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Faster and Stronger: The Role of Anaerobic Exercises in Swimming Performances

Dr. K. Rangaraj[1], Dr. S. Sakthivel[2]

[1]Physical Director, Department of Physical Education and Sports, SRM Institute of Science and Technology, Faculty of Engineering and Technology, Vadapalani Campus, Chennai. Email: rangaraj82@gmail.com

[2]Physical Director, Department of Physical Education and Sports, SRM Institute of Science and Technology, Faculty of Engineering and Technology, Vadapalani Campus, Chennai. Email: sakthi30689@gmail.com

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ABSTRACT

The purpose of the research was to investigate how anaerobic exercise affected particular physiological and physical characteristics. A total of 40 male swimmers from Chennai district, aged between 17 and 21 years, were randomly selected as participants. The study took into account a number of characteristics, including resting heart rate, endurance of muscles, cardio-respiratory endurance, aerobic workouts (an uncontrolled variable), and vital capability. The research employed a pre-test and post-test randomized group design. Participants were randomly divided into two equal groups: Group I, consisting of 20 participants, underwent anaerobic training five days a week for eight weeks, while Group II, also comprising 20 participants, served as the control group and did not engage in anaerobic training. Post-tests were administered following eight weeks of training, while pre-tests were administered before to the training session in order to gather data. For the chosen physiological variables, the pre-test and post-test means of the control and experimenter groups were compared using descriptive analysis and Analysis of Covariance (ANCOVA). The analysis's significance threshold was set at 0.05. The experimental group's resting heart rate, vital capacity, muscular endurance, and cardio-respiratory endurance were significantly improved after the training, according to the results. Conversely, no significant differences were observed in the control group for these variables. Based on these results, it was concluded that anaerobic training significantly enhances selected physical and physiological parameters.

Keywords: *Anaerobic Training, muscular endurance, Physiological Variables, Swimmers.*

1. INTRODUCTION

The dynamic sport of swimming requires a combination of physical power, endurance, and technique. Often seen as graceful and fluid, competitive swimming is an intense test of skill and dedication, involving rigorous training that pushes athletes to their physical limits. Swimmers train tirelessly to develop precise strokes, powerful starts, and efficient breathing techniques, which are all essential for maximizing speed and minimizing resistance in the water [1, 2]. However, the sport also comes with significant challenges. Competitions are won or lost in mere fractions of a second, meaning that every stroke, turn, and breath must be flawless. The mental pressure is immense, as athletes need to maintain focus while managing the strain on their bodies, the pressure of intense races, and the unpredictability of competing in different water environments. Swimmers must also adapt to variations in water temperature, pool conditions, and the psychological pressure of facing top opponents. These challenges make swimming not only a test of physical endurance but also of mental resilience, as athletes must overcome physical discomfort and maintain composure under pressure to achieve their best times. The difficulty of excelling in competitive swimming lies in mastering this unique combination of physical and mental demands.

1.1 Physical and Physiological Fitness in Swimming

Swimming demands a high level of physical and physiological fitness due to the unique challenges posed by water resistance, breathing control, and energy requirements. Physically, swimmers must develop muscular strength, endurance, and flexibility to propel them through water with minimal drag. While flexibility improves stroke mechanics and lowers injury risk, core strength and limb power are essential for effective movement [3, 4]. Cardiovascular fitness is also critical, as swimming requires sustained aerobic capacity to maintain speed and power over various distances.

Physiologically, swimming places unique demands on the body's respiratory and energy systems. Swimmers must master breath control due to the need for precise timing while inhaling and exhaling underwater, a factor that also contributes to improved lung capacity and respiratory efficiency. Furthermore, anaerobic and aerobic energy systems are both heavily utilized, depending on the swimming discipline, with sprint events requiring rapid energy bursts and long-distance swimming relying on sustained energy production [5, 6]. Therefore, swimmers must develop a balance between these two systems to perform at their best. Together, these physical and physiological fitness components enable swimmers to maintain performance, adapt to the demands of different strokes and distances, and enhance overall endurance and speed in competitive swimming.

1.2 Anaerobic Training

Anaerobic training is essential for improving physical and physiological fitness in swimming, as it focuses on enhancing power, speed, and the capacity to perform intense efforts without relying heavily on oxygen. During anaerobic exercises, swimmers train in short bursts of high-intensity activity, such as sprints, which push muscles to perform in low-oxygen conditions. This type of training increases muscle strength, lactic acid tolerance, and fast-twitch muscle fiber recruitment, all of which are crucial for explosive starts, turns, and finishes [7, 8]. By improving anaerobic capacity, swimmers can sustain high speeds for longer durations and improve overall performance in competitions, especially in short-distance events where speed is critical.

2. LITERATURE REVIEW

The first drawback is the amount of time needed to calculate the oxygen demand, which necessitates many submaximal efforts at varying intensities and on various days, making this method less applicable throughout training regimens. The second drawback is that the AOD approach does not allow for the distinct determination of the total phosphagen (AnAl) and carbohydrates (AnLa) investments [9], which limits the potential research of these metabolisms at various swimming lengths. The employment of a snorkel and valve system to measure VO2 while swimming is the third limitations. This slows down swimming and obviously throws off the motor sequence, making it hard to make turns, undulate, or breathe on the side while exerting oneself. Given the significance of these mechanical elements, using a snorkel and regulator system may affect the AOD readings and, as a result, cause the significance of anaerobic digestion in various performances to be misunderstood.

The critical velocity notion has been rediscovered and modified for swimming. It is an extension of the critical power idea that was first presented. The maximum swimming speed that can be sustained without fatigue for an extended period of time is known as the critical swimming velocity (CV) [10]. The regression line's slope between various distances traveled at top speed and the accompanying times is how it is expressed. This measure of aerobic ability can be used as a foundation for analyzing training-induced effects and trends and forecasting future competition performance. In fact, swimming coaches have increasingly employed critical velocity as a gauge of a swimmer's operational aerobic capacity over time, as determined by the anaerobic threshold or a comparable metric.

The methods via which altitude training improves athletes' performance at sea level are typically ascribed to hematological, cardiovascular, or ventilatory effects. A major focus on increasing hemoglobin concentration and retinal mass is thought to be essential for enhancing the body's oxygen transport, which in turn improves VO2max and athletic endurance abilities [11]. The association between erythropoiesis and improved athletic performance is still up for debate, despite the overwhelming body of evidence suggesting that exposure to hypoxic or elevated altitude is erythropoietic. For instance, even though they have been exposed to lower ambient oxygen tension for a long time, native Ethiopian people at 3,530m exhibit no discernible increase in EPO, hemoglobin, or oxygen saturation when compared to the levels of the sea level United States population.

A gifted swimmer must have reached a high level of technique and physical conditioning in order to compete successfully, and the competition performance must be dependable (consistently excellent swimming) throughout the heats, semi-finals (if needed), and finals. A robust psychological foundation, suitable tactical awareness, and a healthy physique all assist technique and development. It may require six to sixteen years of disciplined training, designed by a coach who draws on experience, intuition, and scientific understanding, to achieve success at the Olympian and world levels [12]. Training with purpose and care is more important for success than running hard. This necessitates the planning and tracking of a swimmer's training as well as the evaluation of competition performance in terms of technical aspects and strategy in addition to final time.

One definition of resistance training is the capacity of a particular muscle or group of muscles to produce muscular force under particular circumstances. Concerns regarding increases in muscle bulk (hypertrophy) or decreases in adaptation, which could increase drag forces and impair swimming ability, have led coaches to raise doubts about the benefits of resistance exercise for swimmers [13]. Resistance-training programs are frequently used by swimmers in spite of these reservations. Despite these considerations, there are still considerable gaps in the scientific literature on swimming regarding the impact of resistance-training programs on enhancing muscular strength and, more importantly, how these programs affect important technical aspects of swimming performance.

3. METHODOLOGY

3.1 Experimental configuration

A 49l modified Brett-type swim-tunnel spirometer thermo regulated at 23±0.5°C was used to assess the oxygen uptake (MO2) and swimming performance of fish. In short, the tunnel's working part measured 60 cm in length, 16 cm in width, and 16 cm in height. To encourage the fish to swim upstream, the upstream swimming portion was made darker [14, 15]. In order to encourage rectilinear flow and consistent velocity profiles, a plastic hexagon grid and deflectors were added to the recirculation loop. A propeller and an electrical motor with variable speed produced the water flow. Dye flow patterns were observed in order to visually evaluate the flow properties. By monitoring flow at 33 different voltage settings at a single position in the center of the swimming portion and using the least squares approach to determine the best-fit line, the relationship between water speed and motor voltage produced was determined. In order to get the greatest solid blocking effects [16, 17], swimming speeds were adjusted.

Water pumped from the respirometer using an Ismatec MVGE peristaltic pump (Ismatec SA, Glattbrugg-Zurich, Switzerland) was tested for oxygen content using a flow-through, fiber-optic trace oxygen sensor (PreSens GmbH, Regensburg, Germany). Every day, the oxygen sensor was adjusted for air pressure and temperature.

The Ugt between steady (aerobic) swimming and burst-and-coast swimming was identified thanks to these recordings [18, 19]; the animal was apparently enhancing performance by enlisting the help of anaerobic fast-twitch glycolytic muscle fibers. To calculate Ugt, two factors were taken into account:

- Tail beat frequency (TBF), which is the quantity of tail beats per second (one beat represents a full caudal fin movement);
- The ratio of a fish's entire length to the distance, measured in centimeters, between the lateralmost excursion of its tail tip and the axis of its swimming direction is known as the tail beat amplitude (TBA). These factors were examined up until fish exhaustion. Every 30 seconds of a 5 cms–1 rise in water current speed, one block of 5s was examined. Ugt was evaluated using the first statistical difference in the variables between two successive blocks. The fish's overall length was used to calibrate video analysis.

3.2 Selection of Subjects

The purpose of the study was to investigate how anaerobic exercise affected particular physiological and physical characteristics. Forty male divers from the Chennai area were selected at random to participate in this study. The participants, who ranged in age from 17 to 21, were split into two groups of 20 at random. Group II was the control group, whereas Group I engaged in anaerobic training sessions five days every week for eight weeks.

3.3 SELECTION OF VARIABLES

3.3.1 Independent Variables

1. Anaerobic exercise training

3.3.2 DEPENDENT VARIABLES Physical Variables

1. Muscular endurance
2. Cardio respiratory endurance

3.3.3 Physiological Variables

1. Resting heart rate
2. Vital capacity

3.4 STANDARD MEASURES

Standard testing procedures were used to evaluate the selected variables both before and after the training period.

1. The Sit-Ups Test was used to assess the strength of the muscles, and the variety of sit-ups performed was used to record the outcomes.
2. Cardiorespiratory endurance was determined using Cooper's 12-Minute Run Test, with distances measured in meters.
3. By gently palpating the radial artery and using a timer to count the beats for a minute, the resting heart rate was determined.
4. Using a dry spirometer, vital capacity was measured and expressed in milliliters.

Before beginning anaerobic training, tests were conducted on the control and experimental groups in order to collect pre-training data for specific metabolic and physical factors. To gather post-training data, the same tests were given again following eight weeks of anaerobic fitness training. Participants were provided with necessary instructions prior to the tests.

4. ADMINISTRATION OF TRAINING RESULT

An anaerobic training schedule for swimmers focuses on high-intensity, short-duration workouts that enhance speed, power, and muscle endurance. A well-rounded schedule includes three anaerobic sessions per week for 8 weeks, with each session lasting 45–60 minutes. Swimmers can start with a warm-up of 10–15 minutes to gradually increase heart rate and activate muscles, then move into high-intensity interval sets like 25- to 50-meter sprints at 90–100% effort with 30–45 seconds of rest between each. Sets can include six to eight repetitions of sprint intervals, targeting race-specific strokes. Adding resistance exercises, like using a kickboard or swim parachute, can improve power in the water. After the main set, swimmers should cool down with 5–10 minutes of easy laps to aid recovery and reduce lactic acid buildup. Sessions should be complemented by proper recovery, including rest days and active recovery exercises, to prevent fatigue and enhance muscle repair.

4.1 GEOMETRIC PROCEDURE

Analysis of Covariance (ANCOVA) and descriptive statistics were used to analyze the data. The analysis was conducted with a significance level established at 0.05 for confidence.

TABLE 1. COMPARISON OF COVARIANCE BETWEEN ANAEROBIC EXERCISE AND CONTROL GROUPS ON SELECTED FACTORS

Flexible	**Collection**	**Non Experimental Group**	**Experimental Group**	**'F' Relation**
M. E	Pretest mean±S.D	33.85 ± 3.940	33.30 ± 4.310	0.17
	Posttest mean±S.D	34.45 ± 3.830	40.25 ± 4.250	20.53*
	Adjusted Post test mean	34.180	40.520	864.84*
C. R. E	Pretest mean±S.D	1888.50 ± 115.950	1883.50±114.030	.019
	Posttest mean±S.D	1886.50±117.620	2017.50±109.68	13.27*
	Adjusted Post test mean	1884.090	2019.920	304.30*
R.H.R	Pretest mean±S.D	75.73 ± 7.870	74.33 ± 4.700	.350
	Posttest mean±S.D	74.80 ± 6.370	69.33 ± 4.150	7.750*
	Adjusted Post test mean	74.310	69.830	17.655
V.C	Pretest mean±S.D	3.469 ±. 61130	3.7640 ± .38780	2.485
	Posttest mean±S.D	3.469 ± .61130	4.2920 ± .48630	15.875*
	Adjusted Post test mean	3.6270	4.1470	31.410*

The corrected post-test means for different fitness metrics between the anaerobic exercise group and the control group are shown in the table. The control group's mean score for muscular endurance was 34.18, whereas the anaerobic exercise group's score was 40.52. The resultant 'F' ratio of 864.84 is higher than the crucial table value of 4.107 at a significance level of 0.05. In a similar vein, the control group's adjusted post-test mean for cardiorespiratory endurance was 1884.09 [20], while the anaerobic exercise group's was 2019.92. Both groups' 'F' ratios of 304.30 exceeded the necessary level for statistical significance. The control groups and the anaerobic exercise group's resting heart rates were 74.31 and 69.83, respectively, with a 'F' ratio of 17.655, which was once more higher than the essential value. The anaerobic exercise group had a mean of 4.147 for vital capacity, with a 'F' ratio of 31.410, which is also statistically significant, compared to the control group's mean of 3.627. These results validate that the control and anaerobic exercise groups' adjusted post-test averages differed significantly across all parameters.

5. DISCUSS ION

The results of the study show a substantial difference in resting heart rate, vital capacity, muscular endurance, and cardiorespiratory endurance between the anaerobic training group and the control group. According to recent studies, regular endurance training causes cardiovascular adaptations, and regular anaerobic exercise frequently lowers resting heart rate. In a related study, M. Muralikrishna and P.V. Shelvam (2014) investigated how middle-aged obese men's vital capacity was affected by different levels of anaerobic training. According to their findings, high-intensity anaerobic exercise improves vital capacity and other aspects of cardiopulmonary function (R. Muthu Eleckuvan, 2014). Overall, the study demonstrates that among college males, anaerobic exercise has a considerable impact on a number of physical and physiological characteristics.

6. CONCLUSION

Anaerobic training for eight weeks was found to considerably improve some physiological and physical characteristics, such as resting heart rate, muscle strength, heart rate variability, and metabolic capability.

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