The relationship between arm length and body mass index (BMI) with turbo-throwing performance in elementary school students

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C – Data analysis and interpretation
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ABSTRACT

Background: This research is motivated by insufficient scientific research that specifically examines the relationship between arm length and Body Mass Index (BMI) on turbo throwing performance in elementary school students, especially in preparation for the National Student Sports Olympics (O2SN).

Objectives: This study examines the relationship between arm length and BMI and the turbo-throwing performance of sixth-grade students of State Elementary School Bunulrejo 1 Malang in preparation for the National Student Sports Olympics (O2SN) in 2025.

Methods: The method used is a quantitative descriptive design with a correlational study. The study population comprised 71 male students, with a sample of 45 male students. The research instrument was a turbo-throwing basic motion performance test, arm length measurement, and Body Mass Index (BMI) measurement. The analysis technique uses inferential statistics in the form of multiple correlation analysis, which is complemented by multiple regression analysis.

Results: The results were obtained using inferential statistics through multiple correlation analysis. The results of the multiple correlation test obtained a coefficient value = 0.723 and Sig. P = 0.001 < a = 0.05, and the contribution of the variable effectiveness of arm's length to turbo-throwing performance is 46.3%, while BMI is 5.9%, so the variables arm length and BMI provide an effective contribution of 52.2%.

Conclusions: Arm length and BMI significantly influence turbo-throwing performance. Arm length is the most dominant factor. These results can be a reference for teachers and coaches when selecting O2SNs and coaching athletes at the basic education level. Future researchers are expected to examine other variables that have not been studied to provide a more comprehensive picture of turbo-throwing performance.

Keywords: leg arm length, body mass index, turbo-throw performance.

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INTRODUCTION

Athletics is one of the materials used in sports subjects, and sports compete in the National Student Sports Olympics (O2SN). Especially at the Elementary School (SD) level, athletics have been modified and developed for children aged 8-14. The concept is called kids athletics, where the movements are simplified, and the athletic equipment is adjusted to the child's ability and growth. It is hoped that children will find it easier to do every movement (Inayah & Nurrochmah, 2021). The organization of the National Student Sports Olympiad (O2SN) is an important thing to note and follow up on. O2SN is a special sports event for students from elementary school (SD) to senior high school (SMA)/vocational high school (SMK). Various sports, especially at the elementary school level, are competed in, including athletics. However, specifically at the elementary school level, athletic sports are replaced with the title of kids' athletics (Widiyanto & Kurniawan, 2021).

Turbo throwing is one of the athletics materials taught in grade six, semester one, under the Independent Curriculum. This event is also included in the O2SN competition, which is participated in by several students from various elementary schools. Turbo throwing is a modification of the throwing sport, which, basically in athletics, throwing uses javelins and bullets, which are dangerous for children. It was finally modified with a safer tool, namely turbo throwing (Narbito, 2021). Turbo-throwing aims to place the turbo as far as possible by throwing using the proper technique (Sukmadini et al., 2023). Correctly mastering the turbo-throwing technique will result in a much more effective throw. This can be achieved if supported by players with ideal arm length because the size of the long arm will better support physical abilities (Dirgantoro, 2016).

Several previous studies have examined the factors that affect athletic performance in throwing numbers. However, these studies have not specifically examined the relationship between arm length and BMI on turbo-throwing athletic kids' performance. Research from Bagia (2020) states that anthropometric factors of arm's length have a significant relationship to the distance of throwing sideways-style discs for junior high school children. Another study by Rosa and Sahri (2022) stated that arm length and disc-throwing ability are significantly influenced. As well as previous research, Narbito (2021) stated that a significant relationship exists between arm muscle strength, arm length, and back muscle flexibility on turbo-throwing performance. However, this study has not considered body mass index (BMI) affecting turbo-throwing performance. Research examining the relationship between arm length and BMI with turbo-throwing performance is minimal, so further research must be done.

Another factor that affects throwing distance is body shape. One way to measure body shape is by anthropometry. According to Maulina (2018), anthropometry of the human body is a measurement used to determine the body's shape, size, and topography. Body mass index (BMI) is one of the measurements in anthropometry obtained from the calculation between body weight (BW) and height (TB). Height is measured using a microtome (microtome) with an accuracy of 0.1 cm. The factors of height (TB) and weight (BB) are important in sports because ideal body weight helps athletes achieve their best performance (Untoro & Kurniawati, 2017).

A performance-based assessment is required to support athlete selection for the 2025 O2SN event, particularly in the athletics category of turbo throwing. One of the primary references for this selection is the turbo-throwing performance test, which

reflects students' readiness to compete in the kid's athletics division (Widiyanto & Nurrochmah, 2021). However, limited empirical evidence exists regarding the influence of physical anthropometric factors—specifically arm length and body mass index (BMI)—on turbo-throwing performance among elementary school students. Preliminary interviews with PJOK teachers at State Elementary School Bunulrejo 1 in Malang City revealed a lack of research exploring the correlation between these variables and motor performance in throwing disciplines. Addressing this gap, the present study examines the relationship between arm length and BMI with turbo-throwing performance in elementary school students. The findings are expected to contribute to developing more objective, evidence-based selection and training strategies in elementary athletics, particularly for talent identification in throwing events.

METHODS

Study Design and Participants

This study uses a quantitative descriptive design and an explanatory approach that aims to find relationships between variables. The variables studied were (a) arm length, (b) Body Mass Index, and (c) athletic kids' movement performance in turbo throwing numbers. All variables are measured on a ratio scale to analyze the data using the product moment technique. The population in this study was comprised of sixth-grade male students of State Elementary School Bunulrejo 1, Malang City, totaling 71 students. Sampling used the Purposive Proportional Simple Random Sampling technique with a portion of 63% of 71 6th-grade boys, so the sample amounted to 45 students.

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: 22.07.6/UN32.14.2.8/LT/2024) about the ethical suitability of the study.

Research Instruments

The research instrument was a turbo throwing motion performance test, and body length and BMI measurements were calculated from body weight (kg) divided by height (m) squared.

Data Analysis

The collected data were processed and analyzed using the Statistical Package for the Social Sciences (SPSS) software. Prior to the primary analysis, prerequisite tests were conducted to ensure the validity of parametric testing assumptions, including tests for normality, homogeneity, and linearity. After confirming that the data met these assumptions, further statistical analysis was performed using the Pearson product-moment correlation test (R test) to assess the strength and direction of the relationship between variables. In addition, the F test was employed through multiple linear regression analysis to examine the simultaneous influence of arms length and body mass index (BMI) on turbo-throwing performance. These statistical procedures were performed with a significance level set at $\alpha = 0.05$ to determine whether the observed relationships were statistically meaningful.

RESULTS

The following is the research data, which includes prerequisite tests and hypothesis tests. Prerequisite tests include (1) data normality test analysis results, (2) homogeneity test, (3) regression line linearity test, and hypothesis testing, which includes (1) single correlation test, (2) multiple correlation test, (3) F test, and (4) multiple regression test.

Table 1. Presentation of Data Normality Test

Variable	Sig. *P*	Sig. *a*=0,05	Description
Arm length (X_1)	0,463	Sig. *P* > *a* 0,05	Normal distributed data
Body Mass Index (X_2)	0,540	Sig. *P* > *a* 0,05	Normal distributed data
Turbo Throw Performance (Y)	0,948	Sig. *P* > *a* 0,05	Normal distributed data

Based on Table 1, all variables (arms length, BMI, and turbo throwing ability) showed significance values (Sig. P) greater than 0.05, namely 0.463, 0.540, and 0.948, respectively. This indicates that the data is normally distributed so that parametric statistical analysis can be legitimately used.

Table 2. Presentation of Homogeneity Test

Variable	Test Result	*a*	Description
X_1X_2Y	0,981	0,05	Homogeneous

The significance value (Sig. F) of 0.981 > 0.05 indicates that the variables analyzed have a homogeneous variance (Table 2). This means that the data groups have uniformity in the distribution of values.

Table 3. Presentation of Linearity Prerequisite Test of Regression Line Data

Dependent variable	Independent variable	F_{hit}	Sig. F	Sig. a=0,05	Description
Y	X_1	1.823	0,100	Sig F > 0,05	The regression line is linear
	X_2	1.291	0,372	Sig F > 0,05	The regression line is linear

The linearity test results between arm length (X1) and BMI (X2) on turbo throwing performance (Y) showed Sig. F values of 0.100 and 0.372, respectively, are greater than 0.05 (Table 3). This means the relationship between the variables is linear, an important prerequisite in linear regression.

Table 4. Presentation of Correlation Analysis Results Between Each Independent Variable and the Dependent Variable

Variable	R_{count}	Sig P	Sig a = 0,05	Description
X_1 to Y	0,714	0,001	Sig P < Sig a	There is a positive linear and convincing relationship between variable X_1 and Y
X_2 to Y	0,454	0,003	Sig P < Sig a	There is a positive linear and convincing relationship between variable X_2 and Y

A significant relationship exists between arm length (X1) and performance (Y): R = 0.714; Sig. P < 0,001. BMI (X2) to performance (Y): R = 0.454; Sig. P = 0,003 (Table 4). Both showed a strong and significant positive correlation.

Table 5. Presentation of Multiple Correlation Analysis Results and Coefficient of Determination

Variable	r_{count}	R^2	Conclusion
$R^2YX_1X_2$	0,723	0,522	The independent variables X_1 and X_2 contribute to the dependent variable by 52.2%, meaning that the high and low Y variable is 52.2% influenced by the independent variables X_1 and X_2.

R = 0.723 and R^2 = 0.522 indicate that arm length and BMI influence turbo-throwing performance by 52.2% (Table 5). These two variables can explain more than half of the variation in turbo-throwing ability.

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

Variable	R_{count}	F_{count}	Sig. F	a = 0,05	Description
RYX_1X_2	0,723	20.208	<0,001	Sig F < 0,05	There is a positive and significant relationship between the independent variables X_1 and X_2 together with the dependent variable Y.

Based on Table 6 above, the calculated F value = 20.208 with Sig. F < 0.001 indicates that both independent variables (X1 and X2) together have a significant effect on turbo-throw performance (Y).

Table 7. Presentation of Multiple Regression Equation Line Analysis Results

No.	Constant Variable	Regression Coefficient
1.	Constant *a*	11.031
2.	B_1X_1	0,648
3.	B_1X_2	0,131

Referring to Table 7, the regression equation obtained is $Y = 11.031 + 0.648X_1 + 0.131X_2$. That is, each increase of one arm length increases the performance score by 0.648 units, and each increase of one unit of BMI increases the performance score by 0.131 units.

Referring to Table 8, arm length (X1) made an effective contribution of 46.3% and a relative contribution of 88.6%. BMI (X2) made an effective contribution of 5.9% and a relative of 11.4%. Thus, arm length is the dominant factor influencing turbo-throwing performance compared to BMI.

Table 8. Presentation of the Results of Analysis of Effectiveness Contribution and Relative Contribution

Variable	Effectiveness Contribution (%)	Relative Contribution (%)
Arm lenght (X_1)	46,3%	88,6%
Body Mass Index (X_2)	5,9%	11,4%
Total	52,2%	100%

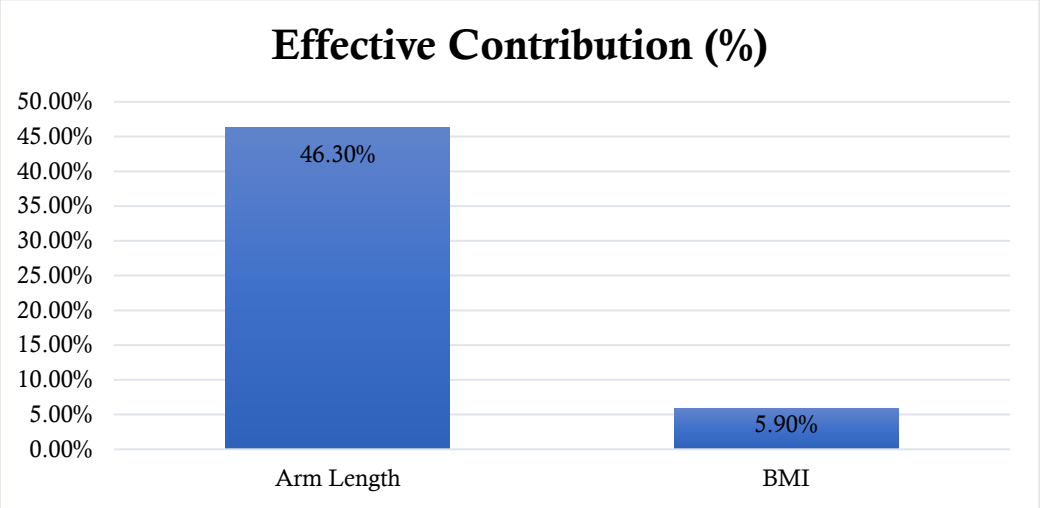

Figure 1. Bar Chart of the Effective Contribution of Each Independent Variable to the Dependent Variable

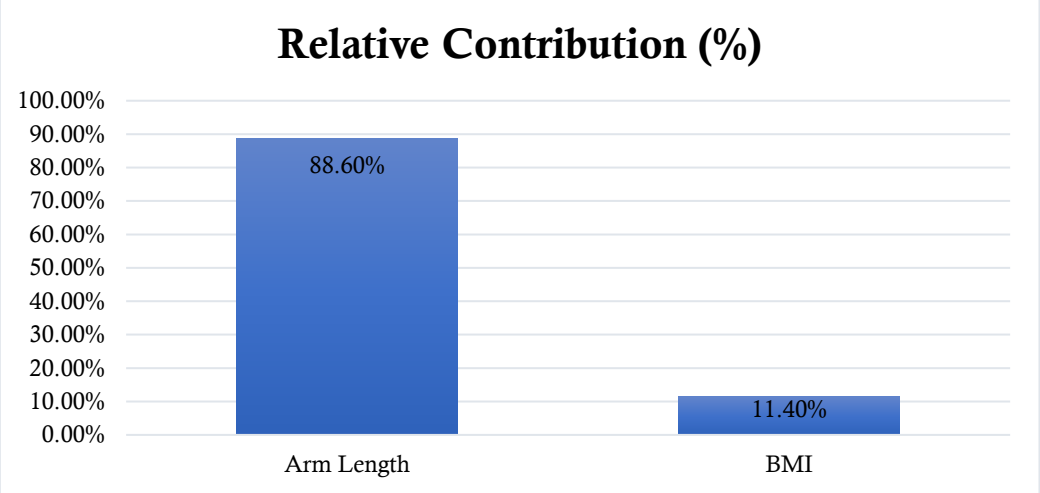

Figure 2. Bar Chart of the Relative Contribution of Each Independent Variable to the Dependent Variable

The analysis of effective contribution and relative contribution shows that arm length provides an effective contribution of 46.3%, and BMI provides an effective contribution of 5.9%. Simultaneously, arm length and BMI effectively contribute 52.2%. At the same time, the relative contribution of arm length is 88.6% and 11.4% for the BMI.

DISCUSSION

Relationship between Arm Length and Turbo Throw Performance in Elementary School Students

The results of data analysis using Pearson correlation techniques show that arm length has a positive and significant relationship with turbo-throwing performance ($R = 0.714$; $P < 0.001$). This is because the arm, as an upper limb, plays an important role in movements such as pushing, pulling, hitting, holding, and throwing (Bagia, 2020). Arm length is measured from the base of the arm to the tip of the middle finger, and its movement is supported by muscles, bones, and joints (Pelana et al., 2021). In throwing sports, arm length is an important anthropometric factor that can increase the potential of athletes to achieve maximum performance (Rosa & Sahri, 2022).

Previous research by Narbito (2021) showed that there was a significant relationship between arm muscle strength, arm length, and back muscle flexibility with turbo throwing ability in fourth and fifth-grade male students of State Elementary School 01 Gedongan, Baki District, Sukoharjo Regency. However, this study is limited to the scope of the subject. In addition, other variables that may affect turbo-throwing ability, such as Body Mass Index (BMI) and psychological and technical factors, have not been analyzed in this study. These findings align with the results of Pearson's product-moment correlation analysis in this study, which showed a positive and significant relationship between arm length and turbo-throwing performance.

The description above aligns with the theory, which reveals that the main components that affect sports performance include body size, body structure, or biometric quality (anthropometric measurements). Achievement in sports requires certain anthropometric qualities based on the type or branch of sport undertaken (Dial, 2019). Furthermore, Oktaria et al. (2020) stated that in addition to arm's length, other components are important in achieving sports achievements, namely good physical, technical, and mental. Thus, arm length is advantageous in sports requiring long throws, such as kids' athletics turbo-throwing numbers.

Another theory about arm's length is put forward by the opinion Morais et al. (2023), which states that to get a long throw, it is necessary to pay attention to the angle of elevation of the throw. This can be seen from the function of the arm as a lever that produces rotary motion from the fulcrum of its axis. So, the longer the arm is, the longer the lever, so the force produced is greater, and the throw can reach a greater distance. In physics, a long lever provides an advantage in generating greater momentum and throwing power.

Relationship Between Limb Muscle Explosiveness with Squat-Style Ability

The results of the F test analysis show a significance value of $F < 0.001$, which means that arm length (X1) and body mass index (X2) simultaneously have a positive and significant relationship with turbo-throwing performance. This study shows that both variables affect the turbo-throwing performance of State Elementary School Bunulrejo 01 Malang City grade VI students. This finding is in line with the research of Rosa & Sahri (2022), which states that arm length is an important physical factor in anthropometry, especially in the athletic throwing branch, because optimal arm length can increase the potential performance of athletes. However, the study does not consider BMI a factor affecting movement performance, especially in throwing activities.

Moreover, this is reinforced by research by Diyono and Astriyana (2019), which states that an ideal body mass index influences children's motor abilities. A low body mass index indicates that the child does not have excess weight and is lighter and more agile in moving. Conversely, children with high BMI values tend to be overweight or even obese. This situation often causes children to be too lazy to move, negatively impacting their motor development. This is relevant to the opinion of Kurniawan et al. (2024), who revealed that a typical/ideal BMI can be used as a person's capital in supporting performance to achieve sports achievements because a more proportional body supports it. The two studies above did not consider arm length as one factor affecting performance, especially in throwing movements. This research provides novelty: a positive relationship between arm length (X1) and Body Mass Index (X2) with throwing performance, especially in turbo throwing sports in elementary school children.

The description above aligns with several theories, namely the factors of body weight and height needed in exercising because ideal body weight helps a person perform at his best (Tur & Bibiloni, 2019). This research is significant as it sheds light on the relationship between anthropometric measurements and sports performance, providing valuable insights for sports scientists, coaches, and researchers. Another theory, Budiwanto (2012), stated that anthropometric and somatotype measurements are needed in several sports. The elements of height, weight, leg length, and arm length are important in several sports. Other research results from Lusiana (2015) stated that anthropometry, in general, will affect specific movements/techniques in sports where anthropometric variables have a significant correlation to the results of throwing ability in addition to body mass index (BMI), which also has a significant effect.

Limitations of the study

This study has several limitations that need to be noted. First, the research subjects only involved sixth-grade male students from one state elementary school in Malang City, so the results cannot be generalized to a broader population or different genders. Second, the variables analyzed were limited to arm's length and body mass index (BMI), whereas turbo-throwing performance can also be influenced by other factors such as muscle strength, throwing technique, motivation, or motor coordination, which were not analyzed in this study. Thirdly, because the approach used is correlational, this study cannot explain the direct causal relationship between the variables studied. For this reason, further research is recommended using an experimental design and involving a more diverse sample to make the results more comprehensive and applicable.

CONCLUSIONS

This study concluded that arm length and BMI have a significant relationship to the turbo-throwing ability of sixth-grade students of State Elementary School Bunulrejo 01 in Malang City, with the contribution of arm length being more dominant than BMI. These results provide novelty in the context of children's athletic sports, especially turbo-throwing numbers. This can be a reference for teachers and coaches as a basis for preparing training programs to consider aspects of arm's length to develop children's potential in O2SN selection at the primary education level. Future researchers are expected to examine other variables that have not been studied so that they can provide a more comprehensive picture of turbo-throwing performance.

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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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