



Developing a Specific Training Program to Improve Butterfly Swimming Performance of Athletes in the Swimming Club

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Abstract

Background and Aims: Current butterfly stroke training in swimming clubs demonstrates notable structural imbalances. Traditional methods place excessive emphasis on static stability exercises, such as planks and Swiss ball routines, which often lead to compensatory activation of superficial abdominal muscles. Insufficient core strength in adolescent athletes directly affects their butterfly speed. Poor core stability leads to reduced movement coordination and low energy transmission efficiency, making it difficult to maintain stable propulsion output during the high-intensity periodic motion of the butterfly. Therefore, this research was to develop a specific training program to improve the butterfly swimming performance of athletes in the swimming club. In the future, this program could be adapted for university-level teaching or integrated into sports training for university athletes.

Methodology: This research was a mixed-method research. The population of this research includes 120 male butterfly swimming athletes aged between 15–18 years, from the Luzhou Ecological Swimming Club, Luzhou Huoshuge Club, and Longma High School Swimming Club, Sichuan Province, People's Republic of China. Through the purposive sampling method, butterfly swimming athletes from the Luzhou Ecological Swimming Club were selected as a sample group. 40 butterfly swimming athletes who voluntarily participated in this experiment will participate in a 100-meter butterfly test. Through a systematic sampling method, the sample group will be divided into two groups. This research was conducted on an 8-week training. The experimental group participated in a specific training program designed to improve butterfly swimming performance, with six sessions per week, each lasting 120 minutes. The control group followed a traditional training program. Performance assessments included the 100-meter butterfly test, a modified plank test, and 30 30-meter sprint test. Data collected from both groups before and after the intervention were analyzed to evaluate the effectiveness of the specific training program. Mean, standard deviation, and independent t-tests were used to analyze the data.

Results: The results showed that using independent t-tests to analyze the data, the post-test results of the experimental group have better performance than the control group in all indicators,





with a significant difference at the 0.05 level. The experimental group had a shorter 100-meter butterfly time (3.47 seconds), longer modified plank duration (13.27 seconds), and faster 30-meter sprint speed (0.23 m/s). This indicates the specific training program was more effective in improving the butterfly swimming performance of athletes in the swimming club.

Conclusion: The developed specific training program was more effective in improving the butterfly swimming performance of athletes in the swimming club, better than the traditional training program.

Keywords: Specific Training Program; Butterfly Swimming Performance; Butterfly Swimming Athletes; Swimming Club

Introduction

In competitive swimming, the butterfly stroke is distinguished by its wave-like propulsion pattern, unlike other strokes. This technique requires swimmers to coordinate undulating trunk movements with precise synchronization of arm strokes and dolphin kicks, relying heavily on the efficiency of core muscle force transmission. Deep core stabilizers play a crucial role, as they must maintain spinal stability during dynamic actions while ensuring seamless power transfer between the upper and lower limbs (Jie, 2023). Research indicates that propulsion efficiency in butterfly swimming depends not only on explosive core strength but also on fine muscle control and dynamic stability, both of which directly influence technical performance and energy utilization. The stroke can be described as a “core-driven” movement, with technical demands concentrated on sagittal plane trunk undulation, frontal plane anti-rotational stability, and horizontal plane torque transfer.

Current training approaches in many swimming clubs reveal structural shortcomings. Traditional methods focus heavily on static stability drills, such as planks and Swiss ball exercises, which tend to overactivate superficial abdominal muscles while failing to replicate the dynamic trunk rotations and eccentric–concentric contractions required for the butterfly technique (Coa, 2012). Athlete evaluations also rely excessively on static indicators, such as plank duration, which show only weak associations with actual underwater performance, leading to low conversion of training outcomes into competition results (KHIYAMI ET AL, 2022). By contrast, advanced three-dimensional motion analysis demonstrates that a swimmer’s core stability index strongly correlates with speed, and even minor deviations in trunk wave amplitude can significantly increase drag. (Li et al., 2023). These insights highlight the limitations of static testing and underscore the need for dynamic, sport-specific assessments that align more closely with real swimming demands. Adolescent butterfly athletes face additional challenges, with a large proportion experiencing anterior pelvic tilt, overreliance on lumbar extensors, and weakness in





deep flexors. Such imbalances increase injury risk, reduce efficiency, and contribute to endurance plateaus frequently observed among Chinese butterfly swimmers (Vegaliftz, 2023). Poor posture, if left uncorrected, elevates lumbar disc stress and accelerates chronic injury risks, while inadequate core stability undermines propulsion efficiency.

In conclusion, current butterfly stroke training in swimming clubs shows a clear gap between traditional experience-based practices and data-driven scientific methods, lacking a systematic, measurable, and replicable model tailored to the stroke's unique demands. These limitations are particularly evident among adolescent athletes, who continue to face difficulties in refining technique, improving speed, building core endurance to sustain anaerobic capacity, and reducing injury risks. In response, this research develops a specific training program aimed at improving butterfly performance in swimming club athletes, combining theoretical framework construction with empirical testing to deliver both scientific evidence and practical guidance for advancing competitive standards. Moreover, the developed program holds broader applicability, as it can be adapted for university-level teaching and athletic training, offering an integrated model that simultaneously cultivates technical skill and physical fitness.

Objectives

To develop a specific training program to improve the butterfly swimming performance of athletes in the swimming club.

Literature Review

Butterfly technique

The butterfly stroke is among the most technically complex and energy-intensive swimming styles, characterized by its core-driven wave-like propulsion, simultaneous bilateral arm strokes, and continuous dolphin kicks. As an Olympic discipline regulated by FINA, its execution is grounded in biomechanics, physiology, and fluid dynamics. Efficiency in this stroke depends on the kinetic chain, where undulating trunk movements generate force that transfers smoothly into arm pulls and dolphin kicks, creating a continuous propulsion cycle. Unlike freestyle's alternating movements or breaststroke's glide phases, butterfly requires uninterrupted coordination to minimize drag and sustain thrust, making it highly reliant on deep core stability and precise limb synchronization (Maglischo, 2001; Jie, 2023). From a technical standpoint, performance hinges on three-dimensional control: sagittal plane trunk wave amplitude, frontal plane anti-rotational stability, and horizontal plane torque transfer. Any deviation, such as exaggerated undulation or poor arm-leg timing, increases resistance and wastes energy. Research further highlights two key mechanisms: the "wave propagation effect," where controlled trunk undulation enhances





streamline and efficiency, and the “high-elbow catch,” which improves lift and propulsive force. Together, these elements are essential for optimizing butterfly stroke performance (Qi et al, 2023).

The departure and midcourse phases are two critical components of butterfly performance, each supported by distinct theoretical foundations aimed at achieving initial speed acquisition and sustained propulsion maintenance. Both are governed by biomechanical principles of force generation and drag reduction. In the departure phase, the crouch start posture utilizes the principle of elastic potential energy storage in muscle mechanics. Optimal joint angles of the hip, knee, and ankle pre-stretch the quadriceps, gluteus maximus, and calf muscles, enabling the explosive release of stored energy during push-off. To maximize propulsion, the swimmer’s center of mass should be positioned slightly forward on the starting block, facilitating horizontal velocity transfer while minimizing unnecessary vertical lift and preventing excessive entry depth or energy loss (Maglischo, 2001). Force generation during the start follows a sequential bottom-up kinetic chain, beginning with ankle plantar flexion and continuing through knee and hip extension, culminating in forward trunk drive. This sequence ensures the effective recruitment of large muscle groups, particularly the gluteus maximus and hamstrings, producing greater propulsive force than isolated actions. Meanwhile, the arms provide stability through their grip on the block, helping maintain balance, control the center of mass, and reduce lateral deviations. From a biomechanical perspective, this coordinated kinetic chain allows stored elastic energy to be efficiently converted into forward momentum, establishing a solid foundation for sustained midcourse propulsion (Counsilman, 1994).

Specific training program

A butterfly-specific training program can be defined as a scientifically structured framework tailored to the unique technical and physiological demands of the stroke, particularly for adolescent club athletes. It integrates three core components. First, specialized core strength training, targeting the “core-driven” propulsion mechanism essential for trunk undulation, dolphin kicks, and overall stroke stability. Second, technical decomposition drills, which isolate complex movements into focused practices, such as refining trunk wave amplitude control and perfecting the high-elbow catch. Third, periodized load management, which systematically adjusts training intensity according to energy system demands, for example, ATP-CP for sprint starts and turns, and the glycolytic system for 100-meter performance. Unlike generalized swimming programs, this model emphasizes sport-specific adaptation by aligning dynamic core training with butterfly trunk mechanics and incorporating land-to-water transfer drills that replicate underwater force production (Zhang, 2023). The program design follows two guiding principles. The first is biomechanical alignment, ensuring that every exercise reinforces efficient wave-like propulsion while minimizing drag (Maglischo, 2001). The second is contextual adaptability, allowing





implementation in resource-limited club settings through cost-effective alternatives, such as smartphone-based underwater video analysis or homemade resistance bands, instead of expensive technology (Ramos Félix, E, et al., 2019). These principles create a practical and scientifically grounded framework that enhances performance, optimizes energy use, and reduces injury risks among adolescent swimmers. Supporting this approach, Szymanski et al. (2007) demonstrated that multi-joint, functional core exercises are superior to static holds in developing strength, stability, and movement efficiency. Their findings highlight that dynamic drills activating both deep stabilizers and superficial muscles improve balance, posture control, and power transfer—directly reinforcing the value of dynamic core training in developing trunk wave control, streamline alignment, and drag reduction for butterfly swimmers.

Escamilla et al. (2015) conducted a detailed biomechanical study on core muscle activation during Swiss ball and traditional abdominal exercises, providing important insights into how dynamic training improves functional movement. Their findings showed that instability-based exercises such as Swiss ball crunches, rollouts, and pikes elicited greater activation of both superficial muscles (rectus abdominis, obliques) and deep stabilizers (transverse abdominis, multifidus) compared to traditional static holds like planks or sit-ups. This increased activation was explained by the kinetic chain principle, in which dynamic, multi-joint movements enhance the efficiency of force transfer across the trunk to the limbs. These results support the idea that dynamic, instability-driven training not only builds core strength but also improves sport-specific performance by enhancing postural control, coordination, and energy transfer. In swimming, particularly the butterfly stroke, this evidence highlights why dynamic core exercises better facilitate “core-driven propulsion” than static drills, directly linking biomechanical theory to improvements in speed and efficiency. Similarly, Vegaliftz (2023) reported that anterior pelvic tilt in swimmers leads to elevated lumbar disc pressure, raising injury risk and reducing hip drive efficiency. Corrective training methods, such as glute bridges and posture-focused stretching, were shown to lower lumbar stress and enhance hip propulsion, directly supporting more powerful dolphin kicks and improved sprint performance in butterfly events.

Principle of training

The principles of training provide the scientific foundation for designing effective butterfly stroke programs by integrating established sports training concepts, such as overload, specificity, and periodization, with the stroke’s distinct biomechanical and energy system demands. These principles ensure that training is systematic, precise, and developmentally appropriate for adolescent club athletes. When applied effectively, they enable coaches to optimize the “core-driven” propulsion mechanics of the butterfly while simultaneously reducing injury risks. For instance, the overload principle emphasizes the gradual and systematic increase of training loads





to stimulate adaptation. Research shows that when overload is carefully managed through progressive resistance and intensity, athletes improve propulsion strength, lactate tolerance, and movement coordination, thereby avoiding stagnation in speed or endurance (Yin, 2023; Liao & Zheng, 2022). The specificity principle underscores the need for training methods that replicate the biomechanical and physiological characteristics of the butterfly, setting it apart from freestyle or breaststroke. Because the butterfly relies on synchronized bilateral arm pulls and trunk wave propulsion, core-centered drills and energy system targeted training are essential. Evidence indicates that technical drills replicating hand entry angles and pull trajectories can substantially enhance propulsion efficiency, while energy system-specific training ensures that sprint and distance butterfly swimmers develop appropriate balances of ATP-CP, glycolytic, and aerobic capacities (Maglischo, 2001; Coachesci, 2012). Without such precision, club-level butterfly programs often default to generic drills that offer limited transfer to competition performance.

The principle of periodization highlights the importance of structuring training into distinct phases: foundation, intensification, and tapering, aligned with athletes' developmental rhythms and competition schedules. For adolescents, this phased approach balances technical refinement, anaerobic conditioning, and peak performance strategies while helping to prevent overtraining during critical growth years. Empirical studies confirm that periodized programs not only improve aerobic and anaerobic capacity but also enhance fast-twitch muscle activation and race-specific technical sharpness (Li, 2021; Wang, 2020). Applied to butterfly, periodization integrates technical drills, resistance training, and recovery protocols across both micro- and macro-cycles, ensuring long-term, sustainable performance gains.

Taken together, the principles of overload, specificity, and periodization create a cohesive framework that combines scientific rigor with practical adaptability, providing coaches with a structured approach to elevating butterfly performance at the club level.

Summary: Butterfly stroke is one of the most demanding swimming styles, requiring core-driven wave propulsion, synchronized arm pulls, and dolphin kicks, which depend on strong core stability and precise coordination. To meet these demands, specialized programs integrate dynamic core training, technical drills, and periodized load management tailored to butterfly biomechanics and energy systems, enhancing propulsion, stability, and injury prevention.



Conceptual Framework

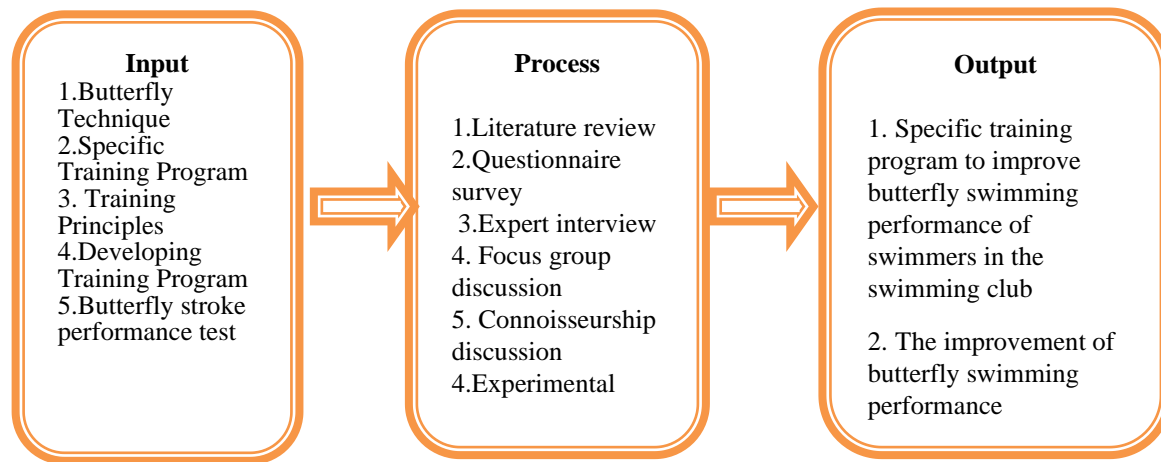


Figure 1 Conceptual framework

This framework illustrates the structured approach to developing a specific training program aimed at improving butterfly swimming performance in swimming clubs. The Input stage identifies the essential elements, including the butterfly technique, training principles, performance testing, and the design of a specialized training program. The Process stage outlines systematic research and validation methods such as literature review, questionnaire surveys, expert interviews, focus group discussions, connoisseurship evaluations, and experimental testing, ensuring both theoretical grounding and practical applicability. Finally, the Output stage highlights the expected results: the creation of a targeted training program tailored for butterfly swimmers and measurable improvements in their performance.

Methodology

Research Tools

In this research, the following instruments were employed to carry out the study: (1) Questionnaire for butterfly swimming athletes and coaches; (2) Expert Interview Questionnaire; (3) Focus Group Outline; (4) Connoisseurship outline; (5) Specific Training Program; (6) Butterfly Performance Testing, namely 100 meter butterfly test, modified plank test, and 30 meter sprint speed.

Population and Sample

The participants in this study included butterfly swimming athletes and coaches from three clubs: Luzhou Ecological Swimming Club, Luzhou Living Water Club, and Longma High School Swimming Club. Across these clubs, there were 120 athletes and 15 coaches in total. All athletes and coaches participated in the questionnaire survey.



For the experimental phase, Luzhou Ecological Swimming Club was purposively selected as the sample site. From this club, 40 butterfly swimming athletes who volunteered to participate underwent a performance assessment using the 100-meter butterfly test. Based on the test results, athletes were ranked from slowest to fastest. Using systematic sampling, the 40 athletes were evenly assigned into two groups: 20 in the experimental group and 20 in the control group.

Data Collection

1. On-site questionnaire surveys were conducted with 120 male butterfly swimming athletes and 15 coaches at the Luzhou City clubs, focusing on collecting detailed data regarding the current training status of butterfly swimming athletes and issues related to butterfly swimming training.

2. In-depth interviews were conducted with 7 experts to gather professional insights on enhancing the butterfly stroke, followed by an analysis of the components of a specific training program aimed at improving the butterfly swimming performance of athletes.

3. A focus group discussion involving 10 experts was organized to develop a specific training program. The program design will be based on the current training status and existing issues among butterfly swimming athletes.

4. A connoisseurship discussion was held with 7 experts to validate the applicability, feasibility, and effectiveness of the developed specific training program.

5. The training program was implemented over 8 weeks, with 40 butterfly swimming athletes undergoing training 6 times per week, each lasting 2 hours. The experimental group adopted a newly developed core strength training program for butterfly stroke training, while the control group maintained traditional training methods.

6. During the experiment, pre-tests and post-tests were conducted on 40 butterfly swimming athletes to evaluate the effectiveness of the specific training program.

Data Analysis

1. The questionnaire survey employed mean (\bar{X}) and standard deviation (S.D.) for data analysis.

2. Expert interviews, focus group discussions, and appreciation discussions were analyzed using content analysis.

3. An independent samples t-test was used to compare the pre-test and post-test results between the experimental group and the control group in the 100-meter butterfly test, the modified plank test, and the 30-meter sprint speed test.

4. The Item-Objective Congruence Index (IOC) was used to evaluate the questionnaire and expert interview questionnaires. The IOC value of the questionnaire for athletes = 0.83, the IOC value of the questionnaire for coaches = 0.81, and the IOC value of the interview questionnaire = 0.81.



Results

The details of data analysis were as follows:

Part 1: Study the current situation and existing problems in butterfly swimming training of athletes in the swimming club.

Part 2: Draft the specific training program to improve the butterfly swimming performance of athletes in the swimming club.

Part 3: Experiment with the specific training program to improve the butterfly swimming performance of athletes in the swimming club.

Part 1: Study the current situation and existing problems in butterfly swimming training of athletes in the swimming club

To clarify the current status and challenges of butterfly stroke training among male butterfly swimming athletes aged 15-18 in Luzhou’s swimming clubs, this study designed and implemented an on-site questionnaire survey of athletes and coaches. The questionnaire was distributed to 120 swimming athletes and 15 coaches, and the following is the analysis of the questionnaire survey results: The results of the questionnaire survey of swimming athletes.

Table 1 Results of the “Training Content Structure” Section (N = 120)

Questionnaire Items	\bar{X}	SD	Results
1. Static stability exercises (e.g., planks, static Swiss ball holds) account for over 60% of core training	3.82	0.76	High
2. Dynamic anti-rotation exercises (e.g., medicine ball rotational throws, TRX anti-rotation) are conducted less than twice a week	3.65	0.81	High
3. Specialized exercises simulating butterfly trunk wave motion (e.g., land wave imitation, underwater dynamic core control) account for less than 30% of training	3.91	0.68	High
4. Training includes targeted correction exercises for anterior pelvic tilt (e.g., glute bridges, cat-cow stretches)	1.72	0.59	Poor
5. Training integrates land-based core drills with underwater butterfly skill transfer (e.g., resistance band stroke simulation → water-based high-elbow pulls)	1.89	0.63	Poor

Table 1 reveals that butterfly training programs in Luzhou’s swimming clubs are heavily imbalanced, with excessive reliance on static core training and major gaps in dynamic, specialized,



and corrective content. Static stability work (e.g., planks) dominates over 60% of training (\bar{X} =3.82, SD=0.76, High), while dynamic anti-rotation exercises occur infrequently (\bar{X} =3.65, SD=0.81, High) and specialized butterfly-specific trunk wave drills remain under 30% of the program (\bar{X} =3.91, SD=0.68, High). Critically, corrective exercises for anterior pelvic tilt (\bar{X} =1.72, SD=0.59, Poor) and integrated land-to-water skill transfer drills (\bar{X} =1.89, SD=0.63, Poor) are largely absent, highlighting a serious disconnect between training design and the biomechanical and injury-prevention needs of butterfly swimmers.

Table 2 Results of the "Evaluation System and Injury Perception" Section (N = 120)

Questionnaire Items	\bar{X}	SD	Results
1. Core ability evaluation mainly uses static indicators (e.g., plank duration, side bridge hold time)	4.12	0.53	High
2. I know my plank duration score, but not its correlation with my 100m butterfly performance	3.89	0.61	High
3. I have experienced lumbar or sacroiliac pain during butterfly training in the past year	3.87	0.71	High
4. The coach explains how core training improves my butterfly propulsion efficiency	1.93	0.67	Poor
5. Training includes warm-up drills specifically for preventing lumbar injuries (e.g., transverse abdominis activation)	1.65	0.58	Poor

Table 2 highlights two major flaws in butterfly stroke training for adolescent swimmers: an evaluation system overly reliant on static indicators and inadequate injury prevention measures. Core ability is mainly assessed through static tests like plank duration (\bar{X} =4.12, SD=0.53, High), which fail to reflect actual underwater performance, while many athletes know their plank scores but not their relation to 100m butterfly results (\bar{X} =3.89, SD=0.61, High), showing a lack of performance-oriented evaluation logic. At the same time, injury risk is pronounced, with a high incidence of lumbar and sacroiliac pain (\bar{X} =3.87, SD=0.71, High), yet coaches rarely explain the link between core training and propulsion efficiency (\bar{X} =1.93, SD=0.67, Poor), and warm-up drills targeting lumbar injury prevention are largely absent (\bar{X} =1.65, SD=0.58, Poor). Overall, the findings reveal that butterfly training suffers from disconnection between evaluation and performance, coupled with high injury risk and insufficient protective awareness, underscoring the urgent need for systematic optimization. The results of the questionnaire survey of swimming coaches.



Table 3 Results of the "Training Content Structure" Section (N = 15)

Questionnaire Items	\bar{X}	SD	Results
1. I design core training mainly based on static stability exercises (e.g., planks)	4.05	0.52	High
2. I lack the professional knowledge to design dynamic anti-rotation exercises for the butterfly	3.78	0.69	High
3. The club has insufficient equipment (e.g., TRX, balance boards) to implement dynamic core training	4.21	0.48	High
4. I incorporate anterior pelvic tilt correction into weekly training plans	1.58	0.51	Poor
5. I regularly adjust training content based on athletes' core strength test results	2.13	0.74	Poor

Table 3 reveals that coaches' reliance on static training stems from both knowledge and equipment limitations, as shown by their heavy use of static stability drills (\bar{X} = 4.05, SD = 0.52, High), lack of expertise in dynamic anti-rotation design (\bar{X} = 3.78, SD = 0.69, High), and inadequate access to training tools such as TRX or balance boards (\bar{X} = 4.21, SD = 0.48, High). Additionally, the absence of personalized and preventive approaches is evident, with very low incorporation of anterior pelvic tilt correction (\bar{X} = 1.58, SD = 0.51, Poor) and minimal adjustments based on core strength test data (\bar{X} = 2.13, SD = 0.74, Poor). Together, these results confirm that limited professional knowledge, insufficient resources, and a lack of data-driven methods are the root causes of imbalanced training content in butterfly programs.

Table 4 Results of the "Evaluation System and Injury Prevention" Section (N = 15)

Questionnaire Items	\bar{X}	SD	Results
1. I use plank duration as the main indicator to evaluate athletes' core strength	4.32	0.47	High
2. I regularly analyze the correlation between core test results and butterfly performance (e.g., 100m time)	1.76	0.62	Poor
3. I have received professional training on butterfly-related injury prevention (e.g., lumbar protection)	2.08	0.73	Poor
4. I use underwater video or motion capture to correct the athletes' trunk wave amplitude	1.45	0.49	Very Poor



Questionnaire Items	\bar{X}	SD	Results
5. I adjust training load based on athletes' subjective fatigue (e.g., RPE scale)	2.31	0.68	Poor

The coach questionnaire highlights three major flaws in butterfly stroke training design. First, evaluation is overly dependent on static indicators like plank duration ($\bar{X}=4.32$, $SD=0.47$, High), with little effort to analyze their correlation with actual performance ($\bar{X}=1.76$, $SD=0.62$, Poor), leading to ineffective performance-based assessments. Second, coaches lack both technical correction tools and professional knowledge in injury prevention, as shown by the absence of training in lumbar protection ($\bar{X}=2.08$, $SD=0.73$, Poor) and the non-use of underwater video or motion capture for correcting trunk wave amplitude ($\bar{X}=1.45$, $SD=0.49$, Very Poor). Third, they fail to adjust training loads according to athletes' fatigue ($\bar{X}=2.31$, $SD=0.68$, Poor), raising risks of overtraining. Collectively, these gaps show that the current training system lacks scientific rigor, technical precision, and individualized adjustments, underscoring the urgent need for better evaluation methods, enhanced injury prevention knowledge, and tool-supported correction mechanisms.

Part 2: Draft the specific training program to improve the butterfly swimming performance of athletes in the swimming club.

1. Expert's interview

The researcher conducted in-depth interviews with seven experts to examine the current state and challenges of butterfly swimming training and to construct a comprehensive and scientifically grounded training framework. The experts unanimously agreed that training for 15–18-year-old athletes in Luzhou clubs is limited by insufficient dynamic specialization, fragmented evaluation systems, and inadequate injury prevention measures, highlighting the need for a more scientific and tailored approach.

Their recommendations emphasized the application of progressive overload and three-phase periodization, adjusted to athletes' biological age, core strength, and postural conditions. Specific priorities included dynamic core stability, trunk wave control, land–water skill transfer, and lactate tolerance. The experts proposed a practical program consisting of six training days per week, with 120-minute sessions, integrating affordable equipment, motivational strategies, and lumbar/sacroiliac protection. They also stressed the importance of combining quantitative evaluations (e.g., 100m butterfly time, sprint speed) with qualitative assessments such as video analysis. Finally, with appropriate recovery protocols and parental support in nutrition, the experts



confirmed that even under resource-constrained conditions, modular training programs can deliver significant improvements in speed, endurance, and injury prevention within eight weeks.

2. Focus group discussion

This study engaged a focus group of 10 experts, comprising 4 professors in physical education, 3 professors in sports training, and 3 professors in biomechanics, each with over a decade of research or practical experience in their respective fields. The purpose of the discussions was to design a specialized training program aimed at improving butterfly swimming performance among club athletes. Through in-depth deliberation, the experts reached a unanimous consensus on four fundamental pillars of the program: dynamic core activation, integration of technique and physical fitness, periodized progression, and injury prevention. The essential components and the finalized eight-week training framework are presented in the table below.

Table 5 The framework of an 8-week specific training program for swimming athletes in a swimming club

Week	Core Training Focus	Technical Training Focus	Fitness Training Focus	Key Supplementary
1	Activate deep core (1kg medicine ball throws, bird-dog planks)	Butterfly basics (30° entry angle, kickboard kicks ≤15°, basic turns)	Low-intensity intervals (400m freestyle + 200m IM, 60% max HR)	120 mins total, core 25%
2	Enhance stability (TRX anti-rotation rows, 1kg side throws, glute bridges)	Refine strokes (band-assisted catch, "3 kicks +1 pull", 120-150° hip turns)	5×100m freestyle (65% max HR) + 2×200m IM	+10min hip yoga post-training
3	Improve core-limb coordination (TRX+medicine ball rotations, plank shoulder taps)	Integrate segments (full butterfly, marker kicks ≤15°, turn connection)	3×400m freestyle (70% max HR) + 800m continuous	Volume +10% vs Week 2, core 25%
4	Start strength training (3kg medicine ball)	Add resistance (light paddles, band kicks, 120-150° hip feedback)	6×100m butterfly (85% max HR) + 4×50m sprints	Intensity 75-80% max HR, core 30%,



Week	Core Training Focus	Technical Training Focus	Fitness Training Focus	Key Supplementary
	throws, weighted single-leg deadlifts)			+protein supplement
5	Optimize force transmission (4kg medicine ball throws, weighted anti-rotation holds)	High-intensity tech (parachute kicks <20°, paddles, underwater video)	8×100m butterfly (85-90% max HR) + 6×50m all-out sprints	HR 75-85% max, rest -10% vs Week 4, +lumbar assessments
6	Stabilize under fatigue (3-4kg medicine ball complex throws, rotational deadlifts)	Fatigue tech (paddle+parachute, symmetry correction, race-pace turns)	10×100m butterfly (90%/80% alternate) + 3×200m anaerobic threshold	Core 30%, optional sEMG monitoring
7	Race rhythm simulation (3kg medicine ball maintenance throws, stability ball waves)	Fine-tune deviations (full race cycles, video entry correction, fast/slow kicks)	8× (50m fast+50m slow) + 2×100m butterfly (90% max HR)	Intensity varies by race phase, core 20%, + sleep monitoring (7-8hrs)
8	Pre-competition recovery (light 3kg medicine ball throws, dynamic planks)	Optimize competition tech (timed simulations, start/stroke refinement, video trunk review)	4×100m (1×95% + 3×85% max HR) + 200m active recovery	Volume -30% vs Week 7, priority to foam rolling + protein recovery

3. Connoisseurship Discussion

Seven experts unanimously confirmed that the eight-week specialized butterfly swimming training program is scientifically rigorous, practically feasible, and highly relevant for adolescent club athletes. Their evaluations highlighted four key strengths:

1. Technical alignment: The dynamic core training and quantitative technical standards (e.g., 18-22° hand entry angle) conform to butterfly swimming's biomechanical principles, effectively improving propulsion efficiency.

2. Adolescent adaptability: The three-phase periodization and 5-8% weekly load progression fit physiological development laws, balancing ability improvement and injury prevention.



3. Club compatibility: Low-cost equipment alternatives and standardized operation manuals address resource constraints, ensuring wide promotion.

4. Effectiveness guarantee: The integration of injury prevention, anaerobic training, and dynamic evaluation ensures sustained performance improvement.

Part 3: Experiment with the specific training program to improve the butterfly swimming performance of athletes in the swimming club.

To evaluate the effectiveness of the developed butterfly-specific training program, an eight-week intervention experiment was conducted. The experimental group followed the specialized program, while the control group continued with traditional training. Three performance indicators were used for assessment: the 100-meter butterfly test, measuring overall speed and technical stability; the modified plank test, assessing core stability and endurance; and the 30-meter sprint test, evaluating explosive power and propulsion efficiency. Data collected before and after the intervention were analyzed using descriptive statistics and independent samples t-tests to determine the program's effectiveness.

Table 6 Descriptive Statistics of the Experimental Group's Test Results (n=20)

Variables	Experimental Group			
	Pre-test		Post-test	
	\bar{X}	SD	\bar{X}	SD
100m Butterfly Time (s)	69.52	2.31	65.28	2.15
Modified Plank Duration (s)	68.35	4.52	85.62	4.38
30m Sprint Speed (m/s)	2.52	0.13	2.85	0.12

Table 6 highlights a clear upward trend in all performance indicators of the experimental group, showing steady and consistent improvement across three tests. The 100m butterfly time, pre-test was 69.52 ± 2.31 and post-test was 65.28 ± 2.15 , which was decreased by 4.24 seconds. Modified plank duration, pre-test was 68.35 ± 4.52 and post-test was 85.62 ± 4.38 , which was improved by only 17.27 seconds. 30m sprint speed, pre-test was 2.52 ± 0.13 and post-test was 2.85 ± 0.12 , it was increased by 0.33 m/s, confirming enhanced explosive power vital for starts and turns. Collectively, these results demonstrate that the specialized training program effectively promotes continuous and comprehensive improvements in butterfly performance, core strength, and power output.

Table 7 Descriptive Statistics of the Control Group’s Test Results (n=20)

Variables	Control Group			
	Pre-test		Post-test	
	\bar{X}	SD	\bar{X}	SD
100m Butterfly Time (s)	69.65	2.43	68.43	2.37
Modified Plank Duration (s)	67.98	4.61	72.15	4.56
30m Sprint Speed (m/s)	2.51	0.14	2.61	0.13

Table 7 reveals that the control group showed only minimal improvements after 8 weeks of traditional static training, with performance gains far behind those of the experimental group. The 100m butterfly time, pre-test was 69.65±2.43 and post-test was 66.43±2.37, which was decreased by 1.22 seconds. Modified plank duration, pre-test was 67.98±4.61 and post-test was 72.15±4.56, it was improved by only 4.17 seconds. 30m sprint speed, pre-test was 2.51±0.14 and post-test was 2.61±0.13, it was increased by 0.10 m/s. Overall, these results highlight the limited effectiveness of static training, which fails to significantly enhance speed, core endurance, or explosive power.

Table 8 Pre-test Comparison Between the Experimental Group and the Control Group

Variables	Exp. G		Cont. G		t	p
	\bar{X}	SD	\bar{X}	SD		
100m Butterfly Time (s)	69.52	2.31	69.65	2.43	-0.17	0.866
Modified Plank Duration (s)	68.35	4.52	67.98	4.61	0.26	0.797
30m Sprint Speed (m/s)	2.52	0.13	2.51	0.14	0.23	0.818

*p < 0.05.

Table 8 shows no significant differences between the experimental and control groups across all indicators before the intervention. This confirms that both groups started with comparable baseline performance levels.

Table 9 Post-test Comparison Between the Experimental Group and the Control Group

Variables	Exp. G		Cont. G		t	p
	\bar{X}	SD	\bar{X}	SD		
100m Butterfly Time (s)	65.28	2.15	68.43	2.37	-4.26	0.001**
Modified Plank Duration (s)	85.62	4.38	72.15	4.56	7.83	0.001**
30m Sprint Speed (m/s)	2.85	0.12	2.61	0.13	5.97	0.001**

*p < 0.05.



Table 9 showed that after 8 weeks of training, the experimental group outperformed the control group across all indicators with statistically significant differences ($p < 0.05$). Their 100m butterfly time was 3.15 seconds faster, reflecting superior speed and technical efficiency, while their modified plank duration was 13.47 seconds longer, demonstrating stronger core stability and endurance. Additionally, their 30m sprint speed was 0.24 m/s higher, confirming enhanced explosive power. These findings validate that the specialized training program is significantly more effective than traditional static training in improving butterfly performance, core capacity, and short-distance propulsion.

Summary: Butterfly swimming demands exceptional physical fitness, precise coordination, strong core stability, refined stroke technique, and explosive power. This study tested a specialized core training program by comparing an experimental group with traditional training controls, and independent t-test results showed significant improvements ($p < 0.05$) in 100m butterfly time, modified plank duration, and 30m sprint speed for the experimental group after 8 weeks. These findings confirm the program's effectiveness in enhancing butterfly performance, fully supporting the research hypothesis.

Conclusion

The results showed that after 8 weeks of training, the post-test comparison between groups, the experimental group outperformed the control group in 100m butterfly time, modified plank duration, and 30m sprint speed, with all differences reaching statistical significance ($p < 0.05$). These findings confirm that the specific training program effectively enhances butterfly swimming performance, which is consistent with the research hypothesis.

Discussion

This study implemented an eight-week specialized core training program for adolescent butterfly swimmers in Luzhou clubs and observed significant improvements across all performance indicators, 100m butterfly time, modified plank duration, and 30m sprint speed, compared with the control group ($p < 0.05$). The experimental group reduced their 100m butterfly time by 4.24 seconds, greatly surpassing the control group's 1.22-second gain. This outcome was largely attributed to dynamic core training, which enhanced "core-driven" propulsion in line with kinetic chain theory, emphasizing efficient force transfer from the core to the limbs (Escamilla et al., 2015). The program also integrated technical drills, such as trunk wave amplitude control, alongside anaerobic conditioning through interval training at high intensity, targeting both biomechanical efficiency and energy system adaptation.





Core stability improved notably, with the experimental group increasing modified plank duration by 17.27 seconds, four times the control group's improvement. This supports Szymanski et al. (2007), who demonstrated that multi-joint, functional core exercises are superior to static holds in enhancing movement quality. Dynamic drills such as planks with shoulder taps, stability ball undulations, and weighted anti-rotation holds effectively activated deep stabilizers (e.g., multifidus) while strengthening superficial muscles for trunk wave motion, thereby improving body streamline and reducing drag. Similarly, 30m sprint speed increased by 0.33 m/s compared with only 0.10 m/s in the control group, reflecting greater explosive power derived from integrated land-water drills and pelvic tilt correction. Addressing anterior pelvic tilt, commonly observed among adolescent butterfly swimmers (FINA, 2022), reduced lumbar pressure and enhanced hip drive, critical for dolphin kicks and sprint propulsion (Vegaliftz, 2023).

Collectively, these findings confirm that specialized dynamic core training is more effective than static approaches, bridging the gap between experience-based practices and evidence-based methods. Moreover, the program provides a practical and replicable model suitable for swimming clubs operating with limited resources.

Recommendation

Recommendation for current research

1. Expand the sample scope to include female butterfly athletes and clubs in other cities (e.g., Chengdu, Chongqing), reducing regional bias and improving the program's generalizability.
2. Unify training equipment (e.g., shared resistance bands, medicine balls) across clubs to eliminate differences in training conditions and ensure data accuracy.

Recommendation for further research

1. Subdivide adolescent athletes into age groups (15–16 years, 17–18 years) to design personalized load plans, such as adjusting weekly overload ratios based on muscle growth rates.
2. Integrate intelligent tools (e.g., underwater EMG sensors, VR race simulations) to track deep core activation and enhance the precision of technical correction.

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