The relationship between limb length and lower-limb explosive power on squat-style long jump performance in junior secondary students

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ABSTRACT

Background: To determine the relationship between leg length and leg muscle explosive power with squat style long jump performance applied to junior high school students.

Objectives: This study examines the relationship between leg length, leg muscle explosive power, and the ability to jump squatting style long.

Methods: The method used is a quantitative descriptive design with a correlational study. The study population amounted to 60 male students in class VIII. Sampling using the Purposive Proportional Systematic Random Sampling technique amounted to 45 students. The collected data were analyzed using three prerequisite tests: data normality test, homogeneity test, and linearity test. After fulfilling the prerequisite test requirements, it can be continued with 4 hypothesis tests, product moment test, multiple correlation test, regression equation line, and practical contribution and relative contribution.

Results: The data obtained using inferential statistics in multiple correlation analysis is complemented by multiple regression analysis. The results of the multiple correlation test obtained a coefficient = 0.687 and Sig. $P = 0.001 < a = 0.05$.

Conclusions: The study concludes a positive and linear relationship between leg length and leg muscle explosive power with squat-style long jump performance. Based on these findings, further research is recommended to explore additional variables such as speed, flexibility, and confidence, which may influence squat-style long jump performance.

Keywords: leg length, leg muscle explosive power, squat-style long jump.

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INTRODUCTION

Physical education, sports, and health are important learning programs in students' formation of physical fitness. The primary purpose of physical education is to utilize physical activity to achieve students' cognitive, affective, and psychomotor aspects (Iswanto & Widayati, 2021). One of the sports developed in schools is athletics. Athletic sports in physical education facilities include strength, endurance, speed, agility, and others. In essence, athletic sports are sports in which there are elements of jumping, running, and throwing. Researchers will examine jumping numbers because jumping is one of the most important parts of human movement besides walking and throwing (Mustafa & Dwiyoga, 2020). One of the styles often used in long jump learning at the junior high school level is the squatting style.

The long jump number is defined as the skill of jumping as far as possible by moving the body to each predetermined point (Sukirno & Pratama, 2019). One of the successes in doing a long jump depends on several main stages: the prefix phase, flying in the air, and landing (Riyanto, Simanjuntak, & Haetami, 2018). Correctly mastering the long jump technique will result in a much more effective jump. This can be achieved if supported by a jumper with excellent physical condition; it can produce maximum jumping results (Muzakki & Alficandra, 2023).

Success in performing a squat-style long jump, in addition to factors from technique, there are physical aspects that also influence support of the long jump. Physical conditions, including the long jump number, are needed for technical skills or physical abilities (Rahyubi, 2017). Some factors related to squat-style long jump performance include speed, flexibility, endurance, leg muscle power, and leg muscle explosiveness (Setyawati & Hartini, 2018). Other important factors, namely body anthropometry, such as limb length, are one aspect of the field that makes a meaningful contribution (Purnomo & Nurrochmah, 2023).

In the athletic sport of long jump numbers, the prefix phase is strongly influenced by the length of the limbs and the maximum explosive power of the leg muscles in achieving maximum jump results. Since the leg is the primary driver in the long jump, athletes must have a leg in good condition. The longer the limbs of an athlete, the greater the potential to achieve a longer jump. The leg length and strong repulsion can significantly increase the jump's distance, allowing maximum jumping results (Ishak et al., 2023). In addition, long jumps require leg muscle explosiveness or explosive strength in the legs to produce maximum repulsion (Zikri, Ramadi, & Juita, 2019). Leg muscle explosiveness is the ability of each individual to optimize maximum strength quickly. It can be concluded that if you only have strength without harmonizing speed, the explosive power will not be optimal. Explosive strength of the leg muscles has an important role in determining success in the long jump because the prefix phase must be carried out at high speed, which is then maintained stably until it reaches repulsion (Lesmana, Ridwan, Donie, 2020).

At State Junior High School 1 Turen, Malang Regency, squat-style long jump material is taught in the Merdeka curriculum as part of physical education learning. This curriculum emphasizes the development of students' competencies and potential according to their characteristics. Learning is directed not only to master basic techniques but also to understand body functions in physical activity. Therefore, variable leg length measurements and leg muscle explosiveness are important because they help teachers assess aspects of students' physical fitness that support squat-style long jump performance.

The previous research discussed the factors that affect long jump performance. However, most of these studies have not specifically examined the relationship between leg length and leg muscle explosiveness with squat-style long jump performance. The study by Hasbunallah (2018) found a significant relationship between leg length and leg muscle explosiveness in long jump results in junior high school students, although it did not explain the jumping style used in detail. Furthermore, according to Darlis & Rahmadani (2023), leg muscle explosiveness significantly contributes to long jump results, but the study did not consider leg length or the use of squat-style long jump. Meanwhile, a study by Hasruddin (2019) revealed that leg muscle explosiveness significantly affects long jump performance, but it has not been studied simultaneously with the variables of leg length and squat-style long jump techniques. Based on this description, studies examining the relationship between leg length and leg muscle explosiveness with squat-style long jump are still limited, so further research is needed in the literature.

Based on the explanation above, this study examines the relationship between leg length and leg muscle explosive power and the ability to squat-style long jump. From the results of the researcher's interview with the corner teacher at State Junior High School 1 Turen Malang Regency, some students have difficulty landing and repulsion, which is not optimal. Difficulties in the repulsion phase that are not maximized cause a lack of forward thrust of the body. Therefore, it is necessary to carry out assessment actions through relevant research related to these problems through research entitled "The Relationship Between Limb Length and Limb Muscle Explosive Power with Squat-Style Long jump performance of Class VIII Students a State Junior High School 1 Turen Malang Regency".

METHODS

Study Design and Participants

This study uses a quantitative descriptive design with Correlation research that aims to connect between variables. The variables studied were (a) anthropometric body length, (b) leg muscle explosive power test, and (c) squat-style long jump performance. The population in this study consisted of male students of class VIII State Junior High School 1 Turen Malang Regency, with a total of 60 students. Sampling using the Purposive Proportional Systematic Random Sampling technique with a portion of 75% of 60 male students in class VIII classes a, b, and c so that the sample amounted to 45 students. This research design can be described as follows:

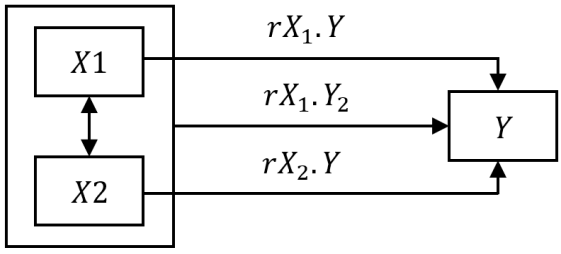

Figure 1. Research Flowchart
Source: Sugiyono, (2017)

Description :
X_1 : Limb Length

X_2 : Limb Muscle Explosiveness
Y : Squat-Style Long jump performance
r : Correlation

Ethical approval statement

This research complies with the Declaration of Helsinki. The research, permission was obtained from the Ethics Committee Chair (Universitas Negeri Malang Ethics Committee, Issue Number: 20.06.6/UN32.14.2.8/LT/2024) about the ethical suitability of the study.

Research Instruments

The research instrument used a test form of physical condition test, namely leg muscle explosive power using the standing broad jump test (m) and squat-style long jump performance test (m). besides this, the researcher measured the anthropometric test form of the body, namely leg length (cm).

Data Analysis

The collected data were analyzed using three prerequisite tests: the normality test, homogeneity test, and linearity test. After fulfilling the prerequisite test requirements, we employed the power of inferential statistics to strengthen our analysis further. This involved using parametric correlation analysis (R) and hypothesis testing with a = 0.05, ensuring the robustness of our findings.

RESULTS

The results of the study were tested with inferential statistics, so first conduct prerequisite test testing including: 1) data normality test analysis results, 2) homogeneity test, 3) regression line linearity test and hypothesis testing which includes: 1) correlation test between variables, 2) multiple correlation test, 3) multiple regression test, 4) effective contribution and relative contribution.

Table 1. Presentation of Data Normality Test Analysis Results

No	Variable	Sig. *P*	*a*	Description
1.	Limb Length (cm)	0,567	0,05	Normal Distributed Data
2.	Limb Muscle Explosive Power (m)	0,507	0,05	Normal Distributed Data
3.	Squatting Style Long jump performance (m)	0,492	0,05	Normal Distributed Data

The normality test (Table 1) was analyzed using the Kolmogorov-Smirnov technique, using the significance of the value of the independent variable limb length obtained by Sig. P = 0.567 > α 0.05, the independent variable of leg muscle explosive power obtained Sig. P = 0.507 > α = 0.05, and on the dependent variable, the squat-style long jump performance obtained exact Sig. P = 0.492 > α = 0.05. This means that overall, the data from the three variables have a normal distribution.

Table 2. Presentation of Analysis Results of Variance Homogeneity Test

Variable	Test Result	*a*	Description
X_1X_2 Y	0,963	0,05	Homogeneous

The results of the homogeneity test (Table 2) using the Levene technique are presented with data that has been converted in the form of standard Z-score values. Data were analyzed using the ANOVA technique. The results of the homogeneity test analysis on the variable of leg length and leg muscle explosiveness with the variable of squat-style long jump performance obtained the results of the Sig value.

0,933 > a 0,05. Conclusion Based on the data exposure obtained, the group variant results come from homogeneous data.

Table 3. Presentation of Analysis Results of Variance Homogeneity Test

Dependent Variable	Independent Variable	F_{count}	Sig.F	*a* = 0,05	Description
Y	X_1	1,410	0,224	Sig F > 0,05	Linear Regression Line
	X_2	1, 445	0,255	Sig F > 0,05	Linear Regression Line

The linearity test results presented in Table 3 show that there is a linear relationship between each independent variable, namely leg length (X_1) and leg muscle explosiveness (X_2), with the dependent variable, namely squat-style long jump performance (Y). The F_{count} value for the limb length variable on squat-style long jump performance is 1.410 with a significance value (Sig. F) of 0.224, while the limb muscle explosive power variable on squat-style long jump performance is 1.445 with a Sig value. F value of 0.255. Because both significance values are greater than $\alpha = 0.05$, it can be concluded that the relationship between each independent variable and the dependent variable is linear. Thus, the analysis model fulfills the linearity assumption and can be continued at the linear regression analysis stage. So, it can be concluded that leg length and leg muscle explosiveness with squat-style long jump performance are linear.

Table 4. Presentation of the Results of Single Correlation Analysis Between Each Free Variable with the Dependent Variable

Variable	R_{count}	Sig. *P*	*a* = 0,05	Description
X_1 to Y	0,777	< 0,001	Sig. *P* < 0,05	There is a positive linear and significant relationship between variable X1 with Y
X_2 to Y	0,769	< 0,001	Sig. *P* < 0,05	There is a positive linear and significant relationship between variable X2 with Y

A single correlation test using Pearson's product-moment correlation analysis (Table 4) shows a positive and significant relationship between the independent and dependent variables. The correlation between leg length (X_1) and squat style long jump performance (Y) obtained a coefficient of r = 0.777 with a significance value of p = 0.001 (p < 0.05). Furthermore, the relationship between leg muscle explosiveness (X_2) and squat-style long jump performance produces a coefficient of r = 0.769 with a significance value of p = 0.001 (p <0.05). The data show that the longer the limbs are and the greater the explosive power of the student's leg muscles, the better the ability to perform a squat-style long jump. Thus, variables X_1 and X_2 have a strong and significant linear relationship with variable Y. However, it should be noted that although this relationship is significant, other factors outside the research model can also affect students' squat-style long jump performance.

Table 5. Presentation of Multiple Correlation Analysis Results

Variable	r_{count}	R^2	Conclusion
$R^2YX_1X_2$	0,829	0,687	The independent variables X_1 and X_2 contribute to the dependent variable Y by 68.7%, meaning that the low dependent variable Y is influenced by the independent variables X_1 and X_2.

The r-test results obtained 0.829, Sig. F = 0.000 and α = 0.05 (Table 5). Because Sig. F is smaller than α = 0.05; it means that there is good and linear continuity between the length of the limbs and the variable explosive power of the leg muscles with the ability to long jump squatting style of students in class VIII State Junior High School 1 Turen Malang Regency. The coefficient of determination analysis results shows an R2 value of 0.687 or 68.7%. This shows that leg length and leg muscle explosiveness can explain 68.7% of squat-style long jump performance. Factors outside the research model explain the rest.

Table 6. Presentation of Advanced Test Analysis Results F Test Technique Independent Variables Simultaneously with Dependent Variables

Variable	R_{count}	F_{count}	Sig. F	a = 0,05	Description
RYX_1X_2	0,829	42,844	< 0,001	Sig F < *a* 0,05	There is a significant positive and linear relationship between the independent variables X_1 and X_2 together with the dependent variable Y

The results of the further test analysis of the F test results obtained F_{count} = 42.844 Sig. F = 0.001, means Sig. F < *a* 0.05 (Table 6), it can be concluded that leg length and leg muscle explosiveness are positively and significantly related to the ability to squat-style long jump. Below are presented the results of the analysis of the constant coefficient, (a) regression coefficient, which includes regression for X1 (b1) and regression X2 (b2). Each coefficient is presented as follows.

Table 7. Presentation of Multiple Regression Analysis Results Between Each Independent Variable and the Dependent Variable

No.	Constant Variable	Regression Coefficient
1.	Constant *a*	5,571
2.	B_1X_1	0,460
3.	B_1X_2	0,428

The multiple regression coefficient analysis results obtained regression coefficient ba1X1 = 0.460 and regression ba2X2 = 0.428 and constant-coefficient = 5.571. Based on the thick regression coefficient (Table 7), the regression equation line can be formulated as follows: $\hat{Y}$ = (5.571) + (0.460X1) + (0.428X2) so that it can be used to interpret the effect of squatting long jump performance.

Table 8. Presentation of Effective Contribution and Relative Contribution of Each Variable Examined

Variable	Effectiveness Contribution (%)	Relative Contribution (%)
X_1	35,7%	52,0%
X_2	32,9%	47,9%
Total	68,7%	100%

The results of the analysis in the Table 8 show that the length of the limbs contributes to the effectiveness of 35.7% and the explosive power of the leg muscles contributes to the effectiveness of 32.9%, while the relative contribution to the length of the limbs and 52.0, the explosive power of the leg muscles is 47.9. Together, the limbs' length and the leg muscles' explosive power amounted to 68.7%.

DISCUSSION

Relationship Between Limb Length with Squat-Style Long jump performance

The results of Pearson's product-moment correlation analysis show that there is a positive and significant relationship between leg length and squat-style long jump performance in class VIII students of State Junior High School 1 Turen Malang Regency ($r = 0.777$ and Sig. $P = 0.000$). The longer the student's limbs, the more likely the student will achieve a longer jump distance. The relationship is linear and in line with the results of the previous linearity test.

There is a relationship between leg length and squat-style long jump performance because the leg is a lower limb with an important role in carrying out movements such as walking, running, jumping, and kicking (Kurniawan, Haryanto, & Sukendro, 2024). The anthropometry of leg length is the vertical distance between the sole and groin measured by standing upright. In order to perform systematic movements, the limbs are supported by a movement system consisting of muscles, bones, and joints (Latuheru, 2019). Leg length is one part of posture that closely relates to a lever when jumping. Long limbs can increase students' potential to achieve maximum distance (Hermawan & Tarsono, 2017).

The above description is based on the theory, which states that one of the important components in achievement is body structure, body size, or biometric quality. Sports achievement requires certain anthropometric qualities based on the type or branch of sport undertaken (Bompa & Carrera, 2015). This finding aligns with anthropometry, an important factor in motor and physical performance, including in long jump sports (Çıplak et al., 2020). This aligns with research conducted by Haryanto, Liputo, and Fataha (2021), which shows that longer limbs provide biomechanical advantages in various aspects, especially in the prefix and repulsion phases. Students with longer limbs generally have a greater range of steps, which helps increase running speed before repulsion. In addition, according to Yusuf & Rubiono (2018), proportional limb length affects the repulsion phase and the take-off and landing phases. A jumper with optimal leg length can more easily control the body's position while in the air, reducing the air resistance that occurs when hovering and maximizing jump efficiency (Wahidi & Nurcahya, 2019). This allows students to generate greater propulsive force and achieve long jumping distances (Irwandi, Karim, & Cakrawijaya, 2022). Mastery of the technique also becomes more effective because the body balance is better maintained, allowing for a more stable landing and resulting in a better jump. Thus, limb length between individuals is one-factor influencing variations in jump achievement. Students with longer limbs tend to have an advantage in biomechanical aspects, allowing them to perform better. Therefore, the limb length aspect can be one indicator in determining students' performance potential to achieve maximum jumping results.

Relationship Between Limb Muscle Explosiveness with Squat-Style Ability

Analysis using product moment correlation techniques showed a positive and significant relationship between leg muscle explosiveness and squat-style long jump

performance (r = 0.769; Sig. P = 0.000). The findings indicate the greater the student's leg muscle explosive power, the better the squat-style long jump performance. The linear relationship is linear, as confirmed by the results of the linearity test, and these results confirm that physical conditions, especially leg muscle explosiveness, have an important role in determining the jump results.

Physical condition is a significant factor in determining the success of each sport. The factors that support long jump numbers, such as strength, leg muscle explosiveness, speed, and coordination, play a role in producing maximum jumps (Kardi et al., 2022). Explosive power is a person's ability to make explosive movements with maximum muscle strength in a short time and rapid body contraction (Haryanto et al., 2021). This is in line with the explanation of Wilkinson Maden et al. (2021), emphasizing the importance of explosive strength in movements that require force acceleration in a short time, such as jumps. Explosive power, especially in the initial phase of muscle contraction, determines the body's ability to produce enough force to propel the body forward and upward in a long jump. Rapid neuromuscular activation and the intrinsic contractile properties of leg muscles contribute to variations in jumping performance, where muscles that are more responsive in developing force quickly tend to produce better jumping distances (Ardana et al., 2018).

A jumper who has good leg muscle explosiveness will be able to make a more substantial and faster repulsion from the repulsion board. Explosive repulsion allows the body to be pushed up and forward at an optimal angle, resulting in a longer jump (Ridwan & Sumanto, 2017). This is in line with previous research stating that leg muscle explosiveness is one of the main factors supporting long jump performance. If leg muscle explosiveness is not considered, it certainly does not help improve long jump performance (Yulmiando, 2020).

Thus, the leg muscles' explosive power significantly affects the jump results and the ability to jump long. This is because the stronger the leg muscles, the stronger the repulsion, so students can achieve a longer jump distance.

The Relationship Between Limb Length and Limb Muscle Explosiveness with Squat-Style Long jump performance

Based on the research that has been carried out, the results show that the length of the limbs and the explosive power of the leg muscles are significantly related simultaneously with the squat-style long jump performance in class VIII students of State Junior High 1 Turen Malang Regency. This finding is in line with the concept that fast and explosive movements, such as jumping, rely heavily on the stretch-shortening cycle (SSC) mechanism in the muscle-tendon system that allows muscles to store and release elastic energy to increase force production and movement efficiency during the jump (Thapa et al., 2024). Longer limbs can provide biomechanical advantages in the repulsion and landing phases, thereby increasing the effectiveness of elastic energy use in SSC and extending the trajectory of the jump. Meanwhile, high limb muscle explosive power makes a stronger explosive contraction, thus accelerating the transition from the eccentric to concentric phase in SSC and increasing the propulsion at take-off. The effectiveness of SSC in the long jump depends on the eccentric strength and concentric contractile capacity of the muscle-tendon, both of which are influenced by limb length and muscle explosiveness.

This is strongly supported by research from Wahidi & Nurcahya (2019), stated that limbs are one of the important physical factors in anthropometry, especially in the athletic sport of long jumping. More limbs can provide biomechanical advantages in the repulsion and landing phases; longer limbs also allow a wider range of steps and assist in building optimal speed before repulsion. Moreover, reinforced by research (Gunawan, 2023), muscle explosive power is the ability of muscles to produce maximum strength in a short time.

This finding can reinforce the previous study Sapwaturrahman, Kesuma, & Syarifoeddin (2021), which states that leg length and leg muscle explosiveness correlate with the effectiveness of repulsion and landing in squat-style long jump performance. Combining the two ensures that the repulsion can be carried out optimally, thus producing maximum forward and upward thrust and allowing a more stable and efficient landing to increase the jump distance.

Thus, if someone wants basic technical skills to be performed well, they should produce effective and efficient movements. Factors instrumental in the performance of the squat-style long jump in athletic sports, such as leg length and leg muscle explosiveness, are important to note to obtain optimal results.

Limitations of the study

This study has several limitations that should be acknowledged. First, the sample was restricted to eighth-grade male students at a single junior secondary school in Malang Regency, which may limit the generalizability of the findings to broader populations or different educational settings. Second, the study only considered two physical variables—limb length and lower-limb explosive power—while other potentially influential factors such as speed, flexibility, coordination, or psychological readiness were not examined. Third, the measurements were conducted in a school-based physical education setting without technological instruments, which may affect the precision and standardization of data collection. These limitations underscore the urgent need for future research to expand the sample scope, include additional performance-related variables, and employ digital tools to enhance measurement accuracy, thereby advancing our understanding of physical education and research methodology.

CONCLUSIONS

Based on the results of data analysis, it can be concluded that leg length and leg muscle explosiveness have a significant relationship with squatting long jump performance in class VIII students of State Junior High School 1 Turen. Leg length and leg muscle explosiveness play an important role in supporting the repulsion movement, hovering in the air, and landing in long jump activities. Although the students in this study are not athletes or learners with competitive goals in athletics, the study's results are still valuable for physical education learning. Every student can improve their long jump performance by understanding the correct technique and optimal use of their physical abilities.

Thus, the results of this study can be the basis for physical education teachers in developing practical and adaptive long jump learning models. A learning approach that considers students' physical characteristics will help improve movement skills. Based on the results of this study, it is recommended for further research to conduct

further studies by considering the addition of variables such as speed, flexibility, and confidence levels that affect the achievement of squatting style long jump results.

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DATA AVAILABILITY

The data supporting the findings of this study are available from the corresponding author upon reasonable request. All data were collected and analyzed by ethical standards and are stored securely by the research team.

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CONFLICT OF INTEREST

The author hereby declares that this research is free from conflicts of interest with any party.

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