the second experimental group that used maximum strength training, Table (7) demonstrated statistically significant differences between pre- and post-tests, favoring the post-test in all technical and time factors.

Which is consistent with what Ahmed Amin Al-Hafnawi (2005) indicated. resistance training program led to a significant improvement in temporal performance of freestyle swimmers, as a result of increased muscle strength in upper and lower limbs. Developing maximum strength contributes to improving swimmer's ability to overcome water resistance and increasing effectiveness of pulling and pushing during different phases of swimming, which positively impacts technical efficiency and overall race time. Zahia Sabah (2010) found, which showed that maximal strength training using high resistances led to a remarkable improvement in time of swimming 50 meters freestyle in competitive swimmers, compared to water training only. She attributed this to improvement in recruiting high-threshold motor units and increasing ability to produce greater force during each stroke, which leads to an increase in stroke length and improved motor balance in water. These results explain remarkable improvement rates in variables of start, flow, and motor alternation in current study, as increase in maximal strength contributed to raising efficiency of technical performance.

The researcher believes that maximum strength training represents an important foundational stage within annual plan, to be later supported by power or plyometric strength training to

maximize transfer of effect of strength to time performance in 50-meter freestyle race. Third: Outlining and discussing the results of the third hypothesis The temporal and technical performance of the third experimental group in the 50-meter freestyle swimming competition differed statistically significantly between the two measurements (pre- and post-), with the post-measurement showing a preference.

Table 8. Shows the differences in statistics (t) test between two measurements, one before and one after, in terms of skill and time for the 50m freestyle swimming contest. It also illustrates the amount of food better the third experimental group did with power training.(n = 15)

Variables	Measurement unit	Experimental group (Power training)				(t) value	Sig. level	Improvement rate
		Pre-measurement		Post-measurement				
		M.	St.d	M.	St.d			
Start	Degree	3.733	0.704	8.467	0.834	20.744 *	0.000	126.81%
Flow	Degree	3.867	0.834	8.267	0.884	16.144 *	0.000	113.78%
Arm movement	Degree	3.533	1.187	7.867	1.246	8.599 *	0.000	122.67%
Leg movement	Degree	3.067	0.884	8.333	0.816	16.681 *	0.000	171.70%
Water balance	Degree	3.067	0.961	8.267	0.961	13,239 *	0.000	169.55%
Breathing timing	Degree	3.267	1.163	7.667	1.496	7.995 *	0.000	134.68%
Kinetic alternation	Degree	3.067	0.458	8,200	1.082	17.665 *	0.000	167.36%
Digital level for 50m freestyle swimming	Sec.	31.933	1.100	27,200	0.862	11.953 *	0.000	17.40%

value of (t) at a significance level of (0.05) = 2.145

For the third experimental group that included power training, Table (8) demonstrates statistically significant differences between the pre-test and post-test mean scores at the 0.05 level. The calculated "t" value ranged from 7.995 to 20.744 in favour of the average post-test measurement in terms of technical and time level in the 50-meter freestyle swimming competition, with an improvement percentage ranging from 17.40% to 171.70%.

Girold indicated (2007) A power -oriented strength training program led to a significant improvement in 50-meter freestyle swimming time of competitive swimmers, and its effect was greater compared to some traditional training methods. researchers attributed this to fact that speed-oriented strength training improves mechanical power output, which enhances effectiveness of stroke and increases speed of acceleration during short race phases.

Aspenes found and others (2009) who confirmed that developing muscular strength accompanied by speed directly contributes to improving performance in short swimming races, due to its association with increasing rate of force production in a short time, which is decisive factor in 50-meter races, and that improvement in muscular ability is reflected in increasing length of stroke and improving efficiency of motor performance, It explains the significant improvement rates in the current study's motor alternation, leg movement, and water balance measures.

The researcher believes that significant increase in improvement rates, especially in technical variables (leg movement, balance, movement alternation), in addition to remarkable improvement in numerical level (17.40%), confirms that training in power is one of most suitable methods for nature of 50-meter freestyle race, which depends on producing a large force in shortest possible time. This type of training contributes to achieving ideal balance between amount of force and speed of its production, which leads to a direct and effective transfer of effect of land training to performance inside water, which explains superiority of this group in terms of magnitude of improvement compared to other groups.

Fourth: The fourth hypothesis's results are shown and discussed: In the post-test measurement, three groups that engaged in plyometric, maximal strength, and power training demonstrated statistically significant differences in both technical and temporal aspects during the 50-meter freestyle swimming race. The analysis of variance (ANOVA) for technical performance in the 50-meter freestyle swimming competition for three groups—power training, maximal strength training, and plyometric training—is displayed in Table 9.

Table 9. displays the findings of an analysis of variance (ANOVA)

Technical performance	Variation source	Freedom degrees	Sum of squares	Mean of squares	F value	Sig. level
Start	Among groups	24.133	2	12.067	14.619 *	000
	Within groups	34.667	42	825		
	Total	58,800	44			
Flow	Among groups	42.133	2	21.067	22.194 *	000
	Within groups	39.867	42	949		
	Total	82,000	44			
Arm movement	Among groups	59.511	2	29.756	27.406 *	000
	Within groups	45,600	42	1.086		
	Total	105.111	44			
Leg movement	Among groups	96,400	2	48,200	45.188 *	000
	Within groups	44,800	42	1.067		
	Total	141,200	44			
Balance in water	Among groups	84.933	2	42.467	47.102 *	000
	Within groups	37.867	42	902		
	Total	122,800	44			
Breathing timing	Among groups	77.911	2	38.956	27.889 *	000
	Within groups	58.667	42	1.397		
	Total	136,578	44			
Alternating motion	Among groups	52.578	2	26.289	19.954 *	000
	Within groups	55.333	42	1.317		
	Total	107.911	44			

Significant at the 0.05 level. The F-value in the table is 3.220 at the 0.05 level. Table 9 displays the findings of an analysis of variance (ANOVA) conducted across three groups (plyometric training, maximum strength training, and power training) regarding technical performance in a 50-meter freestyle swimming competition for the post-test of the research sample. With an F-value ranging from 14.619 to 47.102, the results show significant differences in technical performance in the 50-meter freestyle swimming event between the three groups (plyometric training, maximum strength training, and power training). At the 0.05 level, this number exceeds

the table's F-value. The Least Significant Difference (LSD) test was used to examine the significance of the differences between the four groups of plyometric training, maximum strength training, and power training in a 50-meter freestyle swimming event. The results are shown in Table (10).

Table 10. Using the least significant difference (LSD) test

Technical performance	Groups	M.	St.d	Sig. of differences among means			LSD value
				Plyometric	Maximal strength	Power	
Start	Plyometric	8,000	0.845		1.26667*	-.46667	0.33
	Maximum strength	6.733	1.033			-1.73333*	
	Power	8.467	0.834				
Flow	Plyometric	7.733	0.799		1.73333*	-.53333	0.36
	Maximum strength	6,000	1.195			-2.26667*	
	Power	8.267	0.884				
Arm movement	Plyometric	6.733	1.100		1.66667*	-1.13333*	0.38
	Maximum strength	5.067	0.704			-2.80000*	
	Power	7.867	1.246				
Leg movement	Plyometric	8.133	0.915		3.00000*	-20000	0.38
	Maximum strength	5.133	1.302			-3.20000*	
	Power	8.333	0.816				
Water balance	Plyometric	7,000	0.655		2.06667*	-1.26667*	0.35
	Maximum strength	4.933	1.163			-3.33333*	
	Power	8.267	0.961				
Breathing timing	Plyometric	6,400	1.298		1.93333*	-1.26667*	0.43
	Maximum strength	4.467	0.516			-3.20000*	
	Power	7.667	1.496				
Kinetic alternation	Plyometric	7.333	1.113		1.73333*	-.86667*	0.42
	Maximum strength	5,600	1.242			-2.60000*	
	Power	8,200	1.082				

Table (10) presents the significance of the differences among the three groups that followed plyometric training, maximum strength training, and power training programs in terms of technical performance in the 50-meter freestyle swimming event for the research sample, as determined using the Least Significant Difference (LSD) test .In terms of arm movement, water balance, breathing time, and movement alternation phase, power training outperformed plyometric training and maximum strength training by a large margin. In the start, flow, and leg movement phases, power was noticeably better than maximum strength training.

In terms of start, flow, arm and leg movement, water balance, and breathing timing, plyometric training performed noticeably better than maximum strength training, movement alternating. In this regard, results of Girol study indicated Others (2007) found that training programs that target development of muscular power (Power-Oriented Training) have a greater impact on performance in short sprint races compared to traditional strength training, due to its direct relationship to speed of power production and improvement of motor efficiency. researchers indicated that transition from maximum power to muscular power represents a crucial step in developing

Temporal And Technical Performance Of Swimmer.

Crowley et al. (2017) indicated that effect of maximal strength training alone is relatively limited in sprint races if it is not combined with speed element, whereas training aimed at developing muscular power strength VS speed leads to greater improvements in variables of starting, acceleration, and stroke length, which are critical elements in 50m freestyle race. Programs that focus on developing rate of force production also achieve a better transfer of performance in water compared to purely strength programs.

The researcher believes that superiority of training group on power reflects principle of functional specialization, as this type of training is similar mechanically and temporally to requirements of 50-meter freestyle race, which depends on producing a large force in shortest possible time. Also, superiority of plyometric training over maximal strength training in almost all variables indicates that speed element in force production is differentiating factor in short sprint races. the researcher also believes that maximal strength training is a necessary foundational basis, but maximizing competitive performance in 50-meter freestyle race is achieved more through programs that combine strength and speed, which justifies statistically significant results in favor of power group in post-test.

Table 11. Analysis of variance ANOVA among three groups plyometric training, maximal strength training, Power training for post-testing in a 50-meter freestyle swimming competition

Time performance	Variation source	Freedom degrees	Sum of squares	Mean of squares	F value	Sig. level
Digital level for 50m freestyle swimming	Among groups	46.978	2	23.489	27.303 *	000
	Within groups	36.133	42	860		
	Total	83.111	44			

Significant at 0.05 level. Tabulated F-value at 0.05 level = 3.220

Table (11) shows the results of an analysis of variance (ANOVA) between three groups: plyometric training, maximal strength training, and power training. The results show how each group did in the 50-meter freestyle swimming competition after the test. The research sample revealed significant variations in the performance times of the three groups—plyometric training, maximum strength training, and power training—in the 50-meter freestyle swimming event, with an F-value of 27.303, which is greater than the required F-value at the 0.05 level. The Least Significant Difference (LSD) test was used to assess the significance of the differences between these groups, as indicated in Table 12.

Table 12. The Least Significant Difference (LSD) test was used to determine the significance of differences between the three groups' plyometric, maximum strength, and power training at the numerical level for the 50-meter freestyle swimming race.

Technical performance	Groups	M.	St.d	Sig. of differences among means			LSD value
				Plyometric	Maximal strength	Power	

Digital level for50m freestyle swimming	Plyometric	28,800	0.941	-.86667*	1.60000*	0.34
	Maximum strength	29.667	0.976		2.46667*	
	Power	27,200	0.862			

Table (12) shows how different the measures are for the research sample's three groups: plyometric training, maximum strength training, and power training in the 50-meter freestyle swimming competition. This was found out using the least significant difference test (LSD).

Power significantly outperformed plyometric training, maximum strength training in numerical level of swimming 50m freestyle. These agree results are consistent with those of study by Crowley et al. (2017), which concluded that power training combined with high-speed execution (power training) demonstrates a better transfer of performance in water compared to maximal strength training alone, especially in sprint races. improvement in rate of force development is directly related to time of start, acceleration, and maintenance of maximum speed, which explains statistically significant differences in favor of power group in digital level of 50m freestyle race.

The researcher believes that superiority of training group on power in numerical level reflects suitability of this method to nature of 50m freestyle race, which depends on producing a large force in a very short time, where decisive factor is speed of force production and not just its magnitude. Also, differences between plyometric and maximum strength indicate that introducing element of speed into performance whether through medium resistances at high speed or through explosive drills enhances transfer of effect of land training to time performance inside water. However, this study also has limitations, particularly regarding sample control. There was no grouping of participants into beginners and seniors. This could be considered a limitation of the study. Additionally, external factors may have influenced both mental and physical endurance

CONCLUSION

Based on the study objectives, hypotheses, sample characteristics, methodology, and the results of the statistical analysis, the researcher reached the following conclusions For the first experimental group that underwent plyometric training, the comparison between pre-test and post-test mean scores revealed statistically significant improvements at the 0.05 level. The post-test means were higher in both technical and temporal performance variables in the 50-meter freestyle swimming event, with performance increases ranging from 94.20% to 130.20% as a result of the plyometric training program. Similarly, for the second experimental group that followed maximum strength training, statistically significant differences were observed between the pre-test and post-test mean scores at the 0.05 level. The post-test results indicated superior technical and temporal performance in the 50-meter freestyle swimming competition. In the start, flow, and leg movement phases, power was noticeably better than maximum strength training. In terms of start, flow, moving your arms and legs, maintaining your balance in the water, timing your breathing, and altering your motions, plyometric training performed noticeably better than maximal strength training. When it comes to swimming the 50-meter freestyle, power training outperformed plyometric and maximum strength training. Based on what indicated mechanism results and in border what it was possible reaching mechanism from conclusions recommend the researcher in what following: It is essential to include power training in training programs for 50-meter freestyle swimmers, as it has a clear positive impact on technical and temporal levels. Using plyometric training as an effective means to improve start and wall push phase in short sprint races. Not being satisfied with maximal strength training alone, but rather employing it as a foundational stage followed by targeted training to develop muscular power. Organizing training programs for speed

swimmers according to a training sequence that begins with building basic strength, then moving on to power training before competition periods. Achieving integration between land and water training to ensure that effect of strength development is transferred to actual performance in water. Attention should be paid to periodic measurement of technical variables start, flow, movement alternation in addition to numerical level when evaluating training programs. Applying exercises that develop rate of force development is important in short sprint races. Future research is expected to incorporate more precise control variables and samples to produce high-quality research

ACKNOWLEDGEMENT

The author would like to thank all parties who helped in completing the manuscript

REFERENCES

Ahmed Amin Al-Hafnawi (2005): *effect of strength and speed training on numerical level of butterfly swimmers,* unpublished master's thesis, Faculty of Physical Education, Tanta University.

Ahmed Hani Al-Tarawneh (2019): *effect of plyometric training on improving leg strokes in front crawl swimming,* Master's thesis, Mutah University.

Ali Fahmy Al-Beik (2005): *Methods of measuring aerobic and anaerobic capacities,* Dar Al-Maaref, Alexandria.

Apriandi, D., Salacup, V. L. D., Butali, R. A., Cadiente, D. S. A., Ardian, R., Septianto, I., & Azrina, J. (2023). Pulse rate during running 5 laps: comparative study before and after dehydration? *Tanjungpura Journal of Coaching Research*, *1*(3), 101-1–8. https://doi.org/10.26418/tajor.v1i3.73047

Aspenes , S., Kjendlie , P. L., Hoff, J., & Helgerud , J. (2009). Combined strength and endurance training in competitive swimmers. *Journal of sports science & medicine, 8*(3), 357.

Bishop, D. C., Smith, R. J., Smith, M. F., & Rigby, H. E. (2009). Effect of plyometric training on swimming block start performance in adolescents. *Journal of Strength & Conditioning Research, 23*(7), 2137-2143.

Crowley, E., Harrison, A. J., & Lyons, M. (2017). impact of resistance training on swimming performance: A systematic review. *Sports medicine, 47*(11), 2285-2307.

Ehab Sayed Ismail (2006): *Using plyometric training and aquatic environment to improve explosive power and its effect on starting skill of front crawl swimmers*, Master's thesis, Tanta University.

Ganchar, I., Ganchar, O., Ciorba, C., Medynskyi, S., Pylypko, O., Bliznyuk, Y., Pylypko, A., &

Lyashenko, A. (2022). Monitoring the assessment of the swimming skills formation among swimmers-prize-winners at stages I-II-III of the Olympic Games (1896-2021). *Journal of Physical Education and Sport*, *22*(8), 1869–1877. https://doi.org/10.7752/jpes.2022.08236

Girold , S., Jalab , C., Bernard, O., Carette , P., Kemoun , G., & Dugué , B. (2012). Dry-land strength training vs. Electrical stimulation in sprint swimming performance. *Journal of Strength & Conditioning Research, 26*(2), 497-505.

Hassan Al-Wadiyan, Amjad Al-Madinat (2011): Training methods in performance time using crawl swimming method, *Journal of Educational Sciences Studies, 38*, Jordan.

Ivanov, D. (2025). Comparative analysis of body composition in youth elite football players: Insights from professional academies. *Tanjungpura Journal of Coaching Research*, *3*(2), 122–132. https://doi.org/10.26418/tajor.v3i2.90501

Matitaputty, J. (2020). The Relationship Between Arm Muscle Strength And Leg Muscle Strength Towards 50-Meter Freestyle Swimming Speed. *Edu Sciences Journal*, *1*(3), 198–207. https://doi.org/10.30598/edusciencesvol1iss3pp198-207

Momen Mohamed Abdel Nasser (2020): effect of isometric and plyometric training on some physical variables and speed curve of 200m sprinters , *Scientific Journal of Sports Science and Arts , Faculty of Physical Education for Girls, Helwan University.*

Norberto, M. S., Barbieri, R. A., Bertucci, D. R., Gobbi, R. B., Campos, E. Z., Zagatto, A. M., De Freitas, E. C., & Papoti, M. (2020). Beta alanine supplementation effects on metabolic contribution and swimming performance. *Journal of the International Society of Sports Nutrition*, *17*(1), 40. https://doi.org/10.1186/s12970-020-00365-6

Potdevin , F. J., Alberty , M. E., Chevutschi , A., Pelayo , P., & Sidney, M. C. (2011). Effects of a 6-week plyometric training program on performances in pubescent swimmers. *Journal of Strength & Conditioning Research, 25*(1), 80-86.

Samira Arabi (2016): *Swimming, (Teaching - Training - Organization),* Amjad Publishing and Distribution House, Amman, Jordan.

Zahia Sabah (2010): effect of a variety of exercises to rapidly develop speed and strength, in addition to distinctive and complete freestyle swimming (25 meters) for people with mild

intellectual disabilities, *Journal of Physical Education*, College of Physical Education and Sports Sciences, University of Baghdad.

Zulnadila, Suharjana, Arjuna, F., Sriwahyuniati, C. F., Mappanyukki, A. A., Rahman, A., Agustina, D., & Szczepocki, M. (2025). Traditional games for physical fitness in primary school students: A systematic review in Indonesia. *Tanjungpura Journal of Coaching Research*, *3*(1), 76–86. https://doi.org/10.26418/tajor.v3i2.89690