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The Effect of the Application of *Circuit Training* Exercises in Increasing Freestyle Swimming Leg Speed

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Abstract

This study aims to determine the effect of *circuit training* on freestyle swimming leg speed in athletes aged 8–12 years. Foot speed is one of the important factors that affect swimming performance, so effective training methods are needed to improve it. This study used an experimental method with *a pretest-posttest control group design*. The study sample amounted to 30 athletes who were divided into experimental groups and control groups. The experimental group was given treatment in the form of *circuit training* exercises, while the control group underwent routine exercises. Data collection was carried out using a freestyle leg speed test of 25 meters measured in units of time (seconds). The results showed that both groups experienced improvement, but the improvement in the experimental group was higher than in the control group. The average time in the experimental group decreased from 39.53 seconds to 32.33 seconds, while in the control group decreased from 41.00 seconds to 39.47 seconds. The results of statistical analysis showed a significant difference between the two groups. These findings show that *circuit training* is more effective than regular exercise in increasing freestyle leg speed. The novelty of this study lies in the application of *circuit training* as a structured ground training method to increase foot speed in early age athletes. This study provides empirical evidence on the effectiveness of dryland circuit training in enhancing lower-limb propulsion performance in young swimmers.

Keywords: Circuit training, Foot speed, Freestyle swimming, Dryland training, Swimming performance

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A. Introduction

Exercise is a planned and structured activity that aims to achieve a specific goal in the context of health, fitness, and recreation. This refers to the importance of exercise in maintaining health and improving a person's quality of life (Salahudin and Rusdin, 2020). Exercise is also an organized, competitive, and structured physical activity that aims to improve one's health and fitness. In addition to physical activities, Handoko and Pandiangan emphasized that sports include technical and strategic elements in various sports disciplines (Handoko & Pandiangan, 2019).

This illustrates how learning and honing technical skills is an important aspect of understanding the sport. Involvement in sports has a significant positive impact on physical health, according to various studies. Exercise has been shown to improve mental health by lowering stress and depression and preventing a number of diseases, including obesity, heart disease, and type 2 diabetes (Priyantono et al., 2022). Sport as a social activity shows cultural values and human character, serves as a tool for character building, as well as the promotion of health in society (Annasai & Sabillah, 2021) This shows that sport also serves as a means of social interaction and establishes norms in a community.

Swimming is a form of sport or physical activity that is done by moving the body in the water using certain movements such as freestyle, backstroke, and butterfly style, with the aim of moving places or practicing physical fitness. In the context of sports, (Azmi et al., 2023) states that swimming requires balance and stability throughout the process to reach peak speed, especially in the 50-meter freestyle. The study supports the idea that good technique is essential in swimming, where core muscle strength plays an important role in improving speed.

Therefore, swimming is more than just a physical activity; Swimming also requires special technical skills. Training methods, such as basic training, have a substantial impact on an athlete's swimming ability, implying that the approach to training can affect the technical abilities of swimming (Dwi Wahyuni et al., 2023). This concept underscores the idea that swimming is more than just a physical activity, swimming also involves improving technique through methodical exercise (Fauzi et al., 2023).

Swimming is a sport that has many benefits for athletes and players, including physical fitness as well as social and psychological components. However, this publication focuses on the technical features and equipment used in swimming, making it less important for the development of social and psychological aspects (Supriyanto et al., 2023). Therefore, high-definition swimming can be a comprehensive exercise that develops an individual's potential by paying attention to physical, mental, and social aspects (Dinangsit et al., 2021).

Speed in sports is a very important concept and is often discussed by experts. Speed is defined as a person's ability to perform physical movements or activities in a short period of time . Swimming speed is an important factor in determining an athlete's competitive performance. The speed of swimming is determined by a variety of factors, including physical characteristics, technique, and training. Speed is a key factor in evaluating swimmers in competitions. They found that swimming speed is influenced by a variety of physical factors, including the athlete's anatomical structure, such as Body Mass Index (BMI) and arm length.

This study shows that anatomical characteristics can improve swimming performance (Akbar et al., 2024). (Dwi Wahyuni et al., 2023) underlining the importance of effective and efficient swimming movements in achieving maximum speed. They emphasize the need for good teaching and application of techniques to achieve the fastest time.

Exercise on land has a major impact on

leg strength in freestyle swimming, as evidenced by various studies examining the relationship between strength training and swimming performance. Onshore training is defined as an activity performed outside of the pool with the aim of building muscle strength and endurance, especially leg muscles, needed for freestyle swimming. A study explains that endurance training and leg muscle strength increase freestyle swimming speed by 50 meters.

This study revealed that neck muscle strength training can significantly improve swimmers' performance (Kusmita et al., 2022). This suggests that strengthening the leg muscles with an exercise program on land can help swimmers improve the efficiency of their movements in the water. The importance of training programs that include interval exercises and leg muscle strength exercises are useful for improving athletes' performance in freestyle swimming as a whole. Their research shows that well-designed exercises can result in a significant increase in speed (Prastiwi et al., 2022).

Training on land, although not done directly in the water, helps build and improve muscle endurance, which is beneficial for swimmers' performance in the pool. Furthermore, Anandia and Wahidi found that the application of adequate training methods can improve technical skills and physical strength, both of which are needed for freestyle swimming. Thus, the strength of the leg muscles acquired through training on the ground can provide an edge in competitions and has to do with the development of various technical skills. All of these studies show that onshore exercises aimed at strengthening leg muscle strength have a high potential to improve freestyle swimming performance. This includes increased speed, endurance, and general swimming technique. In the future, coaches should include training on land as part of a comprehensive training program for swimmers to achieve optimal competition results.

Circuit training has been shown to increase freestyle swimming speed in various studies. Circuit training is a training strategy that consists of a series of physical exercises performed over a period of time to improve strength, endurance, and speed. Circuit training is ideal for improving swimming performance, especially leg strength, which is needed for speed. Kurnia's research emphasized that the formation of a training circuit significantly increased the 50-meter freestyle swimming speed of G-Sport Center participants.

The study concludes that various training programs in the training circuit, along with appropriate fitness equipment, directly contribute to an increase in swimming speed (Kurnia et al., 2024). This data shows that circuit training not only improves muscle strength, but also swimming technique and speed.

The combination of muscle strength and endurance training in the circuit method helps athletes swim more efficiently. Leg exercises, especially with movement patterns similar to swimming, can help increase muscle strength and endurance in the water. This is in line with the views of various experts who emphasize the relevance of strength training in supporting optimal swimming performance, although concrete evidence from the references studied does not explicitly address this relationship (Prastiwi et al., 2022).

Better swimming techniques can be achieved not only through in-water exercises, but also by adding out-of-water physical exercise approaches such as circuit exercises. This is reinforced by research showing that an exercise program in dry water can drastically increase freestyle swimming speed. According to a study conducted by Fone and Tillaar, strength training applied on land showed that strength training programs in dry water can increase the muscle strength of experienced swimmers, which directly affects their swimming performance (Fone & van den Tillaar, 2022). Overall, circuit training improves leg strength and swimming speed.

Based on the above problems, this swimming sport must have strong enough leg strength because the intensity of the movement is continuous and alternates between the right and left legs. Coaches should also pay attention to land exercises to strengthen leg strength to speed up the pace in freestyle swimming. With this in mind, coaches should incorporate a circuit training program into a swimmer's training routine to develop leg strength. This will help the overall physical and technical development of the athlete as well as improve their air speed.

Swimming performance, particularly in freestyle events, is strongly influenced by propulsion efficiency, stroke coordination, and lower-limb movement speed. Among these factors, leg propulsion plays an important role in maintaining body position, generating forward thrust, and increasing overall swimming velocity. In young swimmers, the ability to produce fast and efficient kicking movements is essential because lower-limb movement contributes significantly to sprint swimming performance, especially in short-distance freestyle events.

Previous studies have reported that physical components such as muscle strength, endurance, coordination, and flexibility influence swimming speed. Several researchers also emphasized that lower-limb muscle strength is closely associated with kicking efficiency and swimming propulsion. Stronger and faster leg movements enable swimmers to reduce drag and maintain optimal body alignment in the water, leading to improved swimming performance.

To improve lower-limb performance, coaches commonly implement dryland training programs as complementary exercises outside the pool. Dryland training is widely used to develop muscular strength, power, endurance, and neuromuscular coordination that support swimming performance. One of the most frequently applied dryland approaches is circuit training, which combines several exercises performed sequentially with minimal rest intervals. Circuit training is considered effective because it simultaneously develops multiple physical components, including speed, endurance, and muscle strength.

Several previous studies have demonstrated that strength training and dryland exercises can improve swimming performance. Research has shown positive effects of interval training, resistance training, and land-based exercise programs on freestyle swimming speed and muscular endurance. However, most previous studies focused on general swimming performance, upper-body strength, or cardiovascular endurance. Limited research has specifically evaluated structured circuit training programs targeting lower-limb speed performance in young freestyle swimmers aged 8–12 years.

In addition, previous studies rarely examined the specific contribution of circuit-based dryland training to freestyle kicking speed using a controlled experimental design in early-age athletes. This limitation indicates a research gap regarding the effectiveness of structured circuit training in improving lower-limb movement speed as a key component of freestyle swimming performance among youth swimmers.

Therefore, this study aims to determine the effect of circuit training exercises on increasing freestyle swimming leg speed in athletes aged 8–12 years. The novelty of this study lies in the application of a structured circuit training program specifically designed to improve lower-limb speed performance in young freestyle swimmers through dryland training intervention.

B. Methods

This study employed a quantitative approach using a quasi-experimental method with a pretest–posttest control group design. The design was selected to examine the effect of circuit training exercises on freestyle swimming leg speed

by comparing the performance changes between the experimental group and the control group before and after the intervention.

The participants in this study were 30 swimming athletes aged 8–12 years from the Sumedang Aquatic Elephant swimming club. The sampling technique used was purposive sampling based on several inclusion criteria: (1) actively participating in regular swimming training programs, (2) physically healthy and not injured during the study period, and (3) willing to participate in the entire research procedure. The participants were divided into two groups consisting of 15 athletes in the experimental group and 15 athletes in the control group.

The experimental group received a structured circuit training program in addition to regular swimming practice, while the control group only followed the regular swimming training program provided by the coach. The intervention program was conducted for 6 weeks with a frequency of 3 training sessions per week. Each circuit training session lasted approximately 30–40 minutes and consisted of 6 exercise stations focusing on lower-limb strength, speed, and endurance. The exercises included squat jumps, lunges, high knees, skipping, step-ups, and jumping jacks. Each exercise was performed for 30 seconds with 15 seconds of rest between stations. Participants completed 3 sets in each session with a 2-minute recovery period between sets.

To maintain internal validity, several control variables were applied during the study. Both groups participated in the same regular swimming training schedule, training duration, and swimming intensity supervised by the same coach. Participants were instructed not to engage in additional lower-body strength training programs outside the research intervention during the study period. Nutritional intake and rest patterns were also monitored through coach and parent supervision to minimize external influences on performance improvement.

Data collection was conducted using a 25-meter freestyle kicking speed test with a kickboard. The test measured the time required to complete the distance in seconds. A pretest was conducted before the intervention period, followed by a posttest after the 6-week training program.

The collected data were analyzed using descriptive and inferential statistics. The Shapiro–Wilk test was used to examine data normality, while Levene's test was applied to assess homogeneity of variance. Paired sample t-tests were used to analyze differences between pretest and posttest scores within each group, and an independent sample t-test was used to determine differences between the experimental and control groups. Statistical significance was set at $p < 0.05$.

In this study, researchers took *Pre-Experiment* With design *One-Group Pretest-Posttest Design*. In research (Viera Valencia & Garcia Giraldo, 2019) Research requires a research design that allows full control of the number of variables that can affect the accuracy of the results. The following is the design structure *Pre-Experiment*. The design of the research is presented in the picture.

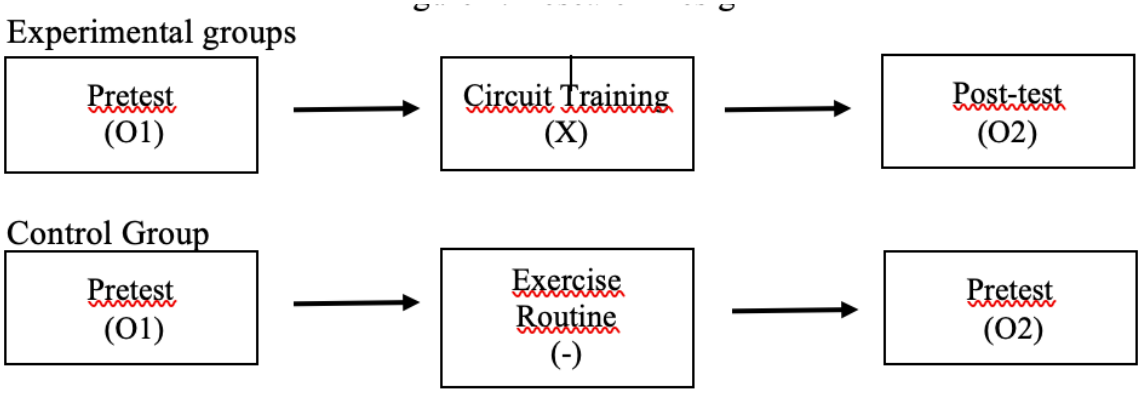

Figure 1. Research Design

C. Result and Discussion

Results

In this section, the results of the study are presented regarding the effect *of circuit training* on freestyle swim leg speed which is displayed in the form of tables and images, including *pretest*, *posttest*, and statistical analysis data.

Table 1. Data on the results of the Pre-test of the Experimental Group and the Control Group

Yes	Experimental Group	Pre-test results	Control Group	Pre-test results
1.	Athlete 1	45 seconds	Athlete 1	42 seconds
2.	Athlete 2	43 seconds	Athlete 2	40 seconds
3.	Athlete 3	37 seconds	Athlete 3	39 seconds
4.	Athlete 4	36 seconds	Athlete 4	38 seconds
5.	Athlete 5	37 seconds	Athlete 5	43 seconds
6.	Athlete 6	36 seconds	Athlete 6	40 seconds
7.	Athlete 7	37 seconds	Athlete 7	44 seconds
8.	Athlete 8	40 seconds	Athlete 8	39 seconds
9.	Athlete 9	43 seconds	Athlete 9	42 seconds
10.	Athlete 10	43 seconds	Athlete 10	44 seconds
11.	Athlete 11	40 seconds	Athlete 11	39 seconds
12.	Athlete 12	42 seconds	Athlete 12	38 seconds
13.	Athlete 13	39 seconds	Athlete 13	39 seconds
14.	Athlete 14	38 seconds	Athlete 14	45 seconds
15.	Athlete 15	40 seconds	Athlete 15	42 seconds

Table 1 presents the pretest results of the experimental and control groups before the intervention was administered. The data indicate that both groups had relatively similar initial freestyle swimming leg speed performance, with the experimental group showing a mean score of 39.53 seconds and the control group 41.00 seconds.

Table 2. Data on Post-test Results of Experimental and Control Groups

No	Experimental Group	Post-test results	Control Group	Post-test results
1.	Athlete 1	37 seconds	Athlete 1	40 seconds
2.	Athlete 2	36 seconds	Athlete 2	38 seconds

No	Experimental Group	Post-test results	Control Group	Post-test results
3.	Athlete 3	31 seconds	Athlete 3	37 seconds
4.	Athlete 4	29 seconds	Athlete 4	36 seconds
5.	Athlete 5	30 seconds	Athlete 5	41 seconds
6.	Athlete 6	30 seconds	Athlete 6	38 seconds
7.	Athlete 7	30 seconds	Athlete 7	42 seconds
8.	Athlete 8	33 seconds	Athlete 8	36 seconds
9.	Athlete 9	35 seconds	Athlete 9	40 seconds
10.	Athlete 10	35 seconds	Athlete 10	42 seconds
11.	Athlete 11	32 seconds	Athlete 11	37 seconds
12.	Athlete 12	34 seconds	Athlete 12	38 seconds
13.	Athlete 13	31 seconds	Athlete 13	38 seconds
14.	Athlete 14	31 seconds	Athlete 14	43 seconds
15.	Athlete 15	31 seconds	Athlete 15	41 seconds

Table 2 presents the posttest results after the training intervention. The experimental group showed a substantial improvement, with swimming times decreasing to an average of 32.33 seconds. In contrast, the control group experienced only a slight improvement, with an average posttest score of 39.47 seconds. These findings indicate that the circuit training program provided greater improvements in freestyle swimming leg speed compared to regular training alone.

Table 3. Normality Test Results

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Pretest eksperimen	.167	15	.200*	.930	15	.275
Posttest eksperimen	.237	15	.024	.910	15	.136
Pretest kontrol	.199	15	.115	.899	15	.092
Posttest kontrol	.190	15	.150	.916	15	.169

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

The normality test was performed using the Shapiro-Wilk test because the number of samples was less than 50 (n = 15 in each group). Based on the test results, all pretest and posttest data in both the experimental group and the control group had a significance value (Sig.) greater than 0.05. Thus, it can be concluded that the research data is normally distributed so that it is eligible for parametric statistical tests.

Table 4. Independent Sample T-test and Data Homogeneity Test Results

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Posttest	Equal variances assumed	.008	.930	-7.858	28	.000	-7.13333	.90781	-8.99291	-5.27376
	Equal variances not assumed			-7.858	27.998	.000	-7.13333	.90781	-8.99291	-5.27375

The homogeneity test was carried out using the Levene's Test to determine the similarity of variance between the experimental group and the control group in the posttest data. Based on the test results, a significance value of 0.930 was

obtained. Since the Sig. value is 0.930 > 0.05, it can be concluded that the variance of the two groups is homogeneous. Thus, the homogeneity assumption is met and the analysis can be continued using the Independent Sample t-test assuming equal variances assumed.

The Independent Sample t-test was carried out to determine the difference in posttest results between the experimental group and the control group. Based on the results of the analysis, a t-value of -7.858 was obtained with a significance value (Sig. 2-tailed) of 0.000 < 0.05. Since the significance value is less than 0.05, H_0 is rejected and H_1 is accepted. This suggests that there was a significant difference between the experimental group and the control group after treatment.

Table 5. Results of Paired Test Sample Test Experimental Group

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	Pretest eksperimen - Posttest eksperimen	7.20000	1.20712	.31168	6.53152	7.86848	23.101	14	.000

Table 6. Paired Test Results Sample Test Control Group

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	Pretest kontrol - Posttest kontrol	1.53333	1.68466	.43498	.60040	2.46627	3.525	14	.003

The Paired Sample t-test is carried out to find out the difference between the pretest and posttest scores in each group. In the experimental group, a significance value (Sig. 2-tailed) of 0.000 < 0.05 was obtained. This shows that there is a significant difference between the pretest and posttest results in the experimental group. Thus, circuit training exercises provide a significant improvement in freestyle swim leg speed. In the control group, a significance value (Sig. 2-tailed) of 0.003 < 0.05 was obtained. This shows that there is a significant difference between the pretest and posttest values in the control group.

Tabel 7. Average Pretest and Posttest Results

Kelas		Pretest	Posttest
Eksperimen	Mean	39.53	32.33
	N	15	15
	Std. Deviation	2.774	2.498
Kontrol	Mean	41.00	39.47
	N	15	15
	Std. Deviation	2.390	2.475
Total	Mean	40.27	35.90
	N	30	30
	Std. Deviation	2.651	4.374

Based on table 7, the average travel time in the experimental group decreased from 39.53 seconds to 32.33 seconds or an increase of 18.22%. Meanwhile, the control group also experienced a decrease in time from 41.00 seconds to 39.47

seconds with a percentage increase of 3.73%. Overall, the average total increased by 10.85%.

Although the control group experienced an improvement, it was likely due to the training *effect* that naturally occurs during the training process. However, the resulting improvement was not as large as the experimental group, suggesting that *the circuit training* intervention provided a more effective exercise stimulus in increasing freestyle leg speed. Thus, it can be concluded that the increase in speed in the experimental group was higher than in the control group, which confirms that *circuit training* exercises are more effective in increasing freestyle swimming speed.

To strengthen the interpretation of the statistical findings, an effect size analysis using Cohen's d was conducted to determine the magnitude of the circuit training intervention on freestyle swimming leg speed. The calculation showed a large effect size (Cohen's d = 1.87), indicating that the circuit training program had a strong practical effect on improving freestyle kicking speed in young swimmers.

According to Cohen's interpretation criteria, effect size values above 0.80 are categorized as large effects. Therefore, the findings of this study not only demonstrate statistical significance but also indicate meaningful practical improvements in swimming performance among athletes aged 8–12 years.

The comparison of pretest and posttest mean scores between the experimental and control groups is presented in Figure 6. The graph illustrates that both groups experienced improvement after the training period; however, the experimental group showed a substantially greater decrease in swimming time compared to the control group.

The experimental group improved from a mean score of 39.53 seconds during the pretest to 32.33 seconds in the posttest, while the control group improved only slightly from 41.00 seconds to 39.47 seconds. These findings visually confirm that the circuit training intervention produced greater improvements in freestyle swimming leg speed than regular training alone.

Table 8. Comparison of Pretest and Posttest Mean Scores

Group	Pretest Mean (s)	Posttest Mean (s)	Improvement
Experimental Group	39.53	32.33	18.22%
Control Group	41.00	39.47	3.73%

The graph demonstrates that the experimental group experienced a greater reduction in swimming time compared to the control group, indicating that circuit training exercises were more effective in improving freestyle swimming leg speed.

Discussion

The results of this study show that *circuit training* exercises have a significant influence on increasing freestyle swimming leg speed in athletes aged 8–12 years. This is proven by the results of the *Independent Sample t-test* which shows a significance value of 0.000 (< 0.05), so it can be concluded that there is a significant difference between the experimental group and the control group after being given treatment. In addition, the results of *the paired sample t-test* in the experimental group also showed a significant increase between the pretest and posttest scores.

The increase that occurred in the experimental group showed that the exercise *Circuit Training* It is effective in improving the components of physical condition, especially the strength and endurance of the leg muscles. The strength of the leg muscles has an important role in producing movement *Kicking* optimal in freestyle swimming. Exercises that are carried out in a structured, repetitive, and various forms of movement are able to

provide a comprehensive training stimulus so as to increase the ability of muscles to work optimally. This is in line with research conducted by (Zhang et al., 2024) which states that programmed physical exercise can significantly improve muscle capacity and movement performance.

In the context of more specific training, *Circuit Training* it is a training method that combines various forms of exercise in a series to increase strength, endurance, and speed simultaneously. This method is considered effective because it is able to provide a varied and continuous training load. This is supported by research (Nurkadri & Kholil, 2024; Simbolon & Novita, 2024) which states that exercises that are systematically and structured are able to improve physical abilities more optimally than conventional exercises.

In the context of swimming, the principle of exercise is also relevant, especially in improving the physical components that support the performance of leg movements. The results of the research conducted by (Amara et al., 2023) showed that the combination of resistance training and water training was able to increase the effectiveness of deep foot movements *Kick Swimming*, which is a crucial component in freestyle swimming. These findings confirm a strong link between leg muscle strength and increased swimming speed.

Physiologically, the increase in the strength of the leg muscles will have a direct impact on the ability to produce thrust (Propulsion) in the water, which plays an important role in increasing the speed of freestyle swimming. The greater the thrust generated through the movement of the legs, the higher the speed achieved. As an illustration, (Sunarto et al., 2023) Explains that increased muscle strength and movement efficiency have a direct contribution to improving swimming performance, especially in the aspect of speed.

On the other hand, the control group also showed a significant increase between pretest and posttest scores (Sig. 0.003 < 0.05). However, the increase was relatively lower compared to the experimental group. This shows that regular training still has an effect on improving abilities through the process of adaptation, but it is not as effective as specially designed exercises such as *circuit training*.

Based on the results of research and support from several previous studies, it can be concluded that *circuit training* exercises are an effective method in increasing freestyle leg speed. This exercise not only increases muscle strength, but also contributes to increased endurance and coordination of movement, which overall supports improved swimming performance.

The implication of this study is that it is important for coaches to integrate *circuit training* into training programs, especially as support exercises on land (*dryland training*), so that they can improve athletes' performance optimally and sustainably. The findings support the transfer of training principle, where improvements in dryland muscular strength translate into enhanced propulsion efficiency in water-based performance.

D. Conclusion

This study concluded that circuit training exercises significantly improved freestyle swimming leg speed in athletes aged 8–12 years. The experimental group demonstrated greater improvement compared to the control group, indicating that structured circuit training was more effective than regular swimming practice alone in enhancing lower-limb movement speed and swimming performance.

The findings support the theoretical perspective that dryland training, particularly circuit-based exercise programs, contributes positively to the development of lower-limb strength, muscular endurance, and propulsion efficiency in swimming. This study also strengthens previous research regarding the relationship between lower-body physical conditioning and sprint

swimming performance, especially in young athletes.

Practically, the results suggest that coaches and swimming instructors can incorporate structured circuit training into regular training programs as an effective complementary dryland training method. The program may help young swimmers improve kicking speed, physical conditioning, and overall freestyle performance in a more systematic and efficient manner.

Although the study demonstrated positive outcomes, several limitations should be acknowledged, including the relatively small sample size and short intervention duration. Therefore, future studies are recommended to involve larger participant groups, longer training periods, and additional variables such as swimming technique, coordination, and psychological factors to obtain more comprehensive findings regarding swimming performance development.

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F. Conflict of Interest

The author states that there is no conflict of interest in this study.

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