THE IMPACT OF PLYOMETRIC EXERCISES ON THE DEVELOPMENT OF LEG KICKS IN FREESTYLE SWIMMING AMONG PHYSICAL EDUCATION MAJORS AT MUTAH UNIVERSITY

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Abstract

This study aimed to investigate the impact of plyometric exercises on the development of leg kicks in freestyle swimming. The study sample consisted of 24 students from the Faculty of Sports Sciences at Mutah University (advanced swimmers). They were randomly divided into two equal groups, with the first group using traditional training methods, and the second group using plyometric exercises. To achieve the study's objectives, the researcher employed an experimental approach suitable for the study's nature. Statistical analysis was conducted using the Statistical Package for the Social Sciences (SPSS). The results of the study, when comparing the pre-test and post-test results of the control group, indicated that the traditional method had a positive effect on improving leg kicks in freestyle swimming. Similarly, when comparing the pre-test and post-test results of the experimental group, the experimental method showed a positive effect in enhancing leg kicks in freestyle swimming. Based on the study's findings, the researcher recommended raising awareness among coaches about the importance of using plyometric exercises due to their positive impact on improving leg kicks in freestyle swimming.

Keywords: Plyometric Exercises. Freestyle Swimming. Advanced Swimmers. Experimental Study

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Introduction and Research Problem

Scientific research has become one of the fundamental factors accompanying the development of contemporary human societies, aiming to reach the highest levels in all aspects of life in general. Undoubtedly, it plays a vital role in the field of sports. In this era, we live in, various scientific and practical aspects of life have been characterized by rapid evolution, continuous progress, and renewed knowledge, focusing on all the theories and scientific facts that humans continuously discover.

Physical conditioning is considered one of the most critical factors for success in the sport of swimming. It is the primary foundation for achieving high athletic levels. Additionally, physical conditioning is one of the essential pillars upon which swimmers rely to reach their goals and attain outstanding performance in competitions. Specialized physical conditioning aims to develop the necessary physical attributes unique to the sport of swimming and strives to enhance them to their maximum potential, leading the athlete to achieve the highest levels of technical performance.

With the advancement of sports training science, various training methods have emerged, including the plyometric training method. This method is known for its high impact on the development of physical and functional abilities, in addition to its technical aspects. This is due to the specificity of this method and its impact on muscles and internal body systems. Plyometric training works on improving muscular capacity, especially in the leg muscles, and enhancing muscle elasticity, as well as improving energy system production, which is essential for swimmers (Ali, 2010).

Bistawi (1999) points out that plyometric exercises comprise a set of exercises primarily based on muscle elasticity to provide them with high kinetic energy by combining maximum strength and speed to develop explosive strength and power.

Plyometric training is considered one of the methods that enhance both strength and power. It bridges the gap between muscle strength and power since the nature of this muscular contraction consists of two phases: the elasticity phase, which precedes the muscular contraction, and helps develop muscles to increase the speed of muscular contraction (Alkhawaldeh & Abu-shihab, 2023).

Plyometric exercises are considered essential for enhancing explosive strength. They improve the relationship between maximal strength and speed-strength. Plyometric exercises aim to increase muscle capacity for stretching, and during the stretching phase, a significant amount of elastic energy is stored in the muscle. This energy is then utilized during the subsequent contraction, making it stronger (Bistawi, 1999).

Plyometric training yields positive results in the neuromuscular adaptations of athletes. It focuses on restoring balance and proper fluidity when performing movements in the aquatic environment. This training method aims to enhance the ability to perform explosive movements in various sports phases, ultimately improving skill levels. The use of plyometric training is one of the most effective methods to positively impact technique by increasing a player's performance capacity, consequently influencing the execution of required movements in the best possible manner (Abu El-ala, 1997).

The problem of the study lies in what the researcher has observed in the fields of coaching, education, and competitions, which is that the majority of coaches tend to focus on the upper body while neglecting the lower body, despite the fact that the lower body is stronger than the arms. This observation is consistent with the findings of researchers such as Abu Tamim (2006), Aldabour (2004), and Alqatt (2006), who agree that leg kicks constitute approximately 15-20% of the propulsive force for the body. The muscles of the thighs with their four heads, the leg muscles, and the posterior muscles of the thigh with their three heads are essential pillars for generating significant muscle strength that swimmers use for rotation, maintaining body balance, and control. This aligns with what Abu El-ala (1997) has pointed out, in addition to the importance of leg kicks in giving the body the ability to float and maintaining body fluidity. Given the significance of plyometric exercises as a fundamental and essential requirement for these muscles, the researcher decided to conduct a study on the impact of using plyometric exercises on the development of leg kicks in freestyle swimming among physical education majors at Mu'tah University.

The Study Objectives

1. To assess the impact of using plyometric exercises on the development of leg kicks in freestyle swimming among individuals in the control group.
2. To evaluate the impact of using plyometric exercises on the development of leg kicks in freestyle swimming among individuals in the experimental group.
3. To identify the differences between individuals in the experimental group and the control group in terms of the development of leg kicks in freestyle swimming.

Study Hypotheses

1. There are statistically significant differences at a significance level ($\alpha \leq 0.05$) between the pre-test and post-test measurements regarding the impact of the conventional method on the development of leg kicks among individuals in the control group, in favor of the post-test measurements.
2. "There are statistically significant differences at a significance level ($\alpha \leq 0.05$) between the pre-test and post-test measurements regarding the impact of using plyometric exercises on the development of leg kicks among individuals in the experimental group, in favor of the post-test measurements.
3. There are statistically significant differences at a significance level ($\alpha \leq 0.05$) in the post-test measurements between individuals in the experimental group (plyometric exercises) and individuals in the control group (conventional training) in freestyle swimming, in favor of the experimental group.

Study Variables

1 Study Design: The experimental design was employed due to its suitability for the nature and problem of this study.

2 Timeframe Variables: The researcher conducted this study during the first semester of the academic year 2022-2023.

3 Human Variables: The study was conducted on students enrolled in the advanced swimming course (major) at Mu'tah University, with a total of 24 students.

Study Terminology

1 Plyometric Exercises: "Plyometric exercises" are also known as "stretch-shortening exercises." They are characterized by the storage and utilization of muscle elastic energy through eccentric and concentric contractions, which positively impact muscle capacity (Rodcliffe and High, 1999).

2 Muscle Power: "Muscle power" refers to the ability to exert maximum force in the shortest possible time (Abdulrazak et al., 2004).

3 Stored Elastic Energy: When muscle fibers are subjected to rapid excessive elongation, they store potential elastic energy, which is used to return them to their natural position after the influencing force causing the elongation has ceased (Al-Kilani, 2006).

Study Procedures

Study Methodology

In this study, the researcher employed an experimental methodology due to its suitability for the nature and procedures of the study. The aim was to investigate the impact of using plyometric exercises on the development of leg kicks in freestyle swimming among physical education major students at Mu'tah University.

Study Sample

The study sample was deliberately selected from students enrolled in the advanced swimming course (major). The total number of participants in the study was 24 students, all of whom had a background in freestyle swimming. They were then randomly assigned to two equal groups through pre-test measurements.

Group Equivalence

To ensure the equivalence of groups before commencing the intervention, the researcher conducted pre-test measurements and assessed group equivalence using the Independent Samples t-test for each variable (age, height, weight). The results of this assessment are presented in Tables 1 and 2.

The data in Table 1 indicates no statistically significant differences at the significance level ($\alpha \leq 0.05$) between the two groups (Control and Experimental) as evidenced by the t-values and their corresponding significance levels. This suggests the equivalence of individuals in both the Control and Experimental groups for the variables represented by (Age, Weight, and Height).

The data in Table 2 indicates no statistically significant differences at the significance level ($\alpha \leq 0.05$) between the two groups (Control, Experimental) in the pre-application assessments based on the t-values and their accompanying significance levels. This suggests the equivalence of the two groups before the commencement of the application.

Data Collection Tools

1. Skill Tests for Freestyle Swimming

A model was designed to obtain the results of skill tests for freestyle swimming, which included each test and its measurement method. These skill tests have been applied in various scientific research studies and are detailed in Appendix 1 (Skill Tests). They include:

a. Sliding on the stomach (Distance, meters).

b. Foot strokes (Distance, meters).

c. Overall compatibility for freestyle swimming (Distance, meters).

2. Plyometric Tests

a. Depth Jump Test.

b. Muscle strength test using the Sargent Vertical Jump Test.

Test Validity and Reliability

The validity and reliability of the plyometric tests have been confirmed as they have been mentioned in several previous references such as (Bastousi, 1999), (Al-Nimr & Al-Khatib, 1996), (Alawi, 2001), and (Shahatah, 1995). Some researchers like (Abdul-Karim & Al-Sirsi, 2005) have also used these tests in their studies, making them reliable tools for measuring strength.

Regarding the skill tests for freestyle swimming, these tests have been applied in various scientific research studies, as indicated by (Al-Qat, 2004), (Rizk, 2003), (Hussein, Ahmed, 2000), (Essam, 1997), (Bahaim, 1994), and (Maglischo, 2003).

Test Reliability

To assess the reliability of the study's instruments, the researcher administered the tests to a pilot sample consisting of 10 individuals from the study population and 10 individuals from outside the study population. The tests were then re-administered one week later. Pearson's correlation coefficient was calculated to assess the reliability. (Table 3) presents the results.

The data in Table (3) indicates that the reliability coefficients of the tests used in the study ranged from 0.92 to 0.97. Such values are considered acceptable for the purposes of the current study.

Study Variables

Independent Variable: Educational Programs

Training Program based on Plyometric Exercises.

Table 1. Independent Samples t-Test to Assess Group Equivalence According to Variables (Age, Weight, Height).

Variable	Group	Mean	Standard Deviation	t-value	Significance Level
Age	Control	21.27	1.42	0.727	0.475
	Experimental	21.77	1.91		
Weight	Control	67.52	6.76	1.89	0.07
	Experimental	72.75	6.84		
Height	Control	172.54	6.1	0.57	0.56
	Experimental	174	6.77		

Table 2. Independent Samples t-Test for Subtests of Swimming and Plyometric Tests.

Test Subtests	Group	Application	Mean	Standard Deviation	t-Value	Significance Level
Swimming Tests	Slip	Control	5.14	1.44	0.08	0.93
		Experimental	5.16	0.89		
	Kicks	Control	10.2	5.88	1.25	0.22
		Experimental	12.63	2.98		
	Free Swim	Control	12.19	6.84	1.68	0.11
		Experimental	15.85	3.72		
Plyometric Tests	Depth Jump	Control	1.58	0.25	1.61	0.12
		Experimental	1.78	0.33		
	Vertical	Control	2.64	0.34	0.8	0.43
	Jump	Experimental	2.71	0.19		

Table 3. Pearson Correlation Coefficient between Test Re-Applications as an Indicator of Study Test Reliability.

Test Type	Sub-Test	Stability Coefficient
Swimming Tests	Glide	0.94
	Leg Kicking	0.93
	Freestyle Total Compatibility	0.97
Plyometric Tests	Standing Long Jump	0.93
	Sargent Vertical Jump	0.92

Table 4. Paired Samples t-Test to Detect Differences Between Pre-Test and Post-Test for the Control Group.

Test	Subtests	Application	Mean Difference	Standard Deviation	t-Value	Significance Level	Effect Size
Swimming Tests	Sliding	Pre-Test	5.14	1.44	3.09	0.00*	46.47%
		Post-Test	5.75	1.47			
Leg Strokes	Pre-Test	10.2	5.88	4.39	0.00*	63.66%	
		Post-Test	12.06	5.15			
Freestyle Swimming Synchronization	Pre-Test	12.19	6.84	3.52	0.00*	52.97%	
		Post-Test	14.58	5.05			
Plyometric Tests	Depth Jump	Pre-Test	1.58	0.25	3.46	0.00*	52.11%
		Post-Test	1.73	0.21			
Vertical Jump	Pre-Test	2.71	0.34	2.17	0.04*	29.98%	
		Post-Test	2.78	0.18			

*Statistically significant difference at a significance level (α≤0.05)

Dependent Variable

Development of Freestyle Swimming Leg Movements.

Statistical Procedures

The researcher conducted statistical analyses using the Statistical Package for the Social Sciences (SPSS), as follows:

1. Descriptive statistics including means and standard deviations were used to describe the performance levels in the pre-test and post-test.

2. Paired Samples Statistics were conducted to detect differences between the pre-test and post-test for each of the study's tests.

3. Independent Samples Statistics were performed to identify differences between the two groups (Control and Experimental) in the post-test for each of the study's tests.

4. Pearson correlation coefficients were calculated to verify the reliability of the study's tools.

Results Presentation and Discussion

1. The first study hypothesis stated

There are statistically significant differences at a significance level of (α≤0.05) between pre-test and post-test measurements for the effect of the conventional method on improving leg movements among the control group in favor of the post-test.

To address this question, the researcher conducted a Paired Samples t-test to detect differences between the pre-test and post-test for the control group for each of the swimming tests (Sliding, Leg Strokes, and Freestyle Swimming Synchronization) and the plyometric tests (Depth Jump, Vertical Jump) (Table 4) illustrates the results.

The data in Table 4 reveals a statistically significant difference at a significance level (α≤0.05) between the pre-test and post-test measurements for the control group, as indicated by the t-values and their accompanying significance levels. The effect size, which ranged from 29.98% to 63.66%, suggests a substantial impact in favor of the post-test for improving leg strokes in freestyle swimming. According to Cohen's classification, these effect sizes indicate a large effect of the traditional method in enhancing leg strokes in freestyle swimming.

The researcher attributes this improvement in results to the substantial positive impact of the traditional program on performance. The traditional method incorporated appropriate training loads to increase muscle strength. This means that any athletic performance, whether physical, skill-based, or tactical, will have a certain degree of influence on various functional systems in the body. Such performance leads to effects on the muscular system, an increase in muscle tension (contraction), an elevation in heart rate, and heightened nervous system activation, all proportionate to the intensity of the exercise performed.

The researcher also attributes the improvement in physical and fundamental skill variables to the fact that the 8-week application period of the traditional program was sufficient and suitable for this sample, as evident from the study's results.

These findings align with previous studies by Hossini (2012), Sahak (2000), and Sati (2016), which collectively demonstrated that traditional training methods have a positive impact on improving and developing both upper and lower limb muscles.

2. The second hypothesis, which states

"There are statistically significant differences at a significance level (α≤0.05) between the pre-test and post-test measurements of the impact of using plyometric exercises in improving (leg kicks) among individuals in the experimental group in favor of the post-test measurements.

The researcher conducted a paired samples t-test to detect differences between the pre-test and post-test measurements of the experimental group for each swimming test (sliding, leg kicks, synchronized free swimming) and plyometric tests (deep jump, vertical jump) (Table 5) presents the results.

the data in (Table 5) reveal significant differences between the pre-test and post-test measurements for the experimental group, as indicated by the t-values and their corresponding significance levels. These differences favor the post-test measurements, with effect sizes ranging from 74.84% to 80.74%. According to Cohen's classification, this suggests a substantial effect of using plyometric training in improving leg kicks among individuals in the experimental group.

The researcher attributes the observed differences in the post-test measurements of the study's sample in the experimental group (plyometric training) to the specific exercises employed in the training program. Various forms of plyometric exercises are known to enhance the ability to generate energy and strength in a short amount of time. This enhancement is associated with the energy produced during muscle contraction, and these exercises improve the muscles' capacity to produce energy.

Furthermore, the researcher believes that this training method aims to enhance the processes of performance enhancement in sports, which rely on this attribute in one of its phases. If there is a deficiency in the ability to jump related to the duration of muscle contraction and muscle relaxation phase, plyometric training is considered one of the best training methods for developing what is known as elastic strength.

As Abu Al-A'la (1997) emphasized, what distinguishes plyometric training from other forms of exercise is that it is suitable for all athletes and contributes to the development of muscle strength. Plyometric training is one of the most effective methods for improving certain physical and physiological abilities, especially muscular strength, and it specifically targets the leg muscles.

The researcher also attributes the improvement in physical variables and basic skills in the research sample to the appropriateness of the plyometric training program in terms of intensity, repetitions, rest intervals, and even the rest between sets. It is an essential method for developing muscle strength and the

Table 5. Paired Samples t-Test to Detect Differences between Pre-test and Post-test Application for the Experimental Group.

Test Type	Subtest	Application	Mean	Standard Deviation	t-Value	Significance Level	Effect Size (%)
Swimming Tests	Sliding	Pre-test	5.16	0.89	6.79	0.00*	80.74%
		Post-test	6.86	0.73			
Leg Kicks	Pre-test	12.63	2.98	6.62	0.00*	79.94%	
	Post-test	17.88	4.91				
Synchronized Free	Pre-test	15.85	3.72	5.72	0.00*	74.84%	
Swimming	Post-test	23.38	4.13				
Plyometric Tests	Depth Jump	Pre-test	1.78	0.33	6.26	0.00*	78.08%
	Post-test	2.57	0.36				
Vertical Jump	Pre-test	2.71	0.19	6.25	0.04*	78.03%	
	Post-test	3.12	0.15				

Statistically, at a significance level (α≤0.05)

Table 6. Independent Samples t-Test to Detect Differences in Post-test Measurements between the Control and Experimental Groups.

Test Type	Subtest	Group	Application	Mean	Standard Deviation	t-Value	Significance Level
Swimming Tests	Sliding	Control	Post-test	5.74	1.47	2.36	0.02*
		Experimental	Post-test	6.86	0.73		
Leg Kicks	Control	Post-test	12.06	5.15	2.83	0.01*	26.69%
	Experimental	Post-test	17.88	4.91			
Synchronized Free	Control	Post-test	14.59	5.05	4.66	0.00*	49.67%
Swimming	Experimental	Post-test	23.38	4.13			
Plyometric Tests	Depth Jump	Control	Post-test	1.73	0.21	6.93	0.00*
	Experimental	Post-test	2.57	0.36			
Vertical Jump	Control	Post-test	2.78	0.18	4.92	0.00*	52.39%
	Experimental	Post-test	3.12	0.15			

Statistically, at a significance level (α≤0.05),

muscles' ability to perform sports movements and overcome speed deficits. The researcher further emphasizes that plyometric training stimulates motor units and increases the speed of muscle fiber contraction due to maximal speed during plyometric exercises. It also enhances the muscle's stretch-shortening cycle, leading to increased muscle tension, which contributes to better motor force.

The results of this study align with the findings of previous studies by Mohammed (2016), Sati (2016), Ali (2015), and Saleh (2000). These studies collectively demonstrate that plyometric training has a significant positive impact on improving and developing lower limb muscles.

3. The third hypothesis, stated as

"There are statistically significant differences at a significance level (α≤0.05) in the post-test measurements between individuals in the experimental group (Plyometric) and individuals in the control group (Conventional Training) in freestyle swimming, favoring the experimental group."

The researcher conducted an Independent Samples t-Test to detect differences between the two groups based on post-test measurements. This analysis was performed for each swimming test (sliding, leg kicks, synchronized free swimming) and plyometric tests (deep jump, vertical jump). (Table 6) illustrates the results.

The data in Table 6 indicate statistically significant differences at a significance level (α≤0.05) between the two groups (Control and Experimental) in post-test measurements, favoring the Experimental group, as evidenced by the t-values and their associated significance levels. The calculated effect size ranged from 20.20% to 68.58%, indicating a substantial effect size, according to Cohen's classification, in favor of plyometric training for improving leg kicks in freestyle swimming.

The researcher attributes the significant positive effect of plyometric training on improving leg kicks in the experimental group to the specific training methodology emphasizing the development of explosive strength in leg muscles. The training also focused on executing the proper muscle action angles during exercises both in dry and aquatic environments. Despite variations in body positioning and swimmer speed in water and on land, these exercises led to improved strength and energy production in arm and leg muscles in a short time frame.

Additionally, the researcher emphasizes that plyometric training is tailored to enhance unique qualities such as speed, strength, and explosiveness in muscles commonly engaged in skill performance. It involves rapid muscle lengthening followed by a quick contraction, which contributes to stimulating maximum motor unit recruitment and enhancing muscle coordination. The success of this training method largely depends on the muscle's ability to generate maximum force in the shortest time possible by utilizing both the stretching and shortening phases of the muscle cycle.

The researcher believes that one of the key reasons for the positive outcome is that these exercises imposed a high level of effort on the body, especially on muscles, tendons, and joints. Therefore, adapting to this type of exercise should occur gradually, starting with lower-intensity exercises and progressively increasing in difficulty. The training program also incorporated a variety of exercises both in and out of the water to match the intensity of the training with the characteristics of the sample.

Furthermore, the researcher highlights the superiority of the plyometric training program over the traditional program in improving leg kicks, as it targets developing explosive strength, speed, and power in the muscles. Plyometric training transforms chemical energy into mechanical work and enhances the mechanical efficiency when using exercises involving the stretch-shortening cycle.

These findings align with the majority of studies, including those by Mohammed (2016), Sati (2016), Ali (2015), Shah (2000), and Hossini (2012), which all concluded that plyometric training has a significantly positive impact on improving lower body muscles.

Supplement Number (1)

Plyometric Tests

1. Standing Long Jump Test

Test Objective

The objective of this test is to determine the player's muscular strength development by calculating the distance of a standing long jump forward performed by the player.

Required Materials

To conduct this test, you will need

• A flat ground with a minimum length of 5 meters.

• A measuring tape with a length of 5 meters.

• An assistant for measurement, helping with the jump start and marking the landing spot.

Test Procedure

• The player warms up for 10 minutes.

• The player places both feet at the starting point of the jump, bends the legs slightly, exerts maximum force using the arms, and pushes off with the legs, jumping as far forward as possible, landing horizontally. They must maintain balance to measure the jump distance.

• The assistant secures the measuring tape at the landing point.

• The coach records the result and repeats it after completing the training program.

2. Sargent Vertical Jump Test

Test Objective

This test aims to measure the maximum muscular strength in the player's legs.

Required Materials

To conduct this test, you will need:

• A Sargent device for measuring vertical jumps.

• A pen and paper for recording results.

Test Procedure:

• Warm-up for 10 minutes.

• Attach the device securely to the player's waist using the provided strap, ensuring the device is on level ground.

• The player stands with both feet flat on the ground.

• The player performs a vertical jump by bending their legs to reach the highest point possible.

• The coach records the number displayed on the device's screen.

Freestyle Swimming Skill Tests

1. Prone Glide with Breath Holding Test:

Test Objective

To measure the participant's ability to perform prone gliding for the maximum distance possible.

Required Materials

To conduct this test, you will need

• A measuring tape along the length of the test area, secured to the edge of the pool.

• A results recording sheet.

Test Procedure

• Stand halfway in the water with your back against the pool wall, tilt the trunk forward on the water's surface, extend your arms, push off the pool floor with your feet, and slide horizontally on the water's surface while exhaling inside the water.

Recording Method

Measure the distance of the prone glide in meters and centimeters, starting from the moment the participant leaves the pool floor until they touch the pool floor again with their feet.

2. Alternate Leg Kicking Test with Breath Holding

Test Objective

To measure the participant's ability to perform alternate leg kicking for the maximum distance possible while holding their breath.

Required Materials

To conduct this test, you will need:

• A measuring tape along the length of the test area, secured to the edge of the pool.

• A results recording sheet.

Test Procedure

• Stand halfway in the water with your back against the pool wall, tilt the trunk forward on the water's surface, extend your arms, push off the pool floor with your feet, and perform alternate leg kicking while holding your breath.

Recording Method

Measure the distance of the performance of alternate leg kicking in meters and centimeters, starting from the moment the participant leaves the pool floor until they touch the pool floor again with their feet.

3. Freestyle Total Compatibility Test

Test Objective

To measure the participant's ability to perform freestyle swimming skills in their entirety (performing prone glide with breath holding, arm movements for freestyle swimming, and alternate leg kicking) collectively (total compatibility).

Required Materials

To conduct this test, you will need

• A measuring tape along the length of the test area, secured to the edge of the pool.

• A results recording sheet.

Test Procedure

• Stand halfway in the water with your back against the pool wall, tilt the trunk forward on the water's surface, extend your arms, push off the pool floor with your feet, and perform the complete freestyle swimming skills, including prone gliding with breath holding, arm movements for freestyle swimming, and alternate leg kicking while holding the breath.

Recording Method

Measure the distance of the entire freestyle swimming skills performance in meters and centimeters, starting from the moment the participant leaves the pool floor until they touch the pool floor again with their feet or cease performing any of the skills.

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