

Development and Validation of a Running Drill Test Battery to Predict 5 m and 20 m Sprint Performance

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Abstract

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<https://doi.org/10.70252/LYKE8231> This study aimed to evaluate the reliability and predictive validity of specific athletic running drills: A-skip, B-skip, bounding step, and jumps, in relation to sprint performance over 5 m and 20 m distances. Sixty-three young males (mean age: 21.3 ± 2.1 years; body height: 183 ± 6.5 cm; body weight: 77 ± 9.3 kg) were enrolled in the study. Running drill performance was recorded on an athletics track using high-speed cameras and evaluated based on predefined criteria and a scoring system. Reliability was assessed using intraclass correlation coefficients (ICC) and coefficients of variation (CV). Predictive validity was determined via Pearson correlations and multiple linear regression analyses. The results indicated good to excellent inter-rater reliability for A-skip (ICC = 0.897) and jumps (ICC = 0.9), while B-skip and bounding step showed good reliability (ICC = 0.808 and 0.874, respectively). The 20 m sprint demonstrated excellent reliability (ICC = 0.969, CV = 2.07%), while the 5 m sprint had good reliability (ICC = 0.863, CV = 3.58%). B-skip emerged as the strongest predictor for both sprint distances, with significant negative associations (5 m: $\beta = -0.531$, $p < 0.01$; 20 m: $\beta = -0.322$, $p < 0.05$). These findings suggest that specific drills, particularly B-skip, demonstrate high inter-rater reliability and moderate predictive validity as indicators of short-sprint performance, with B-skip showing the strongest association. Coaches and practitioners can use these drills to enhance training programs to improve acceleration and speed over short distances.

Keywords: Skills, motor learning, athletics

Introduction

Sprinting ability, a critical component of athletic performance, significantly impacts success across a diverse array of sports.¹ Athletes who are capable of rapid acceleration and can maintain top speed levels often have a competitive advantage over the competition, whether in team sports or individual sports.² The effectiveness of an athlete's sprinting performance is not only dependent on the time taken to get from point A to point B, but also on biomechanical execution of running movements and overall running form.³ Given the crucial role of biomechanical execution in overall success, it is essential to use reliable measuring methods and tools to ensure accurate data collection and performance assessment.⁴ With that being said, inter-rater and

intra-rater reliability ensure consistency among evaluators and within a single evaluator during the measurement process. Such information is critical when it comes to the validity of results used for decision-making in the planning of training programs and competitions.⁵

Motor skills, such as basic athletic running drills like A-skip, B-skip, bounding step, and jumps, are recognized by kinesiologists, track coaches, and strength and conditioning coaches as potential indicators and predictors of sprinting performance in athletes.⁶ These running exercises develop kinesthetic awareness and control to reinforce movement mechanics that are necessary for optimal running performance.^{7,8} Previous research tackling this topic had identified a significant impact of these running drills and plyometric elements on sprint performance.⁸ In their study, Yoshimoto et al⁹ demonstrated that mini-hurdle drills acutely increase step frequency and sprint velocity, supporting the idea that high-frequency movement drills may enhance sprint mechanics. Accordingly, exercises such as A-skip, B-skip, bounding step, and jumps are widely used in practice to improve movement rhythm and coordination. With the goal of improving step frequency in mind, coaches, alongside mini-hurdle drills, often use drills such as A-skip, B-skip, bounding step, as well as various single-leg and two-leg jump variations. Although running drills such as A-skip, B-skip, bounding step, and jumps are recognized for their role in enhancing sprint performance through improvements in technique, coordination, and explosive power,¹⁰ the specific association between these skills and short sprint outcomes over distances like 5 m and 20 m, particularly in recreational athletes, remains largely underexplored.¹¹

Therefore, this study aims to evaluate the reliability of specific athletic motor skills and determine the potential relationships between these specific running skills and short sprint performance at 5 m and 20 m. Additionally, the study investigates the individual contributions of each tested running skill to sprint performance over these distances. The findings of this research are expected to provide valuable insights for coaches and kinesiology professionals, enabling the development of more effective training programs to enhance short sprint performance in sports.

Methods

Participants

The study included a sample of sixty-three young males (mean age: 21.3 ± 2.1 years, body height: 183 ± 6.5 cm, and body weight: 77 ± 9.3 kg), from different sports activity backgrounds, classified as Tier 1 (Recreationally Active) to Tier 2 (Trained/Developmental) per McKay et al,¹² reflecting regular engagement in structured physical activity without elite competitive status. To participate in this investigation, athletes had to fulfil certain criteria: (i) being in good health, defined as having no current cardiovascular or pulmonary diseases, pain, acute or chronic illnesses, or symptoms of metabolic syndrome; (ii) demonstrating physical fitness appropriate to the requirements of the study; and (iii) having no history of serious injuries or medical conditions that could impair their ability to perform the physical tasks in the study. Participants with prior experience in athletics (track, jumping, or throwing) were excluded from the experiment to minimize large initial individual differences. In this way, the potential influence

of prior knowledge of specific elements was eliminated, ensuring a higher level of sample homogeneity in terms of initial motor skills relevant to the experimental tasks. The Institutional Review Board approved this study at the Faculty of Kinesiology, University of Split (approval number: 2181-205-02-05-22-037). This research was carried out fully in accordance with the ethical standards of the *International Journal of Exercise Science*.¹³

A power analysis was conducted using G*Power (version 3.1.9.7; Universitat Kiel, Germany) to ensure an adequate sample size for detecting significant correlations between running skills (A-skip, B-skip, bounding step, and jumps) and sprint performance (5 m and 20 m). Assuming a moderate correlation coefficient ($r = 0.5$), based on Cohen's benchmarks and supported by findings in similar studies assessing relationships between motor skills and sprint performance (e.g., step frequency and sprint performance),^{14,15} a significance level of $\alpha = 0.05$, and statistical power of $1-\beta=0.80$, the analysis determined a minimum sample size of 29 participants. With 63 participants in the study, the sample size exceeded this threshold, providing acceptable power to detect moderate to large correlations.

Protocol

The research process of developing and evaluating a newly constructed battery of tests for assessing athletic sports skills and their association with sprint performance consisted of three main phases. The first phase was test development; this process included the definition of the test structure and the development of precise performance assessment criteria. The second phase included the implementation of reliability tests – the reliability of the assessment was examined via intraclass correlation coefficients (ICC) and coefficients of variation (CV) for each skill component, while validity was assessed by analyzing the association with sprint performance. The third phase referred to the predictive validity analysis, where the effects of individual sports skills on 5 and 20-meter sprint times were examined using multiple linear regression. The purpose of the research was explained in detail to the participants and after receiving all relevant information, they gave written informed consent to participate. The entire research process was conducted per the highest ethical standards and principles, including protecting the privacy and well-being of the participants.

Defining Test Objectives.

The athletic skills assessment battery used in this study was developed using methodological standards to ensure high precision, reliability, and validity in evaluating sports skills and their relationship to sprint performance. The primary objective was to construct a battery of tests that quantitatively assess key athletic skills, including coordination, explosive power, and biomechanical efficiency.

The selection of key test elements was informed by a review of scientific literature on athletic skill development^{16,17} and insights from coaching practice. Based on biomechanical theory and coaching practices,¹¹ the final battery included A-skip, B-skip, bounding step, and jumps, covering essential technical and coordinative aspects believed to influence sprint performance.

Considering scientific and practical insights, each test in the battery was designed based on a robust theoretical framework, with an emphasis on identifying biomechanical and functional components relevant to sprint performance.¹⁸ In line with the findings of Nakano et al,¹⁹ who highlight the importance of precisely structured exercises and training programs for enhancing running ability, the final battery included the following tests: A-skip, B-skip, Bounding step, and Jumps, thus covering a wide range of skills relevant to the analysis of sprint performance. This approach enabled the integration of empirically validated exercises and coaching knowledge into a unique tool for evaluating and improving sprinting abilities.

Table 1. A- skip evaluation and criterion description

Evaluation criteria	Description of the criterion
The angle between the forearm and upper arm is approximately 90°	Proper execution ensures a stable arm position without excessive flexion and extension in the elbow joint
Arms and shoulders are constantly relaxed	This relaxation ensures fluid movement and prevents stiffness, enhancing running mechanics
Hands are raised to chest height and do not cross the sagittal plane	Hands should move to chest height, avoiding crossing the midline, to maintain symmetry and forward motion
The thigh of the swinging leg reaches 45° relative to the ground	The thigh of the swinging leg should rise to about 45° relative to the ground, ensuring proper control and force transfer to the ground
Forward and upward thigh movement occurs with a relatively higher frequency	The swinging thigh moves dynamically with a higher frequency to maintain rhythm and proper technique, emphasizing coordinated upward and forward motion
The phase of amortization is present for the supporting leg with partially relaxed feet	A short amortization phase with relaxed feet ensures proper shock absorption and preparation for the next step
The foot lands on the forefoot as close as possible to the vertical projection of the body	The foot should land on the forefoot near the body's vertical line (optimal contact time), ensuring stable and efficient force transfer without energy loss
Feet land straight on the ground in the direction of motion	The feet should land straight forward without inward or outward rotation, which is crucial for maintaining proper biomechanics
Full extension of the knee at the vertical phase	The knee should fully extend when the body reaches a vertical position, indicating proper step completion and weight transfer
Heel flick in the backward swing phase	The heel should not flick backward during the swing phase. Proper technique involves keeping the heel aligned to ensure movement efficiency

Criteria and Scoring System.

Two basic categories of tests are used to assess motor skills: norm-referenced and criterion-referenced tests. This research focuses on criterion-referenced tests, which assess an individual's performance against predefined criteria rather than comparing participants. This type of test allows for determining the ability or inability to perform specific elements, possibly including a category of partial performance.²⁰ Determining the criteria that served to evaluate the individual performance of the respondents was approached from the perspective of conceptualization as a starting point and operationalization of the evaluated constructs. By this criterion, a ratio scale was constructed for evaluating the performance of participants. A score of 0 represents the absence of a specific element, 1 indicates that the element is partially present, and 2 signifies that

the element is fully present. For each drill, a total score was calculated by summing the values awarded across all evaluation criteria. Since each criterion was rated on a 0–2 scale, this summative method allowed for a composite score representing the overall execution quality of each drill, with higher scores indicating better technical proficiency. This scoring approach was applied uniformly across all four drills (A-skip, B-skip, bounding step, and jumps). Clearly defined and precise criteria were used to ensure valid and standardized assessment of individual and overall drill performance.

Table 2. B-skip evaluation and criterion description

Evaluation criteria	Description of the criterion
The angle between the forearm and upper arm is approximately 90°	Proper execution ensures a stable arm position without excessive flexion and extension in the elbow joint
Arms and shoulders are constantly relaxed	Relaxation promotes fluidity of movement and prevents stiffness, which could negatively affect overall running technique
Hands are raised to shoulder level and do not cross the sagittal plane	Hands should move to chest height, avoiding crossing the midline, to maintain symmetry and forward motion
The heel of the swinging leg is raised to "mid-thigh height"	The heel of the swinging leg should rise to approximately mid-thigh height, completing the motion. This ensures proper preparation of the lower limbs for effective application of force
The thigh of the swinging leg reaches 90° relative to the ground	The swinging thigh must reach a 90° angle relative to the ground. Proper motion ensures balance, effective coordination, and symmetrical running mechanics
Feet land straight on the ground in the direction of motion	Proper foot placement, without inward or outward rotation, is essential for maintaining biomechanical stability
The foot lands on the forefoot close to the vertical projection of the body	The foot should land on the forefoot, near the body's vertical projection, to ensure proper stability and efficient energy transfer
Feet are placed on the ground with toes raised and without heel contact	Toes raised, heel off the ground, ensuring smooth transitions and efficient energy transfer
Full extension of the knee in the vertical phase	When the body reaches the vertical position, the supporting leg must be fully extended and aligned with the torso, indicating proper weight transfer and stability
Backward heel flick in the rear swing phase	The heel should not be pulled backward during the rear swing phase, but should remain aligned with the natural running rhythm to preserve biomechanical efficiency

A-skip.

The A-skip is a technical sprinting exercise primarily used to improve biomechanical efficiency, coordination, and accuracy of running's technical elements.^{21,22} The exercise aims to simulate key kinematic aspects of sprinting, including proper body position, optimal muscle activation, precise foot contact with the ground, and synchronization of arm and leg movements.

B-skip.

The B-skip is an advanced variation of the A-skip, characterized by an increased knee joint flexion angle, enhancing its biomechanical similarity to sprinting mechanics.^{21,22} This drill specifically targets the late swing phase by emphasizing greater knee flexion and hip flexor activation, which enhances movement control and power generation in preparation for ground contact. Additionally, it improves postural stability and rhythmic coordination. Compared to the A-skip, the B-skip involves a higher knee lift and greater hip flexion, closely replicating the mechanics of the sprinting swing phase. This increased range of motion facilitates more effective engagement of the hip flexors and associated muscle groups, optimizing biomechanical readiness for sprint propulsion. Furthermore, the drill encourages greater knee extension just before ground contact, reinforcing proper sprint mechanics during the transition from the swing to the stance phase. Table 2 shows the detailed criteria for evaluating the B-skip performance.

Table 3. Bounding step evaluation and criterion description

Evaluation criteria	Description of the criterion
The angle between the forearm and upper arm is approximately 90°	Proper execution ensures a stable arm position without excessive flexion and extension in the elbow joint
Hands are raised to shoulder height and do not cross the sagittal plane	Hands should move to chest height, avoiding crossing the midline, to maintain symmetry and forward motion
Arms and shoulders are constantly relaxed	Relaxation promotes fluidity of movement and prevents stiffness, which could negatively affect overall running technique.
The thigh of the swinging leg reaches 90° relative to the ground	Proper motion ensures balance, effective coordination, and symmetrical running mechanics
In the front swing phase, the angle at the knee is less than 90°	This ensures better control and readiness for the next step.
Active lowering of the thigh downward and backward to full extension at the vertical phase	The thigh should move downward and backward until the leg is fully extended and the body is vertical, ensuring proper stride completion and forward energy transfer
During the "grabbing" phase, the foot moves downward-backward	In the "grabbing" phase, the foot must actively move downward and backward to provide optimal contact with the ground and assist in energy transfer for the next stride
The foot lands on the forefoot close to the vertical projection of the body	The foot should land on the forefoot, near the body's vertical projection, ensuring stability and minimizing energy loss.
In the vertical phase, the supporting leg and the body are aligned	When the body reaches the vertical position, the supporting leg must be fully extended and aligned with the torso, ensuring proper weight distribution and stability
In the rear swing phase, the knee angle is less than 45°	During the rear swing phase, the supporting leg knee angle must be under 45°, ensuring a smooth transition and maintaining stride dynamics

Bounding step.

The bounding step is an advanced technical sprint exercise that builds on the fundamental biomechanical principles of the B-skip, with a special emphasis on active extension of the lower extremity after reaching the highest knee position.²³ This exercise is key in optimizing sprint biomechanics, mainly through perfecting the swing phase and preparing for effective foot-to-ground contact. Table 3 contains detailed criteria for performing the Bounding step exercise,

emphasizing technical and biomechanical parameters that enable a standardized performance quality assessment.

Table 4. Jumps evaluation and criterion description

Evaluation criteria	Description of the criterion
The angle between the forearm and upper arm is approximately 90°	Proper execution ensures a stable arm position without excessive flexion and extension in the elbow joint
Hands are raised to shoulder height and do not cross the sagittal plane	Hands should move to chest height, avoiding crossing the midline, to maintain symmetry and forward motion
The upright posture of the torso	Proper posture ensures stability, better control of weight distribution, and reduces the risk of improper movements
Clearly defined flight phase	The flight phase demonstrates dynamic movement and a jump that enables smooth transitions between jumps
The thigh of the swinging leg rises to 90° relative to the ground	Proper positioning ensures greater motion amplitude and prepares the body for the next step
In the front swing phase, the angle at the knee is less than 90°	During the front swing phase, the knee of the swinging leg should bend at an angle smaller than 90°. This ensures better leg control and a smooth transition into the support phase
Active placement of the swinging leg foot "underneath itself" – beneath the projection of the knee	The swinging leg foot should be placed "underneath itself," beneath the vertical projection of the knee. This ensures stable contact with the ground and efficient force transfer through the leg
Feet land straight on the ground with toes raised and no heel contact	Feet should be directed forward, toes raised, and no heel contact, ensuring smoother transitions and efficient energy transfer between jumps
Straightened knee during the rear support phase	During rear support, the knee must be fully straightened to ensure proper movement flow and readiness for the next phase
Backward heel flick in the rear swing phase	The heel should not flick backward during the rear swing phase. Instead, it should remain aligned and directed forward, ensuring efficient energy transfer and maintaining rhythm

Jumps.

Jumps are a simple yet highly effective exercise for developing explosive power, balance, coordination, and biomechanical efficiency.²⁴ This exercise mimics the natural pattern of alternating load transfer between the legs, which is crucial for sprinters. The execution involves a powerful push-off from one leg with minimal ground contact time, followed by a controlled landing on the opposite leg. The jumps are performed as alternating unilateral jumps in a horizontal direction, with a distinct flight phase between takeoff and landing, ensuring continuous horizontal propulsion. Table 4 presents the criteria for evaluating the execution of this exercise, including specific parameters that provide a standardized analysis of its technical and biomechanical components.

After defining the criteria for each element, the research process was carried out with careful planning and implementation to ensure the reliability and validity of the results. The subjects

were first introduced to the purpose and objectives of the research. Each athletic element (A-skip, B-skip, Bounding Step, and Jumps) was demonstrated and explained in detail to ensure correct execution. Over the course of three weeks, participants were systematically introduced to the performance criteria for each individual element. During the same period, they practiced executing the assigned elements twice per week for one hour per session, following the predefined technical criteria to refine and optimize their performance. The measurements were conducted during the third week of the teaching process to ensure that students acquired basic knowledge of the correct execution of the tests beforehand. The goal was to prevent elements such as bounding steps and jumps from being performed incorrectly or with significant deviations, which could affect the validity of the results. This approach aligns with findings in educational psychology, where pretesting and prequestioning have been shown to enhance learning and retention by familiarizing individuals with the material before formal assessments.^{25,26} Similarly, in motor learning and sports science, prior teaching of technical tasks is essential for minimizing variability and ensuring reliable and valid performance outcomes. This preparation not only improves task execution but also contributes to a more accurate evaluation of the skills being tested.

The research was conducted on an athletics track, where the performances of each element were recorded using two high-speed cameras (GoPro Hero 7 Black, USA), positioned in a lateral view to capture key movement phases. The cameras recorded at a frequency of 60 frames per second (fps), ensuring a sufficient frame rate for detailed motion analysis. In addition, the subjects performed sprints at distances of 5 m and 20 m from a high start position, starting from a distance of 50 cm behind the starting line. Running time was measured using precise photocells (Brower Timing Systems), with one set positioned at the start and the other at the finish line. The photocells were aligned at a height of 1.5 meters to detect the participant's movement accurately. Each participant performed both sprints three times. This part of the research enabled quantitative data collection on sprint performance, with each round providing reliable time measurements for analysis.

The collected recordings were submitted to three independent raters, experts in the field of athletics, who were previously familiar with the set evaluation criteria. After thoroughly explaining the requirements, the raters analyzed the recordings and rated the subjects based on clearly defined parameters. They were instructed to: 1) adhere strictly to the scoring scale, 2) avoid rewinding the video after completing their scoring, and 3) aim to perform their evaluations at the same time of day for consistency.²⁷ The sequence of the video recordings was randomized to reduce potential bias. The scores obtained from each rater were then subjected to statistical analysis to assess the reliability and validity of the criteria and the levels of inter-rater consistency. These data provided insight into technical performance and the applicability of the defined criteria in assessing athletic skills.

Statistical Analysis

Results are presented as the mean and standard deviation, following confirmation of data normality with the Kolmogorov-Smirnov test with Lilliefors corrections. To determine inter-rater reliability and level of agreement across the trials in sprint performance, the intraclass

correlation coefficient (ICC) with 95% confidence intervals (95% CI) was calculated based on a two-way mixed-effects model for absolute agreement. ICC values range from 0 to 1, with values below 0.5 indicating poor reliability, 0.5–0.75 indicating moderate reliability, 0.75–0.9 indicating good reliability, and values above 0.9 indicating excellent reliability.²⁸ Moreover, to assess the sprint performance's absolute reliability, the coefficient of variation (CV) was calculated with 95% confidence intervals. A custom Microsoft Excel spreadsheet developed by Hopkins²⁹ for consecutive pairwise analysis of three or more trials was used. The Pearson product-moment correlation coefficient (r) was calculated to determine the relationship between skills and 5 m and 20 m sprint time. Correlation strength was interpreted based on the modified scale:³⁰ values of 0.1 indicate a trivial correlation; 0.1–0.3, small; 0.3–0.5, moderate; 0.5–0.7, large; 0.7–0.9, very large; and values above 0.9, nearly perfect. Lastly, multiple linear regression analyses were conducted to determine the individual linear effects of skills on sprint performance, with sprint times as the dependent variables and skills as the predictor variables. Therefore, two separate regression models with the enter method were calculated. To assess the model's explanatory power, the adjusted coefficient of determination (R^2) was calculated using the following formula: $R^2_{adj} = 1 - (1 - R^2) \times (n - 1) / (n - p - 1)$; (R^2) is the sample R-squared, (p) is the number of predictors, and (n) is the total sample size. The significance level (p -value) was set at 0.05. Data were analyzed using SPSS version 28.0 (SPSS, Chicago, IL, USA) and GraphPad Prism 9 (GraphPad Software, Inc., San Diego, CA, USA).

Results

Inter-Rater Reliability

Inter-rater reliability values for the skills score are presented in Table 5. A-skip and jumps demonstrated good (ICC = 0.75–0.90) to excellent (ICC > 0.90) reliability. B-skip and bounding step showed moderate (ICC = 0.50–0.75) to good (ICC = 0.75–0.90) reliability, with lower values observed in lower extremities. These findings suggest consistent and reliable ratings for each skill across raters.

Sprint Performance Reliability

Measures of reliability (with 95% confidence intervals) for 5 m and 20 m sprint performance are presented in Table 6. The reliability analysis for 5 m and 20 m sprints suggests that the 20 m sprint consistently achieved very high reliability, with strong ICC values and low CV%, indicating steady and reliable performance across trials. The 5 m sprint showed good reliability with more variation, as reflected in slightly higher CV%. Notably, reliability for the 5 m sprint improved from the first to the second set of trials, while the 20 m sprint remained consistently reliable with low variability throughout.

Correlation Between Sprint Performance and Skills

Descriptive statistics for skills and sprint performance are shown in Table 7.

Table 5. Inter-rater reliability for skills score.

Variable		ICC	(95% CI)		
A-skip	upper extremities	0.938	(0.907	to	0.96)
	lower extremities	0.773	(0.658	to	0.854)
	Overall score	0.897	(0.845	to	0.934)
B-skip	upper extremities	0.845	(0.76	to	0.902)
	lower extremities	0.724	(0.561	to	0.829)
	Overall score	0.808	(0.705	to	0.878)
Bounding step	upper extremities	0.881	(0.821	to	0.924)
	lower extremities	0.79	(0.675	to	0.867)
	Overall score	0.874	(0.8	to	0.921)
Jumps	upper extremities	0.807	(0.635	to	0.892)
	lower extremities	0.909	(0.862	to	0.942)
	Overall score	0.9	(0.849	to	0.936)

ICC = intraclass correlation coefficient; 95% CI = 95% confidence interval.

Table 6. Measures of reliability (with 95% confidence intervals) for 5 m and 20 m sprint performance (n = 63)

variable	mean change	ICC	95% CI		CV%	95% CI	
<i>Trials 1-2</i>							
5 m (s)	0.007	0.756	(0.601	to 0.851)	4.6	(4.01	to 5.41)
20 m (s)	-0.005	0.969	(0.948	to 0.981)	2.07	(1.81	to 2.43)
<i>Trials 2-3</i>							
5 m (s)	0.002	0.863	(0.755	to 0.916)	3.58	(3.12	to 4.21)
20 m (s)	0.001	0.919	(0.867	to 0.951)	3.18	(2.78	to 3.74)

ICC = intraclass correlation coefficient; (95% CI) = 95% confidence interval; CV% = coefficient of variation; CI% = confidence interval for CV.

Table 7. Descriptive statistics for skills and sprint performance

Variable	Mean	±	SD	Min	Max
<i>Skill</i>					
A-skip (a.u.)	16.23	±	2.02	8.70	19.70
B-skip (a.u.)	16.27	±	2.20	8.70	19.70
Bounding step (a.u.)	15.05	±	2.76	8.00	19.30
Jumps (a.u.)	12.37	±	3.37	4.00	17.70
<i>Sprint performance</i>					
5 m (s)	1.08	±	0.08	0.92	1.21
20 m (s)	3.28	±	0.26	2.82	3.83

Legend: a.u. = arbitrary units, composite score from 0-2 per criterion.

Figures 1 and 2 show the correlation analysis between 5 m and 20 m sprint performance and skill total score. For the 5 m sprint, there was a moderate negative correlation with B-skip and small to moderate correlations with bounding step and jumps. The A-skip showed a trivial correlation with 5 m sprint performance, indicating minimal association. In the 20 m sprint, the B-skip, bounding step, and jumps exhibited moderate negative correlations, suggesting a meaningful association between sprint performance and these movement tasks. The A-skip

again showed a trivial correlation with the 20 m sprint, indicating that this task skill has limited relevance in relation to sprint performance over this distance.

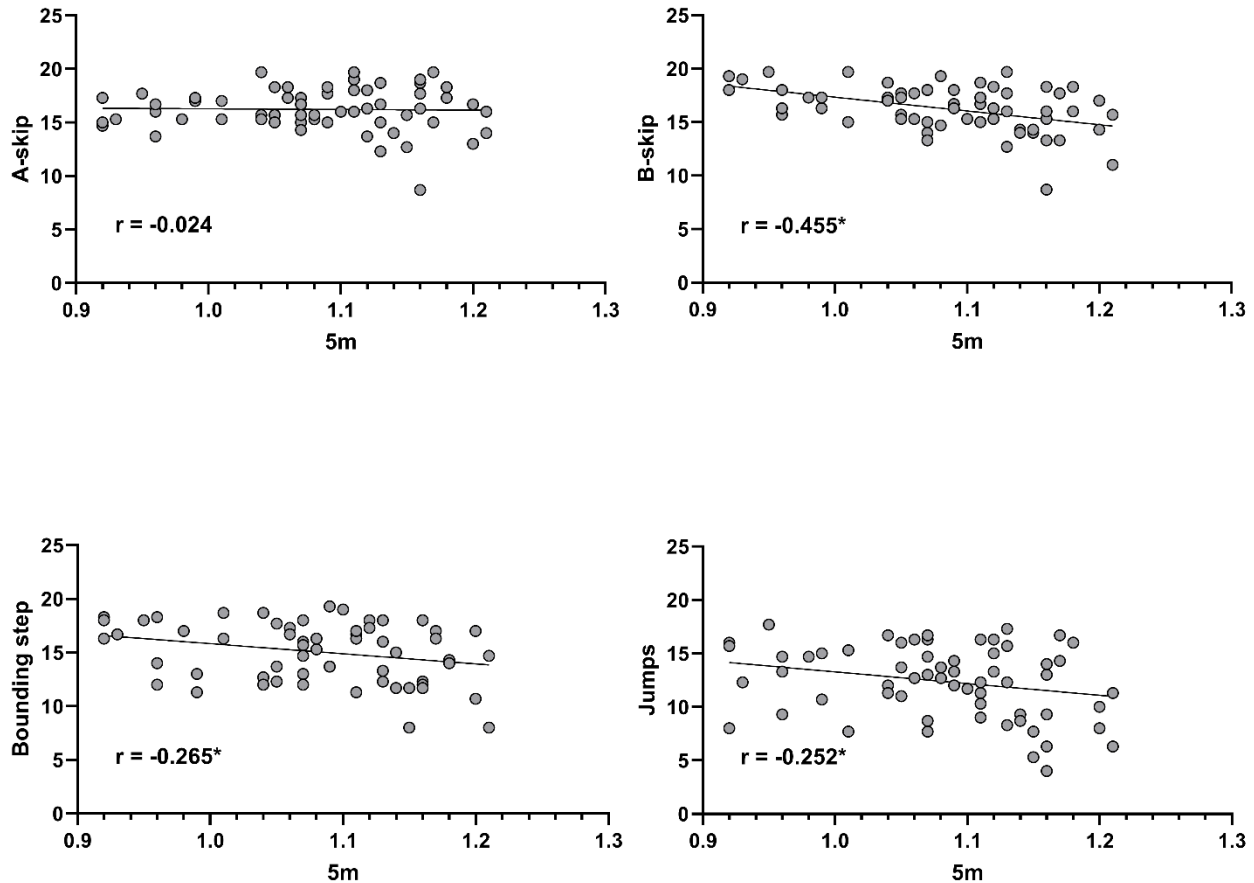


Figure 1. Correlation coefficients between 5 m sprint performance and skills. r = correlation coefficient; * $p < 0.05$.

Linear Relationship Between Skills and Sprint Performance

Unstandardized and standardized Beta values for 5 m and 20 m sprint performances are presented in Table 8. The regression models for both 5 m and 20 m sprint performances were statistically significant, indicating that the movement tasks collectively contributed meaningfully to explaining sprint performance. The Variance Inflation Factor (VIF) values for all predictors were well below the threshold of 10, ranging from 1.389 to 2.096, indicating no issues with multicollinearity. The 5 m sprint model showed an R^2 of 0.256 and an adjusted R^2 of 0.201 ($F = 4.979$, $p = 0.002$), while the 20 m sprint model had an R^2 of 0.274 and an adjusted R^2 of 0.220 ($F = 5.473$, $p < 0.001$), suggesting that approximately 20-22% of the variance in sprint times was explained by the predictors. Across both models, B-skip emerged as the most influential predictor, showing a significant negative association with sprint performance.

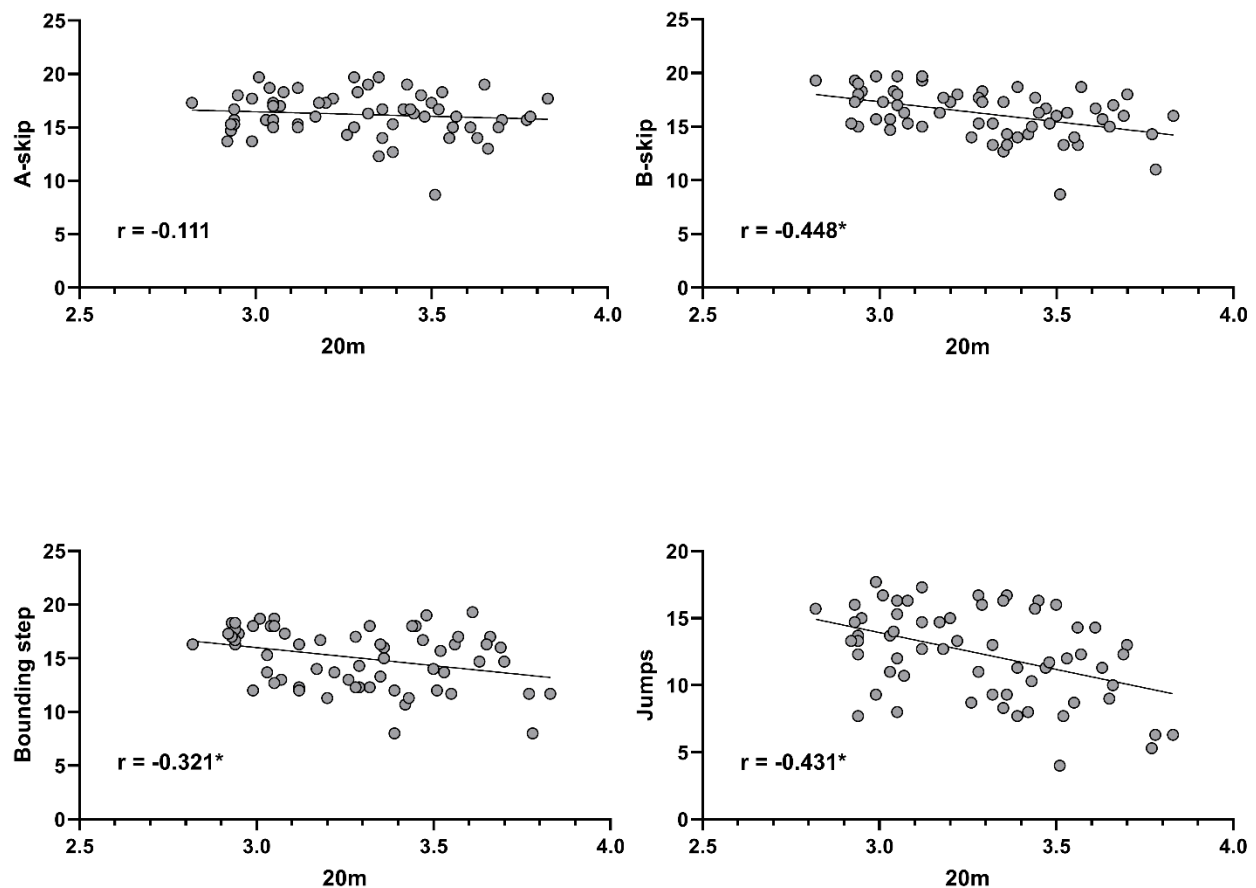


Figure 2. Correlation coefficients between 20 m sprint performance and skills. r = correlation coefficient; * $p < 0.05$.

Table 8. Unstandardized and standardized Beta values for 5 m and 20 m sprint performances

Variable	B	SE	β
5 m			
A-skip (a.u.)	0.009	0.005	0.239
B-skip (a.u.)	-0.019	0.005	-0.531**
Bounding step (a.u.)	-0.002	0.004	-0.069
Jumps (a.u.)	0.000	0.004	-0.006
20 m			
A-skip (a.u.)	0.028	0.018	0.211
B-skip (a.u.)	-0.039	0.018	-0.322*
Bounding step (a.u.)	-0.007	0.013	-0.07
Jumps (a.u.)	-0.024	0.013	-0.303

Legend: a.u. = arbitrary units, composite score from 0-2 per criterion; B = unstandardized regression coefficient; SE = standard error of the coefficient; β = standardized regression coefficient; * $p < 0.05$; ** $p < 0.01$.

Discussion

This study successfully developed a newly constructed battery of tests for assessing athletic skills based on predefined performance criteria within a sports population, representing a significant contribution to sports science. The study's results provide key insights into the validity and reliability of the tests and the relationship between specific athletic skills and sprinting performance. Although these exercises have been used in sports practice for many years, there have been no established criteria by which an athlete's performance can be evaluated. The results highlight how applying standardized exercises with precisely defined performance criteria can contribute to a more detailed understanding and monitoring of sports skills in sports practice and science. In sports practice, these standardized exercises can objectively assess athletes' sports abilities, identify specific areas for improvement, and monitor progress during training. The process-oriented approach analyzes movements' descriptive characteristics, form, and mechanics, allowing for deeper insight into the movement's structural and functional aspects.³¹ Such an approach emphasizes a thorough evaluation of performance elements to aim for a more precise understanding of biomechanical principles and dynamic interactions within movement.

The reliability analysis revealed high inter-rater reliability across most components of the newly developed test battery, indicating that the scoring criteria were applied consistently among raters. A-skip and jumps demonstrated excellent reliability, while B-skip and bounding step showed slightly lower values, likely due to greater technical complexity and variability in execution. Similar issues with scoring consistency in complex motor tasks have been reported in previous studies.^{20,27} These findings highlight the importance of clear evaluation criteria and rater familiarity to ensure reliability. Overall, the high level of agreement supports the practical application of this test battery in both research and sports practice.^{4,28} The results of the reliability analysis of the 5 m and 20 m sprints show high reliability of the 20 m sprint, with ICC values of 0.969 and a low coefficient of variation (CV% = 2.07), indicating stable and repeatable performance across trials. The results confirmed the validity and high reliability of the 20 m sprint test for sports performance analysis, aligning with previous research emphasizing the importance of standardized conditions for precision and repeatability.⁴ Compared to the 20 m sprint, the 5 m sprint showed lower initial reliability values (ICC = 0.756), which improved during repeated trials (ICC = 0.863). This aligns with previous research by Fristrup et al,³² that suggests a learning effect with adaptation to the test conditions, reducing variability. The increased variability in the 5 m sprint can be attributed to the dynamic nature of short acceleration, with reaction time significantly impacting performance.^{33,34}

This research showed a significant correlation, or predictive validity, between the criteria of the B-skip, Bounding step, and jump tests with the results of the 5 m and 20 m sprints, which indicates the validity of these exercises in the context of developing speed and explosive power. This is consistent with previous research confirming the role of B-skip and Bounding step exercises in improving sprint technique.²¹ The analysis found that B-skip has the most significant predictive power for sprint results, especially at shorter distances (5 m and 20 m), which suggests that this exercise is essential for training focused on speed and explosive power. According to Gonçalves et al³⁵, focusing on biomechanical aspects, such as high knee positioning

and active foot contact with the ground, is crucial for improving sprinting performance. Such an approach segments the technique into key components,³⁶ which contributes to improving the sprinting technique and performance.

Although previous research, such as that conducted by Babić et al,²⁴ identified a significant connection between jump performance and sprint performance, it is important to point out that precisely defined criteria condition such results for evaluating and performing jumps. Jump training aims to improve explosive power, biomechanical efficiency, and linear speed.³⁷ However, the optimal benefit from this training cannot be realized without proper technique and precise execution of each jump. Our research has identified valid and reliable criteria for jump performance that significantly improve sprint performance.

On the other hand, the results of the A-skip test did not reveal a statistically significant association with sprint performance at either distance, highlighting its limited predictive value for acceleration and speed performance over shorter distances. These findings diverge from those of Whelan et al,¹¹ who underscored the relevance of A-skip exercises for enhancing sprint performance, primarily based on coaching perspectives. Coaches frequently emphasize the utility of A-skip exercises in sprint training, often citing their contribution to refining general technique and enhancing movement rhythm. While A-skip drills play a role in improving biomechanical efficiency, particularly by promoting knee elevation and optimizing kinematics,³⁸ their direct effectiveness in enhancing sprint speed and acceleration appears constrained.

The results of this research provide key guidelines for optimizing sprint performance and developing explosive power through scientifically grounded training programs. The B-skip has been identified as the most significant predictor of sprint performance over 5 m ($\beta = -0.531$, $p < 0.01$) and 20 m ($\beta = -0.322$, $p < 0.05$) distances, highlighting its crucial role in the biomechanical optimization of movement patterns. Special emphasis was placed on proper execution, including raising the knee to a 90-degree angle and actively landing on the forefoot, ensuring efficient force transfer and minimizing energy loss.³⁹ Similar correlations between the execution of the skip drill and sprint performance were confirmed by Nakano et al,¹⁹ who found a connection between 50-meter sprint speed and the execution of the skip drill, emphasizing the high similarity between the two exercises in the context of biomechanical preparation for sprinting. Skip drills increase stride frequency, but they do not affect the reduction of foot contact time with the ground, which is crucial for sprint efficiency, as reducing contact time directly impacts speed and acceleration.⁴⁰ Therefore, achieving shorter foot contact time with the ground is a key factor in sprint performance, and exercises like jumps⁴⁰ significantly optimize this aspect. Jumps facilitate the development of necessary explosive strength in the lower extremities, contributing to improved force generation ability and reducing the time required to transition from the stance phase to the takeoff phase, which is crucial for achieving maximum sprint speed. By implementing verified and reliable athletic drills, such as A-skip, B-skip, Bounding step, and jumps, coaches can systematically assess the performance of their athletes and tailor training to specific needs, maximizing the development of speed and explosive power. Although these exercises are widely used in the warm-up phase in athletics and other sports,^{11,39} their technical execution is not always scientifically criterion-based, which may limit training effectiveness. These results emphasize the importance of a precise

biomechanical approach when applying these exercises during warm-up, ensuring their impact on sprint performance is significant.

Despite offering valuable insights with practical implications, this study is subject to several limitations that restrict its broader applicability and generalizability. The research was conducted exclusively on young male athletes, classified as recreational to trained, rather than professional track and field athletes or diverse population groups such as children and youth, which may limit the findings' relevance to specialized populations with significantly different biomechanical and motor demands. The cross-sectional design precluded longitudinal tracking, which would have provided a deeper understanding of the long-term effects of the analyzed exercises, and the absence of comparable validation for the collected data underscores the need for additional studies to confirm the reliability of the proposed criteria across varying contexts. Furthermore, although the evaluation criteria were standardized, the potential for subjective bias in scoring remains a factor, even with high inter-rater reliability. Future research should prioritize longitudinal monitoring of sports performance to evaluate and refine the utility of these tests, while also including samples of professional track and field athletes and other diverse groups to gain more precise insights into their specific biomechanical and motor demands and ensure broader applicability.

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