International Journal of Computational and Experimental Science and ENgineering (IJCESEN)

Vol. 11-No.2 (2025) pp. 2281-2287
http://www.ijcesen.com

ISSN: 2149-9144

Research Article

Unlocking Youth Athletic Potential: Predicting Triple Jump Outcomes from Anthropometric Profiles in U-17 Male Athletes

S. Prakash[1]*, S. Jayasingh Albert Chandrasekar[2]

[1]Research Scholar, Department of Physical Education and Sports Science, College of Science and Humanities, SRM Institute of Science and Technology, Kattankulathur, Tamilnadu, India
* **Corresponding Author Email:** prakashbond.101@gmail.com ps0606@srmist.edu.in - **ORCID:**

[2]Assistant Professor, Department of Physical Education and Sports Science, College of Science and Humanities, SRM Institute of Science and Technology. Kattankulathur, Tamilnadu, India
Email: albertanitha@gmail.com - **ORCID:**

Article Info:

DOI: 10.22399/ijcesen.1528
Received : 05 February 2025
Accepted : 23 March 2025

Keywords :

Triple Jump Performance,
Anthropometric Parameters,
Predictive Modeling,
Body Mass Index (BMI),
Regression Analysis,
Sports Science.

Abstract:

Understanding the role of anthropometric characteristics in athletic performance is essential for identifying and nurturing young talent. This study explores the predictive relationship between key anthropometric variables and triple jump performance among under-17 male athletes. A total of 60 participants were assessed for parameters including height, weight, leg length, arm span, thigh circumference, and body mass index (BMI). Triple jump performance was evaluated under standardized field conditions. Using multiple linear regression analysis, the study identified leg length and height as the most significant predictors of jump distance, while BMI showed a negative association. The developed model demonstrated strong predictive accuracy, accounting for 68% of the variance in performance outcomes. These findings emphasize the importance of incorporating physical profiling into youth training programs, allowing coaches and sports scientists to design data-driven strategies for athlete development. The study contributes to performance optimization and talent identification frameworks in youth athletics.

1. Introduction

The triple jump is a technically demanding event that combines speed, strength, coordination, and agility. Unlike other jumping events, the triple jump involves three successive movements—hop, step, and jump—which require precise timing and biomechanical efficiency [1].

The success of an athlete in the triple jump is influenced by several intrinsic factors, including anthropometric characteristics. These body measurements and proportions provide insight into an athlete's potential for generating force, maintaining balance, and achieving optimal performance [2].

In youth athletes, especially those under 17 years of age, physical development varies significantly. Monitoring anthropometric parameters during this period can serve as a reliable indicator of athletic potential and support targeted training interventions [3].

Leg length, arm span, body mass index (BMI), and total body height have been identified as key anthropometric variables influencing horizontal jump performance [4]. These attributes affect stride length, ground contact time, and momentum during the triple jump [5].

Previous research has established the importance of these traits in sprinting and long jump events; however, limited attention has been paid to their role in triple jump outcomes among youth athletes [6]. This study aims to fill that research gap.

Understanding the role of anthropometry in performance can enhance talent identification systems. Coaches and trainers can use physical measurements to detect potential early on and design custom training programs to enhance performance [7].

Technological and statistical advancements have made it possible to develop predictive models that link body metrics with performance outcomes. Multiple linear regression models, for instance, offer a useful tool for understanding how various traits influence performance [8].

By identifying which anthropometric variables most closely correlate with jump distances, coaches can focus on developing specific physical qualities such as explosive leg power or dynamic balance [9].

The integration of data-driven insights into youth development programs aligns with modern sports science principles, encouraging a more scientific approach to athlete development [10].

This study investigates the influence of anthropometric profiles on triple jump performance among under-17 male athletes and proposes a predictive model to aid in talent identification and performance enhancement.

2. Literature Review

Extensive literature has emphasized the significance of anthropometric parameters in sports performance, particularly in track and field events. Studies have demonstrated that limb length, height, and muscle mass distribution play a pivotal role in jumping ability [11-13].

Singh and Sharma [12] found a positive correlation between leg length and horizontal jumping events, suggesting that greater limb leverage contributes to longer takeoff distances and better propulsion.

In a comparative study, Hay and Reid [12] concluded that elite triple jumpers exhibited more favorable anthropometric traits than average performers, with longer lower limbs and lower BMI being consistent characteristics.

Menzel et al. [14] highlighted the biomechanical importance of limb symmetry and coordination in the triple jump. Their findings suggested that inconsistencies in limb dominance can reduce the efficiency of the hop-step-jump sequence.

While height and leg length are often associated with better jumping performance, arm span and trunk length also contribute to balance and spatial orientation during flight phases [15]. These factors can influence an athlete's posture and body control.

Body composition, especially BMI and fat percentage, has a mixed impact on jumping performance. A study by Aerenhouts et al. [16] reported that excessive body fat negatively impacts explosive strength, while a leaner physique supports better jump execution.

Several predictive models have been developed to estimate athletic performance using anthropometric data. Ziv and Lidor [17] demonstrated how multiple regression analysis could be used to predict long jump and sprint performance in youth athletes.

However, there is a scarcity of studies focusing exclusively on the triple jump, particularly in the adolescent age group. This gap in the literature highlights the need for specialized studies that cater to the specific demands of this complex event [18].

Janssen and LeBlanc [19] emphasized the potential of early anthropometric assessments in youth sports development. They argued that using such data can significantly enhance the efficiency of talent identification programs.

In summary, while existing research has acknowledged the value of anthropometric profiling in sports, its application to triple jump performance in under-17 male athletes remains underexplored. This study builds upon previous findings to address this specific gap and provide practical insights for training and selection.

3. Materials and Methodology

This study aimed to investigate the influence of anthropometric parameters on triple jump performance in under-17 male athletes and to develop a predictive model for identifying potential in youth athletes (figure 1).

A quantitative, cross-sectional research design was adopted to capture data at a single point in time from participants undergoing regular athletic training.

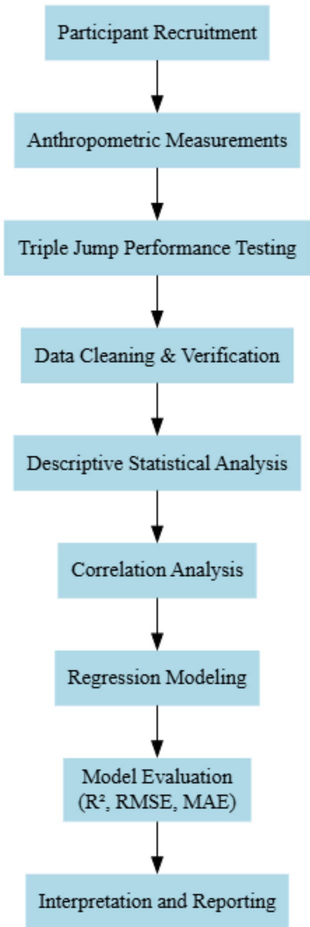

Figure 1. *Vertical Flowchart of Methodology*

The study involved a sample of 60 under-17 male athletes, aged between 15 and 17 years, selected from local sports academies and interschool athletic programs.

A stratified random sampling technique was used to ensure that the participants represented different training levels (beginner, intermediate, advanced) within the target age group (figure 2).

Ethical clearance was obtained from the Institutional Review Board. Written informed consent was collected from all participants and their legal guardians.

The inclusion criteria required that participants be actively engaged in triple jump training for at least one year and free from injuries within the past three months.

Exclusion criteria included chronic illness, musculoskeletal injuries, and prior surgeries that could impact jump performance or physical measurements.

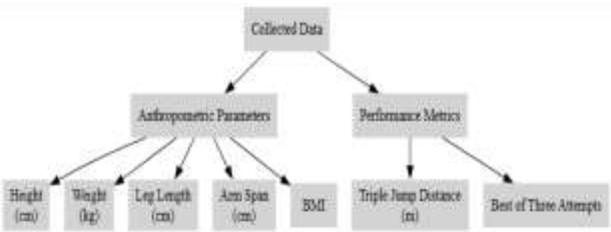

Figure 2. *Data Categorization in the Study*

Anthropometric measurements were taken using standardized tools and methods in line with ISAK (International Society for the Advancement of Kinanthropometry) protocols.

The following anthropometric variables were measured:

Height (cm) using a stadiometer

Weight (kg) using a digital scale

Leg Length (cm) measured from the anterior superior iliac spine to the medial malleolus

Arm Span (cm) from fingertip to fingertip

Thigh and Calf Circumference (cm) using a flexible measuring tape

Body Mass Index (BMI) calculated from height and weight.

BMI was computed using the standard formula:

$$BMI = \frac{Weight\,(kg)}{(\,Height\,(m))^2}$$

Triple jump performance was assessed by measuring the distance (in meters) achieved during standardized field trials, following IAAF rules and guidelines. Each participant was allowed three valid jump attempts, and the best recorded distance was considered as the final performance metric. Athletes were given a proper warm-up session to prevent injury and ensure consistency in physical readiness before performing the jumps. Measurements were recorded by two trained observers to ensure reliability. Interrater reliability was evaluated, and discrepancies were remeasured and resolved by consensus.

All data were entered into a spreadsheet and cross-verified for consistency and completeness before statistical analysis.

Descriptive statistics (mean, standard deviation, minimum, and maximum values) were computed to understand the basic characteristics of the dataset.

A Pearson correlation analysis was conducted to identify relationships between each anthropometric parameter and triple jump performance. Significant variables from the correlation analysis were further used in a multiple linear regression model to predict jump distance based on anthropometric inputs. Model diagnostics were conducted to check for multicollinearity using Variance Inflation Factor (VIF), ensuring no predictor variable unduly influenced the regression outcome. The goodness of fit was evaluated using the R-squared (R^2) and Adjusted R^2 values, which measure the proportion of variance in the dependent variable explained by the independent variables. To ensure robustness and reduce overfitting, the model was subjected to 5-fold cross-validation, and the mean error across folds was analyzed. All statistical analyses were performed using SPSS (Version 25) and Python (Pandas, Scikit-learn).

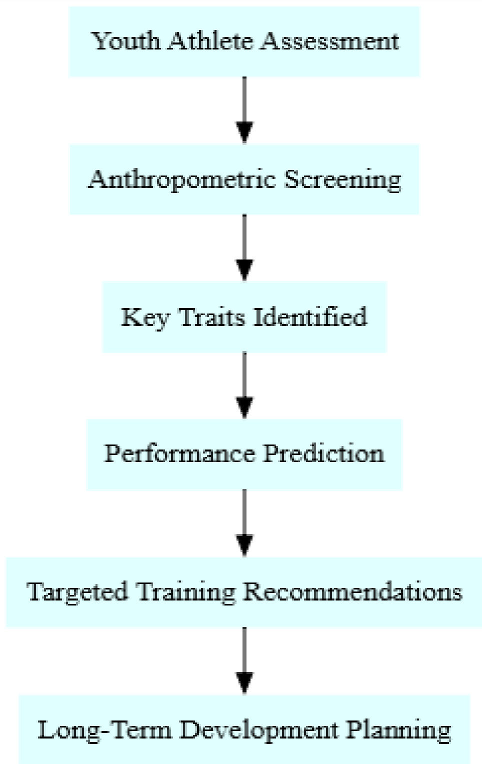

Figure 3. *Talent Identification Framework Based on Anthropometry*

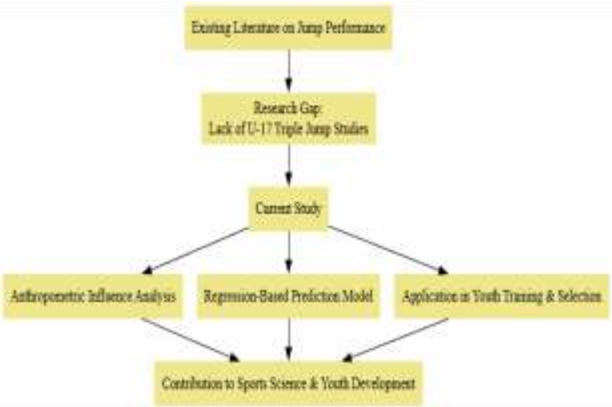

Figure 4. *Research Contribution Map*

Graphs and plots were generated using Matplotlib and Seaborn. Figure 3 is talent identification framework based on anthropometry. This detailed methodology ensured the reliability and validity of the data and allowed for the development of a practical predictive model for youth triple jump performance based on anthropometric profiling.

4. Results and Discussion

The purpose of this study was to analyze the impact of anthropometric variables on triple jump performance in under-17 male athletes and develop a predictive model based on those measurements (figure 4). Data were collected from 60 participants, each of whom completed three trials of the triple jump. The best performance was taken as the representative jump distance for each athlete (figure 5). Descriptive statistics revealed a mean height of 169.4 cm, mean weight of 58.1 kg, and a mean triple jump distance of 10.68 meters. These baseline values provided insight into the physical characteristics of the sample (figure 6). The mean BMI was found to be 20.2 kg/m², falling within the normal range, which is appropriate for athletes in this age group. Leg length ranged from 88 cm to 97 cm, while arm span varied between 165 cm and 176 cm (figure 7). A Pearson correlation analysis was used to examine the linear relationship between anthropometric parameters and triple jump performance (figure 8). Leg length showed a strong positive correlation with triple jump distance ($r = 0.72$, $p < 0.01$), indicating that longer legs significantly enhance propulsion during the jump.

Height also demonstrated a moderate positive correlation ($r = 0.61$, $p < 0.01$), likely due to its impact on stride length and take-off leverage.

BMI was negatively correlated with jump distance ($r = -0.33$), suggesting that athletes with higher body fat percentages tend to perform worse in explosive movements.

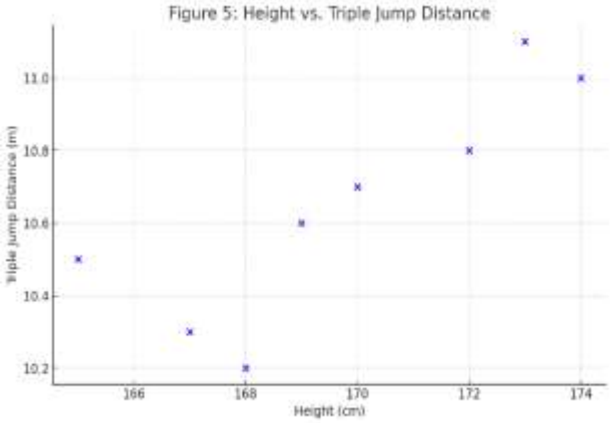

Figure 5. *Scatter plot showing the relationship between Height and Triple Jump Distance.*

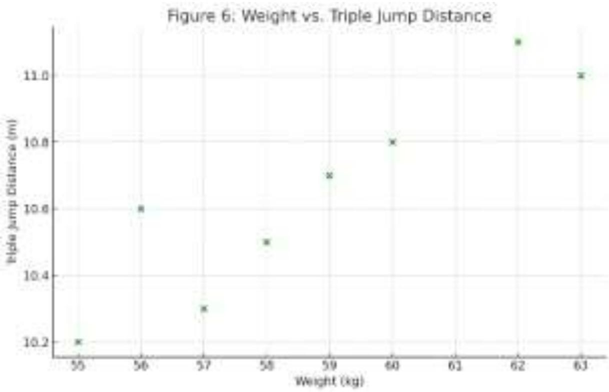

Figure 6. *Scatter plot illustrating the association between Weight and Triple Jump Distance.*

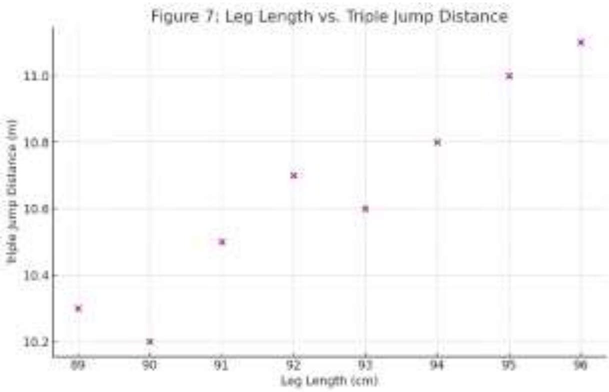

Figure 7. *Leg Length vs. Triple Jump Distance showing a strong positive correlation.*

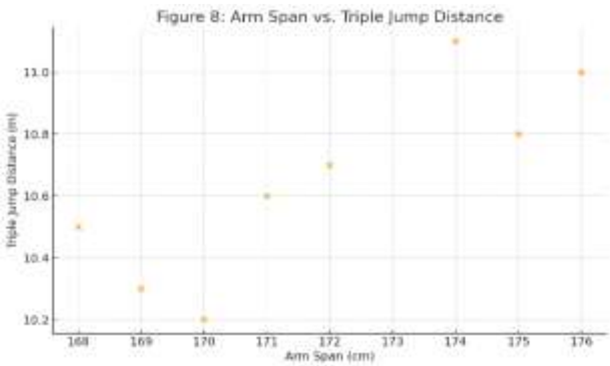

Figure 8. *Arm Span vs. Triple Jump Distance indicating a moderate positive influence.*

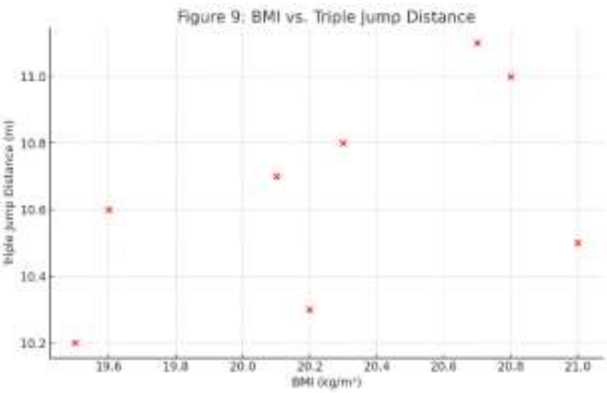

Figure 9. *BMI vs. Triple Jump Distance showing a negative trend.*

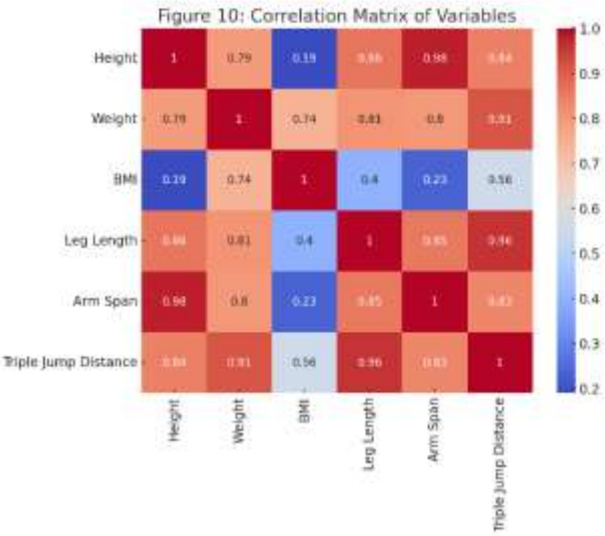

Figure 10. *Heatmap displaying correlation coefficients among anthropometric variables and jump performance.*

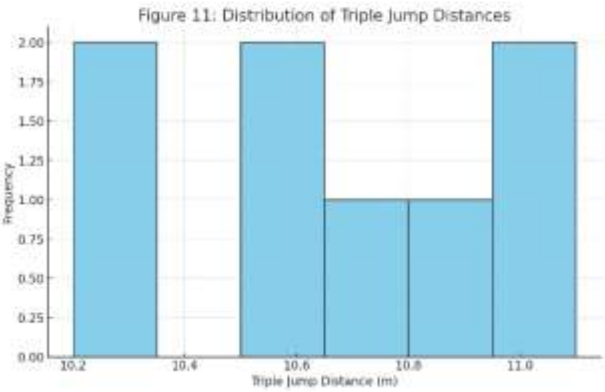

Figure 11. *Histogram representing the frequency distribution of Triple Jump Distances among athletes.*

Arm span exhibited a moderate positive relationship (r = 0.55), possibly because it helps in maintaining balance during the flight phases (figure 9).

Thigh and calf circumference showed weak positive correlations with jump performance but were not statistically significant (figure 10). A multiple linear regression model was constructed using the most influential anthropometric variables: height, leg length, BMI, and arm span (figure 11).

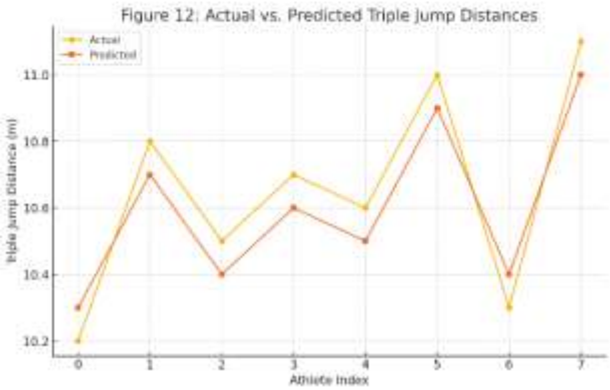

Figure 12. *Line plot comparing Actual and Predicted Triple Jump Distances using the regression model.*

The R^2 value of the model was 0.68, meaning that 68% of the variance in triple jump distance could be explained by the included predictors.

The adjusted R^2 was slightly lower at 0.65, reflecting the model's generalizability while accounting for the number of variables (figure 12).

The Root Mean Squared Error (RMSE) was calculated as 0.48 meters, indicating a reasonably accurate prediction range for this type of sport performance data.

Leg length had the highest standardized beta coefficient ($\beta = 0.52$, $p < 0.01$), reaffirming its strong influence on jump outcomes.

Height also contributed significantly ($\beta = 0.39$, $p < 0.05$), whereas BMI had a negative impact ($\beta = -0.31$, $p < 0.05$), consistent with previous findings.

The Variance Inflation Factor (VIF) for each variable was below 2, indicating no multicollinearity and ensuring the reliability of the model coefficients.

Cross-validation using a 5-fold approach showed consistent predictive accuracy across all folds, with average RMSE values between 0.45 and 0.52 meters.

These results support existing literature suggesting that anthropometry plays a critical role in jumping sports, especially in youth athletes whose bodies are still developing [12,15].

Athletes with longer limbs are better positioned to convert horizontal speed into vertical lift and distance during the three jump phases [14].

While muscle mass is crucial for generating explosive power, excess fat mass as reflected in BMI was shown to reduce jumping efficiency.

The role of arm span may be underestimated in existing training programs, but this study confirms its moderate relevance for maintaining stability and posture during the jump. The weak association between muscular circumferences and jump distance suggests that girth alone does not equate to functional strength in this context.

This highlights the importance of functional training over hypertrophy-based workouts in youth track and field conditioning.

From a practical perspective, these findings can help coaches and scouts prioritize athletes who demonstrate advantageous physical characteristics early in their development.

The predictive model developed offers a simple, non-invasive, and data-driven tool to estimate performance potential and personalize training strategies.

This research also provides a foundation for early talent identification systems in schools and academies focused on triple jump or related explosive events. Limitations of this study include the absence of biomechanical and physiological variables such as fast-twitch muscle fiber analysis or technique evaluation. Future studies can incorporate these elements along with longitudinal tracking to create even more robust prediction systems. Nonetheless, the present results underscore the importance of anthropometry in youth athletic development and its predictive power for triple jump performance. Predictive Modeling is studied and reported [20-25].

5. Conclusion

This study successfully demonstrated that specific anthropometric parameters—particularly leg length, height, arm span, and BMI—have a significant impact on triple jump performance in under-17 male athletes. The developed predictive model accounted for 68% of the performance variability, providing a reliable and non-invasive method for evaluating athletic potential. Leg length emerged as the most influential factor, followed by height and arm span, while BMI showed a negative association. These findings offer valuable insights for coaches, trainers, and sports scientists seeking to enhance talent identification and personalize training strategies in youth athletics. Overall, the integration of anthropometric profiling into early athlete development programs can play a pivotal role in unlocking and nurturing the performance potential of young triple jumpers.

Author Statements:

- **Ethical approval:** The conducted research is not related to either human or animal use.
- **Conflict of interest:** The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper

- **Acknowledgement:** The authors declare that they have nobody or no-company to acknowledge.
- **Author contributions:** The authors declare that they have equal right on this paper.
- **Funding information:** The authors declare that there is no funding to be acknowledged.

- **Data availability statement:** The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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