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Original Article

Plyometric training method potentially increasing explosive power of swimmer's leg muscles compared to untrained swimmer's

ANDRI GEMAINI[1], YANUAR KIRAM[2], SYAHRASTANI[3], USAMA ASHMAWI[4], JAFFRY ZAKARIA[5], EKO PURNOMO[6]
[1,2,3,6] Universitas Negeri Padang, INDONESIA
[4]Port Said University
[5]Universiti Pendidikan Sultan Idris, INDONESIA

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Abstract
Plyometric training is important for swimmers because it provides several important benefits that can improve their performance and performance when swimming. This study aims to determine the potential of plyometric training to improve leg muscle explosiveness and athlete performance in swimming. Pre and post control groups were employed in this experimental investigation. Purposive sampling was used to choose the research volunteers, after which they were split into two groups. namely G1 which only followed swimming training without being given a land training program or plyometrics, and G2 was given plyometric training treatment. The research subjects were 30 male athletes aged 18-19 years who were active in participating in training camps. There was plyometric training for eighteen meetings, four times a week. The individual completed the vertical jump test to collect pre-test data prior to receiving therapy. In this study's statistical analysis, the descriptive tests were used to determine the mean, standard deviation, and standard error using IBM SPSS version 26. Additionally, the Shapiro-Wilk method was used to test the normality of the data; if the results were normal, the paired t-test was used for the subsequent test. In comparison to the group that did not get the plyometric training treatment, the results indicated a substantial increase ($p<0.05$) in the leg muscular explosive power among the participants who received the plyometric training approach. For swimmers who want to increase their performance in the water, plyometric training is essential since it offers several key advantages. For swimmers, the major objective of plyometric training is to improve muscular strength and explosiveness, particularly in the lower body parts like the legs and pelvis.
Keywords: Plyometric, Swimming, leg muscle explosive power, untrained

Introduction

In swimming, the most recommended improvement in swimming performance is strength training. (Amaro et al., 2017) (Lanos et al., 2023). Strength training is necessary at the start of the jump (West et al., 2011), or flip turn (Jones et al., 2018), so as to accelerate swimming. At short distances such as 50 meters, initial speed and acceleration are very important. This involves a strong and fast leg kick to provide a great initial push. The main factor in the success of these actions is explosive power. The training method that can improve explosive power is plyometric training (Bahtra et al., 2023). A plyometric training program has the advantage of potentially increasing swimmers' strength without necessarily increasing their thigh muscle mass, which could result in increased drag in the water and decreased swimming speed. (Toussaint et al., 2004). Plyometric training does not interfere with flexibility in swimmers at all, precisely with high flexibility in swimmers can improve better performance in swimmers. (Willems et al., 2014). The literature search on systematic reviews and meta-analysis studies mentioned that plyometric training is an alternative exercise intervention program. (Ramirez-Campillo et al., 2022) (Ojeda-Aravena et al., 2023). In the previous studies, there were several studies mentioning that plyometric training was able to increase muscle explosive power, but the difference in this study was to show that swimmers if without plyometric training, maximum performance will be difficult to obtain. This study aims to examine how plyometric training techniques may help swimmers improve their leg muscles' explosive strength. This study offerred a thorough examination of the crucial function that plyometric training played in generating exceptional performances among swimmers by concentrating on the distinct relationship that exists between this type of training and achieving optimal performance.

The goal of this study was to go beyond the widely held belief that plyometric exercise increases muscular explosiveness. Furthermore, the goal of this study was to demonstrate that swimmers who do not practice plyometrics may find it difficult to perform at their best (Andrade et al., 2018). Therefore, the primary goal of this study was to investigate and get a deeper understanding of how plyometric training methods can significantly enhance swimmers' leg muscular strength and explosiveness. By using this method, the study sought to give a deeper understanding of the precise effects of plyometric workouts on swimmers, particularly

Corresponding Author: ANDRI GEMAINI, E-mail: andrigemaini@fik.unp.ac.id

when it came to enhancing muscle explosive power. This study has the potential to reveal new insights by thoroughly examining the relationship between these workouts and a swimmer's capacity to initiate a push, execute a flipturn, or conduct other critical swimming tasks (Amaro et al., 2017).

Furthermore, it may contribute to the understanding of whether a deficiency in plyometric training may be a barrier to reaching peak performance and speed over short distances, like 50 meters. Because of this, this study not only examines the advantages of plyometric exercise but also draws attention to the possible drawbacks of its lack.

It has been demonstrated that plyometric training, which focuses on building muscular explosive power, is an efficient technique. However, this study took things a step further by emphasizing how important plyometric training can be to swimmers reaching their peak performance. The goal of the study was to see whether using plyometric training methods can help swimmers become more explosive with their leg muscles (Ojeda-Aravena et al., 2023). The study went beyond listing the advantages of these workouts in general to particularly investigate the possibility that swimmers may not be able to perform to their fullest potential if they do not engage in plyometric training.

This study aims to investigate the relationship between swimmer performance and plyometric training, which should give swimming coaches and athletes a strong foundation for developing more effective training methods and strategies. All things considered, this study may alter the paradigm of training methods used to increase swimmers' muscle explosiveness and attain peak track performance (Jones et al., 2018).

Materials & methods

Study Design

There was a pre and post control group design in this experimental study. Purposive sampling was used to choose the research participants, and after that, they were split into two groups: the treatment group (G2), which used the plyometric method, and the control group (G1), which received swimming instruction.

Subject

Thirty male swimmers with normal BMI who were actively involved in training were the research subjects in this study. The inclusion criteria for this study included swimmers between the ages of eighteen and nineteen. Then, the swimmers under the age of eighteen were excluded from this study. The swimmers who did not participate in regular training were the study's dropout criterion. In addition to signing a written consent form, the research participants got instructions on research procedures.

Procedures

The informed permission form was completed and submitted by the research sample, and the researcher provided an explanation of the study's goals prior to its start. The sample was split up into two groups: group 1, which had 15 swimmers in total, and group 2, which also included 15 swimmers. Group 2 (G2) served as the treatment group, and Group 1 (G1) served as the control group. Eighteen sessions, four times a week, were scheduled to administer the treatment. Pre-test data were gathered for explosive power prior to therapy, and post-test data were gathered for explosive power following 18 sessions of treatment. Utilizing a vertical leap test, explosive power was determined.

Exercise Program

Table 1 . Exercise Program

Day 1-6: Building a Foundation	Day 7-12: Increasing Intensity	Day 13-18: Increasing Complexity
Focus on Legs and Hips	Focus on Legs, Hips, and Core	Focus on Legs, Hips, Core, and Flexibility
Day 1 & 2:	Day 7 & 8:	Day 13 & 14:
Box Jumps: 3 sets x 10 repetitions	Depth Jumps + Med Ball Throws: 3 sets x 8 repetitions	Multi-Directional Box Jumps: 3 sets x 6 repetitions
Split Squats: 3 sets x 10 repetitions per leg	Bulgarian Split Squats: 3 sets x 10 repetitions per leg	Plank Variations: 3 sets x 30 seconds
Day 3 & 4:	Day 9 & 10:	Day 15 & 16:
Depth Jumps: 3 sets x 8 repetitions	Single Leg Box Jumps (higher): 3 sets x 6 repetitions per leg	Lateral Bounds: 3 sets x 8 repetitions
Kettlebell Swings: 3 sets x 12 repetitions	Russian Twists: 3 sets x 12 repetitions	Dead Bug Exercises: 3 sets x 12 repetitions
Day 5 & 6:	Day 11 & 12:	Day 17 & 18:
Single Leg Box Jumps: 3 sets x 8 repetitions per leg	Bounds (Wide Jumps): 3 sets x 10 repetitions	Single Leg Bounds: 3 sets x 8 repetitions per leg
Forward Jumps: 3 sets x 10 repetitions	Romanian Deadlifts: 3 sets x 10 repetitions	Hip Flexor Stretches: 3 sets x 30 seconds

Statistical analysis

The IBM SPSS version 26 application was utilized for statistical analysis in this study. The descriptive tests were run to determine the mean, standard deviation, and standard error. In addition, the Shapiro-Wilk method is used to check for normality. If the data are normally distributed, the paired t test is used to test for differences; if not, the Wilcoxon test signed placement test is used to test for differences.

Results

Based on the data obtained on the subject 30 swimmers with characteristics that are not different, in the age data, the p value was 0.000, the p value in height was 0.641, while in the weight value with a p value of 0.056, and then in BMI the p value was 0.152. The t-test revealed no statistically significant differences in any group's criteria (p≥0.05). For more details, please refer to the following table:

Table 2: Research participants' characteristics

Data	Group	N	X̄±SD	Shapiro-Wilk	p
Age	G1	15	18.47±0.52	0.630	0.000
	G2	15	18.60±0,51	0.643	
Height	G1	15	168.53±1.81	0.957	0.641
	G2	15	169.60±2.07	0.950	
Weight	G1	15	65.47±5.64	0.885	0.056
	G2	15	65.20±5.56	0.878	
BMI	G1	15	23.04±1.90	0.913	0.152
	G2	15	22.66± 1.78	0.924	

With the aid of SPSS 26 and the Shapiro-Wilk test, the normality test of the explosive power test was conducted in this study. If the significance value is larger than 0.05, or Sig>0.05, the data are considered normally distributed; if it is smaller than 0.05, or Sig.<0.05, the data were considered abnormal. The data can be considered regularly distributed since the normality test findings show that the significant value is 0.524> 0.05. The results of the normalcy test are shown in the table below:

Table 3. Results of the normality test for explosive power

Data	Group	Shapiro-Wilk	
		N	p
Explosive Power (Pre-Test)	G1	15	0.053
	G2	15	0.162
Explosive Power (Post-Test)	G1	15	0.018
	G2	15	0.524

In the table of results from explosive power there are significant differences in paired t-tests (p <0.05). The following can be described from the following table:

Table 4. Result of Explosive Power

Different Test Method	Group	p-value
Paired T-test	G1 (Pre-Test and Post-Test)	0.433
	G2 (Pre-Test and Post-Test)	0.000*

An effective graphical tool for comparing a sample of data to a theoretical normal distribution was the Normal Q-Q Plot, also known as a Quantile-Quantile Plot. Determining whether the data has a normal distribution is helpful.

The term "Post-Test G2" designed a variable or dataset, and the "Post-Test G2 Normal Q-Q Plot" would include graphing the data's quantiles against the quantiles of a hypothetical normal distribution. The data may be somewhat regularly distributed if the plot's points almost exactly follow a straight line.

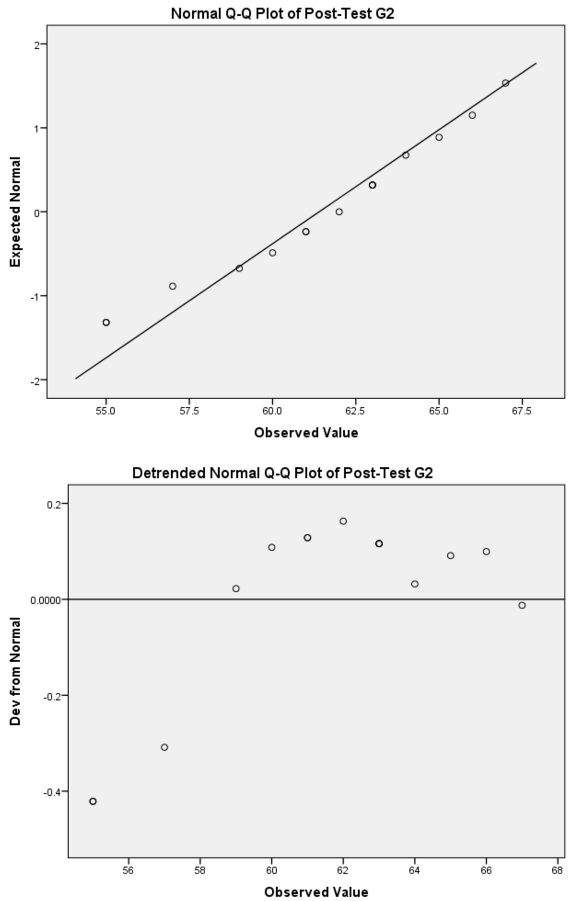

Figure 1: Normal Q-Q Plot of Post-Test G2 and Detrended Normal Q-Q Plot of Post-Test G2.

On the other hand, a Detrended Normal Q-Q Plot was a variation of the normal Q-Q plot where any trend or systematic pattern in the data was removed. This was done to focus specifically on the distributional aspects of the data. It can be particularly useful if there is a suspicion of non-normality due to a trend in the data. Both plots were tools used in statistical analysis to assess the normality assumption, which was often important for certain types of statistical tests and modelling techniques. If the data did not follow a normal distribution, alternative statistical methods may need to be considered.

Dicussions

Analyzing the impact of plyometric exercise on swimmers' explosive training was the aim of this study. Our study's findings demonstrated that although the control group did not considerably boost their explosive power, the treatment group that received plyometric training was able to do so. This is valid with the theory that says that plyometric training can maximize swimmers' performance. Swimming is characterized as a lifelong and low-impact activity, considered one of the most popular among children to adults (Bullough et al., 2015) (Mardesia et al., 2021). Plyometric training plays an important role in improving a swimmer's performance. The fast and explosive movements practiced in a plyometric program can provide a number of crucial benefits to swimming athletes. Firstly, they enable the development of muscular strength and explosiveness(Ramirez-Campillo et al., 2022),(Ihsan et al., 2020) particularly in the legs and pelvis (de Marche Baldon et al., 2014).

This is the key in maximizing the initial push off the starting line and maintaining speed during the race. By swimming training using a plyometric program will increase swimmer performance (Ihsan et al., 2022) because leg muscle explosiveness has a very important role in swimming (Potdevin et al., 2011) (Bishop et al., 2009) (Ihsan et al., 2023). It is seen that the swimmers' explosive power increased when they performed the plyometric exercise eighteen times. Our results are corroborated by a study that found that increasing maximum explosive power through four weekly sessions of plyometric training is a highly effective way to achieve this goal(Ramirez-Campillo et al., 2022). whereas in previous research results there were variations of plyometric exercises to improve athlete performance with a routine training duration of 7 weeks (de Villarreal et al., 2008). There are many ways that can facilitate plyometric training, one of which is by using a digital platform, by using applications that can maximize swimmer performance(Hidayat et al., 2022). some other factors in maximizing this plyometric exercise is the relationship of a good body mass index and also height, ideal body weight (Welis et al., 2023). In the final analysis, the plyometric training approach can increase the explosiveness of the leg muscles (Neldi, 2020). Some limitations in this study are recognized. The physiological and psychological physiological and psychological aspects of the increase in leg muscle explosive power due to the plyometric exercise method have not been investigated and analyzed. It is hoped that further research will analyze the effects of the plyometric training method physiologically and psychologically in order to be able to add insight.

Conclusions

The 18 reps of the plyometric training method, performed four times in a week, have the ability to improve swimmers' explosive power. For swimmers to perform at their best, leg muscle explosiveness is a necessary physical condition. When creating a training program, it is strongly advised to use the plyometric training method. Plyometric training is an important component in improving swimmers' leg muscle explosiveness. By emphasizing fast and explosive movements, these exercises can significantly strengthen and improve the ability of muscles to generate power instantly. This is the key in maximizing a swimmer's performance, especially in situations that require quick initial reaction and drive, such as in swimming races. This plyometric training program is highly recommended for swimmers, the training program must be inclusive and varied and evaluated every time, and also done consistently for maximum improvement results. To sum up, this study highlights the critical role that plyometric training plays as a foundational element in improving the explosive strength of swimmers' leg muscles. These exercises' integration of fast and explosive movements has shown to significantly increase muscle power, offering a vital path to optimizing swimming performance overall—particularly in scenarios requiring quick reflexes and force production, like swimming competitions.

This study's theoretical contribution is that it confirms how important plyometric training is for swimmers. Through a direct correlation between this particular training regimen and enhanced leg muscle explosiveness, the study offers a theoretical framework for comprehending how targeted training might result in observable gains in important domains of athletic performance.

In practical terms, this study has important ramifications for swimming community training approaches. The suggestions for a diverse and inclusive plyometric training program and the requirement for ongoing assessments take into account the real-world issues that coaches and athletes face. The focus on consistency when putting plyometric training into practice emphasizes its long-term benefits and emphasizes the need for persistent, committed work in order to achieve the greatest possible improvement.

The combined data not only validate that plyometric exercise is a useful tool for increasing swimmers' leg muscle explosiveness, but they also offer a tactical guide for incorporating it into training plans. This study adds conceptually and practically to the larger conversation about maximizing athletic performance by providing information that can guide training regimens and approaches in the context of competitive swimming.

Conflicts of interest

This study does not contain any conflicts of interest.

References:

Amaro, N. M., Marinho, D. A., Marques, M. C., Batalha, N. P., & Morouço, P. G. (2017). Effects of dry-land strength and conditioning programs in age group swimmers. *Journal of Strength and Conditioning Research*, *31*(9), 2447–2454. https://doi.org/10.1519/JSC.0000000000001709

Andrade, D. C., Beltrán, A. R., Labarca-Valenzuela, C., Manzo-Botarelli, O., Trujillo, E., Otero-Farias, P., Álvarez, C., Garcia-Hermoso, A., Toledo, C., Del Rio, R., Silva-Urra, J., & Ramírez-Campillo, R. (2018). Effects of plyometric training on explosive and endurance performance at sea level and at high altitude. *Frontiers in Physiology*, *9*, 1415. https://doi.org/10.3389/fphys.2018.01415

Bahtra, R., Putra, A. N., Septri, Dinata, W. W., Andria, Y., & Susanto, N. (2023). Improving endurance ability through endurance training model-based drill technique. *International Journal of Human Movement and Sports Sciences*, *11*(2), 335–341. https://doi.org/10.13189/saj.2023.110210

Bishop, D. C., Smith, R. J., Smith, M. F., & Rigby, H. E. (2009). Effect of plyometric training on swimming block start performance in adolescents. *The Journal of Strength & Conditioning Research*, *23*(7). https://journals.lww.com/nsca-jscr/fulltext/2009/10000/effect_of_plyometric_training_on_swimming_block.33.aspx

Bullough, S., Davies, L. E., & Barrett, D. (2015). The impact of a community free swimming programme for young people (under 19) in England. *Sport Management Review*, *18*(1), 32–44.

de Marche Baldon, R., Lobato, D. F. M., Yoshimatsu, A. P., dos Santos, A. F., Francisco, A. L., Santiago, P. R. P., & Serrão, F. V. (2014). Effect of plyometric training on lower limb biomechanics in females. *Clinical Journal of Sport Medicine*, *24*(1), 44–50.

de Villarreal, E. S. S., González-Badillo, J. J., & Izquierdo, M. (2008). Low and moderate plyometric training frequency produces greater jumping and sprinting gains compared with high frequency. *The Journal of Strength & Conditioning Research*, *22*(3), 715–725.

Hidayat, H., Komaini, A., & Gemaini, A. (2022). Smart Application for Smart Learning: How the influence of the factors on student swimming learning outcomes in sports education. *International Journal of Interactive Mobile Technologies*, *16*(17).

Ihsan, N., Bafirman, Sujana, A., & Permana, A. Y. (2020). Design of instrument explosive power leg muscles sensor based. *Journal of Physics: Conference Series*, *1594*(1). https://doi.org/10.1088/1742-6596/1594/1/012038

Ihsan, N., Hanafi, R., Sepriadi, Okilanda, A., Suwirman, & Mario, D. T. (2022). The effect of limb muscle explosive power, flexibility, and achievement motivation on sickle kick performance in pencak silat learning. *Physical Education Theory and Methodology*, *22*(3), 393–400. https://doi.org/10.17309/tmfv.2022.3.14

Ihsan, N., Satria, R., Rifki, M. S., Komaini, A., & Ilham. (2023). Development of a digital-based tool to measure volleyball players' upper limb muscle explosive power. *Sport Mont*, *21*(1), 87–94. https://doi.org/10.26773/smj.230214

Jones, J. V, Pyne, D. B., Haff, G. G., & Newton, R. U. (2018). Comparison between elite and subelite swimmers on dry land and tumble turn leg extensor force-time characteristics. *Journal of Strength and Conditioning Research*, *32*(6), 1762–1769. https://doi.org/10.1519/JSC.0000000000002041

Lanos, M. E. C., Ihsan, N., Okilanda, A., Handayani, W., Manullang, J. G., & Lestari, H. (2023). Effectiveness of interactive multimedia supported physical education using jurus tunggal tangan kosong in the new normal era. *International Journal of Human Movement and Sports Sciences*, *11*(2), 261–267. https://doi.org/10.13189/saj.2023.110201

Mardesia, P., Dlis, F., Sukur, A., Rusdi, & Abdillah. (2021). Effectiveness of teaching style: An alternative breaststroke swimming learning model in higher education. *International Journal of Human Movement and Sports Sciences*, *9*(6), 1236–1243. https://doi.org/10.13189/saj.2021.090618

Neldi, D. H. (2020). Hand-Eye Coordination and Arm Muscles Explosive Power to Basketball Player's Shooting. *International Journal of Psychosocial Rehabilitation*, *24*(5), 728–733. https://doi.org/10.37200/ijpr/v24i5/pr201740

Ojeda-Aravena, A., Herrera-Valenzuela, T., Valdés-Badilla, P., Báez-San Martín, E., Thapa, R. K., & Ramirez-Campillo, R. (2023). A Systematic Review with Meta-Analysis on the Effects of Plyometric-Jump Training on the Physical Fitness of Combat Sport Athletes. *Sports (Basel, Switzerland)*, *11*(2). https://doi.org/10.3390/sports11020033

Potdevin, F. J., Alberty, M. E., Chevutschi, A., Pelayo, P., & Sidney, M. C. (2011). Effects of a 6-week plyometric training program on performances in pubescent swimmers. *Journal of Strength and Conditioning Research*, *25*(1), 80–86. https://doi.org/10.1519/JSC.0b013e3181fef720

Ramirez-Campillo, R., Perez-Castilla, A., Thapa, R. K., Afonso, J., Clemente, F. M., Colado, J. C., de Villarreal, E. S., & Chaabene, H. (2022). Effects of plyometric jump training on measures of physical fitness and sport-specific performance of water sports athletes: a systematic review with meta-analysis. In *Sports medicine - open* (Vol. 8, Issue 1, p. 108). https://doi.org/10.1186/s40798-022-00502-2

Toussaint, H. M., Roos, P. E., & Kolmogorov, S. (2004). The determination of drag in front crawl swimming. *Journal of Biomechanics*, *37*(11), 1655–1663. https://doi.org/10.1016/j.jbiomech.2004.02.020

Welis, W., Yendrizal, Darni, & Mario, D. T. (2023). Physical fitness of students in Indonesian during the COVID-19 period: Physical activity, body mass index, and socioeconomic status. *Physical Activity Review*, *11*(1), 77–87. https://doi.org/10.16926/par.2023.11.10

West, D. J., Owen, N. J., Cunningham, D. J., Cook, C. J., & Kilduff, L. P. (2011). Strength and power predictors of swimming starts in international sprint swimmers. *Journal of Strength and Conditioning Research*, *25*(4), 950–955. https://doi.org/10.1519/JSC.0b013e3181c8656f

Willems, T. M., Cornelis, J. A. M., De Deurwaerder, L. E. P., Roelandt, F., & De Mits, S. (2014). The effect of ankle muscle strength and flexibility on dolphin kick performance in competitive swimmers. *Human Movement Science*, *36*, 167–176. https://doi.org/10.1016/j.humov.2014.05.004