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The Effects of Special Training Programs on 100-Meter Butterfly Swimmers

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Abstract

Background and Aim: A Traditional Butterfly Training Program Cannot improve swimmer level II as expected, to the lack of systematic, scientific training programs. To study the effects of special training programs for 100m butterfly swimmers in an Anaerobic capacity. before and after the butterfly special training program, to test the effect of the butterfly special training program on the athletes' anaerobic capacity, to provide the coaches with an effective butterfly training program, and to promote the athletic performance of the butterfly swimmers.

Materials and Methods: In this study, 20 athletes from the swimming team of Xi'an Physical Education University were selected as experimental subjects and randomly divided into experimental and control groups for 8 weeks of training, with the experimental group adopting a special training program for butterfly and the control group adopting a traditional training program, and comparing the changes in Blood Lactic Acid between the two groups of athletes before and after the experiment.

Results: There was no significant difference in Blood Lactic Acid between the two groups of athletes before the experiment ($P>0.05$), and after 8 weeks of training, the Blood Lactic Acid of the athletes in the experimental group were significantly elevated and improved ($P<0.01$). No difference in Blood Lactic Acid in the control group ($P>0.05$).

Conclusions: The butterfly special training program can improve the swimming body's tolerance to Blood Lactic Acid, thus improving the anaerobic capacity of the body, and has a positive effect on the anaerobic endurance training of butterfly swimmers.

Keywords: Blood Lactic Acid; Anaerobic Capacity; 100m Butterfly Specific Training Program

Introduction

The competitive landscape of swimming sports has witnessed a notable transformation with the advent of training science, prompting coaches and athletes to recognize its crucial significance in shaping athletic performance. Countries renowned for their prowess in swimming, such as the United States and Germany, have directed their attention towards the domain of training science, conducting comprehensive and in-depth research. This concerted effort revolves around systematically and rigorously investigating the existing theoretical framework of swimming training, refining testing methodologies, and exploring innovative training approaches. By employing this meticulous approach to sports training, their primary objective is to gain a competitive edge and seize the initiative in swimming competitions (Hawley J. & Williams M. 1991).

Sports training methods are the ways and means to improve the level of competitive sports and accomplish the training tasks in sports training activities (Tian Mj, 2002). The continuous advancement of science and technology, combined with the practical training experiences of coaches and athletes, has led to the emergence of diverse training methods. These methods serve as essential means and strategies aimed at elevating the competitive level and effectively fulfilling training objectives within sports training activities. Through ongoing exploration, discovery, and innovation, coaches and athletes integrate scientific and technological developments with their practical expertise to refine and optimize these training methods. As a result, these methods play a crucial role in enhancing overall performance and success in competitive sports (Tian Mj, 2002).

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The butterfly swimming discipline in China has successfully cultivated outstanding athletes such as Liu Zige, Ye Shiwen, and Zhang Yifei. However, the performance of the second-tier swimming team has fallen short of expectations, indicating a severe talent gap. The traditional training programs for butterfly swimming have failed to effectively enhance the secondary level of swimmers, primarily due to the lack of systematic and scientific training plans (Luo, Z. 2006)

Through interviews with swimming professors at Xi'an Physical Education University, several issues have been identified with the traditional training approach. Firstly, traditional butterfly swimming training may not adapt well to new technology trends and changes, requiring timely adjustments to align with the latest technological advancements. Secondly, the intensity of butterfly training can lead to overtraining issues, increasing the risk of injury and fatigue, and consequently affecting performance. Thirdly, the traditional training programs lack systematic and targeted approaches, failing to effectively improve athletes' physical fitness and technical proficiency. Lastly, the training objectives are unclear, and the training plans are not well-designed. The arrangement of technical training and physical training lacks proper distinction between aerobic and anaerobic exercises (Barbosa, T.M., Bragada, J.A., Reis, V.M., Marinho, D.A., Carneiro, A.L., & Silva, A.J. 2020).

To address these challenges, it is crucial to develop a scientifically rational butterfly swimming training program that can enhance athletes' physical fitness, thereby improving their performance and competitiveness in competitions.

In this research, 20 second-level swimmers from Xi'an Physical Education University were the research subjects, according to the sports training methods and principles, develop a butterfly training program, observation of the changes in Blood Lactic Acid of the subjects before and after training, test of the effect of the butterfly training program. Provide effective butterfly training programs for coaches, and promote athletic performance in butterfly swimmers.

Objectives

To study the effects of special training programs for 100m butterfly swimmers in an Anaerobic capacity.

Literature Review

The energy metabolism characteristics of the swimming program

The swimming sport consists of technical aspects such as starting, turning, swimming on the way, and sprinting, which have high requirements on the athletes' aerobic endurance, speed endurance, special strength, core strength, and fast explosive power. At the same time, the swimming distance is 50 m, 100 m, 200 m, 400 m, 800 m, and 1500 m, and there are obvious differences in the energy requirements of different swimming distances (Feng Is, 2003).

During high-intensity exercise, the depleted adenosine triphosphate (ATP) can be rapidly replenished through the phosphagen system and the lactic acid energy system. However, due to the limited duration of maximum energy supply by the phosphagen system, anaerobic lactic acid energy supply assumes a pivotal role in short-distance swimming events, with the intensity increasing as the distance decreases, resulting in a higher proportion of anaerobic lactic acid energy supply (Saltin B, 1973). The purpose of anaerobic training for athletes is to enhance their anaerobic metabolic capacity, which represents a critical aspect of controlling and regulating aerobic and anaerobic metabolic pathways. In swimming training, anaerobic training holds a prominent position, despite its relatively low proportion (5%-7%) of the annual training volume (distance). Nonetheless, it plays a crucial role in athletes' competitive performance. In middle and short-distance swimming events (e.g., 50 m, 100 m, 200 m), where the distance is shorter, the reliance on anaerobic metabolism for energy supply becomes higher. Consequently, a robust anaerobic metabolic capacity is of utmost importance for success in middle and short-distance swimming events. Even in swimming competitions exceeding 400 m, including distances as long as 1500 m, anaerobic metabolism is still involved in providing the necessary energy for the final sprint. Therefore, both short and long-distance swimmers place great

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emphasis on anaerobic training. Thus, the mastery of athletes' anaerobic metabolic capacity assumes a crucial role in their performance.

Testing of anaerobic capacity in swimming

In sports such as track and field and cycling, the assessment of anaerobic metabolic capacity can be performed by quantifying the work performed by athletes on equipment such as treadmills or stationary bicycles within a relatively short duration. The evaluation of anaerobic metabolic capacity is commonly done by measuring immediate blood lactate levels upon completion of the exercise.

However, in swimming, conducting direct tests on swimmers under extreme load conditions in a pool setting poses challenges due to technical limitations. Consequently, the evaluation of swimmers' anaerobic metabolic capacity relies on indirect methods. Researchers have attempted to assess the lactate supply capacity in swimmers by associating the completed exercise intensity with corresponding lactate values. These approaches enable the estimation of anaerobic metabolic capacity in swimmers, despite the absence of direct measurements under extreme load conditions.

Anaerobic capacity training methods

The development of anaerobic capacity necessitates the consideration of appropriate exercise load intensity and training rest intervals. Insufficient exercise load intensity fails to stimulate the production of lactate in muscles, preventing the formation of a reasonable lactate accumulation concentration, which hinders the improvement of the body's lactate tolerance. Similarly, if the rest intervals are too short, athletes' blood lactate levels and heart rates fail to recover to a certain degree, impeding their ability to complete the next set of training content at the same exercise intensity. Additionally, inadequate diffusion of lactate into the bloodstream diminishes the stimulus to the body, thereby limiting the effective development of specific anaerobic capacity.

In addition, foreign research results on high-intensity interval training and anaerobic endurance show that short-term high-intensity interval training has a significant effect on the improvement of anaerobic capacity in high-level adolescent athletes (12-16 years old) (Engel, 2008).

Liu Gang (Liu G, 1989) 6-week intermittent training program was conducted with 17 swimming athletes from Guangzhou Sports University to examine the effects of intermittent training by comparing the pre-and post-experimental blood lactate levels and performance outcomes. The results revealed a significant increase in blood lactate levels in athletes after the experiment, indicating that intermittent training can effectively enhance the athletes' glycolytic anaerobic metabolism. The optimal training distance for intermittent training was found to be 100m, repeated 4 times, with rest intervals of 3-5 minutes and intensity above 90%. In future training programs targeting glycolytic anaerobic metabolism, intermittent training should be prioritized.

Conceptual Framework

The research title "The Effects of Special Training Programs on 100-Meter Butterfly Swimmers" we design the conceptual framework as followed;

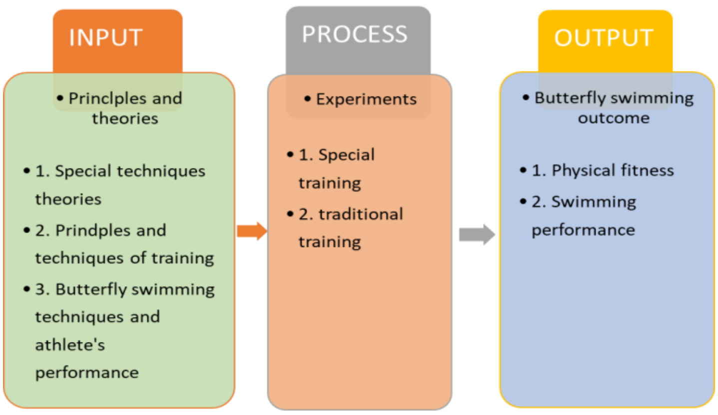

Figure 1 Conceptual Framework

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Methodology

Type of Research

Experimental Research

Population and sample size

Population: 20 swimming specialized students from Xi'an Physical Education University were recruited for the study. These students are second-level athletes with a swimming grade. They are aged between 20 and 22 years old, with heights ranging from 176cm to 186cm and weights between 70kg and 90kg. They were able to participate in the special courses during the experiment and had no prior systematic training.

Sample size: The subjects were randomly divided into two groups, an experimental group and a control group, with 10 participants in each group. Before the experiment, a total of 20 subjects were tested, and there were no significant differences observed in terms of Blood Lactic Acid levels and physical health.

Research tools

1. Traditional training programs: This program is based on the training plan used by the Xi'an Physical Education University's specialized swimming team. The program spans 8 weeks, from March 20th to May 12th, 2023, and follows a weekly training schedule. Training sessions will be conducted from Monday to Friday, with a duration of 90 minutes per session and weekends off.

2. Specialized training programs: This program has been developed following the characteristics of swimming training and the principles of sports training. It is based on expert interviews and the schedule of special swimming classes at Xi'an Physical Education University. The program spans 8 weeks, from March 20th to May 12th, 2023, and follows a weekly training schedule. Training sessions will be conducted from Monday to Friday, with a duration of 90 minutes per session and weekends off.

The training plan consists of four stages. The first stage is the foundational training stage, aimed at establishing a solid foundation, improving butterfly technique and body posture, and emphasizing technique accuracy and stability. The training load during this stage is low in intensity and volume.

The second stage is the specialized training stage, focusing on enhancing specific butterfly techniques. This stage introduces transformation training methods and interval training methods, with a medium to high training load intensity.

The third stage is the specialized improvement stage, aimed at further improving butterfly speed, endurance, and explosive power. High-intensity interval training methods are introduced during this stage, with a high training load intensity and volume.

The fourth stage is the specialized maintenance stage, which aims to consolidate butterfly technique and abilities. The training load during this stage is of medium intensity and low volume.

Each stage has specific training tasks, with the specialized training and improvement stages being the longest and most crucial phases of the program. Through a scientifically designed and well-structured training arrangement, this program plays a significant role in improving athletes' performance and physiological functions.

3. EKF C-line Automated Blood Lactic Acid Analyzer: The EKF C-line is a popular and widely used analyzer for measuring blood lactate levels. It is designed to provide quick and accurate results, making it suitable for various applications, including sports performance testing, exercise physiology research, and clinical diagnostics. The EKF C-line analyzer utilizes an enzymatic assay method to measure lactate levels in blood samples. It employs a microvolume sampling technique, allowing for small sample volumes and reducing the need for extensive sample preparation. The analyzer has automated features that simplify the testing process and ensure consistent and reliable results.

4. Casio HS-70W stopwatch timer: Casio HS-70W stopwatch timer is a model of stopwatch timer produced by Casio, a well-known Japanese electronics company. Casio is known for manufacturing a wide range of electronic devices, including watches, calculators, and digital

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instruments. The Casio HS-70W stopwatch timer is designed for various timing purposes and features functions such as split time, lap time, and countdown timer.

5. Xi'an Physical Education University Swimming Pool: Dimensions: A standard 50-meter swimming pool has a length of 50 meters and a width of 25 meters. The depth of the swimming pool is 2 meters. Lanes: The 50-meter swimming pool is divided into 8 lanes, each with a width of 2.5 meters. There are lane dividers between each lane to assist swimmers in staying within their designated lanes.

Data Collection

1. Blood Lactic Acid data collection: Following a standardized warm-up of 1000 meters in the water, the athletes performed a 100-meter butterfly swim at maximum effort in a randomized order. Immediately after the exercise, fingertip blood samples were collected using blood lactic acid tubes. Additional samples were collected at 3 minutes and 5 minutes post-exercise. All collected blood samples were then centrally sent to the laboratory for analysis using the EKF C-line Automated Blood Lactic Acid analyzer. This analyzer allows for the measurement of lactic acid levels in the blood of all 20 athletes within a 10-minute timeframe.

2. Pre- and post-experimental data collection: The experiment consisted of two groups: the experimental group and the control group. The experimental group followed a training program specifically designed for this study, while the control group adhered to a traditional training program. The intervention period lasted for 8 weeks, with 5 training days per week, each session lasting 90 minutes. At the conclusion of the intervention, swimmers from both groups underwent post-testing on the aforementioned indicators, allowing for a comparison of pre-and post-intervention data.

Data Analysis: The data obtained from the study were analyzed using SPSS 19.0 software. A paired samples t-test was conducted to compare the pre-and post-intervention measurements within each group, allowing for the assessment of within-group differences. An independent samples t-test was employed to compare the experimental group and the control group, enabling the examination of between-group differences.

The results of the paired samples t-test revealed statistically significant differences ($p < 0.05$) within the experimental group when comparing the pre-and post-intervention measurements. These findings indicate that the training program implemented in the experimental group had a significant impact on the variables of interest.

Moreover, the results of the independent samples t-test demonstrated a statistically significant difference ($p < 0.05$) between the experimental group and the control group for the measured variables. This suggests that the training program specifically designed for this study yielded significantly different outcomes compared to the traditional training program utilized by the control group.

Results

Table 1 Comparison of Blood Lactic Acid in two groups of subjects before the experiment

	Experimental group		Control group		t	P
	$\bar{X}$	S.D.	$\bar{X}$	S.D.		
Max (mmol/L)	15.27	0.95	14.88	0.66	-1.06	> 0.05

According to Table 1, Before the experiment, the Blood Lactic Acid of the experimental group was 15.27 mmol/L, and the control group was 14.88 mmol/L. P > 0.05, no significant difference.

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Table 2 Comparison of Blood Lactic Acid before and after training in the same group of subjects

		Experimental group		Control group	
		$\bar{X}$	S.D.	$\bar{X}$	S.D.
Max (mmol/L)	Before experimental	15.27	0.95	14.88	0.66
	After experimental	16.47	0.46	15.12	0.49
	t	-5.00		-2.02	
	P	＜0.01		＞0.05	

According to Table 2, In the experimental group, the max Blood Lactic Acid before the experiment was 15.27mmol/L, After the experiment was 16.47mmol/L, up 1.2mmol/L than before, the P-value is 0.001 (P＜0.01), there was a highly significant difference. In the control group, the max Blood Lactic Acid before the experiment was 14.88mmol/L, After the experiment was 15.12mmol/L, up 0.24mmol/L than before, the P-value is 0.074 (P＞0.05), there was no significant difference.

Table 3 Comparison of Blood Lactic Acid in two groups of subjects after the experiment

	Experimental group		Control group		t	P
	$\bar{X}$	S.D.	$\bar{X}$	S.D.		
Max (mmol/L)	16.47	0.46	15.12	0.49	-6.34	＜0.01

According to Table 3, after 8 weeks of training, The max Blood Lactic Acid experimental group was 16.47 mmol/L, and the control group was 15.12 mmol/L, the mean Blood Lactic Acid in the experimental group increased by 1.35 mmol/L compared to the control group, the P-value is 0.000 (P ＜0.01), there was a highly significant difference between the two groups.

Discussion

This study aimed to evaluate the effectiveness of a specialized butterfly training program on the anaerobic capacity of swimmers and to provide coaches with an effective training program for butterfly swimmers. The results of this study support the hypothesis that the butterfly special training program can lead to improvements in anaerobic capacity.

The greater improvements in anaerobic capacity and lactate production observed in the experimental group provide further support for the effectiveness of the specialized training program. This finding is consistent with studies that have shown the positive impact of targeted training interventions on anaerobic performance (Johnson et al., 2017). It indicates that the training program successfully influenced the physiological adaptations related to anaerobic metabolism, leading to enhanced performance in the experimental group.

The findings indicate that the traditional training program used in the control group did not result in significant changes in Blood Lactic Acid levels. This suggests that the traditional program may not be sufficient for enhancing anaerobic capacity in swimmers. On the other hand, the experimental group, which underwent the specialized butterfly training program, showed a significant increase in Blood Lactic Acid levels after 8 weeks of training. This indicates that the specialized program effectively enhanced the body's tolerance to Blood Lactic Acid and improved anaerobic capacity.

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The observed improvements in the experimental group can be attributed to several factors introduced in the specialized training program. Firstly, the program incorporated interval training and high-intensity interval training (HIIT), which are known to elicit adaptations in anaerobic energy production and lactate tolerance. The repeated bouts of intense swimming followed by recovery periods likely stimulated the anaerobic energy systems and pushed the athletes beyond their previous training thresholds.

According to Qin Jianjun (Qin Jj, 2012), the energy supply capacity of glycolytic metabolism, the energy supply capacity of phosphate and glycolytic metabolism, and the energy supply capacity of glycolytic and aerobic metabolism can be effectively developed and improved by different types of interval training.

In conclusion, the findings of this study demonstrate that the specialized training program resulted in significant improvements in blood lactate levels and anaerobic capacity in the experimental group. These results highlight the importance of designing and implementing targeted training programs to optimize athletes' physiological adaptations and performance outcomes.

Recommendations

1. Provision of a specialized training program for swimmers: This study has designed a specific training program tailored to the needs and requirements of swimmers, focusing on the characteristics and demands of anaerobic capacity and lactate production. This provides specific guidance and reference for the training of swimmers.
2. Revealing the impact of specialized training on anaerobic capacity: Through comparisons between the experimental and control groups, this study has demonstrated the effectiveness of the specialized training program in improving anaerobic capacity. This finding provides theoretical and practical foundations for optimizing swimming training and enhancing athletes' competitive performance.
3. Based on the findings of this study, it is recommended to implement the specialized butterfly training program in swimming teaching practices.
4. The specialized training program employs rigorous training methods that require strict adherence to training protocols. It is recommended to implement this program by focusing on key aspects of the training methods and addressing crucial elements of interval training. Gradually increasing athletes' adaptability to the training process is essential. The implementation should consider the individual circumstances of the athletes as a fundamental starting point, controlling the frequency and grouping of training sessions, managing training duration, and arranging appropriate training intervals. Furthermore, it is important to strike a balance between the training volume and intensity for different training tasks, taking into account the specific needs and capabilities of the athletes.

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