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The Relationship Between Leg Explosive Power Abdominal Muscle Strength and Long Kick Distance in Soccer Among Elementary School Students

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ABSTRACT
Backgroud: This study investigated the individual and simultaneous relationships between leg explosive power, dynamic abdominal muscle strength, and long kick distance in soccer among male elementary school students.
Methods: A descriptive correlational research design was employed. The sample comprised 60 male fifth-grade students (aged 10–11 years) selected via simple random sampling from an accessible cohort of 82 male students at SDN No. 87 Buttakeke, South Sulawesi, Indonesia. Data were collected using standardized field fitness and skill protocols: the Standing Broad Jump Test for leg explosive power (meters), the 30-Second Sit-Up Test for dynamic abdominal endurance (repetitions), and the Maximum Instep Long Kick Test for kicking distance (meters). Analyses in SPSS included Kolmogorov-Smirnov normality tests, Pearson product-moment correlations with 95% confidence intervals, and multiple linear regression modeling.
Results: Descriptive data indicated mean values of 1.472 ± 0.178 m for leg explosive power, 10.650 ± 2.032 repetitions for abdominal muscle strength, and 17.520 ± 2.145 m for long kick distance. Bivariate correlation analyses revealed a strong positive relationship between leg explosive power and kicking distance ($r = 0.720$, 95% CI 0.57, 0.82, $p < 0.001$) and a moderate-to-strong positive relationship between abdominal muscle strength and kicking distance ($r = 0.574$, 95% CI 0.38, 0.72, $p < 0.001$). Multiple regression analysis demonstrated a statistically significant joint relationship (Multiple $R = 0.779$, $R^2 = 0.607$, Adjusted $R^2 = 0.593$, $F(2, 57) = 43.98$, $p < 0.001$). This indicates that the linear combination of leg power and abdominal strength statistically accounts for 60.70% of the variance in kicking distance within the sample, while 39.30% represents variance unexplained by the model. Multiple regression coefficients confirmed unique independent contributions from leg explosive power ($B = 6.992$, beta = 0.581, $p < 0.001$) and abdominal muscle strength ($B = 0.346$, beta = 0.328, $p < 0.001$).
Conclusions: Leg explosive power and abdominal muscular endurance serve as significant biomotor predictors of soccer kicking distance in primary school children. Leg power provides rapid foot acceleration at impact, while abdominal strength stabilizes the lumbo-pelvic complex during trunk flexion and hip deceleration. Physical education teachers should incorporate progressive jump drills and core stabilization exercises into elementary soccer curricula.

Keywords: Abdominal muscle strength; Elementary school students; Leg explosive power; Long kick distance; Soccer.

INTRODUCTION

Physical education in elementary schools plays a vital role in building foundational motor competence, physical health, and lifelong athletic engagement (Lobo & Tagare, 2025; Silverman & Mercier, 2015). Through organized sports curricula, children acquire basic movement patterns that underpin sports-specific proficiency. Among team sports taught in elementary schools worldwide, soccer remains one of the most accessible and popular games. Soccer demands diverse technical competencies, including dribbling, passing, ball control, and shooting. Of these techniques, kicking is arguably the most decisive and frequently executed action, serving as the primary vehicle for scoring goals, delivering long passes, and executing defensive clearances (Hughes, 1990; Lago-Peñas et al., 2020; Lees et al., 2010).

Biomechanical analyses establish that achieving substantial kicking distance requires high ball launch velocity, optimal launch angle, and controlled aerodynamic spin (Kellis & Katis, 2007; Nunome et al., 2006). Ball exit velocity is governed by the linear velocity of the kicking foot at the instant of impact, which results from a coordinated multi-segmental kinetic chain (Inoue et al., 2022). This kinetic sequence initiates with the planting of the support foot, proceeds through pelvic rotation and forward hip flexion, and culminates in rapid knee extension and rigid ankle stabilization (Augustsson et al., 2020; Lees et al., 2010). In primary school children, the execution of this complex motor pattern depends directly upon the functional capacity of the neuromuscular system, particularly lower-extremity explosive power and core muscular endurance (Faigenbaum et al., 2016; Lloyd & Oliver, 2012; Markovic & Mikulic, 2010).

Leg explosive power—defined as the rate of force development produced by the lower extremities during rapid muscle actions—is a primary determinant of kicking potency (Radnor et al., 2021). During the forward swing phase of an instep kick, the quadriceps femoris complex undergoes a rapid stretch-shortening cycle, generating knee extension torque immediately prior to ball contact (Kellis & Katis, 2007; Stølen et al., 2005). Concurrently, dynamic abdominal muscle strength is recognized as an essential stabilizing mechanism for athletic kicking (Behm et al., 2015; Kibler et al., 2006; Prieske et al., 2016). The anterior core musculature (rectus abdominis and obliques) functions as an anatomical bridge connecting the upper torso and lower limbs. During forceful kicking, abdominal contractions stabilize the lumbo-pelvic-hip complex, preventing excessive trunk hyperextension and reducing energy dissipation across the kinetic chain (Yusuf, 2000).

Despite the recognized biomechanical synergy between leg power and core stabilization, educational practice in elementary schools frequently neglects physical conditioning, focusing narrowly on technical ball drills. At SDN No. 87 Buttakeke in South Sulawesi, physical education teachers observe that many male students struggle to achieve adequate kicking distance during goal kicks and clearances, rarely exceeding 15 to 18 meters. While previous research has evaluated adult and academy soccer players (Augustsson et al., 2020; Nunome et al., 2006), empirical evidence examining how lower-limb explosive power and abdominal muscular endurance jointly relate to kicking distance in Indonesian primary school children remains scarce (Meylan et al., 2014; Sallis et al., 2012). Evaluating both biomotor predictors simultaneously provides practical insight for physical education teachers seeking to design developmentally appropriate conditioning. Therefore, this study evaluated the individual and combined relationships of leg explosive power, dynamic abdominal muscle strength, and long kick distance among male elementary school students. The study addressed four specific research questions:

1. What is the relationship between leg explosive power and long kick distance in elementary school students?
2. What is the relationship between dynamic abdominal muscle strength and long kick distance in elementary school students?
3. What is the simultaneous combined relationship of leg explosive power and abdominal muscle strength with long kick distance?
4. What are the unique predictive contributions of leg explosive power and abdominal muscle strength within the multiple regression model?

METHODS

Research Design and Participants

A quantitative descriptive correlational and regression research design was employed to examine the associations between two independent predictor variables—leg explosive power (X1) and abdominal muscle strength (X2)—and one dependent criterion variable: long kick distance (Y) (Creswell & Creswell, 2018). The accessible population comprised 82 male fifth-grade students enrolled at SDN No. 87 Buttakeke, South Sulawesi, Indonesia, during the 2026 academic term. A sample of 60 male students (N = 60; age = 10.65 ± 0.42 years, stature = 137.2 ± 4.5 cm, body mass = 32.9 ± 3.8 kg) was selected using simple random sampling via a lottery procedure (Arikunto, 1991; Mardalis, 2008).

Institutional ethical permission was granted by the institutional review board of Universitas Negeri Makassar and the local education office. Written informed consent was obtained from parents or legal guardians, and verbal assent was secured from each participating student. Medical screening verified that all children were healthy and free of acute musculoskeletal or cardiovascular impairments.

Testing Procedures and Protocol Standardization

Data collection was carried out across two testing sessions under dry, fair-weather morning conditions on the regulation grass field of SDN No. 87 Buttakeke. Testing followed a standardized 10-minute dynamic warm-up led by physical educators, including light jogging, dynamic leg swings, and trunk rotations. The three standardized performance tests were administered as follows:

1. Standing Broad Jump Test (Leg Explosive Power): Measured horizontal jumping distance as an indicator of lower-limb explosive power (Halim, 2004). Participants stood behind a designated takeoff line with feet shoulder-width apart, swung their arms, flexed their knees, and leaped forward explosively onto a flat, non-slip surface. The distance from the takeoff line to the nearest heel touchdown point was recorded in meters. Each student executed three trials with 2 minutes of rest between attempts, and the farthest valid jump was retained.
2. 30-Second Sit-Up Test (Abdominal Muscle Strength): Evaluated dynamic muscular endurance of the anterior abdominal wall (Ismaryati, 2006). The student lay supine on a cushioned gymnastics mat with knees bent at 90°, heels flat on the mat secured by a partner, and fingers clasped behind the neck. Upon a start command, the participant curled the trunk forward until both elbows contacted the knees, then lowered back until the shoulder blades touched the mat. The total number of properly executed repetitions completed within 30 seconds was recorded. It is noted that this test measures repeated dynamic muscular endurance rather than static maximal strength.
3. Maximum Instep Long Kick Test (Long Kick Distance): Evaluated kicking distance using a regulation size 4 youth soccer ball (circumference 63.5–66.0 cm, inflated to standard pressure of 0.7 bar). From a stationary ball placement on a marked penalty-spot line on a flat grass pitch, students took a self-selected approach run (3 to 5 strides) and struck the ball with maximal effort using the instep (laces) of their dominant foot into an unobstructed open field. A fiberglass measuring tape positioned along the center line measured the distance from the kick point to the initial ground contact point in meters. Participants performed three trials separated by 3-minute rest intervals, with the longest valid distance recorded. Test-retest reliability across a preliminary trial with 15 non-sample peers demonstrated strong reliability across all three tests (r = 0.88 to 0.92).

Statistical Analysis

Statistical evaluations were conducted in IBM SPSS Statistics (Version 26.0). Descriptive statistics were computed as means (M), standard deviations (SD), sample variances (SD^2), ranges, minimums, and maximums. Normality of data distributions was tested using the one-sample Kolmogorov-Smirnov test (Z). Bivariate associations were examined using Pearson product-moment correlation coefficients (r) alongside 95% confidence intervals derived from Fisher's z-transformation. Multiple linear regression was conducted to evaluate the joint

relationship and predictive power of the combined model, generating the multiple correlation coefficient (R), coefficient of determination (R^2), adjusted R^2, ANOVA model fit (F), and multiple regression coefficients (unstandardized B, standard error SE, standardized beta β, t-statistic, exact p-values, 95% confidence intervals for B, Tolerance, and Variance Inflation Factors VIF). Significance was set at an alpha level of $p < 0.05$.

RESEARCH RESULTS

Descriptive Statistics and Normality Evaluation

The descriptive statistical parameters for leg explosive power, abdominal muscle strength, and long kick distance across the 60 elementary school students are displayed in Table 1.

Table 1. Descriptive Statistics for Biomotor Predictors and Long Kick Distance

Statistical Indicator	Leg Explosive Power (m)	Abdominal Strength (reps)	Long Kick Distance (m)
Sample Size (N)	60	60	60
Mean	1.472	10.650	17.520
Standard Deviation	0.178	2.032	2.145
Variance (SD^2)	0.032	4.130	4.601
Range	0.890	9.000	6.430
Minimum	0.950	6.000	14.370
Maximum	1.840	15.000	20.800
Sum	88.330	639.000	1051.170

As outlined in Table 1, leg explosive power averaged 1.472 ± 0.178 meters (range: 0.950 to 1.840 m). Abdominal muscle strength exhibited an average of 10.650 ± 2.032 repetitions (range: 6.000 to 15.000 reps). Long kick distance averaged 17.520 ± 2.145 meters, ranging from 14.370 m to 20.800 m. The sample variance for long kick distance is verified at 4.601 m^2 (consistent with SD = 2.145 m, SD^2 = 4.601), rectifying an earlier typographical misprint. Normality testing conducted using the one-sample Kolmogorov-Smirnov test is presented in Table 2.

Table 2. Summary of One-Sample Kolmogorov-Smirnov Normality Test Results (N = 60)

Variable	Kolmogorov-Smirnov Z	Asymptotic Sig. (2-tailed)	Distribution Status
Leg Explosive Power (X1)	0.736	0.650	Normal ($p > 0.05$)
Abdominal Muscle Strength (X2)	0.890	0.406	Normal ($p > 0.05$)
Long Kick Distance (Y)	0.731	0.658	Normal ($p > 0.05$)

Because all asymptotic significance values exceed the critical threshold of alpha = 0.05 ($p = 0.406$ to $p = 0.658$), the distributions conformed to normality, confirming that parametric correlation and linear regression procedures were appropriate.

Bivariate Correlation Analyses

Bivariate Pearson product-moment correlations evaluated the separate relationships of leg explosive power and abdominal muscle strength with kicking distance. The findings are summarized in Tables 3 and 4.

Table 3. Pearson Correlation Between Leg Explosive Power and Long Kick Distance (N = 60)

Predictor Variable	Criterion Variable	Pearson r	95% CI of r	p-value	Inference
Leg Explosive Power (X1)	Long Kick Distance (Y)	0.720	[0.570, 0.823]	< 0.001	Significant

Table 3 shows a strong, statistically significant positive relationship between leg explosive power and long kick distance: r = 0.720 (95% CI [0.570, 0.823], p < 0.001). This indicates that students with superior lower-limb explosive power consistently attained longer kicking distances, supporting the first research hypothesis.

Table 4. Pearson Correlation Between Abdominal Muscle Strength and Long Kick Distance (N = 60)

Predictor Variable	Criterion Variable	Pearson r	95% CI of r	p-value	Inference
Abdominal Muscle Strength (X2)	Long Kick Distance (Y)	0.574	[0.375, 0.722]	< 0.001	Significant

Table 4 reveals a moderate-to-strong, statistically significant positive correlation between abdominal muscle strength and long kick distance: r = 0.574 (95% CI [0.375, 0.722], p < 0.001). This demonstrates that greater core muscular endurance is positively associated with kicking performance, supporting the second hypothesis.

Multiple Linear Regression Analysis

Multiple linear regression evaluated the simultaneous joint relationship of leg explosive power and abdominal muscle strength with long kick distance. Table 5 presents the model summary and ANOVA fit, and Table 6 outlines the regression coefficients and collinearity diagnostics.

Table 5. Multiple Linear Regression Model Summary and ANOVA Test for Joint Predictors (N = 60)

Model Predictors	Multiple R	R^2	Adjusted R^2	ANOVA F (2, 57)	p-value	Model Status
Leg Power (X1) & Abdominal Strength (X2)	0.779	0.607	0.593	43.98	< 0.001	Significant

Table 6. Multiple Linear Regression Coefficients for Predicting Long Kick Distance (N = 60, df = 57)

Model Component	Unstandardized B	SE	Standardized β	t-statistic	p-value	95% CI of B	Tolerance	VIF
(Constant)	3.537	1.764	—	2.005	0.049	[0.004, 7.070]	—	—
Leg Explosive Power (X1)	6.992	1.103	0.581	6.341	< 0.001	[4.784, 9.200]	0.821	1.22
Abdominal Muscle Strength (X2)	0.346	0.097	0.328	3.581	< 0.001	[0.153, 0.540]	0.821	1.22

As reported in Table 5, the simultaneous regression model was statistically significant: F(2, 57) = 43.98, p < 0.001. The multiple correlation was R = 0.779, with a coefficient of determination of R^2 = 0.607 (Adjusted R^2 = 0.593). This indicates that the linear combination of leg explosive power and abdominal muscle strength statistically accounts for 60.70% of the variance in long kick distance within the sample. The remaining 39.30% represents variance unexplained by the current model, attributable to unmeasured factors such as approach speed, foot-ball contact accuracy, ankle stiffness, kicking technique, and maturity status.

The regression coefficients in Table 6 demonstrate that both predictors provided statistically significant unique contributions to the model. Leg explosive power served as the primary contributor (B = 6.992, standardized β = 0.581, t = 6.341, p < 0.001), indicating that each 0.1-meter increase in broad jump distance is associated with an average increase of approximately 0.70 meters in kicking distance when holding core strength constant. Abdominal muscle strength also contributed significantly (B = 0.346, standardized β = 0.328, t = 3.581, p < 0.001), indicating that each additional sit-up repetition corresponds to a 0.346-meter increase in kicking distance.

Collinearity diagnostics yielded high tolerance (0.821) and low variance inflation factors (VIF = 1.22), verifying that multicollinearity was negligible.

DISCUSSION

The empirical findings of this investigation provide clear confirmation for the research hypotheses, demonstrating that leg explosive power and abdominal muscle strength exhibit strong, statistically significant associations with soccer kicking distance among elementary school students. Together, the two biomotor predictors account for 60.70% of the variance in kicking distance within the sample ($R = 0.779$, $R^2 = 0.607$, $F = 43.98$, $p < 0.001$). Because this investigation assessed field-based physical fitness tests and outdoor kicking distances rather than 3D kinematic motion capture, the following physiological and mechanical explanations represent theoretical interpretations grounded in established motor control literature rather than directly measured joint kinetics.

Leg explosive power emerged as the dominant predictor in the regression model ($r = 0.720$, $\beta = 0.581$, $p < 0.001$). Biomechanical research demonstrates that soccer kicking is a multi-segmental whip action governed by proximal-to-distal sequencing (Kellis & Katis, 2007; Lees et al., 2010; Nunome et al., 2006). During the forward swing, powerful contraction of hip flexors and knee extensors accelerates the thigh and shank, imparting high linear foot velocity at impact (Augustsson et al., 2020; Inoue et al., 2022). The standing broad jump test captures the explosive rate of force development across the extensor musculature (gluteus maximus, quadriceps, and gastrocnemius-soleus) (Markovic & Mikulic, 2010; Radnor et al., 2021). Children possessing greater lower-limb power generate higher angular shank velocity prior to ball strike, producing greater mechanical impulse on the ball.

Abdominal muscle strength also demonstrated a substantial, statistically significant association with kicking distance ($r = 0.574$, $\beta = 0.328$, $p < 0.001$). In kicking mechanics, the torso serves as the anatomical anchor for the lower extremities (Behm et al., 2015; Kibler et al., 2006; Prieske et al., 2016). As the kicking leg swings backward and then drives explosively forward, large reactive extension and rotational torques are applied to the pelvis and lumbar spine. Co-activation of the anterior abdominal wall (rectus abdominis and internal and external obliques) stabilizes the pelvis, counteracts unwanted trunk extension, and prevents energy leakage across the kinetic chain (Yusuf, 2000). Students with greater abdominal endurance maintain stable posture through ball impact, enabling efficient kinetic energy transfer to the ball.

At the same time, the joint regression model demonstrates that leg power and core stabilization operate synergistically. High lower-limb power cannot be fully expressed if a weak lumbo-pelvic complex permits pelvic instability; conversely, strong core musculature cannot produce long kicking distances in the absence of rapid lower-limb propulsion. However, it must be noted that kicking distance is also influenced by factors outside the present model, accounting for the 39.30% unexplained variance. These factors include technical execution (e.g., approach angle, placement of the support foot, rigidity of the kicking ankle), chronological age, and biological maturity (Faigenbaum et al., 2016; Lloyd & Oliver, 2012; Meylan et al., 2014).

Methodological limitations should be considered when interpreting these results. First, the sample was confined to 60 male fifth-grade students from one elementary school in South Sulawesi, which limits generalization to female students or older competitive youth cohorts (Sallis et al., 2012). Second, the 30-second sit-up test reflects dynamic core muscular endurance rather than isometric core stiffness. Third, kicking accuracy was not evaluated, focusing solely on maximal linear distance. Future studies should adopt longitudinal designs, examine female student cohorts, and incorporate optical motion tracking to analyze how targeted plyometric and core conditioning influence kicking kinematics and ball exit velocity directly.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

1. Leg explosive power exhibits a strong, statistically significant positive relationship with long kick distance in male elementary school students ($r = 0.720$, $p < 0.001$), serving as the primary predictor in the multiple regression model ($\beta = 0.581$).
2. Dynamic abdominal muscle strength demonstrates a moderate-to-strong, statistically significant positive relationship with long kick distance ($r = 0.574$, $p < 0.001$), contributing uniquely to the regression equation ($\beta = 0.328$).
3. Leg explosive power and abdominal muscle strength simultaneously correlate significantly with long kick distance (Multiple $R = 0.779$, $F(2, 57) = 43.98$, $p < 0.001$), statistically accounting for 60.70% of the variance in kicking distance within the sample, with 39.30% of variance unexplained by the model.

Recommendations

1. Primary school physical education teachers should structure soccer curricula to incorporate age-appropriate plyometric exercises (e.g., two-legged hurdle hops, broad jumps) and dynamic core stabilization drills (e.g., modified planks, controlled sit-ups) alongside technical kicking drills.
2. Youth soccer coaches should ensure that conditioning programs for young players emphasize multi-segmental kinetic chain development rather than isolated kicking practice.
3. Physical education teachers should instruct students on the functional role of the core musculature during kicking to reinforce proper postural alignment.
4. Future sports science researchers should conduct intervention studies examining the effects of combined plyometric and core training on kicking mechanics, including technical accuracy and kinematic flight parameters across diverse youth cohorts.

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