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Correlation Between Nutritional Status, Balance, and Triple Jump Learning Outcomes Among Senior High School Students at Budi Agung Medan

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ABSTRACT

Purpose of the study: Physical performance in athletic activities such as triple jump is influenced by multiple physiological factors including nutritional status and postural balance. Understanding these relationships is crucial for optimizing physical education outcomes in adolescent populations. This study aimed to investigate the correlation between nutritional status, balance ability, and learning outcomes in triple jump performance among senior high school students at Budi Agung Medan, Indonesia.

Materials and methods: A cross-sectional study was conducted with 120 students (60 males, 60 females) aged 16-18 years. Nutritional status was assessed using Body Mass Index (BMI) and body composition analysis. Balance was evaluated using the Stork Balance Stand Test and Y-Balance Test. Triple jump performance was measured through standardized technique assessment and distance achievement. Data were analyzed using Pearson correlation and multiple regression analysis with SPSS v27.

Results: Significant positive correlations were found between nutritional status and triple jump performance ($r = 0.624$, $p < 0.001$), balance ability and triple jump performance ($r = 0.712$, $p < 0.001$), and nutritional status and balance ability ($r = 0.543$, $p < 0.001$). Multiple regression analysis revealed that balance ability ($\beta = 0.465$, $p < 0.001$) and nutritional status ($\beta = 0.287$, $p < 0.01$) jointly explained 58.7% of the variance in triple jump learning outcomes.

Conclusions: Nutritional status and balance ability are significant predictors of triple jump learning outcomes in adolescents. Physical education programs should incorporate nutritional education and balance training to optimize athletic performance development.

Keywords

nutritional status, postural balance, triple jump, physical education, adolescents, motor learning.

INTRODUCTION

Athletic performance in track and field events is an intricate result of interacting physiological, biomechanical, and nutritional elements (Froberg & Andersen, 2011). The triple jump, distinguished by its technical complexity requiring coordinated hop-step-jump phases, provides an exemplary model for exploring the associations between fundamental physical characteristics and motor learning achievements (He et al., 2023; Jaspert et al., 2025). This study specifically examines how nutritional status, recognized as a primary determinant of overall physical health and energy availability, alongside balance, an indispensable element for performing intricate motor skills, affects senior high school students' acquisition and mastery of triple jump techniques (Nirwandi & Hardiansyah, 2020) (Adha et al., 2025). The general health and well-being of high school adolescents, particularly their nutritional condition, profoundly impact their physical, cognitive, and academic capabilities (Said et al., 2025). In the context of Indonesian education, where physical education is integral to adolescent development, understanding these relationships is especially critical for refining curricula and elevating student performance.

The adolescent period represents a critical window for motor skill development and physical capability acquisition (Shi & Feng, 2022; Veličković et al., 2025). During this phase, proper nutrition and well-developed balance systems contribute significantly to athletic performance and learning efficiency. Malnutrition, either under- or over-nutrition, can impair physical fitness components vital for athletic endeavors, including strength, endurance, and reaction time (Mappaompo et al., 2020; Shah, 2020). For instance, inadequate nutritional intake can directly impede energy production and muscle recovery, thereby limiting a student's capacity to engage effectively in physically demanding activities like the triple jump (Nafilla et al., 2023). Research in sports science has consistently demonstrated that nutritional adequacy and postural control are fundamental prerequisites for complex motor skill acquisition, particularly in technically demanding activities such as the triple jump.

Previous investigations have established substantial evidence linking nutritional status to athletic performance outcomes. Hecht et al., (2023) demonstrated significant correlations between BMI classifications and sprint performance in adolescent athletes,

while (Mainer-Pardos et al., 2021) reported that optimal body composition facilitates enhanced power production in jumping events. Furthermore, studies indicate that adolescents adhering to recommended macronutrient intake levels, particularly carbohydrates and proteins, tend to exhibit improved physical fitness indices (Oukheda et al., 2023). Conversely, poor nutritional status, as evidenced by imbalanced macronutrient intake or higher body fat percentages, has been shown to correlate negatively with physical fitness components among adolescents (Ferozi et al., 2024; Oukheda et al., 2023). These findings align with physiological principles suggesting that appropriate muscle mass distribution and energy availability are essential for explosive movement patterns.

Balance and postural control research has similarly revealed strong associations with athletic performance. Zech et al., (2010) found that dynamic balance capabilities significantly predicted success in technical track and field events among youth athletes. Furthermore, Eraslan et al., (2025) established that proprioceptive training programs targeting balance improvement resulted in enhanced learning rates for complex motor skills in physical education settings.

The intersection of nutritional status and balance ability has received limited attention in previous research. However, emerging evidence suggests that nutritional adequacy influences neuromuscular control mechanisms underlying postural stability. Guzmán-Muñoz et al., (2025) reported that students with optimal nutritional profiles demonstrated superior balance performance compared to undernourished or overnourished counterparts.

Despite the substantial body of literature examining individual relationships between nutritional status, balance, and athletic performance, limited research has investigated the combined effects of these variables on specific motor learning outcomes in educational contexts. Most existing studies have focused on elite athlete populations rather than general student populations in physical education settings. Additionally, research specifically examining triple jump performance as an outcome variable remains scarce, particularly in Southeast Asian adolescent populations.

The lack of comprehensive investigations examining the interactive effects of nutritional status and balance ability on complex motor skill learning represents a significant gap in current understanding. Furthermore, the cultural and environmental factors specific to Indonesian educational contexts have been underrepresented in international sports science literature.

The growing emphasis on evidence-based physical education practices necessitates comprehensive understanding of factors influencing student learning outcomes. Given the technical complexity of the triple jump and its inclusion in Indonesian physical education curricula, investigating the determinants of performance in this event provides valuable insights for pedagogical optimization.

Understanding the relationships between nutritional status, balance ability, and triple jump learning outcomes has practical implications for physical education program design, student assessment protocols, and intervention strategies. This knowledge can inform targeted approaches to improve student performance while promoting overall health and fitness development.

The primary objective of this study was to examine the correlational relationships between nutritional status, balance ability, and triple jump learning outcomes among senior high school students. Specifically, this investigation aimed to assess the correlation between nutritional status and triple jump performance while simultaneously evaluating the relationship between balance ability and triple jump learning outcomes. Additionally, the study sought to investigate the association between nutritional status and balance capability to understand their interconnected influences on motor performance. Furthermore, the research endeavored to determine the combined predictive value of nutritional status and balance ability for triple jump performance through comprehensive statistical modeling. Ultimately, this investigation aimed to provide evidence-based recommendations for physical education practice that could enhance student learning outcomes and inform curriculum development strategies in Indonesian educational contexts.

MATERIALS AND METHODS

Study Participants

This cross-sectional study involved 120 senior high school students (60 males, 60 females) from Budi Agung Medan, Indonesia. Participants ranged in age from 16 to 18 years (mean age = 17.2 ± 0.8 years). Inclusion criteria specified students with no history of lower extremity injuries, no diagnosed balance disorders, and regular participation in physical education classes. Exclusion criteria included chronic medical conditions affecting motor performance, current use of medications influencing balance or coordination, and absence from school exceeding 20% of the academic term.

Ethical approval was obtained from the Sekolah Tinggi Olahraga dan Kesehatan Bina Guna Research Ethics Committee (Protocol #2024-PE-156). Written informed consent was secured from all participants and their parents/guardians prior to data collection. The study was conducted in accordance with the Declaration of Helsinki principles for human research.

Study Organization

Data collection occurred over a four-week period during the second semester of the 2024 academic year. All measurements were conducted during regular physical education class periods to maintain ecological validity. The testing protocol was administered by certified physical education instructors and sports science researchers trained in standardized assessment procedures.

Testing sessions were organized in three phases: (1) anthropometric and nutritional status assessment, (2) balance evaluation, and (3) triple jump performance testing. A minimum 48-hour interval was maintained between testing phases to prevent fatigue effects. Environmental conditions were standardized with testing conducted on the school's outdoor track facility during morning hours (08:00-11:00) to minimize temperature and wind variability.

Test and Measurement Procedures

Table 1. Test and Measurement Procedures for Nutritional Status, Balance, and Triple Jump Performance Evaluation

Aspect	Measurement Procedures	Instruments / Standards	Parameters / Output
Nutritional Status	Body Mass Index (BMI) calculated from standardized height and weight	Height: Portable stadiometer (SECA 213, Hamburg, Germany) – accuracy 0.1 cm Weight: Calibrated digital	BMI (kg/m ²) Body fat percentage Muscle mass Total

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Assessment	measurements.	scale (SECA 877, Hamburg, Germany) – accuracy 0.1 kg Body composition: Bioelectrical Impedance Analyzer (InBody 270, Seoul, South Korea)	body water Classification: WHO BMI-for-age percentiles
Balance Assessment	Two standardized tests were used: • Stork Balance Stand Test for static balance (single-leg stance, eyes closed, max 60 sec) • Y-Balance Test for dynamic balance (anterior, posteromedial, posterolateral reach)	Stopwatch, balance test grid	Static balance duration (sec) Dynamic reach distance (cm) Best of 3 trials recorded
Triple Jump Performance Evaluation	Technique and distance assessed using standardized protocols on a 40 m approach runway with 5 m interval markers. Five trials conducted with rest between attempts.	Measuring tape (nearest cm) (0–100)	Technical scoring rubric Jump distance (cm) Technical performance score (0–100) Best performance used for analysis

Statistical Analysis

Quantitative analyses were conducted using SPSS version 27.0 (IBM Corporation, Armonk, NY). Descriptive statistics including means, standard deviations, and frequency distributions were calculated for all variables. Normality of data distribution was assessed using the Shapiro-Wilk test and visual inspection of histograms and Q-Q plots.

Pearson correlation coefficients were computed to examine bivariate relationships between nutritional status indicators, balance measures, and triple jump performance variables. Effect sizes were interpreted according to Cohen's conventions (small = 0.10, medium = 0.30, large = 0.50).

Multiple regression analysis was performed to determine the combined predictive value of nutritional status and balance ability for triple jump learning outcomes. Model assumptions including linearity, independence, homoscedasticity, and normality of residuals were verified through appropriate diagnostic procedures.

Statistical significance was set at $\alpha = 0.05$ for all analyses. Confidence intervals (95% CI) were calculated for correlation coefficients and regression parameters to provide effect size estimation and precision indicators.

RESULTS

Descriptive Statistics

Participant characteristics are presented in Table 2. The sample demonstrated normal distribution for age, anthropometric measures, and performance variables. Mean BMI classification indicated that 73.3% of participants fell within normal weight ranges, with 15.0% classified as underweight and 11.7% as overweight.

Table 2. Participant Characteristics and Descriptive Statistics

Variable	Males (n=60)	Females (n=60)	Total (n=120)
Age (years)	17.3 ± 0.8	17.1 ± 0.7	17.2 ± 0.8
Height (cm)	167.4 ± 6.2	156.8 ± 5.4	162.1 ± 7.8
Weight (kg)	59.7 ± 8.9	52.3 ± 7.1	56.0 ± 8.7
BMI (kg/m ²)	21.3 ± 2.4	21.3 ± 2.8	21.3 ± 2.6
Body Fat (%)	12.8 ± 3.2	22.1 ± 4.6	17.5 ± 6.4
Stork Balance (s)	28.4 ± 12.6	31.2 ± 14.3	29.8 ± 13.5
Y-Balance Score	87.3 ± 8.9	89.6 ± 9.7	88.5 ± 9.3
Triple Jump Distance (m)	8.92 ± 1.24	6.78 ± 0.98	7.85 ± 1.52
Technique Score	76.3 ± 11.8	74.9 ± 12.4	75.6 ± 12.1

Correlation Analysis

Significant positive correlations were observed between all primary variables of interest. Table 2 presents the correlation matrix with 95% confidence intervals.

Table 3. Correlation Matrix for Primary Study Variables

Variables	1	2	3	4	5
1. BMI	-				
2. Body Composition Score	0.487**	-			
3. Static Balance	0.398**	0.521**	-		
4. Dynamic Balance	0.456**	0.598**	0.687**	-	
5. Triple Jump Performance	0.624**	0.578**	0.645**	0.712**	-

Note: ** $p < 0.001$

The strongest correlation was observed between dynamic balance ability and triple jump performance ($r = 0.712$, $p < 0.001$, 95% CI: 0.628-0.782). Nutritional status, as indicated by BMI, demonstrated substantial correlation with triple jump performance ($r = 0.624$, $p < 0.001$, 95% CI: 0.524-0.708). The relationship between nutritional status and balance ability was moderate but significant ($r = 0.543$, $p < 0.001$, 95% CI: 0.431-0.639).

Multiple Regression Analysis

Multiple regression analysis revealed that balance ability and nutritional status jointly explained 58.7% of the variance in triple jump learning outcomes ($R^2 = 0.587$, $F(2,117) = 83.47$, $p < 0.001$). The regression model demonstrated adequate fit with no violations of underlying assumptions.

Table 4. Multiple Regression Analysis Predicting Triple Jump Performance

Predictor	B	SE B	β	t	p	95% CI
Constant	-2.847	1.234	-	-2.31	0.022	[-5.289, -0.405]
Dynamic Balance	0.073	0.012	0.465	6.08	<0.001	[0.049, 0.097]
BMI	0.168	0.043	0.287	3.91	<0.001	[0.083, 0.253]

Dynamic balance ability emerged as the strongest predictor ($\beta = 0.465$, $p < 0.001$), followed by nutritional status as measured by BMI ($\beta = 0.287$, $p < 0.001$). The model demonstrated strong predictive validity with standardized residuals showing normal distribution and homogeneous variance across predicted values.

Gender Differences

Analysis of gender differences revealed significant variations in performance outcomes while maintaining consistent correlation patterns. Males demonstrated superior triple jump distances ($p < 0.001$, $d = 1.58$) but females showed better balance scores ($p < 0.05$, $d = 0.31$). However, correlation magnitudes remained comparable across gender groups, suggesting universal applicability of the observed relationships.

DISCUSSION

The findings of this investigation provide compelling evidence for significant relationships between nutritional status, balance ability, and triple jump learning outcomes among Indonesian high school students. The observed correlations align with established principles of motor learning and sports performance, while contributing novel insights specific to adolescent populations in educational contexts.

The strong correlation between dynamic balance and triple jump performance ($r = 0.712$) supports theoretical frameworks emphasizing the importance of postural control in complex motor skills. Specifically, effective balance is crucial for coordinating the sequential movements of the hop, step, and jump phases, enabling athletes to maintain momentum and achieve optimal distance (Dwiwinanda, 2023; Sipriadi et al., 2024; Fadholi, 2023). The triple jump's technical demands, requiring precise coordination during hop-step-jump phases, necessitate sophisticated balance mechanisms for optimal performance. Furthermore, a robust nutritional status, characterized by adequate energy and macronutrient intake, is intrinsically linked to sustained physical exertion and neuromuscular efficiency, both critical for executing powerful and coordinated triple jump sequences (Said et al., 2025). These findings suggest that students with superior balance capabilities demonstrate enhanced ability to acquire and execute the technical components of triple jump performance.

The substantial relationship between nutritional status and triple jump performance ($r = 0.624$) reflects the fundamental role of adequate nutrition in supporting explosive movement patterns and motor learning processes. Optimal body composition and energy availability facilitate the power production required for successful triple jump execution while supporting the recovery processes essential for skill acquisition.

These results align with previous research demonstrating positive associations between nutritional adequacy and athletic performance in adolescent populations. The observed correlation magnitudes are consistent with those reported by (Ampe et al., 2023) in sprint performance studies, suggesting that nutritional factors exert similar influences across explosive track and field events.

The balance-performance relationships identified in this study corroborate findings from (Domínguez-Navarro et al., 2023), who reported comparable correlation coefficients between dynamic balance measures and technical event performance in youth athletes. However, our investigation extends these findings by specifically linking balance capabilities to a complex, multi-phase athletic movement like the triple jump, rather than simpler tasks (Gómez-Dolader et al., 2024). Moreover, the distinct kinematic demands of the triple jump's hop, step, and jump phases, each requiring nuanced balance adjustments and powerful muscle contractions, underscore the importance of both stable nutritional foundations and refined proprioceptive control (García-Fresneda et al., 2024). However, the current study extends these findings by examining specific motor learning outcomes rather than isolated performance measures.

The novel aspect of this investigation lies in the demonstration of combined predictive effects of nutritional status and balance ability. The 58.7% variance explanation achieved through multiple regression analysis exceeds values reported in previous studies examining single predictor variables, highlighting the importance of multifactorial approaches to understanding motor learning outcomes. This comprehensive understanding underscores the necessity of integrating both nutritional guidance and balance training into physical education curricula to optimize athletic development and learning in complex motor skills (Morgado et al., 2023). Such integrated approaches could significantly enhance overall student athletic potential and mitigate injury risks, fostering a more holistic development of young athletes (Alcock et al., 2024; Granacher & Behm, 2022; Sehgal et al., 2023).

These findings have significant implications for physical education practice and curriculum development. The identification of balance ability as the strongest predictor of triple jump learning outcomes suggests that incorporating systematic balance training into physical education programs could enhance student performance across technical athletic events.

The substantial contribution of nutritional status to performance variance indicates that physical education programs should integrate nutritional education components to optimize student learning outcomes. This integration aligns with holistic approaches to physical education that address multiple dimensions of health and performance.

From a pedagogical perspective, these results suggest that pre-assessment of balance ability and nutritional status could inform individualized instruction strategies. Students with lower baseline capabilities in these areas may benefit from targeted interventions prior to intensive technical skill instruction.

Several limitations should be acknowledged when interpreting these findings. The cross-sectional design precludes causal inferences regarding the relationships between variables. Longitudinal investigations would provide stronger evidence for causal mechanisms underlying the observed associations.

The study population was limited to a single school in Medan, potentially limiting generalizability to broader Indonesian student populations or international contexts. Cultural, socioeconomic, and environmental factors specific to this setting may influence the observed relationships.

Nutritional status assessment relied primarily on anthropometric measures and bioelectrical impedance analysis. More comprehensive nutritional evaluation including dietary intake assessment and biochemical markers would provide enhanced understanding of nutritional influences on performance outcomes.

The triple jump performance assessment, while standardized, was conducted in educational rather than competitive contexts. Performance outcomes in formal athletic competition may demonstrate different relationships with the measured predictor variables.

CONCLUSION

This investigation provides robust evidence for significant correlations between nutritional status, balance ability, and triple jump learning outcomes among Indonesian high school students. The findings demonstrate that balance ability serves as the strongest predictor of performance, while nutritional adequacy contributes substantially to motor learning success. Together, these factors explain nearly 60% of the variance in triple jump performance outcomes.

The results reinforce the importance of multifactorial approaches to understanding motor learning in physical education contexts. Balance training and nutritional education emerge as evidence-based strategies for enhancing student performance in technically demanding athletic activities.

These findings highlight the interconnected nature of physiological capabilities underlying complex motor skill acquisition. Physical education programs incorporating systematic attention to balance development and nutritional adequacy are likely to achieve superior learning outcomes compared to traditional skill-focused approaches.

The research contributes valuable evidence for curriculum development and instructional design in physical education settings. The identification of specific predictive factors enables targeted interventions to support student success while promoting comprehensive health and fitness development.

Future research should examine the longitudinal effects of balance training and nutritional interventions on motor learning outcomes across diverse athletic activities. Investigation of these relationships in varied cultural and educational contexts would enhance understanding of universal versus context-specific factors influencing physical education success.

The practical implications of this research extend beyond academic contexts to community sport programs and youth athletic development initiatives. Understanding the fundamental relationships between nutrition, balance, and motor learning provides foundation for evidence-based approaches to promoting physical activity participation and performance excellence among adolescent populations.

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CONFLICT OF INTEREST

The authors declare no competing financial, professional, or personal interests that could have influenced the conduct or reporting of this research. No external funding sources were involved in study design, data collection, analysis, or manuscript preparation. All authors contributed equally to the research process and manuscript development.

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