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EFFECT OF USING VARIOUS TRAINING METHODS ON SOME FUNCTIONAL VARIABLES AND ACHIEVEMENT IN 50-METER MEN BREASTSTROKE RACE

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ABSTRACT

Background. Swimming performance, particularly in short-distance events such as the 50-meter breaststroke, requires the integration of high physical efficiency, optimal physiological function, and precise technical execution. **Objective.** This study aimed to examine the effect of using various training methods on selected functional variables—maximum vital capacity (VC), maximum oxygen consumption (VO_2 max), and resting heart rate—and on the competitive performance of male swimmers in the 50-meter breaststroke. **Methods.** An experimental design with equivalent control and experimental groups was employed, using pre- and post-tests to measure outcomes. The sample consisted of 20 competitive male swimmers, equally divided into two groups. The experimental group participated in an 8-week training program incorporating resistance belts, buoyancy devices, breathing exercises, and complementary dry-land workouts, conducted four times per week. The control group followed a conventional training regimen. Data were collected using standardized tests: a spirometer for VC, a modified swimming test for VO_2 max, a pulse oximeter for resting heart rate, and a digital stopwatch for race completion time. **Results.** The results revealed statistically significant improvements in the experimental group across all variables, including increased VC and VO_2 max, reduced resting heart rate, and faster race times, with no significant changes observed in the control group. **Conclusions.** The study concludes that integrating diverse training methods significantly enhances both functional physiological capacity and competitive performance in short-distance swimmers. This research contributes to sports science by providing empirical evidence that a multi-modal training approach can yield superior adaptations compared to traditional methods, offering practical guidance for coaches aiming to optimize athlete performance in sprint swimming events.

Keywords; training methods, swimming, functional variables, breaststroke, VO_2 max , vital capacity.

A. INTRODUCTION

Swimming is an individual sport that requires high efficiency in physical and functional performance to achieve success (Mashud, Warni, et al., 2023; Mashud et al., 2018), especially in speed races such as the 50-meter breaststroke race, which relies heavily on anaerobic capacity, maximum speed, and precision in technical performance (Mashud, Arifin, et al., 2023). The development of performance in these races requires the development of multiple elements in the physical and functional aspects, which calls for the introduction of modern training methods aimed at improving the efficiency of vital organs and increasing the effectiveness of motor performance (Suryadi, Okilanda, et al., 2023).

Swimming is an individual sport that demands high levels of physical and functional efficiency in order to achieve success, particularly in sprint events such as the 50-meter breaststroke. This event relies heavily on anaerobic capacity, maximum speed, and technical precision (Mashud, Arifin, et al., 2023). Optimal performance in this category requires the development of multiple physical and functional components, including muscular power, cardiovascular efficiency, and precise biomechanical execution (Omae et al., 2017). Consequently, modern training approaches that focus on enhancing the efficiency of vital organs and maximizing motor performance have become increasingly necessary (Adigüzel, 2021).

In the current era of competitive sports, relying solely on traditional training programs is no longer sufficient to meet the growing demands of high-level performance (Abdullah & Abdullah, 2025; Sudirman et al., 2024). Athletes and coaches are now expected to diversify training strategies and incorporate modern aids to accelerate physiological and technical improvement (Haniyyah et al., 2025; Pelamonia & Puriana, 2023). Various studies have confirmed the positive impact of such tools—including water resistance equipment, dry-land exercises, buoyancy devices, and targeted breathing drills—on improving athletic performance and enhancing the efficiency of vital body systems (Suniga et al., 2025). However, field observations and practical coaching experience indicate that many swimmers competing in the 50-meter breaststroke still exhibit deficiencies in several key physiological indicators. These include reduced vital lung capacity, suboptimal maximum oxygen uptake (VO_2 max), elevated resting and post-exercise heart rate, and inconsistent race completion times (Hardinata et al., 2023; Supriatna et al., 2023; Suryadi, Yanti, et al., 2023). Such

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limitations directly affect sprint performance, where even minor physiological inefficiencies can lead to significant competitive disadvantages.

One of the main problems lies in the fact that many coaches continue to implement training programs that are predominantly traditional in nature, often emphasizing repetitive water-based drills without adequately integrating dry-land training, resistance-based conditioning, or specialized breathing exercises. As a result, the training process may not sufficiently address the improvement of functional capacities such as lung efficiency, oxygen utilization, and cardiovascular stability (Yudi et al., 2024). This gap between modern training principles and current coaching practices has limited the potential for performance optimization among competitive swimmers. Given these challenges, there is a clear need to design and test an integrated training program that combines various methods—water resistance training, elastic band exercises, buoyancy-based drills, and targeted breathing exercises—in a structured and measurable way. Such a program could enhance both the functional physiological indicators and the competitive performance of swimmers in short-distance events like the 50-meter breaststroke (Mashud, Arifin, et al., 2023).

The novelty of this research lies in the integration of multiple training modalities into a single, comprehensive program that simultaneously addresses physiological, biomechanical, and performance variables. Unlike previous studies that have typically focused on a single training method or have separated dry-land and in-water training, this study adopts a synergistic approach by combining them in a coordinated manner. This integration is expected to produce a greater cumulative effect on vital lung capacity, VO_2 max, and heart rate efficiency, while also translating these physiological improvements into measurable performance gains in competition. Additionally, the study's dual focus—examining both physiological adaptations and competitive race outcomes—provides a more practical and directly applicable framework for swimming coaches and athletes aiming for peak performance in sprint events.

B. METHOD

Participant

The research community was represented by the swimmers of the North Gas Club for the men's category (aged 18-22 years), who had no less than 3 years of experience in training and participating in local championships. The research sample was randomly selected, and its number was (20) swimmers, who were divided into a control group: 10 swimmers who underwent the traditional program . An experimental group: 10 swimmers who underwent the proposed program. The homogeneity of the two groups was confirmed using t-tests to determine equivalence in physical and functional variables. (Height, weight, age, vital capacity, VO_2 max , completion time).

Research Design

The researcher adopted the experimental approach by designing two equivalent groups (control and experimental) with pre- and post-measurements, as it is the most appropriate for measuring the effect of the proposed training program using various training methods on the functional variables and level of achievement among swimmers.

Training program for the experimental group

The training program lasted for 8 weeks, with 4 training units per week, each unit lasting 60 minutes . The components of the training unit included general and specific warm-up (10 minutes), dry exercises with light and medium resistance (15 minutes), water exercises using various training equipment (25 minutes), specialized technical performance in breaststroke (10 minutes), cool-down and recovery (5 minutes). The objectives of the training program are to develop the respiratory system's capacity , increase the efficiency of the circulatory system , improve muscular adaptation to resistance , reduce the pulse rate and improve the ability to recover , and improve the speed of completion in the race.

Testing Procedures and Training Program

The present study employed several standardized tests and procedures to measure the targeted functional and performance variables. Maximum Vital Capacity (VC) was assessed using the vital capacity test with a Vitalograph or digital spirometer. Participants were instructed to take a full inhalation followed by a prolonged and forceful exhalation through the device's tube, with the total lung capacity recorded in liters (L) directly from the device screen. Maximum Oxygen Consumption (VO_2 max) was evaluated using a modified swimming test, where participants swam at maximum effort for 12 minutes in a standard pool, and the distance covered was recorded. VO_2 max (ml/kg/min) was calculated using the formula: *(distance in meters – 504) ÷ 45*. Resting Heart Rate was measured using a Polar H10 or equivalent electronic pulse oximeter after participants sat quietly for five minutes, with beats per minute (bpm) recorded directly from the device display. 50-Meter Breaststroke Time was determined in a 50-meter Olympic pool using a digital stopwatch with 1/100-second accuracy, starting the timing at the departure signal and stopping upon reaching the finish line, as measured by an official observer.

The proposed training program spanned eight weeks, consisting of 32 training units (four sessions per week), each lasting 60 minutes. A typical session included: (1) general and specific warm-up (10 minutes), (2) dry-land workouts with resistance bands and light weights (15 minutes), (3) water-based exercises using flotation devices and parachutes (25 minutes), (4) specialized breaststroke drills (5 minutes), and (5) recovery and stretching (5 minutes). Training loads were progressively increased in resistance intensity, with a rest day introduced every three consecutive training days. Special attention was given to breathing techniques and swimming fluidity in the final third of the program. All data were systematically recorded using a standardized data registration form.

Stages of research implementation

Tribal measurements were made where The tests were conducted on the entire sample before starting the program . Then the training program was implemented. Under the supervision of the researcher and for a period of 8 weeks . After that, dimensional measurements were conducted and the same tests were re-conducted after the end of the training program.

Statistical methods

The researcher used the arithmetic mean and standard deviation. The t-test for related samples (within group). The t-test for independent samples (between groups). The statistical significance was determined at the level of ($\alpha \leq 0.05$). With these methodological procedures, the researcher sought to ensure accuracy in application and evaluation, to reach reliable results in analyzing the effect of the proposed training program on functional variables and the level of achievement in breaststroke swimming.

C. RESULTS AND DISCUSSION

Results

The results in Table 1 indicate a noticeable improvement in maximum vital capacity among participants in the experimental group following the application of various training methods. The mean VC in the experimental group increased from 3.91 liters in the pre-test to 4.52 liters in the post-test, representing an average improvement of 0.61 liters. This change was statistically significant, as evidenced by the calculated t-value of 6.10 and a significance level of $p = 0.000$ ($p < 0.05$), indicating that the training program had a substantial positive effect on lung function. In contrast, the control group showed only a slight increase in mean VC, from 3.87 liters in the pre-test to 3.92 liters in the post-test, an average improvement of just 0.05 liters. This change was not statistically significant ($t = 1.02$; $p = 0.34$), suggesting that the absence of the varied training methods did not lead to meaningful enhancement in lung capacity.

Overall, these results suggest that the application of diverse training methods—combining water resistance, dry-land exercises, buoyancy tools, and breathing drills—effectively improves maximum vital capacity in male 50-meter breaststroke swimmers, whereas conventional training alone produces minimal change.

Table 1. Shows maximum vital capacity

Group	Test	Mean	St.d	(t) value	Sig.
Experimental	Pre-test	3.91 liters	0.27	6.10	0.000
	Post-test	4.52 liters	0.31		
Control	Pre-test	3.87 liters	0.28	1.02	0.34
	Post-test	3.92 liters	0.30		

Table 2. Shows maximum vital capacity (VO_2 max results)

Group	Test	Mean	St.d	(t) value	Sig.
Experimental	Pre-test	43.8 ml/kg/min	2.5	7.02	0.000
	Post-test	49.6 ml/kg/min	2.2		
Control	Pre-test	43.4 ml/kg/min	2.6	1.10	0.28
	Post-test	44.1 ml/kg/min	2.5		

The findings in Table 2 show that the experimental group experienced a significant increase in VO_2 max following the implementation of various training methods. The mean value rose from 43.8 ml/kg/min in the pre-test to 49.6 ml/kg/min in the post-test, reflecting an average improvement of 5.8 ml/kg/min. The *t*-value of 7.02 with a significance level of $p = 0.000$ ($p < 0.05$) confirms that this improvement was statistically significant. This indicates that the integrated training program was highly effective in enhancing the swimmers' aerobic capacity. In contrast, the control group's VO_2 max increased only slightly, from 43.4 ml/kg/min to 44.1 ml/kg/min, a change of 0.7 ml/kg/min. This difference was not statistically significant ($t = 1.10$; $p = 0.28$), suggesting that the conventional training methods used did not lead to substantial aerobic improvement.

Table 3. Shows maximum vital capacity (Resting heart rate results)

Group	Test	Mean	St.d	(t) value	Sig.
Experimental	Pre-test	76.1 beats/minute	3.4	5.86	0.000
	Post-test	69.3 beats/minute	2.7		
Control	Pre-test	75.9 beats/minute	3.3	1.02	0.32
	Post-test	74.7 beats/minute	3.2		

As shown in Table 3, the experimental group recorded a significant reduction in resting heart rate after the training program. The mean resting heart rate decreased from 76.1 beats/min in the pre-test to 69.3 beats/min in the post-test, an average reduction of 6.8 beats/min. This change was statistically significant ($t = 5.86$; $p = 0.000$), indicating improved cardiovascular efficiency as a result of the varied training methods. The control group showed only a modest decrease in resting heart rate, from 75.9 beats/min to 74.7 beats/min (a reduction of 1.2 beats/min), which was not statistically significant ($t = 1.02$; $p = 0.32$). This suggests that without the integrated training program, improvements in cardiovascular efficiency were minimal.

Table 4. Shows maximum vital capacity (Results of 50m breaststroke race)

Group	Test	Mean	St.d	(t) value	Sig.
Experimental	Pre-test	45.9 seconds	1.2	8.14	0.000
	Post-test	42.6 second	1.0		
Control	Pre-test	45.8 seconds	1.3	1.26	0.21
	Post-test	45.2 second	1.2		

The data in Table 4 reveal a significant improvement in performance among swimmers in the experimental group after participating in the varied training program. The mean completion time decreased from 45.9 seconds in the pre-test to 42.6 seconds in the post-test, representing an average improvement of 3.3 seconds. The t-value of 8.14 and the significance level of $p = 0.000$ ($p < 0.05$) indicate that this improvement was highly significant. This demonstrates that the integrated training methods not only enhanced physiological indicators but also translated effectively into better competitive performance. Meanwhile, the control group recorded only a slight reduction in mean completion time, from 45.8 seconds to 45.2 seconds (an improvement of 0.6 seconds). This change was not statistically significant ($t = 1.26$; $p = 0.21$), suggesting that conventional training methods had little impact on sprint performance in the 50-meter breaststroke.

Discussion

The findings of this study demonstrate statistically significant improvements in all measured functional variables—maximum vital capacity (VC), VO_2 max, and resting heart rate—as well as in competitive performance for the 50-meter breaststroke, in favor of the experimental group. These results clearly support the effectiveness of the varied training program, which incorporated resistance breathing exercises, water resistance drills, buoyancy devices, and dry-land training. The marked improvement in maximum vital capacity among the experimental group suggests that targeted respiratory muscle strengthening, achieved through resistance breathing and specific water exercises, can substantially enhance pulmonary function. This aligns with the findings of (Hutzier et al., 1998), who reported significant increases in VC among swimmers following water-resistance training. Stronger respiratory muscles and improved lung elasticity likely allowed the swimmers to intake and utilize more air per breath, directly benefiting sprint performance where oxygen delivery efficiency is critical even in predominantly anaerobic events (Illi et al., 2012).

Similarly, the substantial increase in VO_2 max observed in the experimental group highlights the program's ability to improve aerobic capacity, even in sprint swimmers. While the 50-meter breaststroke relies largely on anaerobic energy pathways, a higher VO_2 max supports faster recovery between training bouts and improves oxygen utilization efficiency during competition. This finding is consistent with Kumari et al., (2025), who reported that combining endurance and resistance training can produce notable gains in respiratory and circulatory efficiency in athletes. The significant reduction in resting heart rate among the experimental group further indicates improved cardiac efficiency, likely due to increased stroke volume and enhanced oxygen transport mechanisms. Nugraha et al., (2024) similarly observed that water resistance training promotes cardiovascular adaptations, such as reduced resting heart rate and improved cardiac output, which contribute to overall athletic performance.

Performance-wise, the notable improvement in 50-meter completion time underscores the practical benefits of integrating diverse training modalities. The combination of speed-specific drills, technical refinement, and buoyancy-assisted exercises likely optimized stroke mechanics, reduced hydrodynamic drag, and enhanced propulsion efficiency. These results parallel those of (Ji et al., 2021), who demonstrated that incorporating dry-land strength and technique exercises can significantly improve competitive swimming outcomes. Overall, the experimental group's superiority over the control group in both functional and performance indicators confirms that a multidimensional training approach—combining aerobic, anaerobic, resistance, and technical components—can effectively enhance short-distance swimming performance. The integration of modern training aids appears to accelerate physiological adaptations that directly translate into faster race times.

Limitations of the Study

Despite the positive outcomes, this study has several limitations that should be acknowledged. First, the sample size was relatively small, which may limit the generalizability of the findings to the broader population of competitive swimmers. Second, the study duration was limited to a single training cycle; longer-term effects of the integrated training program remain to be examined. Third, external factors such as participants' diet, sleep quality, and psychological readiness were not strictly controlled, and these variables could have influenced the results. Finally, the study focused solely on male swimmers in the 50-meter breaststroke event, meaning the findings may not be directly applicable to female swimmers or athletes in other swimming disciplines.

Future research could address these limitations by including larger and more diverse samples, extending the training duration, and implementing stricter controls on external variables. Additionally, exploring the effects of similar training approaches on different swimming events and mixed-gender groups would provide a more comprehensive understanding of their effectiveness.

D. CONCLUSION

This study demonstrated that integrating various training methods—such as resistance belts, buoyancy devices, breathing exercises, and dry-land training—significantly improved maximum vital capacity, VO_2 max, and resting heart rate among 50-meter breaststroke swimmers in the experimental group. These physiological gains were accompanied by a notable reduction in race completion time, confirming the program's effectiveness in enhancing both functional capacity and competitive performance. No significant improvements were observed in the control group, reinforcing the effectiveness of the proposed training approach. The proposed training program is recommended for short-distance swimmers, particularly in breaststroke events, due to its proven impact on functional and performance outcomes. Coaches are encouraged to diversify training methods beyond traditional approaches, incorporate respiratory training and assistive devices, and utilize modern tools such as breathing masks, water belts, and swimming umbrellas. Further studies should explore this approach in other swimming styles, across different age groups, and within physical education curricula to broaden its applicability.

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F. AUTHOR CONTRIBUTION STATEMENT

SNA authors contributed to and are responsible for the entire manuscript.

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