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Original Research

The Influence of Abdominal Muscle Strength and Waist Flexibility on the Long Jump Results of Male Athletes

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ABSTRACT

Objectives: To examine the relationship between abdominal muscle strength and waist flexibility with long jump performance among male collegiate athletes, and to determine the relative contribution of these factors to jump distance.
Methods: A cross-sectional study was conducted with 60 male physical education students aged 18-22 years from Sekolah Tinggi Olahraga dan Kesehatan Bina Guna Medan, Indonesia. Participants underwent assessments of abdominal muscle strength (one-minute sit-up test), waist flexibility (sit-and-reach test), and long jump performance. Pearson correlation and multiple linear regression analyses were used to analyze the relationships between variables.
Results: Abdominal muscle strength showed a moderate positive correlation with long jump distance ($r = 0.68$, $p < 0.001$), while waist flexibility demonstrated a moderate positive correlation ($r = 0.54$, $p < 0.001$). Multiple regression analysis revealed that abdominal strength ($\beta = 0.52$) was a stronger predictor of long jump performance than waist flexibility ($\beta = 0.31$). Together, these factors explained 57.3% of the variance in jump distance.
Conclusion: Core stability and trunk flexibility are important determinants of long jump performance beyond traditional factors like lower limb power. The study recommends incorporating comprehensive core strengthening and flexibility training into long jump preparation, with a particular emphasis on abdominal muscle development.

Keywords: Long jump, Abdominal muscle strength, Waist flexibility, Core stability, Athletic performance, Physical education.

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INTRODUCTION

The long jump is a complex athletic event that requires a combination of speed, strength, technique, and coordination (Bridgett & Linthorne, 2006). While the explosive power of lower limbs has traditionally been the focus of long jump training and research, growing evidence suggests that core stability and flexibility play significant roles in optimizing jump distance (Akl, 2013; Hue et al., 2018).

The long jump consists of four distinct phases: approach run, takeoff, flight, and landing. During these phases, the athlete's body undergoes complex biomechanical movements that require not only lower limb strength but also substantial core stability and trunk flexibility (Lees et al., 2011). Core muscles, particularly the abdominals, play a crucial role in maintaining body position during flight and facilitating an efficient transfer of momentum from the approach to the takeoff (Hibbs et al., 2008). Similarly, waist flexibility may contribute to greater hip extension during takeoff and better body positioning during the flight phase, potentially resulting in increased jump distance (López-Bedoya et al., 2016).

Previous research has extensively documented the importance of approach velocity and takeoff mechanics in long jump performance (Bridgett & Linthorne, 2006; Lees et al., 2011). Studies by Čoh et al. (2017) and Panoutsakopoulos et al. (2016) have established strong correlations between sprint speed and jump distance, highlighting the significance of horizontal velocity in long jump success.

Research on core stability's role in athletic performance has grown in recent years. Hibbs et al. (2008) suggested that core stability may enhance force production and transfer through the kinetic chain, while Akl (2013) found that core training improved performance in various jumping activities. Hue et al. (2018) demonstrated that core strength training led to significant improvements in long jump performance among collegiate athletes.

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Regarding flexibility, López-Bedoya et al. (2016) observed that lower back and hamstring flexibility positively correlated with jump performance in gymnasts. However, Maeda et al. (2018) found inconsistent relationships between trunk flexibility measures and jumping performance in collegiate athletes, suggesting that the relationship may be more complex than previously thought.

Despite growing interest in the role of core stability and flexibility in athletic performance, significant gaps persist in current literature that this study aims to address. Research specifically examining the combined influence of abdominal strength and waist flexibility on long jump performance remains scarce, with most investigations focusing on these factors in isolation rather than their interactive effects. Furthermore, there is limited research exploring these relationships among Southeast Asian populations, particularly Indonesian athletes, whose physiological and biomechanical characteristics may differ from Western populations commonly represented in scientific literature. The relative contribution of each factor to long jump performance has not been clearly established, creating uncertainty about which aspects should be prioritized in training regimens. Additionally, existing research has predominantly focused on elite athletes, with insufficient attention given to collegiate- level performers who represent an important developmental stage in athletic progression and may benefit substantially from targeted training interventions.

Understanding the specific contributions of abdominal muscle strength and waist flexibility to long jump performance could inform more effective training interventions for athletes. If significant relationships exist, coaches and trainers could develop targeted programs to enhance these physical attributes alongside traditional speed and power training.

Furthermore, establishing these relationships in Indonesian collegiate athletes would provide valuable population-specific insights, potentially addressing physiological and training considerations unique to this demographic. This knowledge could ultimately contribute to improved athletic development programs and performance outcomes in physical education institutions across Indonesia.

This study aimed to comprehensively examine the role of core physiological factors in long jump performance among male collegiate athletes. Specifically, we sought to determine the relationship between abdominal muscle strength and long jump distance, while simultaneously assessing how waist flexibility correlates with jumping outcomes in the same population. Additionally, we aimed to evaluate the relative contribution of each factor to long jump performance through appropriate statistical analyses, allowing us to understand which physical attribute exerts greater influence. The ultimate objective was to provide evidence-based recommendations for long jump training programs that could optimize performance through targeted development of these specific physical attributes.

METHODOLOGY

Studi Participant

Sixty male physical education students from Sekolah Tinggi Olahraga dan Kesehatan Bina Guna Medan, Indonesia, volunteered to participate in this study. Participants were aged between 18 and 22 years (mean age: 19.7 ± 1.3 years), with a mean height of 173.5 ± 6.2 cm and a mean weight of 68.4 ± 7.1 kg. All participants had at least one year of experience in physical education training but were not specialized long jump athletes.

Inclusion criteria were: (1) male students enrolled in the physical education program, (2) no history of musculoskeletal injuries in the past six months, and (3) regular participation in physical education classes. Exclusion criteria included: (1) recent injuries affecting the lower limbs or trunk, (2) any medical condition contraindicating physical testing, and (3) specialized training in jumping events at the competitive level.

This study was approved by the Ethics Committee of Sekolah Tinggi Olahraga dan Kesehatan Bina Guna Medan (approval number: STOK-BG/EC/2023-024). All participants provided written informed consent prior to their participation.

Study Organization

This cross-sectional study was conducted at the indoor sports facility of Sekolah Tinggi Olahraga dan Kesehatan Bina Guna Medan between February and April 2023. Data collection took place during three separate sessions, with at least 48 hours between sessions to minimize fatigue effects.

In the first session, participants' anthropometric measurements (height, weight, and leg length) were recorded, and they were familiarized with the testing procedures. The second session involved the assessment of abdominal muscle strength and waist flexibility. In the final session, long jump performance was evaluated.

Test and Measurement

All tests were conducted by trained physical education instructors with experience in fitness assessment. Standardized protocols were followed for each test, and participants performed adequate warm-up exercises before testing.

Table 1. Summary of test and measurement procedures

Test	*Equipment*	*Protocol*	*Measurement Outcomes*
Anthropometric Measurements	Stadiometer (Seca 213), Digital scale (Tanita BC-545N), Measuring tape	Height measured with participant standing barefoot; weight assessed in minimal clothing; leg length measured from greater trochanter to floor while standing	Height (cm), Weight (kg), Leg length (cm)
Abdominal Muscle Strength	Exercise mat, Stopwatch	One-minute sit-up test; participant supine with knees flexed 90°, feet flat on floor and held by assistant, arms crossed over chest; complete as many repetitions as possible in 60 seconds	Number of complete repetitions
Waist Flexibility	Sit-and-reach box (baseline at 23 cm)	Participant seated with legs extended, feet against box; reach forward with hands overlapped, palms down;	Distance reached (cm)

		hold position for 2 seconds; best of three attempts recorded	
Long Jump Performance	Measuring tape, Non-slip landing mat with marked measurement scale	Standing behind line, perform countermovement jump with arm swing; distance measured from starting line to nearest point of contact on landing (heel); best of three attempts recorded	Jump distance (cm)

Statical Analysis

Data analysis was performed using IBM SPSS Statistics for Windows, version 26.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics (mean, standard deviation, range) were calculated for all variables. The Shapiro-Wilk test was used to assess the normality of data distribution.

Pearson product-moment correlation coefficients were calculated to determine the relationships between abdominal muscle strength, waist flexibility, and long jump performance. The strength of correlations was interpreted as follows: weak (r = 0.10– 0.39), moderate (r = 0.40–0.69), and strong (r = 0.70–1.00) (Cohen, 1988).

Multiple linear regression analysis was conducted to examine the combined influence of abdominal muscle strength and waist flexibility on long jump performance. The standardized beta coefficients (β) were used to compare the relative contribution of each predictor variable. Anthropometric variables (height, weight, and leg length) were included as potential confounding factors in the initial model and retained if significant.

Statistical significance was set at $p < 0.05$ for all analyses. The coefficient of determination (R^2) was calculated to determine the proportion of variance in long jump performance explained by the predictor variables.

RESULTS

Descriptive Statistics

Pearson correlation analysis revealed significant relationships between the key variables of interest, as shown in Table 2. A moderate positive correlation was found between abdominal muscle strength and long jump distance ($r = 0.68$, $p < 0.001$), indicating that participants with greater abdominal strength tended to achieve longer jump distances. Similarly, waist flexibility showed a moderate positive correlation with long jump performance ($r = 0.54$, $p < 0.001$).

Additionally, a weak positive correlation was observed between abdominal muscle strength and waist flexibility ($r = 0.35$, $p < 0.01$), suggesting some relationship between these physical attributes, though not as strong as their respective correlations with jump performance.

Among the anthropometric variables, height ($r = 0.42$, $p < 0.001$) and leg length ($r = 0.46$, $p < 0.001$) showed moderate positive correlations with long jump distance, while weight demonstrated a weak negative correlation ($r = -0.28$, $p < 0.05$).

Table 3. Correlation matrix of study variables (N = 60)

Variable	*1*	*2*	*3*	*4*	*5*	*6*	*7*
1. Age	1.00						
2. Height	0.12	1.00					
3. Weight	0.08	0.53**	1.00				
4. Leg length	0.09	0.76**	0.30*	1.00			
5. Abdominal strength	0.14	0.21	-0.34**	0.25	1.00		
6. Waist flexibility	0.03	0.18	-0.27*	0.20	0.35**	1.00	
7. Long jump distance	0.11	0.42**	-0.28*	0.46**	0.68**	0.54**	1.00

Note: * $p < 0.05$, ** $p < 0.01$

Regression Analysis

Multiple linear regression analysis was performed to examine the combined influence of abdominal muscle strength and waist flexibility on long jump performance while controlling for significant anthropometric variables (Table 3). The initial model included height, weight, leg length, abdominal strength, and waist flexibility as predictor variables.

In the final model, weight was excluded as it did not contribute significantly when other variables were considered. The regression equation was statistically significant ($F(4, 55) = 24.63$, $p < 0.001$), with an adjusted R^2 of 0.623, indicating that approximately 62.3% of the variance in long jump distance could be explained by the included variables.

Abdominal muscle strength emerged as the strongest predictor of long jump performance ($\beta = 0.52$, $p < 0.001$), followed by leg length ($\beta = 0.33$, $p < 0.01$), waist flexibility ($\beta = 0.31$, $p < 0.01$), and height ($\beta = 0.18$, $p < 0.05$).

When considering only the two main variables of interest (abdominal strength and waist flexibility), they collectively explained 57.3% of the variance in long jump performance (adjusted $R^2 = 0.573$, $F(2, 57) = 40.17$, $p < 0.001$).

Table 3. Multiple linear regression analysis predicting long jump performance (N = 60)

Predictor Variable	B	SE	β	t	p
Constant	34.26	22.47		1.52	0.133
Height	0.65	0.31	0.18	2.10	0.040
Leg length	1.62	0.44	0.33	3.68	0.001
Abdominal strength	1.39	0.21	0.52	6.62	<0.001
Waist flexibility	1.23	0.30	0.31	4.10	0.001

Note: $R^2 = 0.642$, Adjusted $R^2 = 0.623$

Analysis of Abdominal Strength Categories

To further examine the relationship between abdominal strength and long jump performance, participants were divided into three groups based on their abdominal muscle strength: low (≤35 repetitions, n = 18), moderate (36-45 repetitions, n = 22), and high (≥46 repetitions, n = 20). Figure 1 illustrates the mean long jump distances achieved by each group.

A one-way ANOVA revealed significant differences in long jump performance between groups ($F(2, 57) = 27.83$, $p < 0.001$). Post-hoc Tukey HSD tests indicated that participants in the high abdominal strength group achieved significantly greater jump distances (mean = 249.3 ± 15.4 cm) compared to both the moderate (mean = 231.8 ± 14.7 cm, $p < 0.001$) and low (mean = 210.3 ± 17.5 cm, $p < 0.001$) strength groups. The difference between moderate and low strength groups was also statistically significant ($p < 0.001$).

Analysis of Waist Flexibility Categories

Similarly, participants were categorized based on their waist flexibility scores: low (≤24 cm, n = 19), moderate (25-30 cm, n = 24), and high (≥31 cm, n = 17). One-way ANOVA showed significant differences in long jump performance between flexibility groups ($F(2, 57) = 16.42$, $p < 0.001$). Post-hoc comparisons revealed that participants with high waist flexibility jumped significantly farther (mean = 244.8 ± 18.9 cm) than those with moderate (mean = 231.2 ± 17.1 cm, $p < 0.05$) and low (mean = 216.7 ± 21.2 cm, $p < 0.001$) flexibility. The difference between moderate and low flexibility groups was also statistically significant ($p < 0.01$).

DISCUSSION

This study investigated the influence of abdominal muscle strength and waist flexibility on long jump performance in male collegiate athletes from Indonesia. The findings revealed significant positive correlations between both abdominal strength and waist flexibility with long jump distance, with abdominal strength demonstrating a stronger relationship. These results support the hypothesis that core stability and trunk flexibility contribute meaningfully to long jump performance beyond the established factors of lower limb strength and approach velocity.

The moderate to strong correlation ($r = 0.68$) between abdominal muscle strength and long jump performance aligns with biomechanical principles of the long jump. During takeoff and flight phases, strong abdominal muscles likely facilitate better body positioning and control, allowing for more efficient transfer of horizontal velocity into jump distance (Linthorne et al., 2011). Additionally, core stability may enhance force production during the takeoff phase by providing a stable foundation for lower limb extension (Hibbs et al., 2008).

The significant positive correlation ($r = 0.54$) between waist flexibility and long jump performance suggests that greater trunk and hamstring flexibility contributes to jump distance. This relationship can be explained by the potential for improved hip extension during takeoff and better body configuration during flight with increased flexibility (López-Bedoya et al., 2016). Enhanced lumbar-pelvic mobility may allow athletes to achieve more favorable takeoff angles and maintain advantageous body positions throughout the jump.

The regression analysis provided further insights, revealing that abdominal strength was a stronger predictor of long jump performance ($\beta = 0.52$) than waist flexibility ($\beta = 0.31$), even when controlling for anthropometric variables. Together, these two factors explained a substantial proportion (57.3%) of the variance in jump distance, highlighting their collective importance in long jump performance.

Our findings regarding abdominal strength are consistent with previous research by Hue et al. (2018), who reported that core strength training improved long jump performance in collegiate athletes. Similarly, Akl (2013) found that core training enhanced various jumping activities, suggesting a fundamental relationship between core stability and jumping ability across different contexts. The positive association between waist flexibility and jump performance aligns with López-Bedoya et al.'s (2016) findings in gymnasts, where lower back and hamstring flexibility correlated with improved jump metrics. However, our results contradict some aspects of Maeda et al.'s (2018) study, which found inconsistent relationships between trunk flexibility and jumping performance. This discrepancy might be attributed to methodological differences, population characteristics, or the specific flexibility measurements employed.

The stronger predictive value of abdominal strength compared to flexibility is a novel finding that extends previous research. While both Hue et al. (2018) and López-Bedoya et al. (2016) established the importance of these factors individually, few studies have directly compared their relative contributions to long jump performance in the same population.

Our findings regarding anthropometric factors largely support existing literature, with height and leg length showing moderate positive correlations with jump distance (Lees et al., 2011). The negative correlation with weight is consistent with biomechanical principles, as excess body mass may reduce the height and distance achieved during the jump if not accompanied by proportional increases in power.

The findings from this study have several practical implications for athletes, coaches, and physical educators. First, they emphasize the importance of incorporating core strengthening exercises into long jump training programs. The stronger relationship between abdominal strength and jump performance suggests that prioritizing core stability development may yield greater performance benefits than flexibility training alone. Second, the results indicate that waist flexibility should not be overlooked in long jump training. While its contribution appears less substantial than abdominal strength, flexibility training may still offer meaningful performance improvements,

particularly for athletes with limited lumbar-pelvic mobility. Third, the combined influence of abdominal strength and waist flexibility suggests that comprehensive training programs addressing both aspects may be most effective for optimizing long jump performance. Such integrated approaches may be particularly beneficial for collegiate athletes who are still developing their physical capabilities and jumping techniques. Finally, the findings provide evidence-based guidance for talent identification and development in long jump events. Measuring abdominal strength and waist flexibility, alongside traditional assessments of speed and power, may help identify promising athletes and inform individualized training prescriptions.

Several limitations should be considered when interpreting the results of this study. First, the cross-sectional design precludes establishing causal relationships between the variables. While the correlations and regression analyses suggest meaningful associations, longitudinal intervention studies are needed to determine whether improvements in abdominal strength and waist flexibility directly cause enhancements in long jump performance. Second, the study population consisted of physical education students rather than specialized long jump athletes. While this enhances the generalizability of findings to collegiate physical education programs, the relationships may differ in elite jumpers or athletes with more specialized training. Third, the assessment methods, though standardized, may not capture all aspects of abdominal strength and waist flexibility relevant to long jump performance. The one-minute sit-up test primarily evaluates endurance aspects of abdominal strength, while other components like power and rate of force development may also be important. Similarly, the sit-and-reach test assesses combined hamstring and lower back flexibility but does not isolate trunk mobility. Fourth, while the study controlled for several anthropometric variables, other factors known to influence long jump performance, such as approach velocity and takeoff technique, were not measured. Including these variables could provide a more comprehensive understanding of the relative importance of abdominal strength and waist flexibility in the context of all performance determinants. Finally, the study was conducted with male participants from a specific region in Indonesia, potentially limiting the generalizability of findings to other populations, including female athletes and those from different ethnic or training backgrounds.

CONCLUSION

This study investigated the influence of abdominal muscle strength and waist flexibility on long jump performance in male collegiate athletes from Indonesia. The findings reveal significant positive relationships between both factors and jump distance, with abdominal strength demonstrating a stronger association and predictive value.

The results highlight the importance of core stability and trunk flexibility as meaningful contributors to long jump performance, alongside traditional factors such as lower limb power and approach velocity. These findings support a more comprehensive understanding of the biomechanical and physiological determinants of long jump success.

From a practical perspective, the study provides evidence-based support for incorporating core strengthening and flexibility exercises into long jump training programs. Coaches and physical educators should consider prioritizing abdominal strength development while maintaining attention to waist flexibility to optimize athletic performance in the long jump.

Future research should address the limitations of this study by employing longitudinal designs to establish causal relationships, including specialized jumping athletes, utilizing more comprehensive assessment methods, and controlling for additional performance determinants such as approach velocity and takeoff technique. Cross-cultural studies comparing these relationships across different populations would also enhance the generalizability of findings.

In conclusion, this study contributes valuable insights into the specific roles of abdominal muscle strength and waist flexibility in long jump performance, providing a foundation for evidence-based training approaches and future research in this area.

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CONFLICT OF INTEREST

The authors declare no conflict of interest regarding the publication of this paper.

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