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Swimming as an Effective Training Tool for Enhancing Physical Strength: A Theoretical Review and Practical Applications

Beggar Mounira [1]
Institute of Physical Education and Sports,
University of Algiers 3
Algiers
Beggar.mounira@univ-alger3.dz

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Abstract:

This theoretical study explores the role of swimming as an effective training tool to enhance physical strength. It analyzes physiological and functional aspects related to swimming and reviews scientific literature on aquatic and dryland training programs affecting muscular strength and cardiorespiratory capacity. Findings suggest that combining swimming with resistance and structured dryland exercises leads to significant improvements in muscle strength and motor efficiency across different age groups. The study emphasizes the importance of consistent training periods of 4 to 12 weeks for progressive and sustainable strength development. It highlights swimming's value as a comprehensive sport that can be integrated into rehabilitation and training programs for both athletes and amateurs, underscoring the need for long-term planning and gradual progression to achieve optimal results.

Keywords: Swimming as a training tool ‹Enhancement of physical strength ‹Practical applications of theoretical review

Article info

[1] *Corresponding author*

1. Introduction

Swimming is considered one of the oldest and most popular physical activities practiced by humans, combining enjoyment with health benefits. It is recognized as an effective method for enhancing overall physical fitness. According to Sova (2022), swimming uniquely activates most of the body's muscles, making it a comprehensive exercise that contributes to long-term improvements in physical and functional performance (Ahmed Al-Zahrani, 2019, p. 45).

The benefits of swimming concerning physical strength are manifold. Recent studies indicate that regular swimming practice contributes to increased muscular strength, improved flexibility, and enhanced endurance. For instance, a study conducted by Lee et al. (2015) on middle-aged women observed that a structured swimming program led to reductions in body fat percentage, alongside improvements in muscular strength and flexibility, thereby highlighting swimming's value as an effective activity for overall fitness development (Mona Abdul Rahman, 2020, p. 102).

Moreover, swimming is a low-impact activity on the joints, making it suitable for individuals with musculoskeletal issues or those undergoing rehabilitation post-injury. Research published on Healthline emphasizes that water resistance provides an ideal environment for exercise without excessive joint loading, promoting muscle strengthening and cardiovascular health (Mona Al-Khatib, 2018, p. 67).

Despite the variety of physical activities that enhance general fitness and muscle health, swimming stands out due to its unique physiological characteristics. It combines low mechanical impact on joints with balanced activation of multiple muscle groups, making it suitable for various age groups. However, a noticeable knowledge gap exists in Arab field studies regarding the direct impact of swimming on the comprehensive components of physical strength, including muscular strength, endurance, and flexibility. This gap is particularly evident in contexts where swimming is not prioritized within physical education curricula or sports training systems.

On the Arab regional level, recent research points out that the development of aquatic training programs remains limited. This limitation is attributed to several factors, notably weak coordination between educational and sports institutions, as well as constrained financial resources allocated to such activities (Barbash Nour Eddine et al., 2024, p. 73).

In light of these challenges, this study aims to shed light on the role of swimming in enhancing physical strength by analyzing its associated physiological aspects and reviewing scientific evidence supporting its effectiveness in improving muscular structure and physical performance among regular practitioners (Pugh & Faulkner, 2021, p. 755).

Accordingly, the main research question of this study arises:

To what extent does swimming effectively contribute to enhancing physical strength among its practitioners?

2. study objectives

This study aims to:
a. Analyze the effect of swimming practice on the development of physical strength, including muscular strength and physical endurance.
b. Clarify the relationship between the regularity of swimming practice and the degree of improvement in overall physical fitness.
c. Highlight the physiological benefits associated with swimming, particularly regarding the muscular system and the cardiorespiratory system.

2. Significance of the Study

The significance of this study stems from several aspects, notably:

1. The growing need to understand the physiological and training dimensions of swimming and its effective role in developing components of physical strength, especially given the limited research addressing this area compared to traditional land-based sports (Bompa & Haff, 2009, p. 183).

2. Highlighting the positive impact of swimming on muscular strength and physical endurance across diverse age groups.

3. Contributing to the support of motor rehabilitation and physical therapy programs by emphasizing swimming as a low-impact training option on the joints.

3. Theoretical Framework:

This theoretical framework aims to review the scientific literature concerning the impact of swimming on the development of physical strength, with a focus on the factors influencing this relationship and how they can be leveraged to achieve tangible improvements in athletic performance and overall health. By analyzing the findings of recent studies, a comprehensive understanding will be presented regarding the mechanisms that contribute to enhancing muscular strength in swimmers, thereby providing practical recommendations for the development of future training programs.

3.1 The Effect of Swimming on Physical Strength:

3.1.1 Improvement of Muscular Strength:

Studies indicate that swimming enhances muscular strength, particularly in the upper body. The resistance of water during swimming plays a significant role in strength development, as the body generates a propulsive force to counteract this resistance, leading to muscle strengthening. A study conducted by Lee et al. (2015) demonstrated that swimming improves muscular strength in both young adults and older individuals. Specifically, swimming positively affects the strengthening of the arm, chest, and back muscles, making it an ideal exercise for enhancing upper body muscular strength.

According to another study published by Sova (2022), swimming strengthens muscles through the increased resistance created by the movement of water against the body, which stimulates muscle tissue growth and improves strength. The study emphasized that water resistance contributes to balanced muscular development, requiring the body to engage as many muscles as possible to generate the necessary

propulsion during swimming.

3.1.2 Improvement of Cardiopulmonary Strength:

Swimming also contributes to enhancing cardiopulmonary strength, thereby improving the body's ability to perform physical activities efficiently. Swimming is considered an excellent aerobic exercise that improves the efficiency of the cardiopulmonary system. In a study conducted by Pugh & Faulkner (2021), it was confirmed that swimming increases the body's oxygen consumption capacity and enhances circulatory efficiency, leading to improved performance in other sports activities. These improvements ultimately result in increased physical endurance (Pugh & Faulkner, 2021, Journal of Human Sport and Exercise).

Additionally, Ahmed Al-Saeed (2018, p.124), in his study published in the Journal of Sports Research, demonstrated that swimming plays an effective role in improving the heart and lungs' ability to adapt to the demands of continuous physical activity, thereby enhancing cardiopulmonary system efficiency.

3.1.3 The Effect of Resistance Training on Swimming Performance:

Studies indicate that resistance training, whether conducted in water or on land, enhances swimmers' performance. A systematic review by Gauthier et al. (2020) highlights that resistance training improves swimmers' performance in short- and middle-distance events and enhances force transfer and swimming biomechanics. Resistance exercises, such as weightlifting or water-based resistance training, help increase muscle strength and enable swimmers to perform swimming movements more efficiently. The study confirmed that this type of training contributes to overall muscle strength improvement, leading to better competitive performance (Gauthier et al., 2020, *Sports Science Review*).

Additionally, a study by Hussam Al-Khatib (2018, p.102) demonstrates that resistance training is among the most effective methods for enhancing muscle strength in swimmers. It can significantly improve in-water performance, particularly in long-distance events that demand higher physical endurance.

3.1.4 Development of Strength in Children Practicing Swimming

Strength is a fundamental component of athletic performance and is defined as the ability to move a mass or overcome resistance through work (Weineck, 1997, p.164). The importance of strength training is particularly emphasized during childhood, as studies indicate that many children fail to reach their full motor potential later in life due to insufficient stimulation of motor and muscular growth at an early age.

Proper development of strength, aligned with age-related growth characteristics, is a critical factor in building the physical foundation for athletic performance in later stages. The musculoskeletal system in children is more flexible due to incomplete ossification, which necessitates caution when planning training. However, this should not justify avoiding strength training. On the contrary, well-structured and age-appropriate strength training can significantly contribute to improving muscular and supportive structures (Weineck, 1997, p.164).

Statistics show that between 30% to 50% of children entering school age suffer from weaknesses in their supportive system due to insufficient physical activity. Moreover, increasing academic demands, such as schooling and homework, exacerbate this issue, raising the percentage to about 70% during the first two

years of schooling. Data also reveal a significant rise in overweight rates among children, from 3% to 20%, leading to deterioration in motor abilities and decreases in speed and endurance (Fassmund & Bodenstedt, 1985, p.188, as cited in Weineck, 1997, p.165).

Based on the above, strength training is considered a crucial preventive and therapeutic tool, especially for strengthening the muscular and supportive systems and limiting the spread of obesity and poor fitness among children. This positively reflects on athletic performance later on, particularly in sports requiring sustained physical effort such as competitive swimming.

3.2 Previous Studies:

3.2.1. Gourgoulis, V., et al. (2019):
"Effect of an 11-Week In-Water Training Program With Increased Resistance on the Swimming Performance and the Basic Kinematic Characteristics of the Front Crawl Stroke."

A study was conducted to evaluate the effect of an 11-week in-water training program using increased resistance on swimming performance and the basic kinematic characteristics of the front crawl stroke among young female swimmers. Participants were divided into two groups: an experimental group that performed additional training using a water parachute to increase resistance, and a control group that followed the same training program without the parachute.

The results showed a significant improvement in the swimming performance of the experimental group compared to the control group, indicating the effectiveness of using water resistance in enhancing physical strength and overall swimming performance.

3.2.2. Kutlukhan, Y. O., et al. (2020):
"The Effect of Dry-Land Training on Functional Strength and Swimming Performance in Swimmers Aged 10 to 12 Years"

A study was conducted to evaluate the effect of a 3-week dry-land training program on functional strength and swimming performance in 15 young female swimmers aged between 10 and 12 years. The participants were divided into two groups: an experimental group that underwent dry-land training, and a control group that followed the same swimming program without the additional dry-land component.

The results showed an improvement in both functional strength and swimming performance in the experimental group, indicating the effectiveness of dry-land training in enhancing physical strength and swimming performance.

3.2.3. Crowley, E., et al. (2017):
"The Impact of Resistance Training on Swimming Performance: A Systematic Review"

A systematic review was conducted to examine the impact of resistance training on swimming performance. The review indicated that resistance training can significantly improve muscular strength and enhance swimming performance, particularly in short- and middle-distance events. These improvements are attributed to enhanced force transmission and better swimming biomechanics.

3.2.4. Bangmek, N., et al. (2020):
"The Effects of a Dry-Land Training Program on Muscle Strength, Freestyle 100m, and IGF-I Concentration in Youth Swimmers."

A study was conducted to evaluate the effects of a dry-land training program on muscle strength and swimming performance among 11 youth swimmers aged between 9 and 15 years. Participants were divided into two groups: an experimental group that underwent dry-land training, and a control group that followed the same swimming program without the additional dry-land component. The results showed improvements in muscle strength and freestyle performance in the experimental group, indicating the effectiveness of dry-land training in enhancing physical strength and swimming performance.

3.2.5. Analysis of Previous Studies' Findings:

Previous studies indicate that both aquatic and dry-land training programs play a significant role in improving physical strength and swimming performance across different age groups. In the study by **Gourgoulis et al. (2019, p.33)**, an 11-week in-water training program incorporating increased resistance using a water parachute led to a marked improvement in the front crawl performance and basic kinematic characteristics of young female swimmers. This underscores the effectiveness of water resistance as a tool for enhancing muscular strength and swimming efficiency.

On the other hand, studies focusing on dry-land training, such as **Kutlukhan et al. (2020)**, which targeted children aged 10 to 12 years, demonstrated that a 3-week dry-land training regimen significantly improved functional strength and swimming performance compared to control groups.

These findings are supported by **Bangmek et al. (2020)**, who reported a notable increase in muscle strength and 100-meter freestyle performance in youth swimmers who underwent a dry-land training program. Additionally, the study observed a positive impact on IGF-I levels, indicating stimulated muscular growth.

Furthermore, the systematic review by **Crowley et al. (2017, p.47)** confirms that resistance training—whether in water or on land—can enhance muscular strength and improve swimming performance, especially in short- and mid-distance events, through better force transmission and improved stroke biomechanics.

Table: Summary of Findings from Previous Studies on the Impact of Physical Training on Swimming Performance

Study	Type of Training	Duration	Target Group	Key Findings
Gourgoulis et al. (2019)	In-water resistance training (with parachute)	11 weeks	Young female swimmers	Significant improvement in front crawl performance and kinematic characteristics
Kutlukhan et al. (2020)	Dry-land training	3 weeks	Female swimmers aged 10–12	Improved functional strength and swimming performance
Crowley et al. (2017)	Systematic review of resistance training	–	Swimmers at various levels	Resistance training improves performance, especially in short to mid distances
Bangmek et al. (2020)	Dry-land training	Not specified	11 swimmers aged 9–15	Increased muscle strength and enhanced swimming performance

Conclusion:

This table clearly demonstrates that both dry-land and in-water resistance training contribute significantly to enhancing muscular strength and swimming performance, particularly among younger age groups.

3.3. Methods and Approaches for Developing Muscular Strength in Swimmers:

To develop muscular strength in swimmers, it is recommended to implement a range of specialized training methods that specifically target the primary muscles involved in swimming. The focus should be on strength training, plyometric exercises, dry-land training, and functional exercises.

3.3.1. Dry-Land Training: According to *Dryland Training* (2004) and Bishop & al Hoff, J. (2005)

Dry-land training is considered an essential component of swimmers' training programs, as it enhances muscular strength, flexibility, balance, and reduces the risk of injury.

Effective dry-land exercises include:

- **Plank with Shoulder Taps:** Strengthens the core and shoulder muscles, improving body stability during swimming.
- **Squats:** Enhance leg and hip strength, contributing to improved propulsion and starts in swimming.
- **Russian Twists:** Strengthen the core muscles and improve torso rotation, enhancing the effectiveness of rotational movements in swimming.
- **Push-ups:** Strengthen the chest, shoulder, and arm muscles, improving the pushing power during swimming strokes.
- **Medicine Ball Slams:** Develop explosive power and propulsion ability, leading to overall performance improvement in swimming.

3.3.2. Resistance Training: According to Stone, M. & Sands, W. (2007) and Larsson, B. & Larsson, L. (2000)

Resistance training contributes to increasing muscle hypertrophy and strength, thereby enhancing swimming performance.

Effective resistance exercises include:

- **Resistance Band Rows:** Mimic the pulling motion in swimming and strengthen the upper back muscles.
- **Resistance Band Shoulder Rotations:** Strengthen the shoulder muscles and improve joint stability, reducing the risk of injuries.

3.3.3. Plyometric Training: According to Komi & Tesch (1979) and Mero & Komi (1990)

Plyometric training enhances the ability to generate force rapidly, thereby improving swimming performance.

Effective plyometric exercises include:

- **Box Jumps:** Increase leg strength and propulsion power, enhancing the swimmer’s push-off ability.
- **Depth Jumps:** Improve the body’s capacity to absorb and rapidly generate force, contributing to overall swimming performance.

3.3.4. Functional Training

Functional training focuses on improving natural movement patterns used in swimming, thereby enhancing efficiency and performance.

Effective functional exercises include:

- **Medicine Ball Slams:** Enhance explosive power and propulsion ability, leading to improved overall swimming performance.
- **Resistance Band Rows:** Simulate the pulling motion in swimming and strengthen the upper back muscles.

3.4. Timeframe for Developing Physical Strength in Practitioners:

Developing physical strength in swimmers is a process that requires time and systematic training planning, taking into account the initial fitness level, type of training, intensity, and weekly frequency of practice. The results achieved vary according to these variables; however, the literature indicates specific time phases through which muscle strength development can be tracked.

3.4.1. Initial Phase (0–4 weeks):

During this phase, improvements focus primarily on neural adaptations rather than muscular hypertrophy. The brain and nervous system begin to enhance the efficiency of signal transmission to the muscles, resulting in greater strength without a significant change in muscle size. According to Sale (1988, p. 139), the first 3–4 weeks of strength training demonstrate improvements in neural control more prominently than muscle fiber growth.

3.4.2. Intermediate Phase (4–8 weeks):

During this period, the body begins to gradually increase muscle mass alongside the ongoing neural adaptations. A study by Tan (1999, p. 209) demonstrated that this phase is ideal for achieving progressive gains in muscular strength, especially when training programs combine resistance training with dryland and aquatic exercises.

3.4.3. Advanced Phase (8–12 weeks):

Evidence indicates that strength training programs lasting between 8 and 12 weeks produce significant improvements in muscular and athletic performance tests. For instance, a study conducted by Aspenes et al. (2009) on elite swimmers demonstrated that a 9-week resistance training program performed outside the water resulted in substantial gains in strength tests such as the bench press and leg extension, as well as improvements in in-water performance (Aspenes et al., 2009, *European Journal of Applied Physiology*, pp. 2391–2399).

4.4.3. Timeframe for Developing Physical Strength in Swimmers According to Previous Studies:

- A study by Crowley et al. (2017, p. 548) indicated that maximal strength training is the most effective method for improving athletic performance in swimming when conducted over periods ranging from 6 to 12 weeks.
- Plyometric training is specifically used to enhance starting and turning skills and is recommended for a duration of 6 to 8 weeks, performed twice weekly.
- According to Potdevin et al. (2011, p. 290), a 6-week plyometric training program significantly improved start performance and 15-meter swim times.
- Recent scientific research highlights that developing physical strength in athletes, particularly swimmers, depends on the regularity, quality, and duration of training. Bompa & Haff (2009, p. 181)

reported that initial strength gains occur within the first 4 to 6 weeks of consistent training due to neural adaptations, while actual increases in muscle mass begin after the sixth week.

- Furthermore, Crowley et al. (2017) demonstrated that strength training programs lasting 6 to 12 weeks, applied 2–3 times per week, effectively enhance muscular strength and swimming performance, especially in short-distance events.
- Tan (1999) confirmed that maximal strength development programs require a time span of 6 to 10 weeks, to be implemented gradually with progressive increases in intensity and load (Journal of Strength and Conditioning Research).
- Regarding in-water training, Gourgoulis et al. (2019) showed that an 11-week aquatic resistance program led to a noticeable improvement in overall swimmer performance by 3.2% to 7.2%, without negatively affecting swimming technique or kinematic characteristics (Journal of Strength and Conditioning Research).

3.5. Recovery Duration After Training for Muscular Strength Development:

The required recovery time after a training session aimed at developing muscular strength varies according to the type of training, its intensity, the athlete's level, and the condition of the muscles post-exercise.

3.5.1. Recovery After Maximal Strength Training:

According to Gonzalez, A. M. (2016, p. 34) and Freitas de Salles et al. (2009, p. 765):

- **Recommended duration:** 24 to 72 hours.
- **Rationale:** Maximal strength training causes significant muscle fatigue, necessitating sufficient time to repair damaged muscle fibers and replenish energy stores.

3.5.2. Recovery After Plyometric Training:

According to Potdevin et al. (2011):

- **Recommended duration:** 48 to 72 hours.
- **Rationale:** Plyometric training involves rapid and powerful movements that cause significant muscle fatigue, requiring a longer recovery period.

3.5.3. Recovery After Resistance Training:

According to Gonzalez, A. M. (2016, p. 34):

- **Recommended duration:** 24 to 48 hours.
- **Rationale:** Resistance training induces muscle fatigue, but to a lesser extent compared to maximal strength or plyometric training, thus necessitating a shorter recovery time.

3.5.4. Recovery Between Consecutive Training Sessions:

According to Crowley, E., et al. (2017, p. 548):

- **Recommended duration between consecutive sessions:** 48 to 72 hours.
- **Rationale:** To avoid overtraining and to maximize training adaptations, adequate recovery periods between sessions are advised.

Recommendations for Effective Recovery:

- **Listening to the body:** Monitoring signs of fatigue such as persistent soreness or excessive tiredness.
- **Proper nutrition:** Consuming protein and carbohydrates post-exercise to enhance recovery.

- **Rest and sleep:** Ensuring sufficient sleep duration (7–9 hours) to support the recovery process.
- **Light activities:** Engaging in stretching exercises or walking to promote blood circulation and accelerate recovery.

Scientific evidence indicates that swimming is an effective exercise for enhancing physical strength, especially when combined with dryland strength training and resistance training. The study by Lee et al. (2015) demonstrated that regular swimming over a 12-week period improved muscular strength, flexibility, and cardiorespiratory capacity in middle-aged women, accompanied by a significant reduction in body fat percentage and improvements in blood lipid profiles.

Furthermore, dryland training and resistance training are considered complementary methods that enhance the effectiveness of swimming in developing muscular strength. Research shows that integrating these approaches contributes to the overall improvement of physical performance in swimmers.

4. **Conclusion:**

In light of the presented scientific data and analysis of previous studies, it is evident that swimming is not merely a recreational physical activity, but one of the most effective tools for developing physical strength in an integrated and safe manner. Swimming, with its unique physiological characteristics, enables the activation of most muscle groups without excessive joint stress, making it ideal for various age groups and physical abilities, including the elderly, children, and individuals with injuries.

Studies have demonstrated that regular swimming leads to improvements in muscular strength, endurance, and cardiovascular efficiency, especially when combined with resistance and dryland training programs. This underscores the importance of adopting a multidimensional training approach that considers individual characteristics, muscle response times, and required recovery durations.

Accordingly, this study recommends the integration of swimming into fitness and rehabilitation programs, the development of training policies based on combining aquatic and dryland activities, and expanding Arab research in this field to enhance the knowledge base and direct scientific efforts towards effective and sustainable practical applications in sports and public health domains.

5. Study Recommendations:

Based on the study's findings, the following recommendations are proposed:

- **Design comprehensive training programs** that integrate swimming with dryland exercises and resistance training, while accounting for individual differences in age, gender, and fitness level.
- **Introduce swimming into school curricula** at early educational stages, as a strategic component for developing muscular strength and overall physical fitness in youth.
- **Develop specialized aquatic training programs** for rehabilitation and elderly populations, capitalizing on the low-impact nature of swimming to enhance muscular function without joint stress.
- **Incorporate aquatic resistance tools**—such as drag parachutes and resistance bands—within swim training sessions, particularly for novices and youth, to promote strength development without compromising technical execution.
- **Establish well-structured training cycles** that span between 6 to 12 weeks for optimal muscular strength gains, while ensuring appropriate recovery periods of 48 to 72 hours between intense sessions.
- **Utilize advanced performance assessment tools**—including biomechanical analysis and functional strength tests—to monitor progression and tailor training loads accordingly.
- **Foster collaboration between educational and sports institutions** to ensure adequate infrastructure for swimming instruction and athletic development, especially in resource-limited settings.

- **Encourage long-term experimental and field-based research** on the role of swimming in muscular strength development across different age groups, particularly within Arab contexts, to enhance evidence-based practices.
- **Promote continuous professional development** for coaches through targeted workshops and certification programs emphasizing the integration of aquatic, dryland, and resistance-based methods.
- **Align national health and sports strategies** with evidence supporting swimming as an effective approach for improving physical conditioning, preventing injuries, and strengthening the musculoskeletal system across populations.

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