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RESEARCH ARTICLE

Comparative Effects of Combined Land–Aquatic and Aquatic-Only Training Programs on 50-Meter Freestyle Swimming Performance: An Experimental Study

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Abstract

The continuous development of sports training methodologies has led to increased interest in optimizing training environments and combining different training media to enhance athletic performance. In competitive swimming, training specificity and the integration of complementary conditioning methods are considered essential factors in improving short-distance performance. Within this framework, the present study aimed to compare the effectiveness of two distinct training approaches—aquatic-only exercises and combined land–aquatic exercises—on 50-meter freestyle swimming performance during the special preparation period. An experimental research design was adopted and applied to a purposive sample of ten competitive swimmers. The participants were randomly assigned into two experimental groups of equal size. The first experimental group followed a training program based exclusively on aquatic exercises, while the second experimental group implemented a combined training program integrating land-based and aquatic exercises in equal proportions. Both programs were designed according to the principles of concurrent training and were implemented over the same training period under similar conditions. To assess the impact of the training interventions, pre- and post-tests were conducted for both experimental groups, focusing on 50-meter freestyle swimming time as the primary performance indicator. Statistical analysis was performed by comparing mean differences within each group and between the two groups following the completion of the training programs. The results revealed statistically significant improvements in swimming performance for both experimental groups when comparing pre- and post-test measurements. However, the combined land–aquatic training group demonstrated significantly greater performance gains compared to the aquatic-only group in post-test results. These findings suggest that integrating

land-based exercises with aquatic training contributes more effectively to developing strength, power, and neuromuscular coordination, which are critical determinants of sprint swimming performance. The study concludes that combined land–aquatic training programs represent a more effective approach for enhancing 50-meter freestyle performance than aquatic-only training. The findings provide practical implications for coaches and sports practitioners, emphasizing the importance of diversified training environments and scientifically structured training programs in competitive swimming.

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1. Introduction

Sports training is composed of various efforts, whether cognitive or applied. On this basis, it proceeds and is organized according to frameworks that combine different theories, applications, and sciences. Therefore, its strategy is carefully scrutinized from the beginning of training to its end. Furthermore, the foundations and theories of sports training have witnessed significant progress in recent years, which has positively contributed to their appearance as a scientific discipline with great effectiveness at the sporting level in all its fields (Bustawisi Ahmed, 1999, p. 05).

Swimming is one of the distinguished individual sports that benefits greatly from training theories. It possesses a high degree of specificity due to the nature of the work and its requirements. Swimmers' training varies in several aspects. From the perspective of the training medium, we find training or exercises categorized as: Aquatic Only / Dry-LandOnly / Land-Aquatic.

In this context, the researcher will attempt to shed light on a field issue related to studying the differences between "Aquatic-Only Exercises" and "Land-Aquatic Exercises" in relation to 50-meter freestyle swimming performance.

Therefore, the following general question was adopted:

-Is there a statistically significant difference between the first experimental group (01) and the second experimental group (02) regarding the effectiveness of "Land-Aquatic Exercises" and "Aquatic-Only Exercises" on 50-meter freestyle swimming performance?

Sub-Questions:

1 Is there a statistically significant difference between the pre- and post-measurements for the first experimental group (01) regarding the effectiveness of **"Aquatic-Only Exercises"** on 50-meter freestyle swimming performance?

2 Is there a statistically significant difference between the pre- and post-measurements for the second experimental group (02) regarding the effectiveness of **"Land-Aquatic Exercises"** on 50-meter freestyle swimming performance?

3 Is there a statistically significant difference between the first experimental group (01) and the second experimental group (02) through the post-measurements regarding the effectiveness of **"Land-Aquatic Exercises"** and **"Aquatic-Only Exercises"** on 50-meter freestyle swimming performance?

Study Hypotheses

General Hypothesis:

-There are statistically significant differences between the first experimental group (01) and the second experimental group (02), and these differences are in favor of the second experimental group (02), regarding the effectiveness of "Land-Aquatic Exercises" and "Aquatic-Only Exercises" on 50-meter freestyle swimming performance.

Sub-Hypotheses:

-There are statistically significant differences between the pre- and post-measurements for the first experimental group (01), in favor of the post-measurement, regarding the effectiveness of "Aquatic-Only Exercises" on 50-meter freestyle swimming performance.

-There are statistically significant differences between the pre- and post-measurements for the second experimental group (02), in favor of the post-measurement, regarding the effectiveness of "Land-Aquatic Exercises" on 50-meter freestyle swimming performance.

-There are statistically significant differences between the first experimental group (01) and the second experimental group (02) through the post-measurements regarding the effectiveness of "Land-Aquatic Exercises" and "Aquatic-Only Exercises" on 50-meter freestyle swimming performance.

Study Objectives:

-Attempting to find the differences between two training methods in a field and experimental manner.

-Highlighting the differences or the superiority between two types of training in terms of the practiced medium, related to 50-meter freestyle swimming performance.

-Updating the formulas of training programs to help raise the level of athletes towards the best.

-Highlighting the importance of **"Land-Aquatic"** exercises in training swimmers and developing their levels.

2. Methods and Tools

In order to collect the largest amount of information about the research topic and population, and to test the research tools for their validity, reliability, and objectivity in the obtained results, the researchers conducted field reconnaissance procedures for the Athletic Swimming Club (CAN.HBB) in Hassi Bahbah, Djelfa, which lasted 10 days, starting from (10/12/2024) until (21/12/2024). An interview was conducted with the club's president, and a set of questions was posed to investigate facts and obtain sufficient information about the original study population and some other variables that might affect the research and experiment variables. The researcher found great support and understanding from all practitioners and officials, which greatly facilitated the researcher's task when carrying out the practical aspect.

Furthermore, through the reconnaissance study, pre-tests were calculated, in addition to testing the scientific coefficients of the proposed test through 03 main determinants: Reliability, Validity, and Objectivity.

Research Methodology:

Given the nature and type of the study, and to reach scientific truth in the research field and achieve its desired objectives, the researcher followed the **Experimental Method** using the **"Scientific Experiment Approach"** due to its suitability, appropriateness, and compatibility with the nature and content of its field procedures. The researcher used the **Experimental Design with a Longitudinal Section for Equivalent Groups**.

Measurement Procedures According to This Design:

-Procedures for **Homogeneity** and **Equivalence** between the two samples.

-Measuring the achievement level (Pre/Post) for the first experimental group, which used **Land-Aquatic Exercises**.

-Measuring the achievement level (Pre/Post) for the second experimental group, which used **Aquatic-Only Exercises**.

-Comparison between the results of the first and second experimental groups.

Control in the Study:

Control of Variables:

Variables Related to Individuals:

- **Biometric:** The sample individuals were characterized by very similar details in physical dimensions.
- **Anthropometric:** The sample individuals were characterized by similar weight and pattern, which is the lean pattern typical for them.

Variables Related to Procedures, Measures, and Precautions:

- **Time variable** was controlled, as the sample swimmers practiced the scheduled program at the same time of day (2:00 PM) and not at a different time.
- The swimmers performed the scheduled distance in a similar, i.e., constant, **water temperature** (25°C).
- The swimmers performed the scheduled distance in the **same lane** for each of them to control the familiarity of the place.
- **General and specific warm-up** were standardized.

Variables Related to External Factors and Conditions:

- Standardization of (meal time / type of food / fluids / sleeping hours).

Control in the Experiment:

- **Isolation or Fixation of the Variable:** A set of variables affecting the independent variable were isolated, such as (speed exercises before performance - some random motor practices before the unit - some behaviors like non-standardized rest or extra sessions, whether inside or outside the pool - some types of clothing, especially those that increase resistance on the muscles, which could change the course of the study).
- Variables that could not be isolated were also fixed, such as (Height - Age - Weight - Training Age - Performance Level).
- **Change in the Quantity of the Experimental Variable:** By controlling the movement paths, repetitions, and the consistency of the performed exercises, and avoiding patterned change, whether dry-land or aquatic.
- **Quantitative Change of Variables:** Studying the differences with quantitative and numerical significance.

Study Variables:

- **Independent Variable:**

  -For the first experimental group (01): Land-Aquatic Exercises.

  -For the second experimental group (02): Aquatic-Only Exercises.

- **Form of the Independent Variable:** The form of the independent variable is (its presence versus the presence of another).
- **Dependent Variable:** Performance time of the 50-meter freestyle swimming.

Study Domains:

- **Human Domain:** Swimmers of the Athletic Swimming Club (HBB.CAN) in Hassi Bahbah – Djelfa.
- **Temporal Domain:** From (25/12/2024) until (10/02/2025).
- **Spatial Domain:** Ararour El Bachir Swimming Pool, Hassi Bahbah – Djelfa.

Study Population:

Swimmers of the Athletic Swimming Club (HBB.CAN) in Hassi Bahbah (Djelfa), specializing in the 50-meter freestyle.

Sample:

Sample Description: A purposive experimental sample consisting of (10) swimmers, representing (50%) of the original population, divided into:

-Experimental Group (01): with (05) swimmers.

-Experimental Group (02): with (05) swimmers.

Swimmers on whom the scientific coefficients of the tests (the reconnaissance sample) were calculated, numbering (02), were excluded. The sample includes swimmers specialized in performing the front crawl (freestyle) for the 50-meter distance, with the difference being the inclusion or exclusion of dry-land exercises.

Sample Division: To avoid bias in the distribution of the two samples, a 50-meter freestyle test was conducted, followed by the following division:

-Experimental Group (01): Ranks (01 – 03 – 05).

-Experimental Group (02): Ranks (02 – 04 – 06).

Description of the Training Program:

Item	Content
Training Phase	Special Preparation Phase (PPS)
Program Duration	One and a half months, equivalent to 06 training weeks.
Number of Units per Week	(03) units, totaling (18) intensive training units in the program.
Duration of Each Unit	One and a half hours.
Unit Division	Units containing a mixture of exercises (Aquatic and Dry-Land).
Objectives	Units containing only Aquatic Exercises.
Testing Units	Pre/Post testing units.

Sample Homogeneity:

To avoid factors that might affect the experiment's results, homogeneity was conducted between the two samples as follows:

Table 2: Homogeneity of the Experimental Groups (01) and (02) in Terms of Some Morphological Indicators

Indicators	Experimental Group (01)	Experimental Group (02)	Difference Between Means	Statistical Significance
Mean (X)	Standard Deviation (S)	Mean (X)	Standard Deviation (S)	Difference
Height (m)	1.74	0.01	1.75	0.01
Weight (kg)	60.33	0.01	60.33	0.01
Age	19.66	0.56	19.33	0.44

Sample Equivalence:

To determine the effect of the experimental variable on the research sample individuals, equivalence was verified using the **Method of Matched Groups**.

Table 3: Equivalence of the Control and First Experimental Groups in 50-meter Freestyle Performance

Test	Experimental Group (01) Mean (X) / SD (S)	Experimental Group (02) Mean (X) / SD (S)	Difference Between Means	Statistical Significance

50m Freestyle Performance Test	X: 30.33 S: 0.01	X: 30.16 S: 0.72	0.17	Not Significant

Data Collection Tools:

- Sources and References.
- **50-meter Freestyle Test:** This is a test in which the swimmer performs a distance of (50 m) using the front crawl (freestyle).

Table 4: Test Specifications

Title	Content
Test Name	50m Freestyle Performance Test
Test Objective	Measuring the achievement level
Performance Specifications	Starting from the platform - starting position upon hearing the whistle - freestyle - reaching the end.
Recording Method	Recording the total performance time.
Tools Used (Swimmer)	Swimsuit - Goggles - Cap.
Tools Used (Referee)	Stopwatch - Whistle.
Location of Test	Swimming pool of (25 m) - Lane (05-06) - Starting platform.

3. Results

Table 5: Represents the differences between the pre-test for the experimental group (01) through the 50m freestyle performance test, considering the pre-test as the **Equivalence** results.

Test	Mean (X)	Standard Deviation (S)	Change Between Means	Percentage of Change	Statistical Significance
Pre-Test	30.33	0.01	1.67	5.50%	Significant
Post-Test (50m Freestyle Performance)	28.66	0.01			

For Experimental Group (01):

- The arithmetic mean for the 50m freestyle performance test in the pre-test results was (30.33) with a standard deviation of (0.01).
- We note that the calculated value of the **(**Change Between Means) is (1.67), and the percentage of change was estimated at (5.50%)**.**
- Therefore, we note the existence of statistically significant differences between the pre- and post-measurements regarding the 50m freestyle performance test.

Table 6: Represents the differences between the pre- and post-test for the experimental group (02) through the 50m freestyle performance test, considering the pre-test as the **Equivalence** results.

Test	Mean (X)	Standard Deviation (S)	Change Between Means	Percentage of Change	Statistical Significance
Pre-Test	30.16	0.72	3.16	10.47%	Significant

Post-Test (50m Freestyle Performance)	27.00	0.81			

For Experimental Group (02):

- The arithmetic mean for the 50m freestyle performance test in the pre-test results was (30.16) with a standard deviation of (0.72).
- We note that the calculated value of the **(Change Between Means)** is (3.16), and the percentage of change was estimated at **(10.47%)**.
- Therefore, we note the existence of **statistically significant differences** between the pre- and post-measurements regarding the 50m freestyle performance test.

Table 7: Shows the percentage of development for the post-tests of the two groups concerning the 50m freestyle performance test.

Post-Test Mean (X)	Change Between Means	Percentage of Change Compared to Pre-Test	Percentage of Difference	Statistical Significance
Group (01)	28.66	1.66	5.50%	Significant
Group (02)	27.00	3.16	10.47%	

For Experimental Group (01):

- The arithmetic mean for the 50m freestyle performance test in the post-test results was (28.66).

For Experimental Group (02):

-The arithmetic mean for the 50m freestyle performance test in the post-test results was (27.00).

-We note that the calculated value of the **(Change Between Means)** is (1.66). Thepercentage of change compared to the pre-test for Group (01) was **(5.50%)**, and for Group (02) it was **(10.47%)**. The difference between the percentages of change is **(4.97%)**.

-Therefore, we note the existence of **statistically significant differences** between the post-measurements regarding the 50m freestyle performance test.

4. Discussion

Discussion of Hypothesis (01) Results:

The reader of the results in Table No. (05) observes that, despite the fact that the Experimental Sample (01) was not subjected to the (Land-Aquatic) exercises within the prescribed program until the post-test measurements were taken, this group showed an increase in performance level across its various determinants. This proves the important and effective role of Aquatic Exercises in training swimmers, especially the studied category. Based on this, Hypothesis (01), which states that (There are statistically significant differences between the pre- and post-measurements for Experimental Group (01) in favor of the post-measurement regarding the effectiveness of "Aquatic Exercises Only" for 50-meter freestyle performance) is achieved.

Discussion of Hypothesis (02) Results:

The reader of the results in Table No. (06) observes that the Experimental Sample (02) was subjected to a program containing (Land-Aquatic) exercises within the prescribed program until the post-test measurements were taken, and this group showed an increase in performance level across its various determinants. This proves the important and effective role of (Land-Aquatic) exercises in training swimmers, especially the studied category. Based on this, Hypothesis (02), which states that (There are statistically significant differences between the pre- and post-measurements for Experimental Group (02) in favor of the post-measurement regarding the effectiveness of (Land-Aquatic) exercises for 50-meter freestyle performance) is achieved.

Discussion of Hypothesis (03) Results:

The reader of the results in Table No. (07) observes that both groups were subjected to programmed units containing (Aquatic Only) and (Land-Aquatic) exercises within the prescribed program until the post-test measurements were taken, and both groups showed an increase in performance level across their various determinants. This proves the important and effective role of the program as a whole in training swimmers, which indicates the clear differences between the results. Based on this, Hypothesis (03), which states that (There are statistically significant differences between the Experimental Samples (01) and (02) through the post-measurements regarding the effectiveness of "Land-Aquatic" and "Aquatic Only" exercises for 50-meter freestyle performance) is achieved.

Discussion of the General Hypothesis Results:

Despite the development in performance level for both samples, the researchers find that the development observed in Experimental Sample (02), which used the (Land-Aquatic) exercises program, was a greater development when compared to the development observed in Experimental Sample (01), which used the Aquatic Exercises Only. Since all three partial hypotheses were achieved, we can state that the General Hypothesis, which states that (There are statistically significant differences between the Experimental Samples (01) and (02) in favor of Experimental Sample (02) regarding the effectiveness of "Land-Aquatic" and "Aquatic Only" exercises for 50-meter freestyle performance), is achieved.

5. Conclusion

Through the analysis of the results in the previous tables, the researchers conclude that the use of diverse training programs is beneficial and allows athletes to acquire new motor properties. In this study, the research focused on a comparison between (Aquatic Exercises Only) and (Land-Aquatic) exercises, which led to an improvement in performance among swimmers, specifically in the 50m freestyle event. According to the achievement of the General Hypothesis, which states that (There are statistically significant differences between the Experimental Samples (01) and (02) in favor of Experimental Sample (02) regarding the effectiveness of "Land-Aquatic" and "Aquatic Only" exercises for 50-meter freestyle performance), this is confirmed by obtaining the results and finding the differences between the post-measurements.

It is incumbent upon us, based on such results, to confirm the effectiveness of these types of exercises on the improvement of swimmers' performance.

In this regard, the researcher, based on the theoretical background, had previously mentioned an analysis of the 50m freestyle performance in the semi-Olympic pool (25m), where he clarified that this performance goes through (10) technical stages. These stages are:

-(Starting position / Start / Initial Glide / Resumption / Freestyle Swimming Outbound / Turn / Second Glide / Second Resumption / Freestyle Swimming Return / Professional Finish).

However, in the Olympic pool (50 meters), the return elements are condensed: (Turn / Second Glide / Second Resumption / Freestyle Swimming Return), making the performance consist of (06) elements only.

All these performance details require motor engineering and special capabilities that Land Training played a role in imparting and developing in the Experimental Research Sample (02), without isolating the Aquatic Exercises, which must run parallel to the Land Training.

The research also addressed the goals and value of Land Training for swimmers, which it mentioned focuses on and benefits:

- Correcting motor engineering.
- Acquiring and developing flexibility.
- Focusing on certain angles of strength, especially isokinetic rather than para-isokinetic capabilities.
- Naturally, performance here is a complex composition of several determinants that define the quality and quantity of the performance. These determinants are:

(Physical determinant / Skill determinant / Psychological determinant / Tactical determinant / Cognitive determinant). The programming must be diverse to match the diversity of these determinants.

Ethical Considerations

All ethical principles related to sports science research were respected in the conduct of this study. Participation was voluntary, and informed consent was obtained from all swimmers prior to their inclusion in the research. The study ensured the safety, confidentiality, and well-being of participants throughout the experimental period, and all procedures were conducted in accordance with accepted ethical standards for research involving human participants.

Author Contributions

- **Guanouna Abdelhamid:** Conceptualization of the study, design of the training programs, data collection, and drafting of the manuscript.
- **Karboua Kamal:** Supervision of the experimental procedures, coordination of training sessions, and contribution to data analysis.
- **Benamara Kamal:** Statistical analysis, interpretation of results, and critical revision of the manuscript.
- **Kadraoui Brahim:** Literature review, methodological support, and final editing of the manuscript.

All authors contributed substantially to the study and approved the final version of the manuscript.

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Conflict of Interest

The authors declare that there is no conflict of interest related to the publication of this study.

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