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Effects of Dry Land Speed Training on 100-Meter Freestyle Swimming in Adolescent Swimming

Zhang Daqian[1] and Chanchai Siriphan[2]
Faculty of Sports Science and Technology Bangkokthonburi University, Thailand
[1]E-mail: 359923809@qq.com, ORCID ID: https://orcid.org/0000-0003-2666-3841
[2]Email: Chanchai.Sir@bkkthon.ac.th, ORCID ID: https://orcid.org/0009-0000-9981-655X

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Abstract

Background and Aim: The specific strength development in swimming tends to start at a younger age, so it becomes particularly important to conduct effective Specific strength training during adolescence. It is essential to utilize training methods and means that align with the developmental characteristics of Specific strengths in young swimmers. Thus, this study has developed a specific dry-land training program to enhance the 100-meter freestyle swimming speed of adolescent swimmers.

Methods: This study selected 30 male adolescent swimmers from the Shaanxi Provincial Swimming Team and divided them into an experimental group and a control group (15 individuals in each group) based on their 100-meter freestyle speed. Both groups underwent a 12-week training intervention, with 12 training sessions per week, each lasting 2 hours. The total training time and water-based training content were the same for both groups, but the content of dry-land training differed. The experimental group followed a specific dry-land training program, while the control group followed a traditional training program. Comprehensive tests were conducted before and after the 12-week training intervention for both groups, using the physical fitness and test scores of swimmers in the experimental and control groups as research indicators. Experimental and analytical methods, including experimental and statistical methods, were employed to conduct a targeted study on the changes in physical fitness and test scores before and after the training.

Results: show that after 12 weeks of training, the scores for both groups are as follows: Pull-ups (Experimental group: $P=0.000<0.01$, Control group: $P=0.777>0.05$), Vertical jump (Experimental group: $P=0.032<0.05$, Control group: $P=0.848>0.05$), Abdominal muscle endurance (Experimental group: $P=0.000<0.01$, Control group: $P=0.396>0.05$), and Back muscle endurance (Experimental group: $P=0.004<0.01$, Control group: $P=0.583>0.05$). The post-test results reveal that swimmers in the experimental group performed significantly better in pull-ups, vertical jumps, abdominal muscle endurance, and back muscle endurance compared to the control group.

Conclusion: The specialized training program effectively increased the upper limb strength of the participants, with no significant advantage over the traditional training program.

Keywords: Specific Dry-land Training Programs; Dry-land Training Programs; Adolescent Swimmers; Freestyle swimming

Introduction

Swimming as a sport has been receiving increasing attention, and with the development of competitive swimming, many training theories and systems have been improved. Swimming has always adhered to the principle of "strength is the foundation, technique is the key," which is why strength training has been consistently emphasized. For periodic sports like swimming, the movements in

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Specific activities should be complex and diverse. However, when using gym equipment for strength training, the movements can often be simple and limited. This can easily lead to the strength training becoming general rather than Specific. Nowadays, when evaluating swimmers, Specific strength is regarded as one of the most crucial factors for assessing their strength qualities. As a result, coaches and athletes are continuously exploring training methods and means to enhance Specific strengths. As Specific strength development in swimming tends to start at a younger age, it becomes particularly important to conduct effective Specific strength training during adolescence. It is essential to utilize training methods and means that align with the developmental characteristics of Specific strengths in young swimmers. By enhancing Specific strength, we can promote the stability of correct technical movements and balance muscle strength in young swimmers, ultimately improving their competitive abilities.

Dry-land training has several important benefits in improving swimming-specific strength. Firstly, it strengthens the core muscle groups, such as the abdominal, back, and hip muscles, enhancing the swimmer's body stability and posture control. This is crucial for maintaining the correct swimming position, reducing resistance, and improving propulsion efficiency. Secondly, explosive power and acceleration training in dry-land exercises are vital for swimming's explosive power and acceleration abilities. Through training in jumping, sprinting, and explosive movements, swimmers can enhance their key technical skills, such as diving, turning, and sprinting, leading to faster speeds and a competitive advantage in competitions. Additionally, dry-land training can increase muscle strength and endurance, allowing swimmers to sustain high-level performance during races. Through resistance training, repetitive exercises, and high-intensity interval training, swimmers' muscle strength is enhanced, and their endurance and fatigue resistance are improved, delaying the onset of muscle fatigue. In conclusion, dry-land training is essential for improving swimming-specific strength. It enhances core strength, improves explosive power and acceleration, increases muscle strength and endurance, and enhances flexibility and joint stability. These benefits have a positive impact on improving swimming techniques and competitive performance. Therefore, fully utilizing dry-land training in swimming practices will contribute to better achievements and performances for swimmers.

Crawl stroke, also known as freestyle, is a swimming technique where the swimmer alternates arm movements in a windmill-like motion while kicking their legs. It's one of the fastest and most efficient swimming styles. The swimmer breathes by turning their head to the side during arm recovery. The crawl stroke emphasizes continuous and rhythmic movements to maintain propulsion and minimize drag, allowing swimmers to cover longer distances with less effort. Crawl stroke is a full-body swimming technique that involves training various parts of the body, including the upper limbs, lower limbs, waist and back muscles, and core muscles. Generally, the upper limbs' pulling motion plays a crucial role in training, accounting for about 40% to 50% of the overall training. The kicking action of the lower limbs is equally important, but the training proportion is relatively lower, about 20% to 30%. Training the waist, back, and core muscles contributes to maintaining proper swimming posture and stability, constituting around 20% to 30% of the training. Additionally, some minor muscle groups such as leg side muscles and hand muscles also require approximately 5% to 10% of the training.

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In this study, 30 adolescent swimmers were selected from the Shaanxi Province Youth Swimming Team as research subjects. A dry-land training program was developed to observe changes in their 100m freestyle speed after training. The effectiveness of the dry-land training was tested to provide coaches with an effective training plan, ultimately improving the athletic performance of adolescent swimmers.

Objective

To construct a Specific dry-land training program aiming to enhance the swimming speed in the 100-meter freestyle event for adolescent swimmers.

Literature Review

One of the main experiences in China's swimming training is to emphasize talent selection and systematic training over the years. Many athletes show significant athletic potential during the foundational training stage, achieving good sports performance without using heavy training loads or Specific training methods. As they grow and develop, their performance improves significantly. This aspect is particularly crucial during adolescence, indicating that athletes' athletic level relies mainly on their foundational training level and individual innate conditions. The success of many athletes also demonstrates that years of systematic foundational training, emphasizing comprehensive physical development and comprehensive technical training in all four swimming styles, gradually increasing training content and difficulty as their bodies grow, are the path to success for swimmers (Xie & Wang, 1992).

Due to the dominant factor of competitive ability being speed for swimmers in sprint events, race time serves as the judgment standard for athletic performance. In the 100m freestyle, both cross-over turns and flip-turns are commonly employed. Speed, power, and speed endurance are the main components of the 100m freestyle. Among these, the power of flip-turns is the highest, followed by cross-over turns, and front turns have the lowest power. Therefore, the technique of flip-turns can be used to exert speed and power. As speed endurance is also required in the 100m freestyle, swimmers with relatively weaker absolute strength might find flip-turns causing instability. In such cases, cross-over turns can be employed. The speed qualities in the 100m freestyle are primarily reflected in movement speed, reaction speed, and transitional speed, with the main energy system being a combination of phosphagen and glycolytic metabolism (Chen & Teng, 2022).

A large proportion of young swimmers undergo strength training on dry land. However, things are far from simple, as there are many examples where dry-land training has improved performance, but the aquatic results have not shown similar progress. One major drawback is that dry-land training is not fully integrated with water-based movements (Chen, 2003). Dry-land training must be systematic and consistent, taking into consideration the age-specific characteristics of young swimmers (Yan & Wang, 2005). In the study on the effects of pressure training on lower limb strength of swimming students, the corresponding test indicators selected include lower limb circumference (thigh and calf), SJ (Squat Jump), and CMJ (Countermovement Jump) vertical jump height in two forms, hang time, vertical jump power, maximum strength in half squat, maximum strength in full squat, and sports performance (Guo, 2019). The focus of training for power-dominated speed events is to enhance athletes' competitive abilities and speed qualities. Improving speed qualities is evident in starts, flip-turns, arm propulsion, and increasing stroke frequency while maintaining stroke length. In training, physical conditioning forms the foundation, while technique ensures its execution. Sufficient physical fitness guarantees a stable performance level in athletes, enabling them to overcome fatigue during intense competitions and achieve commendable results.

In summary, it is known that specialized strength training for freestyle swimmers can be conducted in water or on land. Whether in water or on land, specialized strength training should closely resemble actual freestyle movements. This is reflected in muscle work modes, force directions, joint

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angles, muscle loads, major muscle groups involved, etc., which should be kept consistent with the working characteristics of muscles during freestyle swimming. Scholars generally believe that specialized strength training for swimming.

Conceptual Framework

Based on the theory of swimming land training, this paper independently designs the training plan and experiments by using swimming pool training and land physical training. From the athletes' physical fitness index and 100 m freestyle speed, four indexes were measured to verify the effect of the special swimming land training program on the exercise ability of the experimental subjects.

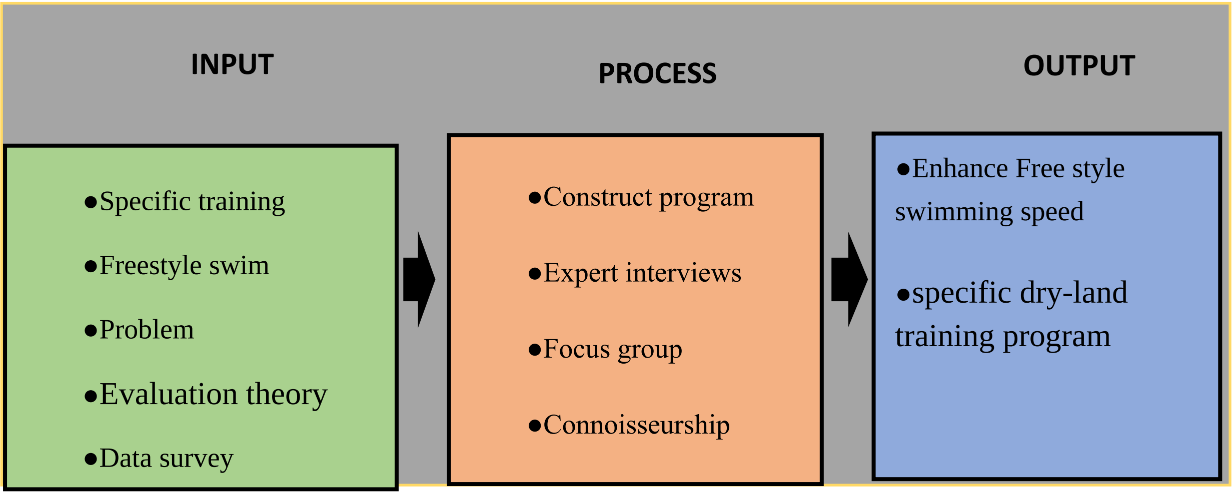

Figure 1 Conceptual Framework

Methodology

In this study, the literature method, experiment method, and mathematical statistics method are combined, with the experimental method as the main method; (1) 30 young swimmers. The participants in this study were young swimmers from the Shaanxi Youth Swimming Team; (2) Measurement variables: Pull-up, vertical longitudinal jump, abdominal muscle endurance, dorsal muscle endurance, 100 m freestyle speed; (3) Experimental control: The experiment lasted for 12 weeks, with training conducted 6 days a week and 1 day for adjustment. There were two training sessions each day, each lasting two hours. Morning sessions were dedicated to water training, and on Monday, Wednesday, and Friday afternoons, land training was conducted.

Population and sample

Sample for Questionnaire Survey: This study has selected 30 coaches from 10 different clubs to construct a diverse and varied population sample， Questionnaires were distributed by email. These clubs vary in size, geographical location, and training programs. The surveyed 30 coaches represent different levels of coaching qualifications, including novice, intermediate, and advanced coaches. Through this extensive population sample, the research aims to gain in-depth insights into the perspectives and practices of coaches with diverse backgrounds and experiences regarding the current status of freestyle training programs for adolescent swimmers. The goal is to facilitate a comprehensive understanding of this field and contribute to future improvements.

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Population: 30 young swimmers. The participants in this study were young swimmers from the Shaanxi Youth Swimming Team. The inclusion criteria for participants were as follows: aged between 13 and 14 years old, with at least 5 years of training experience. They were in good health, volunteered to participate in the experimental research, and ensured their availability to attend swimming training during the study period.

Sample for Experts Interview: In this study, a panel of experts was selected to provide insights and opinions on "A construction of Specific dry-land training program to enhance swimming speed on 100 meters freestyle of adolescent swimmer." The panel consisted of 9 experts with extensive experience as university professors, professional team coaches, and accomplished athletes. These experts were chosen based on their established reputation, publications, and contributions to the field. The selection of experts was based on a snowball sampling method.

Sample for Focus Group: A series of focus group sessions were conducted to gather insights from group members regarding "A construction of Specific dry-land training program to enhance swimming speed on 100 meters freestyle of adolescent swimmer." Each focus group session consisted of 12 participants with diverse backgrounds and experiences related to swimming coach. The participants were selected to ensure a well-rounded perspective on the topic.

Sample for Connoisseurship method: Nine experts, including representatives from authoritative swimming organizations, university leadership, and physical education instructors, were selected to form an appraisal group. This group conducted discussions to assess and determine the effectiveness of the training program.

Research Tools: Use a SEIKO stopwatch to time the duration of the test, ensuring it is not too high, too low, or stopped prematurely. Measure the time for a 100-meter freestyle race using a digital sports electronic timing board.

For training locations and training programs:

Experimental location: The test in this study was divided into an experimental group and a control group. The experiment locations are all at the Swimming Center in Shaanxi Province.

Experimental control: The experiment lasted for 12 weeks, with training conducted 6 days a week and 1 day for adjustment. There were two training sessions each day, each lasting two hours. Morning sessions were dedicated to water training, and on Monday, Wednesday, and Friday afternoons, land training was conducted.

Training time and frequency: The experimental group and the control group trained for 6 days from Monday to Saturday, 2 times a day in the morning and afternoon, 2 hours each time. Dry-land training was conducted on Monday, Wednesday, and Friday afternoons.

Land-based Physical Fitness Test Indicators and Methods:

- Pull-ups: Hold the bar with an overhand grip, maintain a static position without swinging, and count the number of chin-ups performed.

- Vertical Jump Test: Use a vertical jump tester and perform a countermovement vertical jump. Take the highest of two attempts.

- Back Muscular Endurance and Abdominal Muscular Endurance: Perform a plank position with the waist above a bench, keeping the body parallel to the ground. Use a SEIKO stopwatch to time the duration of the test, ensuring it is not too high, too low, or stopped prematurely.

Swimming Performance Test Indicators and Methods:

- Main Event Performance: Measure the time for a 100-meter freestyle race using a digital sports

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electronic timing board.

Data Analysis

The data obtained from the study were analyzed using 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

1. Comparison of Upper Limb Strength between the Two Groups after 12 Weeks of Experiment

Table 1: Comparison of Pull-Up Quantity between Experimental Group and Control Group

	Experimental group		Control group		t	P
	M	SD	M	SD		
Pull-up	13.93	1.27	11.67	1.79	3.97	.000

It can be observed that after 12 weeks of training, the pull-up quantity for the experimental group was 13.93±1.27 times, while for the control group, it was 11.76±1.79 times. The t-value was 3.97 ($p < 0.05$), indicating a significant difference between the two groups.

2. After the 12-week experiment, a comparison of lower limb strength between the two groups.

Table 2: Comparison of Vertical Jump Heights between the Experimental Group and the Control Group.

	Experimental group		Control group		t	P
	M	SD	M	SD		
Vertical jump (CM)	54.99	1.73	53.55	2.07	2.07	.047

After 12 weeks of training, the vertical jump height of athletes in the experimental group was 54.99±1.73 cm, while that of the control group was 53.55±2.07 cm. The t-value was 2.07 ($p < 0.05$), indicating a significant difference between the two groups.

3. After the 12-week experiment, a comparison of core strength between the two groups.

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Table 3: Comparison of Abdominal Endurance and Back Endurance between the Experimental Group and the Control Group

	Experimental group		Control group		t	P
	M	SD	M	SD		
Abdominal endurance (s)	61.03	4.72	54.93	3.90	3.85	.001
Back endurance (s)	142.42	9.52	133.38	9.58	2.59	0.015

After 12 weeks of training, as observed in Table 19 and Figure 15, athletes in the experimental group demonstrated abdominal endurance of 61.03±4.72 seconds, while those in the control group showed a value of 54.93±3.90 seconds. The t-value was 3.85 ($p<0.05$), indicating a significant difference. Additionally, the experimental group exhibited back endurance of 142.42±9.52 seconds, compared to 133.38±9.58 seconds in the control group, with a t-value of 2.59 ($p<0.05$), signifying a significant difference between the two groups.

4. After the 12-week experiment, a comparison of the 100-meter freestyle swimming performances between the two groups.

Table 4: Comparison of 100-meter Freestyle Swimming Performances between the Experimental Group and the Control Group

	Experimental group		Control group		t	P
	M	SD	M	SD		
100M freestyle (s)	64.14	3.16	66.62	3.08	-2.18	.038

After 12 weeks of training, as evident from Table 20 and Figure 16, athletes in the experimental group achieved a 100-meter freestyle swimming time of 64.14±3.16 seconds, while those in the control group recorded a time of 66.62±3.08 seconds. The t-value was -2.18 ($p<0.05$), indicating a significant difference between the two groups.

Table 5: Paired Sample t-test for the Number of Pull-ups between the Experimental Group and the Control Group.

	Experimental group		Control group	
	M	SD	M	SD
Before experimental	11.40	1.96	11.47	2.03
After experimental	13.93	1.27	11.67	1.79
t	-4.19		-0.29	
p	.000		.777	

Experimental group: $p<0.01$, Control group: $p>0.05$

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From Table 5, it can be observed that the experimental group had an initial count of 11.40±1.96 pull-ups, and after 12 weeks of training, the count increased to 13.93±1.27. The experimental group exhibited a significant increase of 2.53 pull-ups ($t = -4.19$, $p<0.01$) before and after the experiment. In contrast, the control group had an initial count of 11.47±2.03 pull-ups, which slightly increased to 11.67±1.79 after 12 weeks of training. The increase was 0.20 pull-ups, with a t-value of -0.29 ($p>0.05$), indicating no significant difference before and after the experiment.

Table 6: Paired Sample t-test for Vertical Jump Heights within the Experimental Group and the Control Group.

	Experimental group		**Control group**	
	M	**SD**	**M**	**SD**
Before experimental	53.35	2.23	53.41	1.94
After experimental	54.99	1.72	53.55	2.07
t	-2.25		-0.19	
p	.032		.848	

Experimental group: $p<0.05$, Control group: $p>0.05$

From Table 6, it can be observed that the experimental group had an initial vertical jump height of 53.35±2.23 cm, and after 12 weeks of training, the height increased to 54.99±1.72 cm. The experimental group exhibited a significant increase of 1.64 cm ($t = -2.25$, $p<0.05$) before and after the experiment. In contrast, the control group had an initial vertical jump height of 53.41±1.94 cm, which slightly increased to 53.55±2.07 cm after 12 weeks of training. The increase was 0.14 cm, with a t-value of -0.19 ($p>0.05$), indicating no significant difference before and after the experiment.

Table 7: Paired Sample t-test for Abdominal Endurance within the Experimental Group and the Control Group.

	Experimental group		**Control group**	
	M	**SD**	**M**	**SD**
Before experimental	53.72	3.88	53.71	3.88
After experimental	61.03	4.71	54.93	3.91
t	-4.63		-0.86	
p	.000		.396	

Experimental group: $p<0.01$, Control group: $p>0.05$

From Table 7, it can be observed that the experimental group had an initial abdominal endurance of 53.72±3.88 seconds, and after 12 weeks of training, the endurance increased to 61.03±4.71 seconds. The experimental group exhibited a significant increase of 7.31 seconds ($t = -4.63$, $p<0.01$) before and after the experiment. In contrast, the control group had an initial abdominal endurance of 53.71±3.88 seconds, which slightly increased to 54.93±3.91 seconds after 12 weeks of training. The increase was

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1.22 seconds, with a t-value of -0.86 (p>0.05), indicating no significant difference before and after the experiment.

Table 8: Paired Sample t-test for Back Endurance within the Experimental Group and the Control Group.

	Experimental group		Control group	
	M	SD	M	SD
Before experimental	131.16	10.37	131.44	9.63
After experimental	142.41	9.52	133.38	9.58
t	-3.09		-0.56	
p	.004		.583	

Experimental group: p＜0.01, Control group: p>0.05

From Table 8, it can be observed that the experimental group had an initial back endurance of 131.16±10.37 seconds, and after 12 weeks of training, the endurance increased to 142.41±9.52 seconds. The experimental group exhibited a significant increase of 11.25 seconds (t =-3.09, p<0.01) before and after the experiment. In contrast, the control group had an initial back endurance of 131.44±9.63 seconds, which slightly increased to 133.38±9.58 seconds after 12 weeks of training. The increase was 1.94 seconds, with a t-value of -0.56 (p>0.05), indicating no significant difference before and after the experiment.

Table 9: Paired Sample t-test for 100-meter Freestyle Swimming Performances within the Experimental Group and the Control Group.

	Experimental group		Control group	
	M	SD	M	SD
Before experimental	66.74	3.36	67.17	3.43
After experimental	64.14	3.16	66.63	3.08
t	2.18		0.45	
p	.038		.655	

Experimental group: p＜0.05, Control group: p>0.05

From Table 9, it can be observed that the experimental group had an initial 100-meter freestyle swimming time of 66.74±3.36 seconds, and after 12 weeks of training, the time decreased to 64.14±3.16 seconds. The experimental group exhibited a significant improvement of 2.6 seconds (t = 2.18, p<0.05) before and after the experiment. In contrast, the control group had an initial 100-meter freestyle swimming time of 67.17±3.43 seconds, which slightly decreased to 66.63±3.08 seconds after 12 weeks of training. The decrease was 0.54 seconds, with a t-value of 0.45 (p>0.05), indicating no significant

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difference before and after the experiment.

Discussion

Based on the findings of this study, we can discuss the training effects on the dependent variables (pull-ups, vertical jump, abdominal endurance, back endurance, and 100-meter freestyle swimming speed) in line with the study's objectives as follows.

1. Analysis of the Impact of Two Training Protocols on the Number of Pull-ups

There was no statistically significant difference in the number of pull-ups between the experimental group and the control group before the experiment ($P > 0.05$). This indicates that the experimental grouping method was reasonable, and intervention measures can be implemented.

This exercise, analyzed from a strength perspective, primarily involves the utilization of muscle groups such as the latissimus dorsi, biceps brachii, and forearm muscles. When considering its movement form, it falls within the category of anaerobic exercise. During the process of performing pull-ups, the emphasis lies on relying on the body's anaerobic metabolic pathways to achieve the corresponding energy supply and movement effects. Therefore, the number of pull-ups can be used to assess an individual's anaerobic capacity.

The data reveals that after the 12-week training intervention, the experimental group demonstrated a significant increase in the number of pull-ups, with an average increase of 2.53 ($t=-4.19$, $p<0.01$); whereas the control group showed no significant change in the number of pull-ups (Control Group: $t=-0.29$, $p=0.777>0.05$).

The average growth rate of pull-ups in the experimental group was significantly higher than that of the control group, indicating that increasing the emphasis on on-land-specific strength training can lead to better results for adolescent swimmers in pull-up tests.

In conclusion, the specialized on-land training program has demonstrated remarkably significant effects in improving pull-up performance.

2. Analysis of the Impact of Two Training Protocols on Vertical Jump Height

There was no statistically significant difference in vertical jump height between the experimental group and the control group before the experiment ($P>0.05$)

This indicates that the experimental grouping was appropriate and allowed for intervention measures. The vertical jump is a test of athletes' leg strength and explosive power. The vertical jump scores of the two groups of athletes before and after the training intervention are presented. The data shows that after 12 weeks of training intervention, the experimental group demonstrated a significant improvement in vertical jump scores, with an average increase of 1.64 cm compared to the pre-training period ($t=-2.25$, $p<0.05$). In contrast, the control group's scores showed minimal improvement, with an average increase of only 0.14 cm compared to the pre-training period ($t=0.19$, $p>0.05$). Conducting a comparative analysis of the performance of the experimental and control groups after the intervention, it is evident that the experimental group has a significant advantage.

This indicates that the specialized on-land training program can better enhance the lower limb strength and explosive power of adolescent swimmers.

3. Analysis of the Impact of Two Training Protocols on Abdominal Endurance

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There was no statistically significant difference in abdominal endurance between the experimental group and the control group before the experiment (P > 0.05). This indicates that the experimental grouping method was reasonable and allowed for intervention measures.

Abdominal endurance and back endurance complement each other, both aiming to maintain the stability of an athlete's body position. Additionally, these endurance capacities come into play as the body enters the fatigue phase during the later stages of exercise, ensuring the stability of the body position and enabling optimal athletic performance. Both groups of athletes underwent abdominal endurance testing before and after the training intervention.

The data indicates that after 12 weeks of training intervention, both groups experienced improvements in abdominal endurance. The experimental group showed a significant average increase of 7.31 seconds in abdominal endurance, with a notable difference before and after training (experimental group $t=-4.63$, $p<0.01$). In the control group, abdominal endurance increased by an average of 1.22 seconds, and the difference before and after training was not statistically significant (control group: $t=-0.86$, $p>0.05$).

In summary, a specialized training program proves highly effective in enhancing abdominal endurance, while the differences in this aspect are minimal with traditional training approaches. These research findings also indicate that the specialized training plan is particularly effective in improving abdominal endurance.

4. Analysis of the Impact of Two Training Protocols on Back Endurance

There was no statistically significant difference in back endurance between the experimental group and the control group before the experiment (P > 0.05). This indicates that the experimental grouping method was reasonable and allowed for intervention measures.

The endurance of back muscles significantly influences athletes' performance. In aquatic sports like swimming, core stability determines the speed of forward movement, and back muscle endurance plays a crucial role in maintaining the stability of athletes' technical movements, particularly during the maintenance of actions following muscle fatigue and lactic acid accumulation. The data on back muscle endurance before and after training for both groups are detailed.

The results show that after 12 weeks of training intervention, both groups experienced improvements in back muscle endurance (experimental group: $T=-3.071$, $P=0.015<0.05$; control group: $T=-2.481$, $P=0.038<0.05$). When comparing the post-intervention scores between the experimental and control groups, a significant difference in back muscle endurance was observed, with the experimental group athletes showing a notable increase of 11.25 seconds compared to before training ($t=2.18$, $p<0.05$). In contrast, the control group athletes exhibited an average increase of 1.94 seconds after training ($t=0.45$, $p>0.05$). Analyzing the growth in scores, it is evident that the average increase in the experimental group is significantly superior to that in the control group.

In conclusion, a specialized training program is highly effective in improving back muscle endurance, while the differences in this aspect with traditional training approaches are minimal. These research findings also underscore the effectiveness of the specialized training plan in enhancing back muscle endurance.

5. Analysis of the Impact of Two Training Protocols on the 100m Freestyle Swimming Speed

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There was no statistically significant difference in the 100m freestyle swimming speed between the experimental group and the control group before the experiment (P > 0.05). This indicates that the experimental grouping method was reasonable and allowed for intervention measures.

The average speed of the experimental group in the 100m freestyle race was 64.14 seconds, while the control group recorded an average time of 66.62 seconds. The performance of the experimental group was significantly faster than that of the control group, with an average difference of 2.48 seconds (P < 0.05). These results suggest that a specialized training program is more effective in improving the speed of the 100m freestyle race compared to a traditional training program.

The 100m freestyle swimming speed of the experimental group significantly increased by an average of 2.6 seconds compared to the pre-intervention stage (P < 0.05). On the other hand, the control group showed an average improvement of 0.54 seconds, which was not statistically significant compared to the pre-intervention stage (P > 0.05). In summary, the specialized training program effectively increased the speed of the 100m freestyle swimming event, while the traditional training program did not significantly improve the speed of the 100m freestyle event.

The importance of physical conditioning in enhancing athletic performance has been acknowledged (Sammoud, 2019). Our study results indicate that increasing the emphasis on land-based specialized strength training can improve the physical fitness of swimmers compared to traditional training methods. Based on relevant test data, the experimental group showed significant improvements in squatting, bench press, and vertical jump scores after 12 weeks of training. These three assessments primarily evaluate an athlete's maximum strength and explosiveness, suggesting that increasing the emphasis on land-based specialized strength training can better enhance an athlete's maximum strength and explosiveness.

Marques et al. conducted a study on the training of adolescent swimmers during the season and found that adding two sessions of land-based specialized strength training per week significantly improved the squatting, bench press, and vertical jump performance of adolescent swimmers. Additionally, it enhanced their performance in the 50m freestyle event (Neiva, et al, 2015). Weston et al. discussed the impact of 12 weeks of isolated core training on 50m freestyle speed and core muscle tissue related to swimming function. The study concluded that land-based core training contributes to an increase in peak electromyographic activity of core muscles, indicating a significant improvement in the athlete's neural recruitment ability, thereby enhancing absolute strength (Weston, 2015). Lopes et al. researched Portuguese athletes, revealing that adding one land-based training session per week for 8 weeks significantly improved the upper and lower limb muscle strength of athletes. The increase in upper body muscle strength was directly related to improvements in 50m and 100m freestyle speeds (Lopes, et al, 2021).

Sammoud et al. investigated the impact of land-based jump training specifically designed to enhance jumping ability on swimming performance. They found that replacing traditional water-based training with two land-based training sessions per week for 8 weeks resulted in improved leg strength. Integrating short-term, in-season land-based jump exercises into regular swimming training proved more effective for improving jumping and specialized swimming performance in pre-adolescent male swimmers compared to traditional swimming training alone (Sammoud, 2019).

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In summary, specialized training programs tailored to the energy demands of the 100m freestyle event have been scientifically developed. These programs encompass customized training content, tasks, and methods, resulting in a significant improvement in the speed of the 100m freestyle. In contrast, the impact of traditional training methods on the speed of the 100m freestyle is limited.

Conclusion

1. The specialized training program effectively increased the upper limb strength of the participants, with no significant advantage over the traditional training program.

2. The specialized training program significantly improved the lower limb strength of the participants, surpassing the gains achieved with the traditional training program.

3. The specialized training program significantly enhanced the core strength of the participants, outperforming the results obtained with the traditional training program.

4. The specialized training program successfully improved the 100m freestyle speed of the participants, demonstrating superiority over traditional training methods.

Recommendation

It is advised to incorporate specialized training programs into athletic training regimens to improve lower limb strength, core strength, and 100m freestyle speed, as indicated by the data conclusions. The particular suggestions are as follows:

1. Adopt Specialized Training for Lower Limb and Core Strength: Athletic training programs should include these specialized exercises to maximize these particular areas, as the specialized training program significantly improves lower limb and core strength when compared to traditional methods. This can lower the chance of injury and improve overall athletic performance.

2. Combine Traditional and Specialized Training to Increase Upper Limb Strength: Although the program with specialized training increased upper limb strength, it did not prove to be a particularly better approach than the traditional ones. Therefore, to guarantee balanced development and take advantage of the advantages of both training modalities, a combined approach that incorporates both specialized and traditional exercises may be helpful.

3. Emphasis on Specialized Training for Speed Enhancement: The participants' 100-meter freestyle time was improved by the specialized training program. To attain the best outcomes, athletes who want to improve their sprinting performance should give priority to specific training methods designed for speed and agility.

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