

Development and Internal Validation of a Field-Based Equation for Predicting Half-Squat One-Repetition Maximum in Youth Soccer Players Using Standing Long Jump Performance and Body Mass

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Purpose: This study aimed to examine the validity of field-based tests, specifically the 5-Jump Test (5JT) and Standing Long Jump (SLJ), combined with anthropometric measures for predicting one-repetition maximum (1RM) half-squat performance in U-13 male soccer players.

Methods: Forty-one male youth soccer players (age: 12.77 ± 0.25 years; body-mass (BM): 46.54 ± 7.86 kg; body-height: 157.70 ± 9.58 cm) participated in this investigation. Following a one-week familiarization session that included practice trials of all testing procedures and movement pattern instruction, participants completed three testing sessions comprising anthropometric measurements, 1RM half-squat assessment, and field tests (5JT and SLJ). Multiple linear regression analysis was employed to develop prediction equations, with model validation including assessments of normality, homoscedasticity, and multicollinearity.

Results: The final prediction model incorporating only BM and SLJ explained 70% of the variance in 1RM half-squat performance ($R^2 = 0.696$, $P < 0.001$). The resulting equation ($1RM = -114.503 + 1.953 \times BM + 71.468 \times SLJ$) demonstrated robust statistical properties, with both predictors showing significant contributions (BM: $\beta = 1.953$, 95% CI [1.3-2.5], $P < 0.001$; SLJ: $\beta = 71.468$, 95% CI [45.3-97.6], $P < 0.001$). The model satisfied assumptions of normality (Shapiro-Wilk: $P = 0.06$) and homoscedasticity (Breusch-Pagan: $P = 0.521$), with acceptable multicollinearity indices ($VIF < 4.0$). While initially considered, age, standing height, and 5JT did not significantly improve prediction accuracy.

Conclusions: This study validates a practical equation for estimating maximal half-squat strength in youth soccer players using readily available field measures. The combination of SLJ performance and BM provides coaches with a time-efficient, low-risk method for strength assessment in young athletes. This approach provides coaches with an accessible, time-efficient tool for strength monitoring that requires minimal equipment while maintaining scientific validity.

Keywords: Anthropometric Measurements; Exercise Performance; Lower Extremity; Physical Fitness Testing; Power Output; Training Load.

Introduction

Soccer involves intermittent high-intensity actions including sprinting, jumping, and rapid directional changes that determine match outcomes.¹ Elite male players cover 9-14 km per match. Critical segments occur at high speeds ($>19.8 \text{ km} \cdot \text{h}^{-1}$) with over 700 directional changes. These demands underscore the necessity of explosive power and agility.¹ These actions require lower-body strength and power that correlate with sprint performance, jump height, and change-of-direction ability.^{2,3} Furthermore, strength imbalances between starting and non-starting players highlight its role in competitive success, with

stronger players demonstrating superior match performance metrics.¹ Beyond performance, adequate strength mitigates injury risks, particularly amid congested match schedules, emphasizing its dual role in athletic development.^{4,5} The one-repetition maximum (1RM) test, the gold standard for assessing maximal dynamic strength, quantifies the heaviest load lifted in a single repetition.^{6,7} In soccer, the half-squat 1RM is widely used due to its relevance to sport-specific movements.⁸ However, practical limitations hinder its application in youth populations. Direct 1RM testing requires extensive familiarization, supervised warm-ups, and technical expertise. While studies demonstrate safe 1RM testing in youth

populations with proper supervision, practical constraints including time requirements and equipment needs limit its routine application.^{9,10} Additionally, testing large cohorts is time-prohibitive, complicating its integration into routine assessments.¹¹ These constraints are acute in youth soccer, where developmental variability and resource limitations demand efficient, accessible alternatives.¹²

To address 1RM's limitations, submaximal protocols and prediction equations have emerged. These methods leverage relationships between load and repetitions, using submaximal lifts or anthropometric data to estimate 1RM.¹³ While valid in controlled settings, many still require resistance training equipment and multiple sessions, limiting practicality in field environments.¹⁴ Consequently, researchers advocate for field-based tests that assess strength indirectly through functional movements, such as jumps and sprints, which correlate with 1RM performance.^{15,16} Horizontal jump tests, like the standing long jump (SLJ) and 5-jump test (5JT), are particularly promising due to their simplicity and minimal equipment needs.¹⁷

Horizontal jumps evaluate lower-body power through horizontal displacement, reflecting force production capabilities akin to maximal strength.¹⁶ Studies demonstrate moderate-to-strong correlations between SLJ/5JT performance and 1RM half-squat in adult athletes.^{3,18} However, the transferability of these relationships to youth populations requires investigation due to developmental differences in neuromuscular coordination, training adaptations, and movement efficiency that characterize adolescent athletes. For instance, Styles et al.³ reported significant associations between 1RM and sprint/jump metrics in professional players. However, conflicting findings, such as Martínez-Valencia et al.¹⁹'s null results in youth cohorts, highlight context-dependent variability. Discrepancies may arise from differences in age, training status, or test administration, underscoring the need for population-specific validation.²⁰

Despite progress, critical gaps persist. First, existing prediction models often neglect anthropometric variables, such as body mass and body dimensions, which modulate strength expression.¹⁴ Second, few studies validate horizontal jumps for 1RM prediction in youth soccer players. A systematic search of the literature revealed only three studies examining jump-strength relationships specifically in youth soccer populations (aged 12-16 years), with none developing validated prediction equations for 1RM estimation using horizontal jump tests.^{10,15} A population characterized by ongoing neuromuscular development and varied training adaptations.^{10,15} Third, practical frameworks for integrating field tests into routine monitoring remain underdeveloped, leaving coaches without actionable tools.¹¹ Addressing these gaps could revolutionize strength assessment in resource-constrained settings, enabling evidence-based training prescriptions. While external validation represents the gold standard for prediction model development, this initial development study provides the foundation for subsequent validation investigations.

The integration of field-based tests into strength assessment protocols addresses a critical need in youth sports. By validating SLJ and 5JT as proxies for 1RM, this study bridges the gap between scientific rigor and practical applicability. The resulting algorithms could democratize strength monitoring, allowing coaches with limited resources to tailor training loads effectively. Ultimately, this approach aligns with the growing emphasis on evidence-based practice in athlete development, ensuring that strength assessment remains both scientifically valid and contextually feasible. This study investigates the utility of the SLJ and 5JT, combined with anthropometric data, in predicting

half-squat 1RM in youth team-sport athletes.

Methods

Study Design

This cross-sectional validation study employed a single-cohort repeated measures design to examine the predictive validity of field-based tests for estimating maximal half-squat strength in youth soccer players. The investigation followed a systematic three-phase testing protocol incorporating anthropometric assessment, maximal strength evaluation, and field-based power tests, with sessions separated by one week to maintain training status consistency while minimizing fatigue effects. The study design prioritized internal validity through rigorous standardization of testing conditions and procedures.

Participants

Forty-one male youth soccer players (age: $12.77 \pm .25$ years; body-mass (BM): 46.54 ± 7.86 kg; body-height: 157.70 ± 9.58 cm) recruited from regional youth soccer academies. Sample size determination was conducted using G*Power software (Version 3.1.9.7, University of Düsseldorf, Germany) for multiple linear regression analysis with five predictors. Based on an alpha level of .05, desired power ($1-\beta$) of .80, and anticipated effect size (f^2) of .35 from similar studies, the required sample size was 36 participants. The recruitment of 41 participants provided a 14% oversampling to maintain statistical power in case of attrition or missing data.

Inclusion criteria were: (1) male soccer players aged 12-13 years, (2) minimum two years of systematic soccer training, (3) current participation in 3-5 weekly training sessions plus competitive matches, and (4) medical clearance for sports participation. Exclusion criteria included: (1) any musculoskeletal injury in the previous six months, (2) any medical condition contraindicating maximal strength testing, and (3) less than 90% attendance at regular training sessions.

Both written informed consent from parents/legal guardians and written assent from the participants were obtained prior to participation. All subjects were informed about the potential risks and benefits associated with the investigation, and their right to withdraw from the study at any time without consequence was emphasized.

Procedures

Testing was conducted over three sessions separated by one week. A familiarization session was completed one week before testing to minimize learning effects. All sessions were conducted at the same time of day (± 1 hour) to control for circadian variation, under standardized environmental conditions (temperature: $22 \pm 1^\circ\text{C}$; humidity: 45-55%).

Anthropometric Measurements

Anthropometric assessments were performed by ISAK Level 2 certified anthropometrists following standardized procedures.²¹ Body-mass was measured using a calibrated digital scale (Seca Instruments Ltd, Hamburg, Germany; precision: .1 kg), and body-height (BH) was assessed using a wall-mounted stadiometer (Seca Instruments Ltd; precision: .1 cm). Each measurement was taken twice, with a third measurement if the difference exceeded the ISAK-specified tolerance.

Strength Testing Procedures

1RM half-squat testing was conducted using a standardized protocol²² with an Olympic barbell (20 kg) and calibrated weight plates. A qualified strength and conditioning specialist supervised all testing. Knee angle was monitored using a digital goniometer (Easy Angle®) to ensure consistent squat depth (90°). The 1RM protocol followed established guidelines with

progressive loading: participants performed 8-10 repetitions at 20-40% estimated 1RM, 4-6 repetitions at 40-60%, 2-3 repetitions at 60-80%, and 1-2 repetitions at 80-90% estimated 1RM, with 2–3-minute rest intervals between sets. Following warm-up, participants attempted their estimated 1RM with 3–5-minute rest periods between attempts. Load increments of 2.5-5 kg were applied until failure occurred within 3-5 attempts. Termination criteria included inability to complete the full range of motion, forward lean exceeding 30°, or participant request to stop.

Field Testing Procedures

All field tests were conducted on an indoor synthetic surface to standardize testing conditions. Participants wore their regular training footwear and performed standardized warm-up protocols specific to each testing session.

Warm-up Protocol

Participants completed a standardized progressive warm-up including: (1) five minutes light jogging, (2) ten minutes dynamic stretching targeting lower body muscle groups, and (3) five minutes progressive acceleration runs (50-80% perceived maximum effort). For 1RM testing, an additional strength-specific warm-up followed established guidelines with progressive loading from 20% to 90% estimated 1RM across 4-5 sets, maintaining 2-3 minute rest intervals.⁹

Standing Long Jump Test

The standing long jump test followed standardized procedures validated for youth populations.¹⁵ A measuring tape was secured to the floor, and takeoff line was clearly marked. Three attempts were permitted with 60-second rest intervals. Performance was measured to the nearest 1 cm from the takeoff line to the rear heel mark upon landing. Attempts were invalidated if participants stepped backward after landing or touched the ground with any body part other than the feet. Test-retest reliability for SLJ has been established in youth populations (ICC = .91-.95; CV = 2-4%).

Five-Jump Test

The 5-jump test protocol followed established procedures.¹⁷ Participants performed five consecutive forward jumps alternating between legs, with the final landing on both feet. Two trials were permitted with 60-second recovery periods. Distance

was measured from the starting line to the rear heel position upon final landing using a calibrated measuring tape (precision: 1 cm). Previously established reliability metrics for this test in youth soccer players show high reproducibility (ICC = .89; CV = 3.2%).

Quality Control Measures

All testing sessions were supervised by the same two experienced investigators to ensure standardization. Testing order was randomized to minimize systematic bias. Environmental conditions were monitored and recorded for each session. Equipment calibration was verified daily before testing.

Statistical Analysis

Data analysis was performed using R software version 4.1.2 (R Core Team, 2024) with a significance level set at $\alpha = .05$. Data normality was assessed using Shapiro-Wilk tests and visual inspection of Q-Q plots. Descriptive statistics are presented as means $\pm$ standard deviations (SD). Pearson correlation coefficients (*R*) were calculated to examine relationships between variables, with coefficients interpreted as: weak (<.35), moderate (.36-.67), strong (.68-1.0), and very strong (>.90) following Hopkins et al.²³ Multiple linear regression analysis was employed to develop prediction equations for 1RM, with the following predictor variables: age, body mass, standing height, standing long jump, and 5-jump test performance. Model assumptions were verified through: residual normality (Shapiro-Wilk test), homoscedasticity (Breusch-Pagan test), multicollinearity assessment (Variance Inflation Factor - VIF), and influential observations analysis (Cook's Distance). Missing data (<5%) were handled using multiple imputation techniques. Model selection combined theoretical considerations with statistical significance, retaining variables based on both biological plausibility and statistical contribution ($P < .05$), with variables retained based on significance level ($P < .05$) and contribution to model fit (R^2).

Results

Physical performance of youth players

The physical performance results of the youth soccer players across various tests are presented in Table 1.

Table 1. Mean and standard deviation (SD) of the physical performance (n = 41)

Tests	1RM (kg)	SLJ (m)	5JT (m)
Mean $\pm$ SD	99.44 $\pm$ 1.65	1.65 $\pm$ 0.18	9.09 $\pm$.79

1RM = one repetition maximum; SLJ = standing long jump test; 5JT = 5 jumps test.

Normality of data distributions

An assessment of the normality of the data distributions was conducted. The results in Table 2 demonstrate that all variables followed a normal distribution, as evidenced by the skewness

and kurtosis coefficients being less than twice their respective standard error values for each variable. This finding supports the appropriateness of using parametric statistical analyses on this dataset.

Table 2. Normality assessment using Shapiro-Wilk test

Variable	<i>W</i> Statistic	<i>P</i> -value	Interpretation
BM	0.976	0.54	Normal
BH	0.982	0.73	Normal
1RM	0.969	0.31	Normal
SLJ	0.985	0.82	Normal
5JT	0.971	0.35	Normal

BM = body mass; BH = body height; 1RM = one repetition maximum; SLJ = standing long jump test; 5JT = 5 jumps test. All variables demonstrated normal distributions ($P > .05$), supporting the use of parametric statistical analyses.

Initial multiple linear regression model

A multiple linear regression analysis was performed to examine the relationships between the predictor variables (age, BM, BH,

SLJ and 5JT) and the dependent variable of 1RM strength. The results of this initial model are displayed in Table 3.

Table 3. Multiple linear regression analysis.

	$R^2 = .723$	$F = 18.31$	$P < .001$	
Characteristics	Beta	Standardized Beta	IC 95%	P-value
Constant	74.00	-	[-186:334]	.600
SLJ	93.00	.65	[42:144]	<.001
5JT	-5.90	-.08	[-18:5.7]	.300
Age	-14.00	-.23	[-33:5.5]	.200
BM	2.20	.48	[1.2:3.2]	<.001
BH	-.04	-.01	[-.94:.85]	.900

General model: $1RM = 74 + 93 \times SLJ - 5.9 \times 5JT - 14 \times Age + 2.2 \times BM - .04 \times BH$

R^2 = Coefficient of determination; BM = body mass; BH = body height; 1RM = one repetition maximum; SLJ = standing long jump test; 5JT = 5 jumps test. Standardized beta coefficients facilitate comparison of predictor importance.

The coefficient of determination (R^2) for this model was .72, which decreased minimally to .70 when non-significant predictors were removed, indicating robust model stability, indicating that 72% of the variance in 1RM could be explained by the set of independent variables. The overall model was statistically significant, $F_{(5, 32)} = 18.31$, $P < .0001$, suggesting the

model had good predictive power. However, examination of the individual regression coefficients revealed that age ($P = .200$), 5JT ($P = .300$), and BH ($P = .900$) did not significantly contribute to the model. Figure 1 provides a visual depiction of the relative magnitude and direction of the standardized regression coefficients.

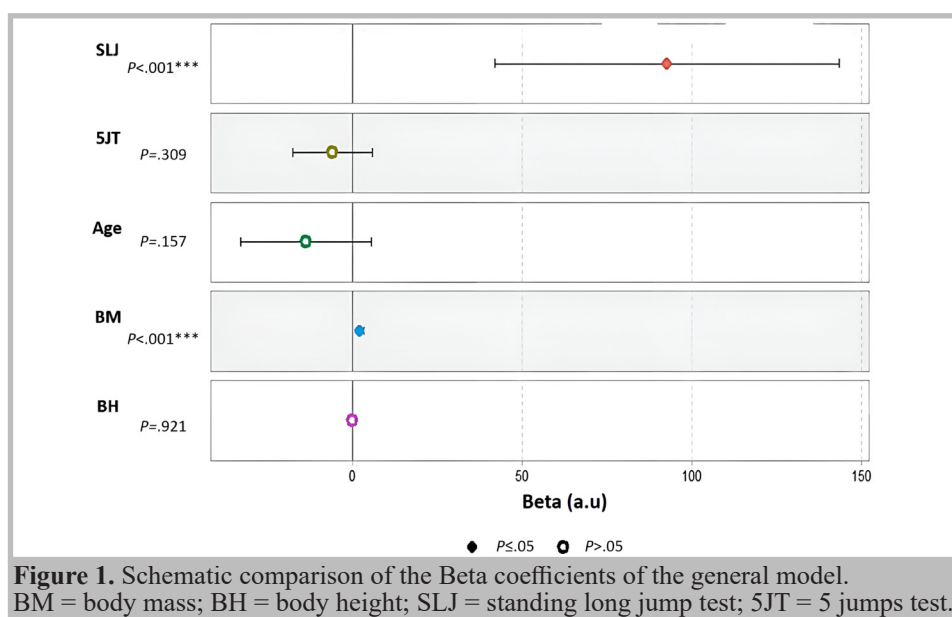


Figure 1. Schematic comparison of the Beta coefficients of the general model. BM = body mass; BH = body height; SLJ = standing long jump test; 5JT = 5 jumps test.

Final multiple regression model

Based on the initial regression results, a refined model was developed using only the significant predictors of BM and SLJ distance. The results of this final multiple regression model are presented in Table 4. The final model yielded an R^2 value of .70, meaning that body mass and standing long jump distance alone accounted for 70% of the variation in 1RM scores. This model

was highly significant, $F_{(2, 35)} = 43.47$, $P < .001$. The resulting regression equation was:

$$1RM = -114.503 + 1.953 \times BM + 71.468 \times SLJ$$

Where BM represents body mass in kilograms and SLJ represents standing long jump distance in meters. Both regression coefficients were statistically significant at $P < .001$.

***Please Insert Table 4 About here ***

Table 4. Final regression model

	R^2	F	P -value
	.696	43.47	<.001
Characteristics	Beta	IC 95%	P-value
(Constant)	-114.50	[-162.4:-66.5]	<.001
SLJ	71.47	[45.3:97.6]	<.001
BM	1.95	[1.3:2.5]	<.001
Final model	$1RM = -114.503 + 1.953 \times BM + 71.468 \times SLJ$		

R^2 = Coefficient of determination; BM = body mass; 1RM = one repetition maximum; SLJ = standing long jump test.

Validation of regression assumptions

Several diagnostic tests were conducted to evaluate the validity of the regression model assumptions. The Shapiro-Wilk test indicated that the residuals were normally distributed ($P=.06$). Visual inspection of the residual plots (Figures 2 and 3) further supported the normality and homoscedasticity assumptions. Multicollinearity was assessed using VIF. The VIF values were

2.81 for body mass and 3.90 for SLJ distance, both below the common cut-off of 10, suggesting an absence of problematic multicollinearity. Influential data points were examined using Cook's distance. No observation exceeded a Cook's distance of .5 (Figure 4), indicating no overly influential cases. Additional diagnostic plots are provided in Figures 5 and 6.

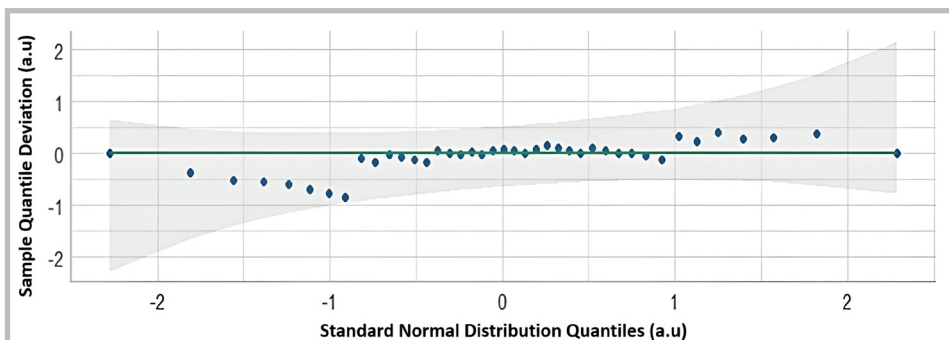


Figure 2. Residual normality analysis.

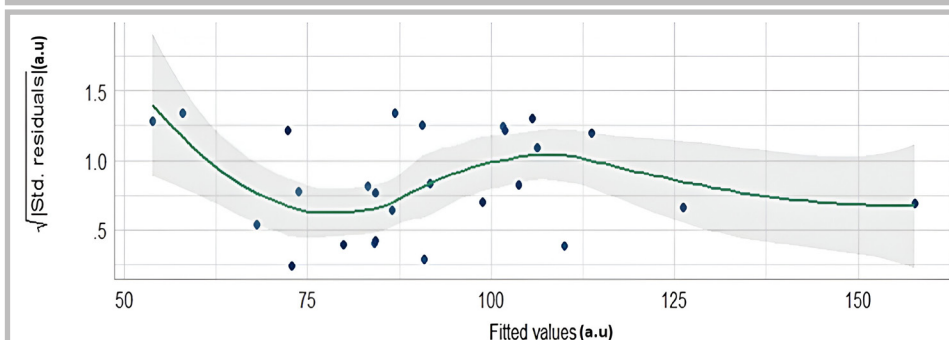


Figure 3. Graphical representation of homoscedasticity analysis.

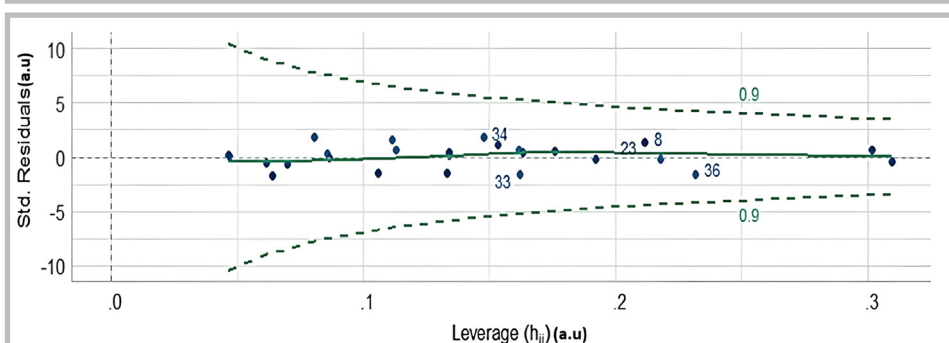


Figure 4. Diagnosis of influential observations.

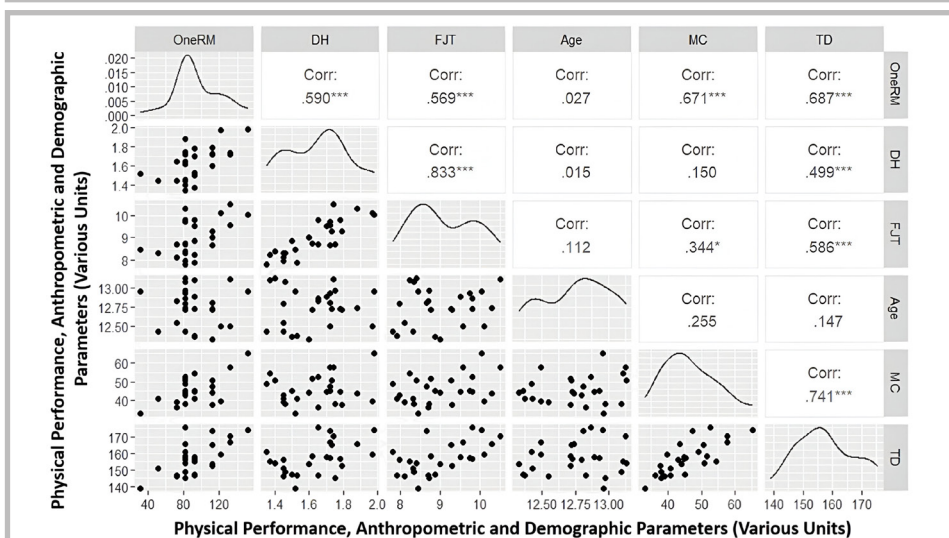
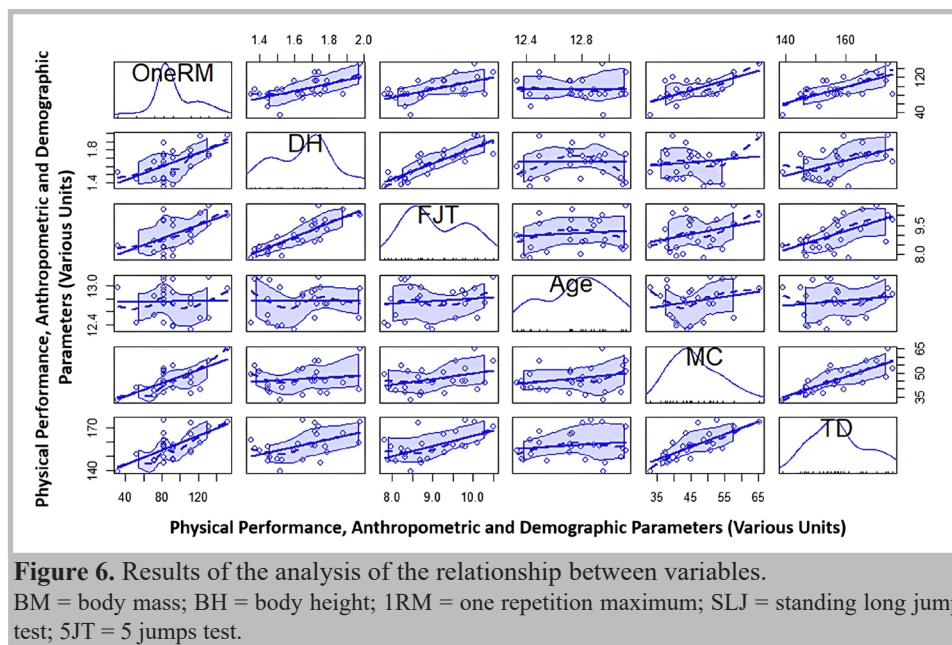


Figure 5. Results of the correlation analysis established between the performance of the different tests.

BM = body mass; BH = body height; 1RM = one repetition maximum; SLJ = standing long jump test; 5JT = 5 jumps test.



Discussion

This study investigated the predictive capacity of field-based tests, specifically the Standing Long Jump (SLJ) and the 5-Jump Test (5JT), in estimating 1-Repetition Maximum (1RM) half-squat performance in young team sport athletes. The primary finding revealed that a combination of body mass (BM) and SLJ performance effectively predicts 1RM half-squat strength, explaining approximately 70% of the variance ($R^2=.70$). The final predictive equation ($1RM = -114.503 + 1.953 \times BM + 71.468 \times SLJ$) demonstrated robust statistical properties, with both predictor variables showing significant contributions ($P<.001$). Statistical validation revealed favorable properties, including normality of residuals (Shapiro-Wilk test, $P=.06$) and homoscedasticity (Breusch-Pagan test, $P=.52$). The absence of significant multicollinearity ($VIF<4.0$) and influential observations (Cook's Distance $< .5$) further supported the model's robustness.

BM emerged as a significant positive predictor, demonstrating a moderate correlation with maximal strength ($R=.54$, $P<.001$). This relationship reflects the established link between BM and lower-body strength metrics in athletic contexts.^{1,14} The significant contribution of body mass to strength expression aligns with established research demonstrating positive associations between anthropometric characteristics and maximal strength performance in youth populations.^{7,14} From a physiological perspective, the contribution of body mass to 1RM prediction reflects the relationship between lean body mass and maximal strength, where greater muscle cross-sectional area facilitates enhanced force generation potential.

The SLJ emerged as the strongest predictor, with a standardized coefficient of 71.47 [CI: 45.3-97.6]. The robust relationship between SLJ and 1RM half-squat performance ($\beta=71.468$, $P<.001$) aligns with Castro-Piñero et al.'s¹⁵ findings, regarding SLJ as an indicator of muscular fitness in youth, though their study examined broader age ranges and different strength outcomes who identified the standing long jump as a valuable indicator of overall muscular fitness in youth populations. This strong predictive relationship can be attributed to shared neuromuscular mechanisms between the SLJ and half-squat movements, including rapid force development and similar muscle activation patterns.^{24,25} Both exercises engage the quadriceps, hamstrings, and gluteal muscles, with the SLJ

emphasizing explosive concentric contractions and the half-squat requiring sustained force production under load.

Our initial model included additional variables (5JT, age, and BH), but their exclusion from the final model produced minimal impact on predictive power (R^2 reduction from .70 to .72). This simplified model's comparable effectiveness supports recent findings by Dhahbi et al.¹⁴ who demonstrated that parsimonious prediction models can maintain high accuracy while improving practical utility. The non-significant contribution of the 5JT ($\beta=-5.90$, $P=.300$) may reflect several biomechanical and coordinative factors. The 5JT requires alternating single-leg landings and takeoffs, demanding greater neuromuscular coordination and balance control compared to the bilateral SLJ.¹⁷ Additionally, the 5JT emphasizes stretch-shortening cycle efficiency across multiple contacts, whereas the half-squat represents a single, maximal concentric effort similar to the SLJ movement pattern.²⁴ The alternating leg requirement may also introduce variability due to potential limb asymmetries common in youth athletes, reducing the correlation with bilateral strength measures.²⁵ Furthermore, the extended distance covered in the 5JT ($9.09 \pm 0.79m$) may involve different energy system contributions compared to the single explosive effort required for both SLJ and half-squat performance.

The strong predictive capability of our model proves particularly noteworthy given our young sample ($12.77 \pm .25$ years). Previous research has highlighted challenges in strength assessment within youth populations, including technical complexities and safety considerations in maximal testing protocols.^{9,19} Our findings indicate that field-based testing provides a reliable alternative while maintaining predictive accuracy. While some studies have reported weaker relationships between field tests and maximal strength metrics, particularly in untrained populations,^{27,28} our focus on trained athletes likely reduced variability associated with skill level and technical proficiency.

The strong predictive relationship observed in our youth cohort aligns with the principle that field-based assessments should be population-specific, particularly considering the unique neuromuscular characteristics of developing athletes.^{12,15} The effectiveness of horizontal jump tests in this age group may reflect the stage-specific nature of force production capabilities during adolescent development. The stronger predictive capability observed in our study might reflect the specific nature of the half-squat movement pattern, which appears more closely

related to single-effort horizontal displacement as measured by the standing long jump.

This study is not without limitations. The sample consisted exclusively of young male soccer players, limiting the generalizability of the findings to other sports or female populations. Future research should examine the predictive validity of these models in diverse athletic cohorts. Additionally, the cross-sectional design prevents inferences about the model's stability over time, especially given the rapid physical development characteristic of youth athletes. Future studies should adopt a longitudinal design to address this limitation. Importantly, the absence of external validation represents a critical limitation that constrains the generalizability and clinical applicability of our findings. Contemporary prediction model development standards emphasize that models require validation across independent datasets to establish transportability and reduce overfitting bias.²⁹ Without external validation, the risk of optimistic performance estimates increases substantially, limiting confidence in real-world application.³⁰ This model provides a foundation for strength assessment in youth soccer players, with external validation studies needed to confirm broader applicability across different populations and settings across diverse youth soccer populations, different geographic regions, and varying training environments to establish the model's robustness and practical utility. While the sample size (n=41) provided sufficient statistical power for the primary analyses, larger-scale validation studies would further strengthen confidence in the model's applicability across different youth sporting populations. Finally, while the model explains a substantial portion of the variance, other factors, such as muscle architecture, tendon stiffness, and neural adaptations,¹⁰ likely contribute to 1RM performance and warrant further investigation.

Future research should explore the longitudinal effects of strength and power training on the predictive accuracy of these models. Tracking changes in BM, SLJ, and 1RM over a competitive season could reveal how training-induced adaptations influence the relationships between these variables. Integrating other field tests, such as sprint times or change-of-direction drills, may also improve the comprehensiveness of predictive models. Additionally, exploring the application of machine learning algorithms to identify complex interactions between predictors could uncover non-linear relationships and enhance the precision of strength predictions.

Practical implications

The findings of this study have significant practical implications for coaches and practitioners working with young athletes. Following external validation, the derived predictive equation may enable coaches to estimate 1RM half-squat performance in similar populations without direct testing, which is often time-consuming and carries a higher risk of injury, particularly for novice athletes.⁹ This approach is especially valuable in large group settings or when resources are limited. Furthermore, the inclusion of SLJ as a predictor highlights the importance of explosive power in strength development programs. Coaches should prioritize exercises that enhance both maximal strength and power, such as plyometrics and Olympic lifts, to optimize performance in field-based assessments and sport-specific tasks.³

Conclusions

This study validates a practical approach for estimating maximal

half-squat strength in young soccer players using readily available field tests. The combination of SLJ performance and BM provides a robust prediction model explaining 70% of variance in 1RM performance. The simplified two-variable equation offers coaches and practitioners a time-efficient, low-risk method for strength assessment in youth populations. Future research should examine the model's longitudinal stability and potential applications across different age groups and sporting populations. These findings represent an important step toward more accessible and practical strength assessment protocols in youth soccer.

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Informed Consent Statement

The authors report there are no competing interests to declare.

Ethical Committee approval

The study protocol was approved by the local institutional ethics committee of the Higher Institute of Sport and Physical Education of Kef, Tunisia (C-0010/2024 – September 19th, 2024) and was conducted in accordance with the Declaration of Helsinki.

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Topic

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Conflicts of interest

The authors have no conflicts of interest to declare.

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Author-s contribution

Writing – original draft, Validation, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. ABA: Writing – original draft, Validation, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. WD: Writing – review & editing, Visualization, Methodology, Formal analysis, Conceptualization. JP: Writing – review & editing, Visualization, Methodology, Formal analysis, Conceptualization. YH: Writing – review & editing, Supervision,

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