The effectiveness of preparatory strength training on muscle strength and power in male swimmers

La eficacia del entrenamiento de fuerza preparatorio sobre la fuerza y la potencia muscular en nadadores masculinos

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Abstract

Introduction: A key factor in the success of a swimmer in competition is their ability to swim fast, and strength and muscle power further enhance this efficiency.
Objective: The objective of this research was to compare the effectiveness of strength training during physical preparation on muscle strength and power.
Methodology: The sample consisted of fifteen Thai national swimming team athletes (age: 17.0 ± 3.14 years; weight: 66.36 ± 10.13 kg; height: 172.73 ± 7.83 cm). All athletes underwent pre-exercise readiness assessments and had no history of muscle injury prior to the experiment. The sample was assigned to perform upper and lower body strength training at 67–85% 1RM, 3 days per week for 8 weeks. Data were analyzed using a paired sample t-test with a statistical significance level of 0.05.
Results: The experiment showed a statistically significant increase in upper and lower body muscle strength and power ($p < 0.05$).
Discussion: The results of this current study indicate that muscle strength and muscle power can be improved by increasing the appropriate amount of resistance during muscle contractions, taking into account the principles of specificity, overload, and progression.
Conclusions: Strength training at 67–85% 1RM during preparation can effectively increase upper and lower body strength and power in Thai national swimmers.

Keywords

Swimmers; strength training; muscle performance.

Resumen

Introducción: Un factor clave para el éxito de un nadador en competición es su capacidad para nadar rápido, y la fuerza y la potencia muscular mejoran aún más esta eficiencia.
Objetivo: El objetivo de esta investigación fue comparar la efectividad del entrenamiento de fuerza durante la preparación física en la fuerza y la potencia muscular.
Metodología: La muestra estuvo compuesta por quince atletas del equipo nacional de natación tailandés (edad: 17,0 ± 3,14 años; peso: 66,36 ± 10,13 kg; altura: 172,73 ± 7,83 cm). Todos los atletas se sometieron a evaluaciones de preparación previas al ejercicio y no tenían antecedentes de lesiones musculares antes del experimento. La muestra se asignó a realizar entrenamiento de fuerza de tren superior e inferior al 67-85 % de 1RM, 3 días a la semana durante 8 semanas. Los datos se analizaron mediante una prueba t de muestras pareadas con un nivel de significación estadística de 0,05.
Resultados: El experimento mostró un aumento estadísticamente significativo en la fuerza y la potencia muscular de tren superior e inferior ($p < 0,05$). Discusión: Los resultados de este estudio indican que la fuerza y la potencia musculares pueden mejorarse aumentando la cantidad adecuada de resistencia durante las contracciones musculares, teniendo en cuenta los principios de especificidad, sobrecarga y progresión.
Conclusiones: El entrenamiento de fuerza al 67-85 % de 1RM durante la preparación puede aumentar eficazmente la fuerza y la potencia del tren superior e inferior en nadadores tailandeses.

Palabras clave

Nadadores; entrenamiento de fuerza; rendimiento muscular.

Introduction

Swimming is a widely popular sport across all continents, including the Americas, Europe, Asia, and Australia. Competitions are held at both national and international levels, such as the Southeast Asian Games, Asian Games, and Olympic Games, as well as professional competitions involving leading countries worldwide (Fone & Tillaar, 2022). In Thailand, important swimming competitions include the Thai National Swimming Championships. Swimming is competed under the rules of the Federation Internationale de Natation (FINA), now known as World Aquatics. During competition, athletes must swim at high speeds to achieve their best possible time and win.

A key factor in an athlete's success in competitive swimming is their ability to swim quickly and efficiently. Therefore, physical fitness is extremely important in swimming, encompassing muscle strength, muscle endurance, muscle power, body composition, and cardiovascular endurance. At the beginning of training, coaches or sports scientists should prepare training programs focused on transforming physical characteristics (Fone & Tillaar, 2022), such as increasing muscle size and mass. Strength training improves muscle size and mass (Souza et al., 2020) and can prevent injuries. Insufficient muscle strength increases the risk of injury and negatively impacts athletic performance (Jason, 2024). The principle of resistance training is that, over a time period, the training program's intensity is adjusted according to the competition schedule (Blagrove et al, 2020). Therefore, coaches or sports scientists need to constantly monitor the athlete's training load. This involves systematically increasing the ability of specific muscle groups to build muscle strength under strength training conditions (Crowley et al., 2017). Previous studies reported that swimmers aged 15-22 years who received core muscle strength training using high-intensity interval training showed improved muscle function, core stability, and muscle power compared to swimming training alone (Hiruntrakul et al., 2025; Kwok et al., 2025). Furthermore, upper body resistance training, using bench press and medicine ball throws at 60-80% 1RM for at least 6 weeks, significantly improved strength and swimming performance (Amra et al., 2021). However, for optimal muscle development, training should be done gradually, incorporating overload and progression (Blagrove et al, 2020). That is, the workload should be assessed to determine the appropriate intensity increase in each training phase.

This improves performance, reduces the risk of overreaching, and allows for tailored training intensity to each individual athlete, thereby minimizing the risk of injury during training and competition (Johansen et al., 2017; Jason, 2024; Graham & Cleather, 2021). Most importantly, strength training focuses on improving muscle efficiency in athletes, which directly impacts athletic performance (Li et al., 2021; Llanos-Lagos et al., 2024). Therefore, pre-sport training for swimmers is crucial to prepare them with technical skills such as breathing, stroke training, starts, and turns. Another key aspect is the functional capacity of the muscles used in swimming, which utilizes both upper and lower body muscles. Developing the ability of muscles to contract and exert resistance more effectively is essential for athletes' athletic performance. Being strong and powerful will contribute to more effective swimming technique throughout the competition (Jansupom et al., 2025).

Method

Participants

Fifteen male Thai national swimmers (aged 13-18) underwent a pre-exercise fitness assessment. They had at least one year of competitive experience and no history of musculoskeletal injuries or chronic illnesses. The participants underwent muscle strength tests using a chest press (upper body) and leg dynamometer (lower body), and muscle power tests using a 5kg overhead ball throw (upper body) and countermovement jump (lower body). All participants received strength training consisting of upper body exercises, including barbell thruster, barbell bent over row, barbell bench press, easy barbell biceps curl, and hanging knee raise; and lower body exercises, including barbell squat, barbell stiff leg deadlift, barbell lunge, adduction machine, and abduction machine. The training was conducted at 67-85% of 1RM. This study was approved by the Human Ethics Committee of Bangkok Thonburi University, reference number 105/2567.

Table 1. Basic anthropometric data of the male swimmers (mean ± SD)

Variables	Subjects (n=15)
Age (y)	17.00 ± 3.14
Height (cm)	172.73 ± 7.83
Weight (kg)	66.39 ± 10.13

Procedure

The study group underwent strength training three days a week for eight weeks. The strength training program consisted of: 1) a 15-minute warm-up session (jogging and dynamic stretching), a 30-minute conditioning session (upper body exercises: barbell thruster, barbell bent-over row, barbell bench press, easy barbell biceps curl, and hanging knee raise; lower body exercises: barbell squat, barbell stiff leg deadlift, barbell lunge, adduction machine, and abduction machine) at 67%-85% of 1RM, and a 15-minute stretching session (static stretching), as shown in Table 2. Muscle strength and upper and lower body power were tested before and after the experiment.

Table 2. Muscle strength intervention program

Warm up session (15 minutes) dynamic stretching: Jogging, forward lunge with overhead reach, alternating high knee pull, standing leg swing, dynamic squat to calf raises, standing torso rotation with arm swing, and lateral lung with reach		
Conditioning session (30 minutes):		
Upper body training		Lower body training
1. barbell thruster		1. barbell squat
2. barbell bent over row		2. barbell stiff leg deadlift
3. barbell bench press		3. barbell lunge
4. easy barbell biceps curl		4. adduction machine
5. hanging knee raise		5. abduction machine
Volume	Week 1 - 4	Week 5 - 8
Set × reps	3 × 6-8	4 × 6-8
Rest/ sets (min)	2 - 3	2 - 3
Rest/ exercise (min)	2 - 5	2 - 5
Intensity (% 1RM)	> 67%	> 67% - 85%
Cool Down Stretching session (15 minutes) static stretching: Jogging, standing hamstring stretch, standing quadriceps stretch, standing calf stretch, standing hip flexor stretch, standing chest and shoulder stretch, standing lateral trunk stretch		

Instrument

Upper body muscle strength is tested using the chest press to assess maximum muscle force capacity (Baechle & Earle, 2008), and lower body muscle strength is tested using a leg strength dynamometer (Najiah et al., 2021). Upper body muscle power is tested with an overhead ball throw weighing 5 kg (Leite et al., 2020), and lower body muscle power is tested with a counter-movement jump (Hou et al., 2025). The exercise is performed twice, and the best value is recorded.

Data analysis

The data were presented as mean and standard deviation. Muscle strength and muscle power data were analyzed before and after the experiment using a paired sample t-test. Statistical analysis was performed using SPSS IBM version 22. The statistical significance level was set at 0.05.

Results

The data on upper and lower body muscle strength and power obtained from this study showed that: The participants showed a significant increase in muscle strength after the experiment, as measured by the chest press test (upper body) (116.80 ± 5.40 kg, $p = 0.001$) compared to before (106.73 ± 4.30 kg) at the 0.05 level. Similarly, their leg strength dynamometer test (lower body) increased significantly after the experiment (157.00 ± 3.14 kg, $p = 0.001$) compared to before (139.47 ± 3.85 kg), $p < 0.05$. Muscle power in the overhead ball throw test (upper body) increased significantly after the experiment (523.93 ± 79.73 cm, $p = 0.033$) compared to before (504.93 ± 58.18 cm) at the 0.05 level, and their counter movement jump test (lower body) increased significantly after the experiment (34.11 ± 2.97 cm, $p = 0.007$). There was a significant increase compared to before (32.22 ± 4.55 cm), $p < 0.05$, as shown in Table 3.

Table 3. Muscle strength and power parameter of the subjects

Variables	Before	After	Change Δ (%) [95% CI]	P-value
Muscle strength performance				
Chest press (kg)	106.73 ± 4.30	116.80 ± 5.40*	10.1 (9.44%) [-6.92 to -13.22]	0.001
Leg strength dynamometer (kg)	139.47 ± 3.85	157.00 ± 3.14*	17.53 (12.57%) [-15.90 to -19.17]	0.001
Muscle power performance				
Overhead ball throw (cm)	504.93 ± 58.18	523.93 ± 79.73*	19.0 (3.76%) [-1.82 to -36.18]	0.033
Counter movement jump (cm)	32.22 ± 4.55	34.11 ± 2.97*	1.89 (5.87%) [-0.59 to -3.19]	0.007

Values are mean ± SD, significantly different, *p < 0.05.

Discussion

This research aimed to compare the effectiveness of preparatory strength training on upper and lower body muscle strength and power in Thai national swimming athletes. Data from the sample group showed that an 8-week strength training program (Table 2) significantly improved post-test muscle strength and power (Table 3). Previous studies have reported that appropriate resistance training includes using intensity in the range of 60–85% 1RM, training frequency of 2–4 times per week, 5–10 repetitions, and 2–4 sets (Amra et al., 2021; Bompa & Carrera, 2005), and training patterns tailored to the muscles used for movement and force application. For example, swimmers use both upper and lower body muscles to maintain buoyancy and propel themselves forward rapidly over the course of a competition (Nugent et al., 2022). Jansupom (2025) reported that early muscle development in the first 4 weeks requires appropriate resistance training to facilitate gradual neurological adaptation, leading to efficient stimulation of muscle fiber activity. Systematic weight-based resistance training stimulates muscle contractions in response to various targeted movements. These contractions result from the stress levels created by the resistance training, leading to increased muscle strength and power (Hong et al., 2014; Hiruntrakul et al., 2025; Kwok et al., 2025) in both individuals and athletes of all types, thus contributing to improved athletic performance (Behringer, 2010). Therefore, the strength training model and muscle performance evaluation presented in this study show that after 8 weeks of experiment, the swimmers had an increase in upper body muscle strength of approximately 9.44% and lower body muscle strength of approximately 12.57%, and upper body muscle power efficiency of approximately 3.76% and lower body muscle power efficiency of approximately 5.87%.

The results of this current study indicate that muscle strength and muscle power can be improved by increasing the appropriate amount of resistance during muscle contractions, taking into account the principles of specificity, overload, and progression (Haff & Triplett, 2015).

However, it can be seen that appropriately increasing the intensity of training during each period can effectively improve muscle performance, reduce the likelihood of overreaching in individual athletes, and importantly, strong and powerful muscles reduce the risk of injury during training and competition (Day et al., 2004; Testa et al., 2012; Graham & Cleather, 2021).

Limitations

This study, while indicating that strength training for strength and power development results in significant post-training improvements in male swimmers' strength and power performance, has limitations due to its small sample size and the absence of a control group for comparison. Future studies should address these crucial aspects to obtain more conclusive data.

Conclusions

This study demonstrated the effectiveness of strength training during pre-fitness on muscle strength and power in male Thai national swimmers after an 8-week trial. The results showed a significant increase in muscle strength and power, as evidenced by the substantial average increases in strength and power after 8 weeks of strength training. This indicates that strength training at 67-85% of 1RM during pre-fitness can effectively improve upper and lower body muscle strength and power in swimmers.

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Conflict of interest

The author has no conflict of interest regarding the author or the results of other studies.

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