Effects of a Proposed Training Program to Develop Core, Arm, and Leg Muscle Strength on Middle-Distance Swimmers' Time Performance

by Maan Hasan Mahmood Maan Hasan Mahmood

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Effects of a Proposed Training Program to Develop Core, Arm, and Leg Muscle Strength on Middle-Distance Swimmers' Time Performance

[1]Maan Hasan Mahmood*

*Corresponding Author: **Hasan Mahmood, Maan, e- mail:** Maanhasan@uokirkuk.edu.iq

[1]Faculty of Physical Education and Sports Sciences, University of Kirkuk, Iraq.

Abstract

Objectives. This study examines whether a targeted strength program for the core, arms, and legs can improve middle-distance swimming performance time. Specifically, it evaluates changes in (1) core strength, (2) arm strength, (3) leg strength, and (4) overall time performance in youth middle-distance swimmers.

Materials and Methods. An experimental method with a pre-test–post-test control group design was used. Participants were 45 youth-category swimmers, randomly selected from several sports groups in Kirkuk Governorate. They were divided into an experimental group and a control group. The experimental group followed a specialized, integrated strength program focusing on the core, arms, and legs, while the control group continued with regular training.

Results. Swimmers who completed the specialized strength exercises showed better time performance than those who only followed the usual training. Post-test comparisons also indicated a statistically significant advantage for the experimental group across all measured variables.

Conclusions. It summarizes and wraps up the ideas, presenting the key findings and insights derived from your study. It should include a concise summary of the main points discussed in the paper, including the research objectives, methodology, and results.

Keywords: Strength training program, Core muscle strength, Upper- and lower-limb strength, Middle-distance swimming, Time performance.

Introduction

In the last few decades, swimming has made great strides thanks to advances in sports training, measurement and evaluation, movement sciences, and physiology(Abid et al., 2024; Bishop et al., 2009). These advances have helped swimmers improve their times at all levels of competition and age. Contemporary training regimens are grounded in exact scientific principles designed to enhance the physical and technical skills pertinent to the particular execution of each race (Cañas-Jamett et al., 2020). Improvement in swimming is no longer only contingent upon augmenting training volume; instead, it is predicated on the quality of exercises and their relevance to the swimmer's motor and physiological performance demands (Crowley et al., 2018) Middle-distance swimming races are considered among the most physically and technically complex events, as they require the availability of an integrated combination of muscular strength, endurance, anaerobic capacity, and technical efficiency in performance. Success in these distances depends on the swimmer's ability to maintain a relatively high swimming speed with economical effort, which requires high efficiency in the work of the arms and legs along with trunk stability throughout the race duration (DeLuca & Andrews, 2010). (Fish & Rohr, 1999) stated that muscular strength is one of the most important variables affecting the improvement of swimmers' time performance, especially arm strength, which is responsible for generating the primary propulsive force, and leg strength, which contributes to improving starts and turns and maintaining a horizontal body position, in addition to core muscle strength, which serves as the link between the upper and lower limbs and plays a pivotal role in efficiently transferring force and reducing energy loss during swimming (Hui, 2022).

Core training has become one of the modern trends in sports training due to its positive effect on improving balance, stability, and motor control, which is directly reflected in the quality of technical performance in swimming (Lavoie & Montpetit, 1986; Rumpoko et al., 2025). Weak core muscles lead to increased water resistance and reduced effectiveness of arm and leg strokes, whereas developing them contributes to improving body streamlining and reducing the effort exerted during the race (Asher et al., 2022; Gupta et al., 2020). The increasing interest in strength training for swimmers, many training programs applied to the youth category focus on technical aspects and the volume of swimming in water, while neglecting or minimizing attention to strength training outside the water, especially training directed toward developing the functional strength of the core, arm, and leg muscles in accordance with the performance requirements of middle-distance races. This may limit the expected performance improvement for this category (@ Charles et al., 2017; Amiri et al., 2025; Brazier et al., 2025). on the importance of linking theoretical and practical aspects, the need has emerged to design proposed training programs based on clear scientific foundations to develop the muscular strength of the core, arm, and leg muscles, and to study their effect on the time performance level of middle-distance swimmers, thereby contributing to the provision of a training model that can be utilized in developing the training process within clubs.

Novelty. This study contributes new evidence by testing an 8-week integrated strength program that simultaneously targets the core, arms, and legs and links these changes directly to 200 m freestyle time performance in youth middle-distance swimmers. Unlike many youth-focused programs that emphasize pool volume and technique alone, the present work uses a controlled pre–post design and a practical test battery to show whether structured dry-land strength training provides measurable performance gains beyond traditional training, offering a program model that can be applied and adapted within club settings.

Research Problem

Despite the significant development witnessed in swimming at the global level, the performance times of middle-distance swimmers in the youth category in many clubs remain below the desired levels, indicating shortcomings in some components of the training process, particularly those related to specialized physical preparation associated with the requirements of these races. Through the researcher's practical experience in training and teaching swimming, and his follow-up of swimmers' results in the 200-meter freestyle event, it was observed that many swimmers suffer from a decline in performance efficiency in the final parts of the race despite their proficiency in basic skills, reflecting weakness in some physical abilities that affect continuity and motor stability.

The researcher also observed that the applied training programs place great emphasis on in-water swimming and increasing training distances, with limited use of targeted strength training, especially core muscle training, and a lack of clear integration between arm and leg training in a way that serves the specialized performance of middle-distance races. The results of some physical measurements indicate a clear disparity between the levels of arm and leg strength among juniors, along with a relative weakness in core muscle strength. This negatively affects the efficiency of force transfer between different parts of the body during swimming, leading to increased water resistance and a decrease in the swimmer's average speed.

Despite the abundance of studies that have addressed the effect of strength training on athletic performance in general, studies that have examined the effect of integrated training programs to develop the muscular strength of the core, arms, and legs on the time performance level of middle-distance swimmers in the youth category remain limited, especially in the Arab environment. This lack of applied studies has led to the absence of clear scientific training models that coaches can rely on to develop muscular strength in an integrated manner that suits the physical and physiological characteristics of youth and achieves tangible improvement in the performance times of middle-distance races.

Research Objectives

The present study seeks to examine the impact of a proposed training program designed to enhance the strength of the core, upper limbs, and lower limbs on the time-based performance of middle-distance swimmers. To reach this goal, we need to look at the following:

1. Looking into how the planned training program may affect the core muscle strength of middle-distance swimmers.
2. Investigating the effect of the proposed training program on improving arm muscle strength in middle-distance swimmers.
3. Analyzing the effect of the proposed training program on enhancing leg muscle strength in middle-distance swimmers.
4. Determining the effect of the proposed training program on improving the time performance outcomes of middle-distance swimmers.

Research Hypotheses

1. It is assumed that significant statistical differences will be present between the pre and post-measurements of the experimental group in terms of core muscle strength,

arm muscle strength, leg muscle strength, and swimming time performance for middle-distance swimmers, with superior results in the post-measurement.

2. It is also expected that statistically significant differences will appear between the pre- and post-measurements of the control group regarding core muscle strength, arm muscle strength, leg muscle strength, and swimming time performance for middle-distance swimmers, favoring the post-measurement results.
3. Moreover it is anticipated that statistically significant differences will emerge between the experimental and control groups in the post-measurements of core muscle strength, arm muscle strength, leg muscle strength, and swimming time performance for middle-distance swimmers, in favor of the experimental group.

Materials and Methods

Study Participants

This study involved youth-category swimmers registered in several clubs in Kirkuk Governorate during the 2025–2026 season. A total of 45 swimmers were selected using random sampling and then allocated into three groups (Table 1). The pilot group included 15 swimmers and was used to standardize the study tests, including checking validity and reliability. The remaining swimmers were assigned to the main experiment: 15 swimmers in the experimental group, who followed the proposed training program, and 15 swimmers in the control group, who continued the traditional training program used at their clubs (Sugiyono, 2012).

To minimize the influence of factors outside the intervention, basic characteristics of the sample—age, body weight, and height—were recorded before the program started. These baseline data were used to confirm that the groups were comparable prior to the experimental treatment (Table 2).

Table 1. Characteristics of the research sample

Classification	Number of players	Percentage
Pilot sample	15	33.33%
Experimental group	15	33.33%
Control group	15	33.33%
Total	45	100%

Study organization

An experimental approach was chosen because it matched the aim of the study, which was to test the effect of a proposed strength program on swimmers' performance. The research used a pre-test–post-test control group design with two main groups: an experimental group and a control group (Arikunto, 2010). Both groups completed the same set of measurements before the training period (pre-test) and after the training period (post-test). During the intervention phase, the experimental group performed the proposed program that focused on developing core, arm, and leg muscle strength, while the control group followed the usual training program applied in their clubs.

Statistical analysis

Data were processed using descriptive and inferential statistics. First, participants' baseline characteristics (age, height, and body weight) were summarized using appropriate descriptive indicators (Table 2). Then, pre-test and post-test results were compared to examine changes within each group and differences between the experimental and control groups after the intervention. Statistical testing was used to determine whether the observed differences were significant.

Results

Sample description and distribution checks

Table (2) presents the baseline descriptive statistics for the whole sample (n = 45). Participants had a mean age of 17.24 ± 0.36 years, body weight 73.69 ± 1.58 kg, and height 177.25 ± 2.01 cm. The normality indicators were within acceptable ranges, with skewness between −0.36 and 1.06 and kurtosis between −0.85 and 1.62. This suggests the data were reasonably well distributed and the sample was sufficiently homogeneous for the experimental analysis (Table 2).

Table 2. Statistical Indicators of the Research Sample for the Basic Variables Prior to the Experiment. n = 45

Variables	Unit of measurement	Mean	Standard deviation	Skewness coefficient	Kurtosis coefficient
Age	Year	17.24	0.36	1.06	1.62
Weight	kg	73.69	1.58	0.99	0.55
Height	cm	177.25	2.01	0.36-	-0.85

Measurement tools and test set

The study outcomes were assessed using the test battery listed in Table (3): front plank (core strength), inclined push-up and 5 kg medicine ball throw (arm strength), standing long jump (leg strength), and 200 m freestyle time (performance).

Table 3. Tests Used in the Research

Abilities	Tests	Unit of Measurement
Core muscle strength	Front plank test	Sec.
	Inclined prone push-up test	Rep.
Arm muscle strength	Medicine ball throw (5 kg) with both hands for maximum distance	Meter
Leg muscle strength	Standing long jump test	cm.

Abilities	Tests	Unit of Measurement
Swimming time performance	Numerical level of 200 m freestyle swimming	Sec.

Pilot study: validity and reliability

The pilot study (n = 15) was conducted from 6/9/2025 to 15/9/2025 to check the quality of the tests. Discriminant validity was supported by significant differences between the upper and lower quartiles across all tests (Table 4). The calculated t-values ranged from 3.52 to 6.89, exceeding the tabulated value at $p < 0.05$, which indicates that the tests were able to differentiate between higher and lower performers.

Table 4. Significance of Differences Between the Upper and Lower Quartiles for Determining the Discriminant Validity of the Tests Under Study. n = 15

Tests	Unit of Measurement	Upper Quartiles		Lower Quartiles		t-value	Significance Level
		Mean	± SD	Mean	± SD		
Front plank test	Sec.	79.31	.32	72.36	1.03	5.01	0.00
Inclined prone push-up test	Rep.	14.95	1.24	11.02	1.46	4.36	0.00
Medicine ball throw (5 kg) with both hands for maximum distance	Meter	5.86	0.96	4.97	0.89	3.52	0.00
Standing long jump test	cm.	172.94	0.30	159.02	0.52	6.89	0.00
Numerical level of 200 m freestyle swimming	Sec.	145.20	1.25	139.42	1.95	5.02	0.00

Test–retest reliability was examined with a 7-day interval using the same pilot sample. The correlation coefficients were high (r = 0.941–0.971), confirming that the tests were consistent and stable across repeated measurements (Table 5).

Table 5. Reliability Coefficient by Calculating the Correlation Between the First Application and the Re-Test in the Tests. (n = 15)

Tests	Unit of Measurement	Experimental Group		Control Group		r-value
		Mean	± SD	Mean	± SD	
Front plank test	Sec.	75.36	1.63	75.44	1.52	0.942*
Inclined prone push-up test	Rep.	12.41	1.24	12.56	1.03	0.953*
Medicine ball throw (5 kg) with both hands for maximum distance	Meter	5.33	0.58	5.39	0.63	0.971*
Standing long jump test	cm.	165.92	1.28	165.85	1.69	0.950*
Numerical level of 200 m freestyle swimming	Sec.	142.31	1.47	142.53	1.52	0.941*

Baseline equivalence between groups

Before the intervention, the experimental and control groups were statistically comparable (Table 7). The calculated t-values (0.56–1.02) were below the tabulated t-value (2.048 at $p = 0.05$), indicating no meaningful pre-test differences in core strength, arm strength, leg strength, or 200 m freestyle time (Table 7).

Table 7. Equivalence Between the Control and Experimental Groups in the Tests (Core Muscle Strength – Arm Strength – Leg Strength – Swimmers' Numerical Performance Level) Before the Experiment. n = 15

Tests	Unit of Measurement	Experimental Group		Control Group		t-value	Significance Level
		Mean	± SD	Mean	± SD		
Front plank test	Sec.	76.23	1.02	75.93	1.32	1.02	0.00
Inclined prone push-up test	Rep.	13.26	0.83	13.86	1.52	0.89	0.00
Medicine ball throw (5 kg) with both hands for maximum distance	Meter	5.18	1.06	5.12	0.77	0.56	0.00
Standing long jump test	cm.	163.92	1.67	164.82	2.01	1.05	0.00
Numerical level of 200 m freestyle swimming	Sec.	143.85	2.03	144.02	1.96	0.86	0.00

Tabulated t-value at significance level (0.05) = 2.048

Pre–post changes in the experimental group

After completing the proposed training program, the experimental group showed clear improvements in all study variables (Table 8). Post-test means were higher for the strength measures and lower (better) for the 200 m freestyle time. The calculated t-values ranged from 4.92 to 13.82, indicating statistically significant pre–post differences in favor of the post-test across core, arm, and leg strength, as well as swimming time performance (Table 8).

Table 8. Significance of Differences Between the Pre-Measurement and the Post-Measurement for the Experimental Group in the Tests (Core Muscle Strength – Arm Strength – Leg Strength – Swimmers' Numerical Performance Level). n = 15

Tests	Unit of Measurement	Pre-Measurement		Post-Measurement		t-value	Significance Level
		Mean	± SD	Mean	± SD		
Front plank test	**Sec.**	**76.23**	**1.02**	**92.42**	**1.36**	**8.94**	**0.00**

Inclined prone push-up test	Rep.	13.36	0.85	21.21	1.65	13.82	0.00
Medicine ball throw (5 kg) with both hands for maximum distance	Meter	5.18	1.06	6.96	1.56	4.92	0.00
Standing long jump test	cm.	163.92	1.67	187.36	1.69	9.15	0.00
Numerical level of 200 m freestyle swimming	Sec.	143.85	2.03	132.78	1.98	7.36	0.00

Tabulated t-value at significance level (0.05) = 2.145

Pre–post changes in the control group

The control group also improved in several measures after the training period (Table 9). Significant gains were found in the plank, push-up, standing long jump, and 200 m freestyle time. However, the medicine ball throw did not reach statistical significance (t = 2.03; p = 0.09), suggesting that the traditional program may not have provided enough stimulus to improve this specific arm power component (Table 9).

Table (9). Statistical Significance of Differences Between Pre-Test and Post-Test Measurements for the Control Group in Core Muscle Strength, Arm Strength, Leg Strength, and Swimmers' Time Performance Level. n = 15

Tests	Unit of Measurement	Pre-Measurement		Post-Measurement		t-value	Significance Level
		Mean	± SD	Mean	± SD		
Front plank test	Sec.	75.93	1.32	83.69	1.56	4.72	0.00
Inclined prone push-up test	Rep.	13.88	1.52	16.02	1.32	6.39	0.00
Medicine ball throw (5 kg) with both hands for maximum distance	Meter	5.12	0.77	5.96	0.82	2.03	0.09
Standing long jump test	cm.	164.82	2.01	171.28	1.93	6.88	0.00
Numerical level of 200 m freestyle swimming	Sec.	144.02	1.96	139.69	1.25	4.92	0.00

Tabulated t-value at significance level (0.05) = 2.145

Post-test comparison between the experimental and control groups

In the post-test comparison (Table 10), the experimental group outperformed the control group across all variables. The differences were statistically significant, with t-values ranging from 3.01 to 7.36. These patterns are also visible in Figure (1), which shows higher post-test means for the experimental group in strength measures and a better (lower) mean time in the 200 m freestyle event (Table 10)

Table 10. Significance of Differences the Two Groups (Experimental and Control) in the Post-Measurement in the Tests (Core Muscle Strength – Arm Strength – Leg Strength – Swimmers' Numerical Performance Level). n = 15

Tests	Unit of Measurement	Experimental Group		Control Group		t-value	Significance Level
		Mean	± SD	Mean	± SD		
Front plank test	Sec.	92.42	1.36	83.69	1.56	5.69	0.00
Inclined prone push-up test	Rep.	21.21	1.65	16.02	1.32	7.36	0.00
Medicine ball throw (5 kg) with both hands for maximum distance	Meter	6,96	1.56	5.96	0.82	3.01	0.00
Standing long jump test	cm.	187.36	1.60	171.28	1.93	6.92	0.00
Numerical level of 200 m freestyle swimming	Sec.	132.78	1.98	139.69	1.25	4.86	0.00

Tabulated t-value at significance level (0,05) = 2.048

Discussion

This study was built on the hypothesis that a structured strength program targeting the core, arms, and legs would improve strength-related capacities and, in turn, enhance 200 m freestyle time performance in middle-distance swimmers. Overall, the findings support this hypothesis. The experimental group showed clear gains in all strength variables, accompanied by a meaningful reduction in 200 m time. The control group also improved in several measures, but the changes were smaller, and the medicine ball throw did not reach statistical significance.

When viewed alongside the literature, this pattern is consistent with earlier work linking strength development to swimming performance, particularly in events that require both speed and sustained power. (Albalad-Aiguabella et al., 2025; Crowley et al., 2018)highlights muscular strength as an important contributor to swimmers' competitive performance, especially in races that are not long in duration. The improvement in core strength observed here also fits with the view that a stronger trunk supports body stability and more efficient force transfer between the upper and lower limbs, which can help maintain an effective swimming position and stroke mechanics (Lopes et al., 2021). In addition, the gains in leg power align with the argument that lower-limb strength plays a key role in starts, turns, and maintaining a streamlined posture in the water—factors that can directly influence overall race time (Dello Iacono et al., 2017).

At the same time, the control group results provide a useful comparison. Their traditional in-water training was enough to produce improvements in several outcomes, which supports the idea that consistent swimming practice can raise performance through physiological adaptation. However, the lack of a significant change in the medicine ball throw suggests that conventional training alone may not sufficiently develop certain strength qualities, particularly those related to upper-limb power. This point matches (Amiri et al., 2025) observation that traditional programs can improve swimmers' fitness and performance, but the gains are often uneven across strength components when specific dry-land strength work is limited or absent.

From a practical standpoint, these findings matter because they show that better 200 m performance is not only a technical issue in the pool. Strength capacity—especially when developed in an integrated way across the core, arms, and legs—appears to support stroke effectiveness, body alignment, and energy efficiency over the race distance. In other words, dry-land strength training should not be treated as an optional add-on; it can be a meaningful part of preparation for youth middle-distance swimmers when it is planned and progressed properly.

In terms of application, coaches can incorporate functional strength work for the core, arms, and legs into weekly training without sacrificing technical and skill-focused sessions in the water. The key is gradual load progression, exercise selection that relates to swimming demands (Darmanto et al., 2019; Gupta et al., 2020), and close attention to safety and technique, especially for adolescent athletes. The control group findings also serve as a reminder: regular swimming training remains beneficial, but if the goal is a larger performance gain, a more targeted strength stimulus is likely needed (Cañas-Jamett et al., 2020; Crowley et al., 2018).

Future research can extend these results in several ways. Studies with larger samples and swimmers from different clubs or regions would help confirm how widely the program can be applied. It would also be useful to compare different program durations (e.g., 6 vs. 8 vs. 12 weeks) to identify the most efficient training period for improvement. Finally, adding more swimming-specific variables—such as start and turn performance, stroke rate and stroke length, or physiological indicators—could clarify how strength gains translate into faster race times in middle-distance events(*Item - Investigations into the Teaching of Swimming in Secondary Schools - Loughborough University - Figshare*, n.d.).

Conclusions:

After completing the recommended program, the experimental group showed a clear and statistically significant improvement in core strength compared with their pre-test results. The same trend appeared in arm strength: the gains in the experimental group were noticeably larger than those seen in the control group. Leg strength also improved more strongly under the proposed regimen, as reflected in the experimental group's better post-test performance relative to the control group. When the two groups were compared at the end of the study, the experimental group consistently came out ahead across all measured variables. Overall, these findings indicate that a program combining targeted strength work for the core, arms, and legs produces better improvements in middle-distance swimmers' time performance than depending on traditional training alone.

Recommendations:

Based on the study results, the proposed program deserves to be included in the regular preparation of middle-distance swimmers because it was linked to better time performance. Training plans should also give more space to functional strength work for the core and limbs, instead of depending only on traditional in-water sessions. Just as importantly, dry-land strength work needs to be planned alongside in-water technical training so that physical improvements actually show up in stroke quality and race execution. Coaches and clubs are encouraged to track swimmers' development through regular testing of key physical variables and 200 m performance using standardized, well-established tests. The findings also point to the need for stronger coach awareness of core training, especially its role in trunk stability and efficient force transfer while swimming. Finally, these results can be used as a practical reference for updating training plans in clubs and junior preparation centers to match current directions in modern sport training.

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