

ANALYSIS OF THE EFFECT OF SWIMMING TRAINING ON THE 400M FREESTYLE TEST

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ABSTRACT

Swimming and water exercise are effective methods for improving physical fitness, endurance, and swimming technique. The aim of the study was to examine the impact of swimming training on the results of the 400-meter freestyle test (choice of stroke or style), focusing on changes in time, technique selection, and differences in progress between beginner and advanced swimmers. Swimming represents a complex physical activity that involves the interaction of technical execution, endurance, and energy efficiency. A swimmer's effectiveness often depends on the ability to coordinate biomechanical factors and physiological adaptations, such as improved aerobic capacity, efficient oxygen usage, and enhanced movement patterns. The study included 19 participants who attended a structured swimming program once a week for 8 months. The program was designed to include exercises for improving technique, endurance, and speed, as well as targeted work on optimizing energy expenditure. Results showed that participants improved their average swimming time by 5.9% after completing the program. The analysis also revealed changes in swimming technique preferences, with more participants adopting more economical techniques, such as front crawl and a front crawl-breaststroke combination, after the training. The study confirmed that beginner swimmers achieved greater progress compared to advanced swimmers, which can be attributed to the greater adaptability of those with less prior experience. However, due to the small sample size, statistically significant differences between the groups could not be confirmed. The findings of the study emphasize the importance of a holistic approach to swimming training, encompassing both physiological and biomechanical aspects. Further research could expand insights by examining longer time periods, different age groups, or the use of various tools, providing a more in-depth understanding of the long-term effects of swimming training.

Key words: swimming training, 400-meter freestyle test, beginners, advanced swimmers, swimming technique, physiological adaptation

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INTRODUCTION

During swimming, energy is primarily expended to overcome water resistance and maintain the body on the surface. These two processes, combined with proper technique, determine how efficiently a swimmer utilizes energy while moving through water. Swimming efficiency is assessed based on the amount of oxygen consumed at submaximal speed. More efficient swimmers use less oxygen under the same conditions. In addition to technical skills, physical characteristics such as buoyancy, body size, and the efficiency of force transfer to water also play an important role in achieving better efficiency (Costill et al., 1992).

Swimming is a cyclical sport that includes elements of starts, turns, and freestyle swimming techniques (Veiga et al., 2014), where swimmers aim to cover distances in the shortest possible time using one of the four allowed strokes (backstroke, breaststroke, butterfly, or freestyle). Recreational swimming may involve a mix of styles (Saavedra et al., 2012). Different swimming styles vary significantly in terms of energy efficiency. Among all techniques, butterfly and breaststroke are the least economical, as they require greater energy expenditure to overcome water resistance and maintain proper technique. Backstroke is somewhat more efficient due to better energy distribution, while freestyle is the most economical stroke because of its biomechanical advantages and lower oxygen consumption at the same speed, making it the most efficient swimming style (Barbosa et al., 2006; Pendergast et al., 2006).

Swimming enhances physical endurance, muscle strength, and self-confidence. It protects joints, improves circulation, vascular flexibility, and heart function, strengthens respiratory muscles, increases lung capacity, and enhances chest flexibility. Moreover, the humid air above the water positively affects the respiratory system. The supine body position reduces stress on the spine, while swimming movements maintain joint flexibility and proper posture. Swimming involves large muscle groups, such as those in the shoulders, chest, and legs, without the risk of injury, as movements are controlled and non-explosive. Additionally, swimming positively impacts the body's thermoregulation (Juba, 2010; Praznik & Cresnar, 2001; Jurak & Kovač, 2002). Progress in sports significantly differs between beginners and advanced swimmers due to variations in training experience, physiological adaptations, and the complexity of training programs. Beginners often achieve rapid improvements with regular training, as their bodies quickly adapt to new stimuli. Conversely, advanced athletes typically experience slower progress, requiring more specialized and intensive training approaches for further improvements (Rippetoe & Baker, 2013).

RESEARCH OBJECTIVES

The objectives of the study were as follows:

- To determine changes in time and progress in the 400-meter freestyle test before and after the swimming training program.

- To examine which swimming technique or style participants most frequently choose to achieve the fastest result and to analyze how this choice changes before and after the swimming training period.
- To identify differences in progress based on the level of swimming proficiency (beginners versus advanced swimmers) and the changes in results for the 400-meter freestyle test.
- We proposed the following hypotheses:
- After completing the swimming training program, participants will improve their times in the 400-meter freestyle test, indicating progress in swimming skills
- Before starting the program, participants will use various swimming techniques to achieve the fastest result, but after the training, they will likely begin choosing techniques that provide greater efficiency and speed. Most participants will opt for a combined technique (front crawl-breaststroke).
- There will be a noticeable difference in progress between beginners and advanced swimmers in the 400-meter freestyle test, with beginners showing greater improvements due to initial gains, while experienced swimmers will achieve smaller enhancements.

RESEARCH METHODS

Study participants

The study included 19 participants, of which 15 (79%) were students and 4 (21%) were young employed individuals (under 30 years old). Among the participants, 10 (53%) were male and 9 (47%) were female. The student participants attended various faculties at the University of Ljubljana, while the young employed individuals were all advanced swimmers who initially joined the swimming training program as students at the University of Ljubljana and continued with sports training after completing their studies.

Procedure and equipment

Data was collected by measuring swimming times for the 400-meter freestyle test. Swimming time was recorded using timers/stopwatches, and swimming technique was assessed through participant observation. The testing took place at the Tivoli swimming pool. Participants used swimsuits (one-piece for women and tight-fitting shorts for men), swimming goggles, and swim caps of their choice.

Initial measurements were conducted in October 2023, and final measurements were taken in May 2024, with data collected over two training sessions. The 400-meter freestyle test began with an auditory signal and a push-off from the pool wall. Three participants swam in the same lane, starting at 15-second intervals. Each lane had two observers assigned: one to record the time and observe the participants'

swimming techniques, and the other to measure the distance swum. The swimming technique was not predefined. During the initial measurements, participants used any technique they were already familiar with. In the final measurements, all participants chose a technique they learned during the swimming program, such as breaststroke, front crawl, or backstroke. The timer/stopwatch was stopped when the participant touched the wall after completing 400 meters. The collected data was entered into Microsoft Excel and analyzed using IBM SPSS Statistics 20 and Microsoft Excel. To assess changes in time and progress in the 400-meter freestyle test before and after the swimming training program, a dependent sample t-test (nonparametric Wilcoxon Rank Sum Test) was conducted. Frequency and descriptive analyses were performed to identify the swimming techniques used to achieve the fastest results and the changes in technique selection before and after the training period. A t-test for independent samples (nonparametric Mann-Whitney U Test) was used to evaluate differences between swimming proficiency levels (beginners versus advanced swimmers) and changes in 400-meter freestyle test results.

STATISTICAL DATA ANALYSIS

The data was obtained through measurements of swimming times in the 400-meter freestyle test and observations of the swimming techniques or styles chosen during the test. The selected data represents both numerical and nominal variables.

The variables were analyzed using a dependent samples t-test (nonparametric Wilcoxon Rank Sum Test) to evaluate changes in time and progress in the 400-meter freestyle test before and after the swimming training program. Additionally, the variables were presented using frequency and descriptive analyses in tables, and graphs were created to display the collected data regarding the swimming techniques chosen for achieving the fastest result and the changes in these decisions before and after the training period. Differences between swimming proficiency levels (beginners versus advanced swimmers) and changes in the 400-meter freestyle test results were analyzed using an independent samples t-test (nonparametric Mann-Whitney U Test). All results were evaluated as statistically significant at a 5% significance level.

RESULTS

Paired Samples Statistics					
		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	test_before_beginning_s econds	631,16	19	103,257	23,689
	test_after_conclusion_se conds	593,95	19	88,459	20,294

Figure 1 Change in time in the 400-meter freestyle test before and after the swimming training program

Test Statistics ^a	
	test_after_con clusion_seco nds - test_before_b eginning_sec onds
Z	-3,362 ^b
Asymp. Sig. (2-tailed)	,001

a. Wilcoxon Signed Ranks Test

b. Based on positive ranks.

Figure 2 Statistical analysis of data on time changes in the 400-meter freestyle test before and after the swimming training program.

In Figures 1 and 2, the data on changes in time and progress in the 400-meter freestyle test before and after the swimming training program were statistically analyzed using a dependent samples t-test (nonparametric Wilcoxon Rank Sum Test). The analysis revealed that the average time for the 400-meter freestyle test before the start of the training program was 631.16 seconds, while the average time after the completion of the swimming program was 593.95 seconds. This indicates that the average time for the 400-meter freestyle test decreased. This conclusion is further supported by the p-value (less than 0.05), allowing us to accept the alternative hypothesis, which posits a significant difference between the given samples.

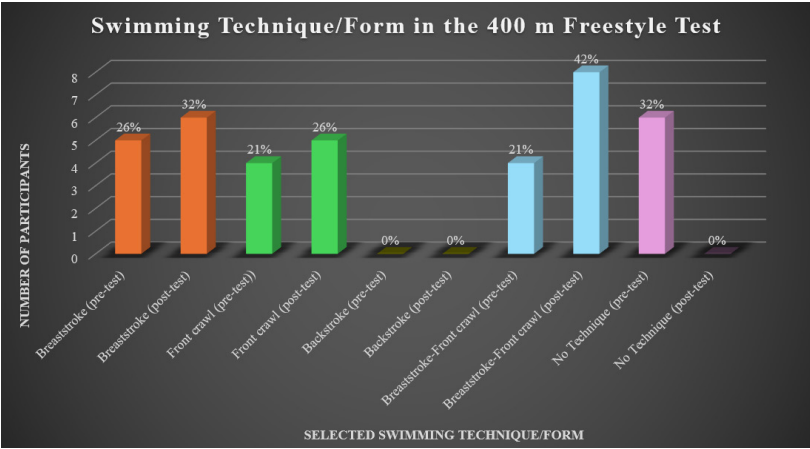


Figure 3 Selected swimming technique/style in the 400-meter freestyle test before the start of the swimming training program and after its completion.

In Figure 3, a histogram presents the frequency and descriptive analysis of data on the choice of swimming technique in the 400-meter freestyle test before the start of the swimming training program and after its completion. The data shows that more participants opted for the breaststroke and front crawl techniques after completing the program, with an increase of 6% for breaststroke and 5% for front crawl. The backstroke technique was not used either before or after the training program. A combination of breaststroke and front crawl was chosen by 21% more participants in the final test. The most significant change (32%) was observed among participants who initially swam without a defined technique or completed the test using a recreational swimming form; by the end of the training program, all participants swam using at least one defined technique or a combination of techniques. The data also reveals that the majority of participants selected the breaststroke-front crawl combination to achieve the fastest time in the 400-meter swimming test.

Descriptive Statistics						
condition		N	Minimum	Maximum	Mean	Std. Deviation
beginner swimmer	difference_before_after_seconds	9	-183	-5	-59,33	60,560
	Valid N (listwise)	9				
advanced swimmer	difference_before_after_seconds	10	-52	32	-17,30	23,099
	Valid N (listwise)	10				

Figure 4 Difference in time improvement between beginner and advanced swimmers in the 400-meter freestyle test.

Test Statistics ^a	
	difference_before_after_seconds
Mann-Whitney U	23,500
Wilcoxon W	68,500
Z	-1,759
Asymp. Sig. (2-tailed)	,079
Exact Sig. (2*(1-tailed Sig.))	,079 ^b

a. Grouping Variable: condition

b. Not corrected for ties.

Figure 5 Statistical analysis of data on the difference in time changes between beginner and advanced swimmers in the 400-meter freestyle test.

Figure 4 and 5 shows the descriptive analysis of the data on differences in swimming skill levels (beginners vs. advanced swimmers) and changes in the 400m freestyle test results, along with statistical analysis using the t-test for independent samples (non-parametric Mann Whitney U test), is shown. From the descriptive analysis, we can see that the average improvement in the 400m freestyle test time for beginners

is 59.33 seconds and for advanced swimmers, it is 17.30 seconds, indicating that beginners made larger improvements compared to advanced swimmers. However, statistical analysis with the p-value slightly higher than 0.05 (0.79) suggests there isn't enough statistical evidence to confirm this difference. Nonetheless, the p-value is close to 0.05, and considering the smaller sample size, we can consider the descriptive analysis where the difference in progress between beginners and advanced swimmers is visible.

DISCUSSION

Training is a key factor for progress in any sport, as only systematic and targeted training can lead to improvements in performance and technical execution, enabling long-term improvements and achieving better results (Chatard & Stewart, 2011). When analyzing the effect of swimming training on the results of the 400m freestyle test, conducted at the beginning and after the training period (8 months, once a week), we observed significant progress both in time and in performance quality. The training sessions were designed to positively affect various aspects of swimming performance, including improvements in technique, endurance, and overall swimming efficiency. Participants demonstrated better coordination of movements and improved control of swimming rhythm, allowing for more consistent and balanced performance throughout the entire distance. Additionally, noticeable progress was made in their movement control and power distribution, confirming the effectiveness of the planned swimming training program.

We selected the study sample and obtained data from participants in a swimming training program at the Student Organization, who were part of the academic process and attended different faculties of the University of Ljubljana, while the young employees were all advanced swimmers who started the program as university students and continued training after graduation. All participants attended the swimming program once a week for a total of 8 months. Although the results cannot be generalized to the entire student population, they offer insight into the group of students and young employees who choose guided swimming training.

Regarding the first objective of the study, we aimed to examine the change in time and progress in the 400m freestyle test before and after the swimming training. We hypothesized that participants would improve their 400m freestyle times after the swimming program, indicating progress in their swimming abilities. The analysis of the 400m freestyle test results showed that the average time significantly improved after the training period compared to the time before training. The average time before training was 631.16 seconds, and after training, it was 593.95 seconds, which represents an average improvement of 37.21 seconds (5.9%). This finding is consistent with the research by Pyne et al. (2004), which emphasizes that improvements in times between measurements are likely a result of the overall effect of training on the athlete's performance. They highlight key factors contributing to progress, including improvements in physical fitness and conditioning, which allow for greater endurance and explosiveness in the water. Training also enhances swimming skills

and technique, which leads to more efficient energy expenditure and reduced drag during swimming. In addition to these elements, the development of pacing strategies plays a crucial role, allowing athletes to distribute their energy more effectively over the entire test distance. Psychological skills such as focus, stress management, and self-confidence also contribute to better performance during measurements. The combined effect of all these factors contributes to consistent progress and better results (Pyne et al., 2004).

For the second objective of the study, we wanted to investigate which swimming technique participants most commonly chose for achieving the fastest results and analyze the changes in this decision before and after the training period. We hypothesized that participants would use different techniques before the program to achieve the fastest result, but after the training, they would most likely choose a technique that offered greater efficiency and speed, with many opting for a combination of breaststroke and front crawl. The results confirmed this hypothesis, as after the training program, the use of the combined breaststroke-front crawl technique, as well as individual breaststroke and front crawl techniques, increased, while the backstroke technique was not chosen. The number of participants who swam without a specific technique significantly decreased, as by the end of the training, all participants were using at least one technique or a combination of techniques, with breaststroke-front crawl combination (42%) being the most common choice for achieving the fastest times.

Regarding the differences in progress between beginners and advanced swimmers in the 400m freestyle test, we hypothesized that there would be a visible difference in progress, with beginners showing greater improvements due to initial gains, while experienced swimmers would make smaller improvements. The descriptive statistics revealed that beginners made more substantial improvements in time than advanced swimmers in the 400m freestyle test. Although the descriptive analysis indicates a noticeable difference, the statistical analysis does not confirm this difference as statistically significant. However, the results highlight a trend of greater progress in beginners. Pyne et al. (2004) also confirm that for experienced athletes, progress slows down due to physiological adaptations. Mujika et al. (2018) found that in addition to physiological adaptations, less progress in advanced swimmers is also due to optimized technique and minimal changes in movement techniques before and after the training process.

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