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The Effect of Pulley Training on Leg Muscle Power in Swimming Athletes at the Bekasi Olympic Aquatic Club, Bekasi Regency

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Abstract

Leg muscle strength is a crucial physical component for swimmers, which will determine their initial speed during the start and turns. This study explicitly analyzes the impact of a structured pulley training program on the leg muscle strength of 30 swimmers at the Bekasi Olympic Aquatic Club, where limitations in this area had previously been identified. Using a quasi-experimental design with one pre-test and post-test group, athletes underwent a combined land and water pulley training intervention for 14 days. Leg muscle strength was measured directly through Vertical Jump (VJ), while its functional impact was measured through 50-meter butterfly swimming time. A Paired-Samples T-Test revealed two significant outcomes: first, a highly significant increase in leg power, evidenced by a 2.30 cm average increase in VJ height ($t(29) = -8.460$, $p < .001$); and second, a highly significant improvement in swim performance ($t(29) = 6.565$, $p < .001$). It is concluded that pulley training is a valid and effective intervention. These dual findings provide strong empirical evidence for coaches to implement this program to optimize athletes' fundamental physical capabilities and directly enhance competitive performance.

How to Cite

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INTRODUCTION

Swimming has been around since prehistoric times. Evidence that swimming was practiced in the past can be found in paintings of swimmers in the "Swimmer's Cave." Meanwhile, competitive swimming as a sport only began around the 1800s after many swimming pools were built. At that time, the world was first introduced to the breaststroke. (Rahmani et al., 2017). Swimming also has a history that is closely linked to the history of human life. And this history of swimming needs to be known by swimmers in general. (Asa, 2013). In ancient countries, swimming was used to train and prepare young people for national defense. Similarly, after the establishment of schools in ancient times in countries such as Egypt, China, Greece, Rome, and many others, swimming was always included in the school curriculum. Therefore, swimming has been known and has continued to develop since ancient times until the present day. This is evidenced by the existence of swimming competitions at the national, regional, and international levels.

Nowadays, swimming has become a popular sport for many people. Swimming is also competed in world championships between countries. Swimmers compete fiercely to win gold medals by being the fastest. In the past, when swimming was not yet an official sport, people would swim in fish ponds, rivers, or even bathing wells. Swimming indeed has numerous benefits for the body. Among other things, children who regularly swim will have good physical growth, maintain healthy breathing, and have excellent stamina.(Bompa & Haff, 2009).

Based on the quote (Tiara & Supriyono, 2021) the history of Indonesian swimming achievements is a long journey from pioneers at the Asian level to becoming a dominant force in Southeast Asia. It began with pioneers like Habib Nasution, who made a name for himself at the Asian Games in the 1960s. The peak of this journey occurred during the golden era of the 1980s to the early 2000s, when legend Richard Sam Bera, with his collection of 23 gold medals, led Indonesia to dominate the SEA Games stage outright. In the modern era, the torch of the struggle was carried forward by I Gede Siman Sudartawa, a standout in the backstroke events, and marked by the rise of the women's sector through new talents like Masniari Wolf. Despite increasingly fierce competition, this study shows a consistent transformation in Indonesian swimming, which will continue to produce champions and strive to bring pride to the country at the regional and global levels.

Swimming at the Bekasi Olympic Aquatic Club, Bekasi Regency, includes two main branches: Competitive Swimming and Artistic Swimming. For athletes in both branches, mastery of leg muscle strength is an absolutely essential and irreplaceable element. Lower body muscle strength is vital for generating propulsion, maintaining buoyancy, and achieving speed in the water, whether it be kicking movements in various competitive swimming styles or supporting acrobatic maneuvers and lifting the body above the water surface in artistic swimming.

According to (Edy Dharma Putra Duhe, 2019) Leg muscle strength is one of the physical components required in all sports. Leg muscle strength is used to perform movements such as pushing, kicking, and jumping.

Developing optimal and efficient leg muscle strength is very important. Swimming is not only about the ability to move in water, but also requires greater leg muscle strength and speed, which are the main drivers and determinants of stability when in the pool.

Referring to the statement (Subhan, Sukardi Putra, 2016),"power is the result of a combination of strength and speed." With trained leg muscle power, swimmers can create greater thrust, maintain swimming speed, and improve movement efficiency in all swimming styles (such as freestyle, backstroke, breaststroke, and butterfly). Additionally, this will significantly support the performance of synchronized swimmers in executing complex movements and mastering their movements in the water. According to (IRHANA, 2020) strength is a component of a person's physical condition regarding their ability to use their muscles to bear loads while working.

According to (Amanda Syukriadi et al., 2020), "the leg muscles are the lower limb muscles" which are divided into two main segments, namely the thigh muscles or upper leg muscles and lower leg muscles. Leg muscle strength has a direct correlation with the duration and intensity of the leg kick in generating forward movement speed when swimming. As one of the essential components of physical condition, lower limb muscle strength significantly determines swimming speed, particularly in the effectiveness of a swimmer's leg movements. Strong leg kicks and swings generate maximum propulsive force to move the body quickly, and over certain distances, provide a speed advantage over other forms of movement.

Based on initial observations conducted at the Bekasi Olympic Aquatic Club, it was found

that some athletes still experience limitations in leg muscle strength, especially when pushing off from the pool wall and at the start, which affects swimming speed and movement efficiency. Given the crucial role of lower limb muscle strength in achieving maximum performance in competitive swimming and synchronized swimming, testing the effectiveness of pulley training as an intervention is highly relevant. This study is expected to make a real contribution to efforts to develop more effective training programs for athletes at the Bekasi Olympic Aquatic Club, with the aim of optimizing their lower limb muscle strength, which will ultimately improve the club's performance.

Seeing the existing problems, researchers proposed the application of pulley training methods (both on land and in water) with the hope of providing a direct effect on the leg muscles, thereby increasing the athletes' thrust. (Chortane et al., 2022) mentions that. The pulley training method, developed by Pietro Enrico, is used in swimming training to help swimmers achieve maximum speed and develop strong, optimal leg muscles.

Training with resistance bands, commonly known as pulleys. Designed and developed as a form of physical fitness training to improve swimming performance. This exercise can be done both outside and inside the pool and includes a series of movements tailored to the physical demands of swimming. These movements are integrated with comprehensive and optimal swimming techniques, making them an effective alternative during training. Resistance band exercises provide an instant solution for increasing lower body muscle strength. (Tama, 2015).

Resistance training in water is intended for the leg muscles. This exercise is based on general swimming movements, but can also be modified for more specific purposes, such as focusing on the leg muscles that directly affect propulsion when swimming. These exercises aim to increase the speed and propulsive power of the leg muscles, which play a crucial role in mastering swimming skills. Physical attributes such as muscle strength, endurance, agility, balance, and body stability can be improved through these water resistance exercises, which indirectly increase the efficiency and effectiveness of swimming movements. (Wicaksana & Rachman, 2018).

Leg muscle strength is the ability of the lower body muscles, such as the quadriceps femoris, hamstrings, gluteus maximus, and gastrocnemius, to generate power quickly and explosively. This set of components is a crucial aspect of swimming, especially during the start, wall push-off, and leg kick, which will determine the speed and efficiency of an athlete's movements in the water. Theoretically, muscle strength development is based on the Strength Theory proposed by Tudor O. Bompa and Gregory G. Haff in their book Periodization: Theory and Methodology of Training (2009). In this theory, strength (muscle explosive power) is defined as the product of force and velocity, formulated as: Strength = Force × Velocity. (Bompa & Haff, 2009).

The main problem for swimmers at the Bekasi Olympic Aquatic Club is uneven leg strength. Some junior athletes struggle with proper training techniques and lack variety, resulting in inefficient use of their legs while swimming. As a result, their movements waste energy and it is difficult for them to reach maximum speed. They need training interventions that focus on overcoming this weakness.

Based on the identified problems, namely limitations in explosive power and leg muscle strength among athletes, researchers sought to conduct research focusing on the application of pulley training methods (both in water and on land) for swimmers at the Bekasi Olympic Aquatic Club. This research is an important step because few studies have specifically examined the impact of cable training methods on physiological aspects, particularly leg muscle strength, among club-level swimmers. It is hoped that this research will reveal the significant effects of pulley training methods, thereby providing accurate data and contributing to the development of effective training programs to improve the performance of swimmers in Indonesia.

The novelty of this study focuses on the implementation of a modified water resistance training protocol. Overall and specifically, this study combines pulley exercises with the use of a swimming board, aiming to completely isolate the leg muscles by eliminating movement in the arms. This study then introduces a new training method that focuses on purely increasing leg muscle explosive power. By restraining hand movement using a swimming board when performing resistance training (pulley), the research subjects can only rely on leg thrust, thereby providing a more focused stimulus on the targeted muscle group.

METHODS

According to (Kusumawati, 2015), This experimental study is a type of research in which samples are given treatment or manipulation. Three important elements in experimental rese-

arch are control, manipulation, and detailed observation. This research method aims to determine whether there is an effect of pulley training on leg muscle strength in Bekasi Olympic swimmers.

This study employs a quantitative approach using a quasi-experimental design, which is methodologically intended to test the causal relationship between the independent variable (pulley training) and the dependent variable (leg muscle power) without random assignment of subjects. This approach is highly suitable for research in the field of elite sports, particularly in real-world situations where randomization is difficult due to practical and ethical constraints, such as the homogeneity of training groups or the continuity of athlete development programs. As noted by (Listyana, 2021), quasi-experimental design is an effective strategy for testing interventions in real-world contexts without losing empirical relevance.

The population in this study consisted of all swimmers who were members of the Bekasi Olympic Aquatic Club, Bekasi Regency. This club is one of the regency-level swimming training centers that actively trains young athletes up to children's age and regularly participates in regional and national championships. This population was deliberately selected because its characteristics were in line with the study objectives, namely to assess the effectiveness of pulley training in increasing lower limb muscle strength in athletes who already have relatively uniform technical skills and fitness levels. Homogeneity in terms of biological age, training experience, and fitness status is very important in experimental design because it can reduce the influence of confounding variables on research results. (Hidayat, 2021).

The population was selected deliberately, with only 30 children chosen from all the athletes at the Bekasi Olympic Aquatic Club. A pretest was conducted on the first day, followed by testing of the pulley training method for 14 days of training, or a two-week training period, with regular water and land pulley training.

Table 1. Population & Sample

Age Group	Number of people	(%)
KU 3	8	26.7%
KU 4	8	26.7%
KU 5	14	46.7%
Total	30	100%

The population in this study consisted of all 30 active athletes at the Bekasi Olympic Aquatic Swimming Club. The distribution of the population based on age groups can be seen in **Table 1.** The researchers conducted a preliminary pretest on this data to determine the initial data before applying the water and land pulley training method.

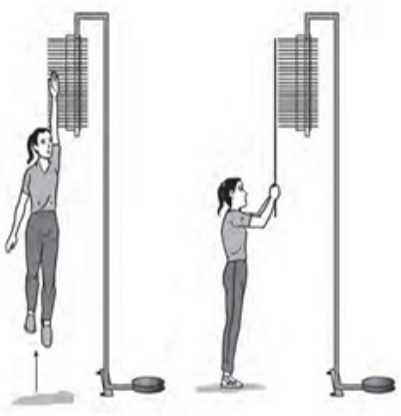

Figure 1. Vertical Jump Test

In its implementation and its basic concept the measurement of Power tungkai using Vertical Jump measures the difference between the initial achievement and the final achievement by making a vertical jump. Then we get the centimeter size of the result of the jump which is an indicator of the level of leg power for those tested. In line with the opinion of Ismaryati according to (Prabowo et al., 2020) Seeing the current era of globalization there are several tools that can measure limb muscle power that has been based on technology in its use according to (Prabowo et al., 2020) a measurement tool for leg power, among others Jump DF and Force Plate. But in reality, he prefers to use conventional methods to measure leg power using Vertical Jump. In this case the researcher tries to develop and make a prototype tool that develops a Vertical Jump instrument based on digital, which will use sensors and software in the process of calculation and input of existing data. While in the process of research and development of this tool will involve several elements in it, among others, students majoring in electronics, physics and test and measurement experts who are in the environment of Padang State University. So researchers are interested in taking the title "Development of Digital-Based Vertical Jump Test Instrument" which is expected to be useful and useful to support the learning process of test and measurement courses at the Faculty of Sports Sciences and the achievement of Indonesia's achievements in the future as well as the development of sports science along with the development of science and technology.

RESULTS AND DISCUSSION

The data collection process was conducted over a period of 14 days. Initial data collection produced pretest data. The water and land pulley training methods were applied during a 14-day period of routine training, revealing significant differences in the changes in the athletes' time records who were given these training methods.

Referring to the table above shows the results of the analysis of the difference between pretest and post-test leg muscle power data measured using a vertical jump instrument. The results of the Paired-Samples T-Test show that there is a statistically significant difference between the results before and after treatment ($t(29) = -8.460$, $p < .001$). Specifically, there was an average increase in jump height of 2.30 cm in athletes after participating in the pulley training program. This finding indicates that the intervention provided was effective in significantly improving lower limb muscle power.

Descriptive statistical analysis was performed on data from 30 research subjects (N=30) to compare scores before and after treatment with pulley exercises. The results of the analysis at baseline (before treatment) showed that the group's mean score was 5497.57, with a standard deviation of 352.34. The range of scores at baseline was between 4501.00 (minimum score) and 5988.00 (maximum score). After receiving treatment (post-treatment), the group's average score decreased to 5359.97, with the standard deviation also decreasing slightly to 333.29. The score range after the intervention was recorded between 4321.00 (minimum score) and 5811.00 (maximum score).

Overall, the comparison in this description shows a downward trend in average scores after the research subjects participated in the training program. Additionally, the smaller standard deviation in the post-test data suggests that the group's performance scores became slightly more uniform or consistent after the treatment.

Before conducting the main hypothesis test, a prerequisite analysis test was first performed to ensure that the assumption of data normality was met. The normality test was performed on the residual data using the One-Sample Kolmogorov-Smirnov method, supplemented with the Lilliefors significance correction to improve accuracy. Based on the analysis of 30 samples (N=30), the Kolmogorov-Smirnov test statistic value was 0.158. The significance level (p-value) obtained from this test was $p = 0.055$ (Asymp. Sig. (2-tailed) = .055).

According to the testing criteria, where the obtained significance value (0.055) is greater than the set significance level ($\alpha = 0.05$), the null hypothesis (H_0) stating that the data is normally distributed is not rejected. Thus, it can be concluded that the research data meets the assumption of normality. The fulfillment of this assumption validates the use of parametric statistical tests, namely the Paired-Samples T-Test, in the next stage of analysis.

To evaluate the effectiveness of the pulley exercise intervention, a paired sample t-test was conducted to compare subjects. performance scores before (pre-test) and after (post-test) the treatment. The results of the analysis showed a statistically significant difference between the two conditions, $t(29) = 6.565$, $p < .001$. Specifically, there was a decrease in the average score of 137.60 ($M = 137.60$, $SD = 114.80$) from pre-test to post-test, indicating a significant improvement in performance among the study subjects after participating in the training program.

The 95% confidence interval (95% CI) for the mean difference ranges from 94.73 to 180.47. Since this interval does not include zero, this finding further supports that the impact of the pulley exercise intervention is statistically significant.

Specifically, the effectiveness of this intervention was first confirmed through an analysis of the vertical jump instrument, which serves as the primary measure of lower limb muscle power. The results of the Paired-Samples T-Test showed an average increase in jump height of 2.30 cm between the pre-test and post-test. This increase was statistically significant ($t(29) = -8.460$, $p < .001$), validly indicating that the pulley training program directly provided the appropriate stimulus to enhance the lower limb muscles' ability to generate explosive force.

Furthermore, improvements in these fundamental physical attributes were shown to have a positive impact on the athletes' aquatic performance. Analysis of the second variable, the 50-meter butterfly swim time, also showed a very significant improvement in performance ($t(29) = 6.565$, $p < .001$). This dual finding reinforces the argument that the increase in lower limb muscle strength resulting from pulley training is not merely an isolated physical improvement, but rather a functional advancement that can be effectively applied to faster and more efficient swimming movements. This improvement addresses the limitations previously identified in athletes, particularly during the start phase and wall push-off. These findings are consistent with

previous research by (Chortane et al., 2022), who stated that resistance training in water also has a positive impact on the explosive power of the leg muscles during the push-off phase of a sprint start.

Similar results were also reported (Crowley et al., 2017), where researchers reported that high-intensity training using water pulleys can provide additional speed at the start or reversal.

These results contradict a study by (Valkoumas & Gourgoulis, 2024), which states that these differences are likely due to differences in the sample population of athletes studied and slight differences in the intensity of the training methods used.

CONCLUSION

Based on the series of data analysis and discussion outlined above, this study draws the fundamental conclusion that the implementation of a pulley training program, which integrates land and water training sessions over a 14-day period, has been proven to be significantly and effectively improve lower limb muscle power in swimmers at the Bekasi Olympic Aquatic Club. This conclusion is based on strong empirical evidence from two dependent variables measured: direct physical component measurements and functional performance measurements in water.

Pulley training can be recommended as one of the most effective supplementary training methods to be routinely integrated into athlete development programs. For future research, it is suggested to examine the effectiveness of pulley training over a longer period or compare it with other power training methods to identify the most optimal training protocol for swimmers across various age groups and skill levels.

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