Muscle Strength of Students in Wetland Area Schools: Internalizing Physical Literacy through Physical Education Learning Based on Project-Based Learning

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Abstract. Muscle strength refers to the ability of muscles to contract and generate tension against resistance or a load, allowing them to support the body's activities. It does not develop automatically but requires regular training, measurement, and programming. However, strength training habits have not yet become a cultural norm among students in wetland area schools. This research aims to assess the impact of incorporating physical literacy into physical education through project-based learning on students' muscle strength. The study employs a quasi-experimental design with a pretest-posttest group design. The research population includes 11th-grade students at Madrasah Aliyah Negeri I Barito Kuala, with classes XI-A and XI-B serving as the experimental groups and classes XI-D and XI-E as the control groups. Arm muscle strength was measured using the push-up test, back muscle strength with the back-up test, and abdominal muscle strength with the sit-up test. Data analysis was performed using IBM SPSS version 26. Initial tests included normality, homogeneity, and multicollinearity checks. For normally distributed and homogeneous data, the Paired t-test was used to compare pretest and posttest results within the experimental and control groups. For non-normally distributed data, the Wilcoxon Signed-Rank Test was used. To compare the experimental and control groups, ANOVA Welch Test and Brown-Forsythe Test were applied as robust tests due to non-homogeneous variance between groups. The results indicated an increase in muscle strength among students in wetland area schools after incorporating physical literacy into physical education through project-based learning, compared to the control group, which received direct instruction.

Keywords: Muscle strength; Physical Literacy, Physical Education, Wetlands

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1 Introduction

Muscle strength is a basic component of physical fitness that refers to the ability of muscles to produce maximum power when fighting external weights or resistance. Muscle strength is a key component of physical fitness, alongside cardiorespiratory fitness, body composition, muscular endurance, and flexibility [1] According to [2] muscle strength is positively correlated with physical and mental Health-Related Quality of Life (HRQoL), suggesting that interventions to increase muscle strength can improve overall well-being. These strengths are important for supporting posture, improving physical performance, and maintaining joint stability, all of which are essential for reducing the risk of injury and improving quality of life.

The ideal muscle strength for adolescents, based on the theory of physical development, is influenced by biological age, testosterone, and estradiol [3] In adolescent boys, muscle strength develops rapidly during puberty along with increased levels of the hormone testosterone, which increases muscle mass, strength, and endurance [4] According to Tanner's theory of physical development stages, the peak of muscle strength increase occurs at Tanner stages 3, 4 and 5, which are around the age of 13-15 years [5][6][7] In contrast, in adolescent girls, muscle strength also increases but more slowly and limitedly, due to hormonal differences and body composition that tend to have more fatty tissue than muscle [8]

The benefits of muscle strength are not only related to physical ability, but also to long-term health. The results of the study [9][10][11] show that strength training done regularly since adolescence can help reduce the risk of chronic diseases such as obesity, type 2 diabetes, and cardiovascular disease and can improve physical fitness. Resistance training not only improves metabolic rate by increasing fat-free mass and calorie expenditure, but also plays an important role in managing obesity and metabolic disorders, as well as improving mental health by reducing anxiety, depression, and improving cognitive function [12]

Adolescent boys' muscle strength experienced an increase in strength during puberty, with an increase of about 12–13% compared to only 5–7% of girls [13] Skeletal Muscle Mass (SMM) increases significantly during puberty, with boys showing greater muscle mass accruals compared to girls, influenced by hormone levels and physical activity [14] According to the theory of physical development, the peak of muscle strength in adolescent boys usually occurs at the age of 16-18 years, along with the development of the musculoskeletal system faster than that of women. Research [15] and [16] showed that boys experience significant spikes in strength around the Peak Height Velocity (PHV), usually around 14 years, continuing to develop until about 18 years old. In contrast, girls experience increased strength around the age of 12 to 14, leading to a noticeable difference in strength at age 18 [17] [16]

Considerable involvement in moderate to vigorous physical activity during adolescence is essential for maximizing muscle strength and bone density, especially in adolescence [18] Physical activity, such as resistance training, exercise, and good nutrition, has a profound effect on increasing muscle strength [19] Resistance training improves physical function in various age groups, including children and older adults, by increasing muscle strength and strength, which is the basis for overall fitness [20] Muscle strength that can be trained includes the muscles of the legs, back, arms, and hands which have an important role in supporting daily activities [21]

The Sport Development Index (2022) report states that the physical fitness of students who are categorized as "less" and "less than once" is 82.7% for elementary school/equivalent, 85.8% for junior high school/equivalent, and 83.9% for high school/equivalent. Furthermore, based on the researcher's observations through interviews and observations with teachers and students of Madrasah Aliyah Negeri (MAN) Barito Kuala South Kalimantan. Researchers obtained data on the strength of the students' arms, abdomen, legs and back muscles is very concerning. When students do warm-up activities before the core activities of physical education learning begin, many students are not able to perform push-ups, sit-ups, back-ups, and squats well. In addition, many students are unable to participate in physical activities in learning for a long time. This is corroborated by information from physical education teachers that "MAN students are dominant students with a background in Islamic boarding school education, sports and physical activities are seen as taboo and not commonly done". So it is very natural that the strength and muscle fitness profile of MAN students is very low. Looking at the fact that both SDI and data on MAN Batola show that physical activity has not become a culture, students have not felt needed, and have not formed the habit of actively moving. Muscle strength cannot be born on its own, but it needs to be trained regularly, measured and programmed.

Based on the strength data of the muscle strength profile of MAN Batola, it is very worrisome about the condition of students in the future, especially for health and endurance in carrying out activities to support productivity in their lives. For example, contracting non-communicable diseases at a young age such as obesity, laziness to move/sedentary lifestyle.

Based on the gap mentioned above, the researcher provides a solution from an early age, namely in high school-age adolescents by internalizing physical literacy (PL) in project-based learning (P-BL) PJOK learning. Physical literacy is defined as an individual's ability to move his or her body effectively in a variety of physical situations while understanding the importance of physical activity for well-being throughout life. According to [23] the virtue of PL lies in the development of students' basic motor skills, motivation, and confidence in the face of daily physical challenges, which ultimately forms an important foundation for active participation in lifelong physical activity. PL also promotes the development of physical, cognitive, and social balance, which is essential in achieving physical fitness and mental well-being [24]. Meanwhile, the advantage of the P-BL model is that it provides an authentic and meaningful learning experience through the completion of projects that focus on exploring real problems and are relevant to students' lives [25]. According to [26] and [27] P-BL promotes deep learning by engaging students in the process of critical thinking, cooperation, and applied problem-solving. Students not only learn the theory but also apply it in projects that require intensive physical and mental involvement. The PB-L model has been shown to be effective in improving learning motivation, independence, as well as social and emotional skills, which in turn can support physical development, such as muscle strength [28][29].

Through the integration of PL and P-BL, this solution is expected to be able to overcome the problem of low muscle strength of students in wetland schools, which is caused by the lack of opportunities for challenging and contextual physical activities. In wetland environments, the physical challenges students face are generally different, such as challenges in mobility and adapting to environmental conditions [30][31]. This also affects their ability to participate in conventional sports activities. By internalizing PL, students are equipped with an understanding of the importance of physical activity in daily life, and through P-BL, they are given the opportunity to apply those physical skills in relevant projects, such as environment-based activities that require physical

strength and endurance. This integration is expected not only to increase muscle strength, but also to form a more independent, creative, and critical character in facing the physical challenges and wetland environment.

2 Methods

This study uses a quasi-experimental design with a pretest-posttest control group design approach. The research population consisted of grade XI students at Madrasah Aliyah Negeri I Barito Kuala, with purposive sampling techniques used. The research sample involved the experimental group (XI-A and XI-B) and the control group (XI-D and XI-E). The instruments used in this study include a push-up test to measure arm muscle strength, a back-up test to measure back muscle strength, and a sit-up test to measure abdominal muscle strength. Data collection was carried out through pretest and posttest measurements to identify changes in muscle strength in both groups. Data analysis was carried out using IBM SPSS version 26. Initial testing includes normality, homogeneity, and multicollinearity tests. For normally distributed and homogeneous data, the Paired t-test was used to compare the pretest and post-test in the experimental and control groups. If the data is not normally distributed, Wilcoxon Signed-Rank is used as an alternative. To compare the experimental and control groups, the ANOVA Welch Test and Brown-Forsythe Test were used as robust tests because the variance between the groups was not homogeneous.

3 Results and Discussion

3.1 Results

After conducting a series of tests and analyzing the data obtained, the following are the results of the study that include the main findings of each stage of the test. These results include analysis of pre-test and post-test data in the experimental and control groups, as well as statistical tests used to determine the significance of the differences between groups. These findings provide an overview of the effectiveness of interventions that have been carried out on increasing muscle strength and the impact of the implementation of physical literacy and project-based learning in physical education learning.

The table below presents the results of the normality test using the Shapiro-Wilk method to determine whether the data used in this study is normally distributed or not. This test was carried out on pre-test and post-test data from the experimental group and control group. The results of this test will determine the type of statistical test used in the next stage of analysis. The following are the results of the Shapiro-Wilk normality test that has been carried out:

Table 1. Shapiro-Wilk Test Results

Group	Test Type	Shapiro-Wilk Sig.
Pretest Experiment	0,200	0,065
Posttest Experiment	0,200	0,979

Pretest Control	0,70	0,042
Postest Control	0,200	0,177

The normality test of the pretest and post-test data was carried out using the Shapiro-Wilk test showing that the pretest data in the control group was not normally distributed **(**$p = 0.042$**),** while the other data were normally distributed ($p > 0.05$). Therefore, the subsequent statistical analysis uses a combination of parametric and non-parametric tests.

The comparison of pre-test and post-test in the experimental group used a paired t-test because the data was normally distributed, while in the control group Wilcoxon Signed-Rank Test was used because the pretest was abnormal; while the post-test comparison between groups was carried out with an independent t-test because of the post-test data in both groups were normally distributed.

Furthermore, to test the similarity of variance between groups, the Levene test was carried out. The results of this test are presented in Table 2, which will determine whether the assumption of variance homogeneity is met before proceeding to the stage of further statistical analysis. Here are the results of the Levene test:

Table 2. Levene Test Results

Calculation Basis	Levene Statistic	df1	df2	Sig.
Mean	5.243	1	92	0.024
Median	5.182	1	92	0.025
Median & df	5.182	1	79.175	0.026
Trimmed Mean	5.359	1	92	0.023

The Levene test was used to check the similarity of variance between the experimental and control groups. Based on the results of the test in table 2, the variance between the groups was declared to be non-homogeneous, with the significance values for all methods (*mean, median, adjusted df, and trimmed mean*) below 0.05 ($p < 0.05$).

Table 3 below presents the results of the paired *t-test* conducted on the pretest and posttest data of the experimental group.

Table 3. Paired T Test Results for Experimental Classes

Condition	Mean	N	Standard Deviation	t	df	Sig. (2-tailed)
Pretest Experiment	68,48	48	13,549	-11,548	47	0,000
Posttest Experiment	110,00	48	30,232			

The results of the paired t-test showed that there was a significant increase in muscle strength between the pre-test ($M = 68.48$, $SD = 13.55$) and the post-test ($M = 110.00$, $SD = 30.23$), with $t(47) = -11.548$, $p < 0.001$. The 95% confidence interval difference showed that the intervention applied had a significant effect in improving muscle strength in the study participants.

The following table displays the results of the Wilcoxon Signed Rank Test applied to the control group's pretest and posttest data.

Table 4. Wilcoxon Signed Rank Test Results of Control Class

Statistic Test	Value
Negative Ranks (Posttest < Pretest)	N = 1, Mean Rank = 1,00
Positive Rank (Posttest > Pretest)	N = 38, Mean Rank = 20,50
Z	-5,430
Asymp.Sig. (2-tailed)	0,000

The Wilcoxon Signed Ranks Test is used to compare muscle strength scores between pretest and posttest in the control group. The test results showed that of the 46 participants, 38 participants experienced an increase in muscle strength, 1 participant experienced a decrease, and 7 participants did not experience any changes. A Z value of -5.430 with a p-value of <0.001 indicates that this increase is statistically significant. Thus, the intervention provided was shown to be effective in increasing muscle strength in the control group.

The table below presents the results of the ANOVA, along with Robust Tests (Welch and Brown-Forsythe) to ensure the validity of the findings despite the presence of variance heterogeneity between groups. These tests were conducted to compare the posttest results between the experimental group and the control group.

Table 5. ANOVA and Robust Test Results between Experimental and Control Groups

Test	*F-value*	*df1*	*df2*	*Sig. (p-value)*
ANOVA (Between Groups)	*10.996*	*1*	*92*	*0,001*
Welch Test	11.180	*1*	*82,232*	*0,001*
Brown-Forsythe Test	*11.180*	*1*	*82,232*	*0,001*

ANOVA results showed a significant difference with F-value = 10.996 and p-value = 0.001, indicating a statistically significant difference in muscle strength between the experimental and control groups. Since $p < 0.05$, it can be concluded that the intervention applied to the experimental group had a significant impact compared to the control group.

Welch Test and Brown-Forsythe Test, which account for heterogeneity of variances, also showed a p-value = 0.001. This indicates that, even though there is variance inequality between the experimental and control groups, the difference in mean muscle strength remains statistically significant. Since the p-value was less than 0.05, it can be concluded that the treatment given to the experimental group significantly increased muscle strength compared to the control group.

Based on the ANOVA and robust test results between the experimental and control groups, it can be concluded that there is a significant difference in muscle strength between the two groups post-intervention. These results confirm that the intervention applied to the experimental group had a significant effect.

3.2 Discussion

Based on the results of the analysis of research data, it was found that the application of learning with the internalization method of physical literacy through P-BL-based physical education learning has a significant influence on increasing students' muscle strength in wetland schools. This conclusion shows that the experimental group that uses P-BL-based PL internalization obtains better results than the control group that uses the direct learning method.

The increase in students' muscle strength as an impact of internalization of PL in P-BL-based physical education learning is driven by the virtue of PL in building a strong physical, mental, and social foundation. The advantage of the P-BL learning model lies in the active involvement of students in contextual and applied learning, thus encouraging them to understand and develop physical abilities in more depth through structured and relevant projects to real life [32][33][34]

The concept of physical literacy is essential for developing lifelong fitness habits. PL provides provisions to individuals that an individual will be able to form an active life culture when there is an element of motivation, strong confidence in himself, in addition to being consistent in doing physical activities, an experience that constructs knowledge and understanding of the activities carried out is built [35] Mashud [29] explained in his research that physical activity that is done with full awareness, confidence and high motivation and is done regularly will help an individual improve his physical fitness including the strength of his body muscles. In addition, the concept of physical literacy gives a message to the perpetrator to be aware of physical activity and make physical activity a necessity for his life and become a culture and even his lifestyle [36]

The advantages of the P-BL learning model include that project-based learning, which emphasizes the internalization of an active lifestyle, led to an increase in physical fitness scores among students, with the average score increasing from 2,936 to 3,376 after the intervention [29] Project-based learning has been shown to improve student motivation and learning outcomes in physical education. Research has found that students who engage in project-based activities show better performance and motivation compared to traditional methods [37] Additionally, project-based learning effectively improves social skills among high school students, demonstrating its broader benefits beyond physical fitness [38]. The findings of [39] also indicate that the P-BL model is effective in enhancing numerical and digital literacy. The implementation of P-BL helps students achieve the expected indicators in numerical and digital literacy.

The virtues of internalizing PL in P-BL-based physical education learning as described above, have a significant impact on increasing students' muscle strength. Students are still students, students are not adults who have been embedded with independence, responsibility and understand the needs of life. Students need to be escorted in learning by providing learning applying the right methods to lead students to achieve their teaching goals. The role of teachers is very central in learning. The application of learning methods must be in accordance with the goals to be achieved in a learning.

This study has important implications for the development of physical education learning, especially in areas with special geographical conditions such as wetlands, where the characteristics of the area are hot and the air is not cool [40] If physical education learning is carried out at school at 08.00-10.00 WITA, it is certain that students feel hot and sultry which causes discomfort. So, this learning method that internalizes P-BL-based PL is very appropriate to be given to students. Students below to understand their learning problems, so that students know and understand their learning

problems and needs. Furthermore, by implementing the concept of homework, problems and learning needs can be done by students while at home or at a time that they feel comfortable to do based on the reference project guided by the teacher as a student learning bill. Gradually, with the frequent passage of time and the consistency of the control carried out by the teacher, students will be able to carry out learning well and be able to achieve their learning goals. Therefore, it is recommended that schools in wetland areas adopt this approach in physical education learning activities.

The recommendation for further research is to expand the scope of this study by involving more related variables, such as aspects of motivation, behavior, and students' perception of PL and P-BL, as well as their long-term impact on muscle strength, physical fitness and student health.

4 Conclusion

The conclusion of this study is that the internalization of PL in P-BL-based physical education learning can increase the muscle strength of students in wetland schools. These results show that the internalization of PL in physical education learning wrapped in P-BL is more effective in increasing muscle strength than the direct teaching method. The internalization of P-BL-based PL in physical education learning provides a direct learning experience for students, students build responsibility, motivation and confidence so that learning tasks in the form of projects can be carried out according to the project stage and learning goals can be achieved.

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