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Physical Predictors of Sprint Performance in Moroccan Female Football Players Across Competitive Levels

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Abstract

Physical performance profiling is essential for monitoring player development and guiding individualized training in women's football. However, multidimensional evidence from North African female football players remains limited. This study aimed to compare neuromuscular performance, sprint ability, change-of-direction speed, and maximal aerobic speed between Moroccan first- and second-division female football players. A total of 105 Moroccan female football players participated in this cross-sectional study, including 45 first-division and 60 second-division players. Participants completed a field-based testing battery including squat jump, countermovement jump, countermovement jump with free arms, drop jump, 10 m, 20 m, and 30 m sprint tests, a 20 m change-of-direction speed test, and the Vameval test. Between-division differences were examined using independent samples t-tests, while Pearson correlations, simple linear regressions, and multiple linear regression models were used to examine individual and combined associations with sprint performance. First-division players demonstrated superior performance in DJ ($p < .001$, $d = 1.05$), CMJ ($p < .001$, $d = 0.82$), CMJ-FA ($p < .001$, $d = 0.86$), 10 m sprint ($p = .044$, $d = 0.40$), 20 m sprint ($p = .013$, $d = 0.49$), 20 m change-of-direction speed test ($p = .002$, $d = 0.65$), and VMA ($p < .001$, $d = 0.86$). No significant differences were observed for squat jump or 30 m sprint performance. Countermovement jump was associated with sprint performance across all sprint distances. The 20 m change-of-direction speed test also predicted sprint performance across 10 m, 20 m, and 30 m, explaining 12.5%–21.7% of the variance. Competitive level in Moroccan women's football appears to be characterized by dynamic jump performance, short-distance acceleration, change-of-direction speed, and aerobic fitness rather than by a single isolated physical quality. Multidimensional field-based testing may help coaches monitor player development and individualize training, with CMJ performance and 20 m change-of-direction speed potentially representing useful field-based indicators of sprint ability and competitive level.

Keywords: *women's football; sprint performance; countermovement jump; change-of-direction; maximal aerobic speed; physical profiling*

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Introduction

Women's football has undergone substantial growth, accompanied by increasing match intensity and higher physical preparation standards (Compton et al. 2025). Modern female football requires repeated accelerations, decelerations, sprints, changes of direction, jumps, duels, and rapid transitions between defensive and offensive phases (Stanković et al. 2025). Therefore, sprint capacity, lower-limb power, change-of-direction speed, and aerobic fitness are increasingly recognized as important components of competitive readiness (Mäkiniemi et al. 2023).

In female football, standardized physical profiling is particularly relevant because neuromuscular, biomechanical, and physiological characteristics may influence both performance interpretation and injury risk (Elliott-Sale et al. 2021; Hewett, Ford, and Myer 2006). Field-based testing batteries can therefore help identify individual strengths and weaknesses, guide training prescription, and support player development.

Sprinting is central to football performance because many decisive actions, such as pressing, defensive recovery, duels, and attacking transitions, occur over short acceleration distances of 5–20 m (Haugen et al. 2014; Haugen and Buchheit 2016). However, sprint ability is multidimensional and depends on lower-limb force production, neuromuscular power, braking ability, re-acceleration capacity, movement coordination, and sprint-specific technical factors (Haugen and Buchheit 2016; Zhang et al. 2022). Accordingly, 10 m and 20 m sprint tests are commonly used to assess initial and extended acceleration, whereas 30 m sprint performance provides additional information about longer linear sprint ability (Haugen, Breitschädel, and Seiler 2020).

Vertical jump tests may provide practical insight into sprint-related neuromuscular qualities. The squat jump mainly reflects concentric force-production capacity, whereas the countermovement jump and drop jump involve rapid eccentric-concentric actions and may provide indirect information about stretch-shortening cycle-related explosive performance (Bishop et al. 2022; Taube, Leukel, and Gollhofer 2012). These qualities are relevant to acceleration, which requires rapid force production within short ground-contact times (Haugen and Buchheit 2016). Previous studies have reported associations between vertical jump and sprint performance in football and team-sport athletes, although these relationships are not always strong because sprinting also depends on horizontal force application, mechanics, and technical efficiency (Loturco et al. 2015, 2019; Slimani et al. 2016).

Beyond linear sprinting and vertical jump performance, change-of-direction speed may represent an important field-based indicator of football-specific locomotor ability. Football sprint actions are rarely performed in purely linear conditions; they are often preceded or followed by braking actions, directional adjustments, re-accelerations, changes in body orientation, and duels (Chaabene et al. 2018; Zhang et al. 2022). Therefore, combining linear sprint tests with change-of-direction speed assessment may provide a more complete understanding of the physical qualities associated with sprint ability in female football players.

Aerobic fitness represents a complementary component of the female football player's physical profile. Match play requires players to sustain repeated high-intensity actions and recover efficiently between accelerations, sprints, and changes of direction (Bangsbo, Mohr, and Krustrup 2006; Baptista et al. 2022). Maximal aerobic speed, commonly assessed through field-based tests such as the Vameval, is useful for estimating aerobic fitness and prescribing individualized training intensities (Bok and Foster 2021). Although it is not expected to directly explain maximal linear sprint performance, it may indirectly support repeated high-intensity efforts through improved recovery capacity and repeated-effort tolerance (Gonçalves et al. 2021).

Taken together, previous studies suggest that sprint performance in football is associated with multiple physical qualities rather than a single isolated factor. Vertical jump performance has been related to sprint ability in football and team-sport athletes (Loturco et al. 2015, 2019; Slimani et al. 2016), while change-of-direction speed has been linked to acceleration, deceleration, and re-acceleration ability (Chaabene et al. 2018; Zhang et al. 2022). In adult female football players, repeated-sprint ability has also been associated with sprint performance, change-of-direction ability, vertical jump performance, and aerobic capacity (Gonçalves et al. 2021). However, these variables have rarely been examined together within the same multidimensional field-based testing battery, particularly across different sprint distances in female football players.

Despite the growing literature on women's football, several gaps remain. First, although previous studies have linked sprint performance with jump, change-of-direction, and aerobic-related variables, fewer have simultaneously considered these qualities within the same field-based testing battery (Compton et al. 2025; Gonçalves et al. 2021). Second, it remains unclear whether these variables are similarly associated with short acceleration and longer sprint performance, particularly in female football players (Haugen and Buchheit 2016; Loturco et al. 2019; Zhang et al. 2022). Third, evidence from North African female football players remains limited, restricting the development of context-specific benchmark values and limiting the transferability of findings from better-studied football contexts.

Accordingly, the aim of the present study was to compare physical performance profiles and examine the associations between neuromuscular performance, change-of-direction speed, maximal aerobic speed, and sprint performance in Moroccan first- and second-division female football players. A secondary aim was to determine the individual and combined predictive contribution of these variables to sprint performance over 10 m, 20 m, and 30 m. It was hypothesized that first-division players would demonstrate superior sprint, jump, change-of-direction speed, and aerobic performance compared with second-division players. It was also hypothesized that countermovement jump performance and 20 m change-of-direction speed would be significantly associated with sprint performance, whereas maximal aerobic speed would represent a complementary but distinct physical quality.

Materials and methods

Study Design

This study adopted a cross-sectional comparative design to examine differences in aerobic capacity, sprint performance, 20 m change-of-direction speed, and lower-limb neuromuscular performance between Moroccan first- and

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second-division female football players. In addition, correlational and regression analyses were conducted to explore the associations between jump performance, sprint ability, change-of-direction speed, and maximal aerobic speed. This design was selected to provide a multidimensional field-based physical performance profile of female football players competing at different national competitive levels.

Participants

A total of 105 Moroccan female football players participated in this study. Players were recruited from four teams competing in the Moroccan women's football championship, including two first-division teams and two second-division teams. Forty-five players competed in the first division and sixty players competed in the second division. All players were Moroccan, officially registered with their respective clubs, and regularly involved in structured football training. To ensure a minimum level of competitive and training exposure, participants were required to have at least three years of football experience and to complete at least four training sessions per week in addition to one official match per week during the competitive season.

First-division players had a mean age of 22.98 ± 4.69 years, whereas second-division players had a mean age of 21.42 ± 2.54 years. First-division players had a mean body mass of 59.40 ± 8.39 kg, height of 1.64 ± 0.05 m, and body mass index of 22.04 ± 2.58 $kg{\cdot}m^{-2}$. Second-division players had a mean body mass of 55.56 ± 7.33 kg, height of 1.63 ± 0.05 m and body mass index of 20.81 ± 2.64 $kg{\cdot}m^{-2}$. Playing positions were classified into four broad categories: goalkeepers, defenders, midfielders, and forwards. The sample included 10 goalkeepers (9.5%), 32 defenders (30.5%), 24 midfielders (22.9%), and 39 forwards (37.1%). In the first division, there were 4 goalkeepers, 15 defenders, 11 midfielders, and 15 forwards, whereas the second division included 6 goalkeepers, 17 defenders, 13 midfielders, and 24 forwards.

To be included in the study, players had to be officially registered with their club, have at least three years of football experience, complete at least four training sessions per week, regularly participate in official competition, and be free from injury at the time of testing. Players were excluded if they reported a recent musculoskeletal injury or any medical condition that could affect maximal physical effort or prevent completion of the full testing battery.

Ethical Approval

Prior to participation, all players were informed about the study procedures, potential risks, and benefits, and written informed consent was obtained from each participant. For players under 18 years of age, written informed consent was obtained from their legal guardians, and assent was obtained from the players. The study was approved by the Ethics Committee for Biomedical Research of the Faculty of Medicine and Pharmacy of Rabat, Morocco (CERB: 63/21; approved on October 23, 2023). All procedures ensured participant confidentiality, voluntary participation, and data protection.

Experimental Procedures

Testing was conducted during the middle of the competitive season over three consecutive morning sessions. The mid-season period was selected to reflect the players' regular competitive fitness status while minimizing the influence of early-season adaptation or end-season fatigue. All tests were performed under standardized field conditions and supervised by qualified strength and conditioning specialists.

Players were instructed to avoid strenuous physical exercise during the 24 hours preceding testing and to maintain their usual hydration and nutritional habits. Before each testing session, players completed a standardized warm-up consisting of light jogging, dynamic mobility exercises, lower-limb activation drills, progressive accelerations, and familiarization trials for the sprint and jump tests. Standardized warm-up routines are commonly recommended before maximal field-based testing because they improve neuromuscular readiness and reduce the risk of performance variability (McGowan et al. 2015).

The testing battery included linear sprint tests over 10 m, 20 m, and 30 m, a 20 m change-of-direction speed test, vertical jump assessments using the Optojump system, and maximal aerobic speed assessment using the Vameval test. Tests were performed in the following order: linear sprint tests, 20 m change-of-direction speed test, jump assessments, and the Vameval test. The Vameval test was performed last to minimize fatigue-related interference with sprint and jump performance. Similar field-based testing batteries have been used in football to assess sprint ability, lower-limb explosive power, change-of-direction-related speed, and aerobic fitness under applied conditions.

Sprint Performance Assessment

Linear sprint performance was assessed over 10 m, 20 m, and 30 m using Witty timing gates (Microgate, Bolzano, Italy). Players started from a standing position 0.5 m behind the first timing gate to avoid prematurely triggering the timing system, and were instructed to sprint maximally through the final timing gate. Sprint times were recorded in seconds. Each player performed two maximal trials for each sprint distance, with the best trial retained for statistical analysis. A recovery period of 2–3 minutes was provided between sprint trials to minimize fatigue effects. The 10 m sprint was interpreted as an indicator of initial acceleration, the 20 m sprint as an indicator of extended acceleration capacity, and the 30 m sprint as an indicator of longer linear sprint performance. Electronic timing gates are recommended for field-based sprint testing because they provide more precise measurements than manual timing and are widely used in football performance research (Haugen et al. 2020).

Change-of-Direction Speed Assessment

Change-of-direction speed was assessed using a 20 m change-of-direction speed test adapted from the field-based football testing procedure described by Cazorla et al. (2008). The test was designed to evaluate the player's ability to accelerate, brake, change direction, and re-accelerate rapidly without the ball. The course consisted of a marked running path including directional changes over a total running distance of 20 m. Although the straight-line distance between the start and finish was approximately 16.6 m, the imposed directional changes increased the total distance covered to 20 m. Players started from a standing position behind the start line and were instructed to complete the course as quickly as possible while respecting the marked trajectory. The test was performed without the ball, and completion time was recorded in seconds using Witty timing gates (Microgate, Bolzano, Italy). Each player completed two maximal trials separated by 2–3 minutes of passive recovery, and the best valid trial was retained for statistical analysis. A lower completion time indicated better change-of-direction speed performance. This test was included because football-specific high-speed actions are rarely performed in purely linear conditions and often involve acceleration, braking, directional adjustment, and re-acceleration under time constraints (Chaabene et al. 2018; Sporis et al. 2010; Zhang et al. 2022).

Jump Performance Assessment

Lower-limb neuromuscular performance was assessed using the Optojump system (Microgate, Bolzano, Italy). The jump battery included the squat jump, countermovement jump, countermovement jump with free arms, and drop jump. For the squat jump, players started from a static semi-squat position with hands placed on the hips and were instructed to jump vertically as high as possible without performing a countermovement. The SJ was used to assess concentric jump performance from a static starting position. For the countermovement jump, players began from an upright standing position and performed a rapid downward movement followed immediately by a maximal vertical jump. During the standard CMJ condition, players kept their hands on their hips to limit arm contribution. The CMJ was used as an indicator of lower-limb explosive jump performance during a rapid eccentric-concentric action. For the countermovement jump with free arms, players performed the same movement while allowing unrestricted arm swing. This condition was included to assess jump performance under a more functional movement condition involving unrestricted arm swing. For the drop jump, players stepped down from a 30 cm box and immediately performed a maximal vertical jump after ground contact. The DJ was used to assess field-based jump performance during a rapid landing-to-take-off action (Bishop et al. 2022).

Each jump test was performed twice, and the best valid trial was retained for analysis. A recovery period of 60–90 seconds was provided between trials. Trials were repeated if the technique was invalid or if the player failed to follow the required protocol. Vertical jump assessments were selected because SJ, CMJ, CMJ with free arms, and DJ provide complementary information regarding lower-limb jump performance under different movement conditions, including static, countermovement, arm-assisted, and landing-to-take-off actions. The Optojump system has demonstrated acceptable validity and reliability for estimating vertical jump height in applied sport settings (Glatthorn et al. 2011).

Maximal Aerobic Speed Assessment

Maximal aerobic speed was assessed using the Vameval test. The test was performed on a marked running area according to the audio-paced protocol. Players were required to maintain the imposed running rhythm for as long as possible as running speed progressively increased. The test ended when the player was no longer able to maintain the required pace despite verbal encouragement. Maximal aerobic speed was recorded in $km \cdot h^{-1}$ and used as an indicator of aerobic fitness. The Vameval test was selected because it is a practical field-based assessment for estimating maximal aerobic speed and prescribing individualized aerobic training intensities in intermittent team-sport athletes (Garcia-Retortillo et al. 2019).

Statistical Analysis

All statistical analyses were performed using IBM SPSS Statistics. Descriptive statistics are reported as mean ± standard deviation (SD). Normality was assessed using the Shapiro–Wilk test, skewness and kurtosis values, and visual inspection of distributional characteristics. When variables showed deviations from normality, non-parametric sensitivity analyses were performed to verify the robustness of between-division comparisons. Differences between groups in neuromuscular performance, sprint performance, 20 m change-of-direction speed, and maximal aerobic speed were analyzed using independent samples Student's t-tests. When the assumption of homogeneity of variances was violated, Welch's correction was applied to ensure robustness of the results. Effect sizes were calculated using Cohen's d and interpreted as small (0.20), medium (0.50), and large (0.80), according to Cohen (1992).

Pearson correlation coefficients were used to examine the relationships between jump performances, sprint performance, change-of-direction speed, and maximal aerobic speed, in order to assess the strength and direction of linear associations among variables. Simple linear regression models were conducted to evaluate the individual predictive contribution of each physical performance variable to sprint performance over 10 m, 20 m, and 30 m. Each predictor was entered separately into the model. The coefficient of determination (R^2) was reported to indicate the proportion of explained variance. Multiple linear regression analyses were performed to examine the combined predictive contribution of selected physical variables to sprint performance over 10 m, 20 m, and 30 m. To avoid redundancy among highly related jump variables, CMJ, 20 m change-of-direction speed, and VMA were entered simultaneously as predictors using the enter method. Model fit was evaluated using R^2, adjusted R^2, F statistics, and p-values. Standardized beta coefficients were used to interpret the independent contribution of each predictor. Multicollinearity was assessed using tolerance and variance inflation factor values. Finally, a one-way analysis of variance (ANOVA) was performed to compare physical performance variables according to playing positions. Effect sizes were calculated using partial eta squared (ηp^2), interpreted as small (0.01), medium (0.06), and large (0.14). The level of statistical significance was set at $p < 0.05$.

Results

Descriptive statistics and distributional characteristics

Descriptive statistics, distributional characteristics, and Shapiro–Wilk normality test results are presented in Table 1. Shapiro–Wilk tests indicated deviations from normality for DJ, SJ, 20 m sprint, 30 m sprint, 20 m change-of-direction speed test, and VMA ($p < .05$), whereas CMJ-FA, CMJ, and 10 m sprint did not significantly deviate from normality. Non-parametric sensitivity analyses produced the same interpretation pattern as the parametric between-division comparisons; therefore, parametric results are reported for consistency.

Between-division differences

Between-division comparisons are presented in Table 2. First-division players showed significantly better per-

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Table 1. Descriptive statistics, distributional characteristics, and Shapiro–Wilk normality test results of aerobic, sprint, change-of-direction speed, and jump performance variables in female football players

Variable	Mean	SD	Skewness	Kurtosis	Shapiro–Wilk W	Shapiro–Wilk p
DJ (cm)	27.91	5.82	-0.46	1.76	0.954	.001
SJ (cm)	21.62	4.33	0.54	1.67	0.970	.017
CMJ-FA (cm)	28.06	5.11	0.14	0.41	0.978	.073
CMJ (cm)	23.09	4.21	-0.08	0.45	0.982	.166
10 m sprint (s)	2.01	0.12	0.61	0.89	0.977	.062
20 m sprint (s)	3.51	0.22	-0.46	4.39	0.943	< .001
30 m sprint (s)	5.01	0.39	-2.15	5.94	0.821	< .001
COD Speed (s)	5.93	0.57	-2.33	6.43	0.813	< .001
VMA ($km \cdot h^{-1}$)	12.22	1.22	-0.20	-0.32	0.973	.032

Values are presented as mean and standard deviation. DJ = drop jump; SJ = squat jump; CMJ = countermovement jump; CMJ-FA = countermovement jump with free arms; COD = change of direction; VMA = maximal aerobic speed.

formance in DJ, CMJ, CMJ-FA, 10 m sprint, 20 m sprint, 20 m change-of-direction speed test, and VMA compared with second-division players. The largest effect sizes were observed for DJ, CMJ-FA, CMJ, and VMA. No significant between-division differences were observed for SJ or 30 m sprint performance.

Table 2. Between-division differences in aerobic, sprint, change-of-direction speed, and jump performance among female football players

Variable	Division 1 (M ± SD)	Division 2 (M ± SD)	t	df	p-value	95% CI for mean difference	Cohen's d
DJ (cm)	30.96 ± 4.34	25.63 ± 5.76	5.196	103	p < .001	3.30 to 7.37	1.05 (large)
SJ (cm)	22.24 ± 3.89	21.16 ± 4.61	1.305	101.516	.195	-0.56 to 2.73	0.26 (small)
CMJ (cm)	24.92 ± 3.67	21.72 ± 4.09	4.145	103	p < .001	1.67 to 4.74	0.82 (large)
CMJ-FA (cm)	30.37 ± 4.89	26.32 ± 4.58	4.354	103	p < .001	2.20 to 5.89	0.86 (large)
10 m sprint (s)	1.99 ± 0.12	2.03 ± 0.11	-2.037	103	.044	-0.09 to -0.00	0.40 (small)
20 m sprint (s)	3.45 ± 0.24	3.56 ± 0.19	-2.525	103	.013	-0.19 to -0.02	0.49 (small)
30 m sprint (s)	4.98 ± 0.31	5.03 ± 0.44	-0.706	103	.482	-0.21 to 0.10	0.15 (small)
COD Speed (s)	5.74 ± 0.36	6.07 ± 0.65	-3.120	103	.002	-0.55 to -0.12	0.65 (medium)
VMA ($km \cdot h^{-1}$)	12.77 ± 1.07	11.81 ± 1.17	4.322	103	p < .001	0.52 to 1.40	0.86 (large)

Values are presented as mean ± standard deviation. DJ = drop jump; SJ = squat jump; CMJ = countermovement jump; CMJ-FA = countermovement jump with free arms; COD = change of direction; VMA = maximal aerobic speed; CI = confidence interval. Cohen's d was interpreted as small (0.20), medium (0.50), and large (0.80). Lower values indicate better performance for sprint and change-of-direction speed tests.

Correlations between jump, sprint, change-of-direction speed, and aerobic performance

The correlation matrix is presented in Table 3. Overall, jump variables were moderately interrelated and were generally associated with sprint times, indicating that higher jump performance tended to be related to faster sprint performance. CMJ showed the most consistent associations with sprint performance across 10 m, 20 m, and 30 m. The 20 m change-of-direction speed test was also associated with all sprint distances, whereas VMA showed no significant association with linear sprint performance.

Table 3. Pearson correlation matrix between jump performance, sprint performance, change-of-direction speed, and maximal aerobic speed in female football players

Variable	DJ	SJ	CMJ-FA	CMJ	10 m	20 m	30 m	COD speed	VMA
DJ	1	.505**	.739**	.760**	-.299**	-.373**	-.175	-.260**	.231*
SJ		1	.717**	.719**	-.235*	-.247*	-.293**	-.136	.144
CMJ-FA			1	.853**	-.331**	-.391**	-.311**	-.291**	.228*
CMJ				1	-.423**	-.440**	-.323**	-.330**	.227*
10 m					1	.726**	.630**	.466**	-.181
20 m						1	.622**	.428**	-.132
30 m							1	.353**	-.093
COD speed								1	-.226*
VMA									1

DJ = drop jump; SJ = squat jump; CMJ = countermovement jump; CMJ-FA = countermovement jump with free arms; COD = change of direction; VMA = maximal aerobic speed. Sprint and change-of-direction speed variables are expressed as completion times; therefore, negative correlations with jump performance indicate that higher jump performance is associated with faster sprint or change-of-direction speed performance. *$p < .05$; **$p < .01$.

Simple linear regression analyses

Simple linear regression analyses were conducted to examine the individual predictive contribution of jump performance, 20 m change-of-direction speed, and VMA to sprint performance over 10 m, 20 m, and 30 m. The results are presented in Table 4.

Table 4. Simple linear regression analyses predicting sprint performance from jump performance, change-of-direction speed, and maximal aerobic speed

Dependent variable	Predictor	B	SE	β	t	p-value	R^2
Sprint 10 m (s)	DJ (cm)	-0.006	0.002	-0.299	-3.177	.002	.089
	SJ (cm)	-0.006	0.003	-0.235	-2.450	.016	.055
	CMJ (cm)	-0.012	0.002	-0.423	-4.744	< .001	.179
	CMJ-FA (cm)	-0.008	0.002	-0.331	-3.561	.001	.110
	COD Speed (s)	0.096	0.018	0.466	5.350	< .001	.217
	VMA ($km \cdot h^{-1}$)	-0.017	0.009	-0.181	-1.869	.064	.033
Sprint 20 m (s)	DJ (cm)	-0.014	0.003	-0.373	-4.074	< .001	.139
	SJ (cm)	-0.013	0.005	-0.247	-2.592	.011	.061
	CMJ (cm)	-0.023	0.005	-0.440	-4.978	< .001	.194
	CMJ-FA (cm)	-0.017	0.004	-0.391	-4.310	< .001	.153
	COD Speed (s)	0.165	0.034	0.428	4.811	< .001	.183
	VMA ($km \cdot h^{-1}$)	-0.024	0.018	-0.132	-1.356	.178	.018
Sprint 30 m (s)	DJ (cm)	-0.012	0.006	-0.175	-1.809	.073	.031
	SJ (cm)	-0.026	0.008	-0.293	-3.114	.002	.086
	CMJ (cm)	-0.030	0.009	-0.323	-3.461	.001	.104
	CMJ-FA (cm)	-0.024	0.007	-0.311	-3.315	.001	.096
	COD Speed (s)	0.242	0.063	0.353	3.835	< .001	.125
	VMA ($km \cdot h^{-1}$)	-0.029	0.031	-0.093	-0.945	.347	.009

B = unstandardized regression coefficient; SE = standard error; β = standardized regression coefficient; R^2 = explained variance. DJ = drop jump; SJ = squat jump; CMJ = countermovement jump; CMJ-FA = countermovement jump with free arms; COD = change of direction; VMA = maximal aerobic speed. Sprint and change-of-direction speed variables are expressed as completion times. Therefore, negative coefficients indicate that higher jump or aerobic values are associated with faster sprint times, whereas positive coefficients for the 20 m change-of-direction speed test indicate that slower change-of-direction speed performance is associated with slower sprint performance.

Multiple linear regression analyses

Multiple linear regression analyses were conducted to examine the combined predictive contribution of CMJ, 20 m change-of-direction speed, and VMA to sprint performance over 10 m, 20 m, and 30 m. As shown in Table 5, the models predicting 10 m, 20 m, and 30 m sprint performance were significant, explaining 30.0%, 28.4%, and 17.3% of the variance, respectively. CMJ and the 20 m change-of-direction speed test were significant predictors across all sprint distances, whereas VMA did not provide an independent predictive contribution. Collinearity diagnostics for the multiple regression models indicated no evidence of multicollinearity, with tolerance and variance inflation factor values within acceptable ranges.

Table 5. Multiple linear regression models predicting sprint performance

Dependent variable	Predictor	β	p-value	Model R^2	Adjusted R^2	F
10 m sprint	CMJ	–.297	.001	.300	.279	14.43
	COD speed	.361	< .001			
	VMA	–.032	.713			
20 m sprint	CMJ	–.339	< .001	.284	.263	13.37
	COD speed	.321	.001			
	VMA	.017	.847			
30 m sprint	CMJ	–.236	.017	.173	.149	7.05
	COD speed	.281	.005			
	VMA	.024	.796			

CMJ = countermovement jump; VMA = maximal aerobic speed; COD = Change of direction speed; β = standardized beta coefficient. Model R^2, adjusted R^2, and F values are reported for each dependent variable.

Positional differences

Descriptive performance data for each playing position are provided in Supplementary Table S1. These values are presented as exploratory positional reference data because playing positions were classified into broad categories and the number of goalkeepers was relatively small.

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One-way ANOVA results are presented in Table 6. No significant differences were observed across playing positions for any investigated variable, and effect sizes were small across all outcomes, indicating limited positional variation in jump performance, sprint performance, 20 m change-of-direction speed, and VMA within this sample.

Table 6. One-way ANOVA summary for performance differences across playing positions

Variable	F(df1, df2)	p-value	ηp^2
DJ (cm)	F(3,101) = 0.703	.552	.020
SJ (cm)	F(3,101) = 0.744	.528	.022
CMJ (cm)	F(3,101) = 0.251	.861	.007
CMJ-FA (cm)	F(3,101) = 0.622	.603	.018
10 m sprint (s)	F(3,101) = 0.190	.903	.006
20 m sprint (s)	F(3,101) = 0.315	.814	.009
30 m sprint (s)	F(3,101) = 0.794	.500	.023
COD Speed (s)	F(3,101) = 0.190	.903	.006
VMA ($km \cdot h^{-1}$)	F(3,101) = 1.709	.170	.048

ηp^2 = partial eta squared; DJ = drop jump; SJ = squat jump; CMJ = countermovement jump; CMJ-FA = countermovement jump with free arms; COD = change of direction; VMA = maximal aerobic speed.

Discussion

The aim of this study was to compare physical performance profiles and examine the associations between neuromuscular performance, change-of-direction speed, aerobic fitness, and sprint performance in Moroccan female football players competing at different competitive levels. The main findings were that first-division players outperformed second-division players in DJ, CMJ, CMJ-FA, 10 m sprint, 20 m sprint, 20 m change-of-direction speed test, and VMA, whereas no significant differences were observed for SJ or 30 m sprint performance. In addition, CMJ and the 20 m change-of-direction speed test showed the most consistent associations with sprint performance and remained significant predictors in the multiple regression models. These findings suggest that sprint performance in Moroccan female football players should be interpreted as a multidimensional quality involving neuromuscular, locomotor, and aerobic-related components rather than as the expression of a single isolated physical capacity.

Competitive level and neuromuscular profile

The between-division differences in jump performance indicate that competitive level was more clearly reflected in dynamic eccentric-concentric jump tasks than in the squat jump. First-division players showed superior CMJ, CMJ-FA, and DJ performance, while no significant difference was observed for SJ. This finding suggests that dynamic jump tests may be more sensitive to competitive level than isolated squat jump performance. This interpretation is consistent with the intermittent and dynamic nature of football, where accelerations, re-accelerations, duels, pressing actions, and jumping situations are rarely initiated from static conditions. Previous research has shown that vertical jump performance, particularly in tests involving countermovement or reactive actions, is associated with sprint-related neuromuscular qualities in football and team-sport athletes (Loturco et al. 2015, 2019; Slimani et al. 2016). However, these findings should be interpreted cautiously because the present study did not include direct biomechanical measures such as ground reaction force, contact time, stiffness, impulse, or eccentric braking variables. Therefore, the observed differences should be considered as better performance in field-based jump tasks involving stretch-shortening cycle-related actions, rather than as direct evidence of superior stretch-shortening cycle function (Santos et al. 2024). This is consistent with recommendations emphasizing that CMJ and DJ outcomes should be interpreted according to the selected metric and the specific performance quality being assessed (Bishop et al. 2022).

Sprint performance and change-of-direction speed

The sprint results showed that first-division players were faster over 10 m and 20 m, whereas no significant difference was observed over 30 m. This suggests that competitive-level differences in the present sample were mainly expressed during the early acceleration phase rather than over a longer linear sprint distance. In football, many decisive actions, such as pressing, defensive recovery, offensive transitions, and short runs into space, occur over relatively short distances. This may explain why 10 m and 20 m sprint performance were more sensitive to competitive level than 30 m sprint performance. Previous studies have also reported that sprint performance varies according to playing standard, sex, age, and positional demands (Armada-Cortés et al. 2022; Haugen et al. 2020; Haugen, Tønnessen, and Seiler 2012; Haugen and Buchheit 2016). Nevertheless, the absence of significant differences over 30 m should not be interpreted as indicating that longer sprint ability is unimportant, but rather that it was less discriminative of competitive level in this sample.

The associations between CMJ and sprint performance support previous evidence suggesting that vertical jump performance is related to sprint ability, although these relationships are generally moderate and cannot fully explain sprint performance (Loturco et al. 2015, 2019; Slimani et al. 2016). Sprinting is a complex task influenced not only by vertical neuromuscular qualities but also by horizontal force application, sprint mechanics, step kinematics, technical efficiency, and coordination of the acceleration pattern (Aloui et al. 2021; Haugen and Buchheit 2016). Therefore, CMJ may be considered a useful field-based marker of sprint-related neuromuscular qualities, but it should not replace direct sprint assessment.

The multiple regression models further clarified the combined contribution of the investigated variables to sprint performance. When CMJ, 20 m change-of-direction speed, and VMA were entered together, CMJ and the 20 m change-of-direction speed test remained significant predictors across 10 m, 20 m, and 30 m sprint performance, whereas VMA did not provide an independent predictive contribution. This suggests that sprint performance in this sample was more closely related to explosive jump performance and football-specific locomotor ability than to aerobic fitness. However, the explained variance was moderate for 10 m and 20 m sprint performance and lower for 30 m sprint performance, indicating that other factors not assessed in this study, such as horizontal force production, sprint technique, step kinematics, and neuromuscular coordination, may also contribute to sprint performance (Haugen and Buchheit 2016; Zhang et al. 2022).

The 20 m change-of-direction speed test was also associated with sprint performance across sprint distances. This finding supports the idea that football-specific speed involves more than linear acceleration alone. Change-of-direction speed requires the ability to accelerate, decelerate, brake efficiently, reorient the body, and re-accelerate rapidly. These qualities are highly relevant to football, where players rarely sprint in purely linear and isolated conditions. Previous research has shown that change-of-direction performance is influenced by acceleration, deceleration, braking capacity, and re-acceleration ability (Chaabene et al. 2018; Zhang et al. 2022). In adult female football players, repeated-sprint ability has also been associated with sprint performance, change-of-direction ability, vertical jump performance, and aerobic capacity (Gonçalves et al. 2021). The present findings add context-specific evidence by showing that change-of-direction speed may provide complementary information when profiling sprint-related physical qualities in Moroccan female football players.

Aerobic fitness as a complementary quality

VMA differentiated competitive level but was not significantly associated with linear sprint performance. This result is consistent with the physiological role of aerobic fitness in football. Aerobic capacity contributes to sustaining repeated high-intensity actions, tolerating training and match demands, and recovering between intense efforts, but it does not necessarily explain maximal acceleration or linear sprint speed (Bangsbo et al. 2006; Baptista et al. 2022). This distinction is important because a player may present a higher aerobic fitness level without necessarily being faster over short linear sprint distances, as these qualities depend on different physiological, neuromuscular, and mechanical mechanisms. Accordingly, VMA should be interpreted as a complementary marker of aerobic readiness rather than as a direct predictor of sprint performance. From an applied perspective, this supports the use of VMA for aerobic training prescription and monitoring, while confirming that sprint and neuromuscular assessments remain necessary when the objective is to evaluate acceleration and explosive performance (Bok and Foster 2021).

Position-based comparisons and contextual interpretation

The absence of significant positional differences should also be interpreted with caution. Although goalkeepers, defenders, midfielders, and forwards were included, positions were classified into broad categories, which may have reduced the sensitivity to detect meaningful role-specific differences. Previous studies have shown that physical match demands vary according to more specific positional roles in women's football, with differences in high-intensity running, accelerations, and match-related actions across playing positions (Baptista et al. 2022; Mäkiniemi et al. 2023). Therefore, grouping central defenders and full-backs together as "defenders", or considering all forwards as a single category, may have masked more specific positional demands. In addition, the relatively small number of goalkeepers may have limited the robustness of position-based comparisons, particularly because goalkeepers present specific physical and tactical demands that differ from those of outfield players (White et al. 2020). Future studies should use larger samples, match-running data, and more refined positional classifications.

Overall, the present study contributes to the development of contextualized physical profiling in Moroccan women's football. The findings suggest that competitive level may be better characterized through a combination of dynamic jump performance, short acceleration, change-of-direction speed, and aerobic fitness than through any isolated physical measure. This supports the use of multidimensional field-based testing batteries combining Optojump-derived jump assessments, short sprint tests, change-of-direction speed assessment, and Vameval-based aerobic profiling. Such an approach may help coaches identify individual performance needs, monitor player development, guide training prescription, and support more individualized conditioning models in Moroccan women's football.

Limitations

This study has several limitations. First, the cross-sectional design prevents causal interpretation of the relationships between physical performance variables, sprint performance, and competitive level. Second, although all field-based tests were performed using standardized procedures and two trials were completed for each test, within-session reliability indices were not calculated because only the best trial was retained in the final dataset. Future studies should retain all trial-level data and report intraclass correlation coefficients and coefficients of variation for sprint, jump, and change-of-direction speed assessments. Third, menstrual cycle phase and hormonal contraceptive use were not controlled, although these factors may influence neuromuscular and aerobic performance in female athletes. This limitation is relevant because methodological guidelines for studies involving women recommend reporting and controlling reproductive hormonal status where possible (Elliott-Sale et al. 2021). Fourth, match-running data and training-load measures were not included, limiting the ability to directly link field-test outcomes to competitive match demands. Finally, the sample was recruited from four Moroccan teams only, which may limit the generalizability of the findings to all female football players. In addition, playing positions were classified into broad categories, which may have reduced the sensitivity to detect role-specific differences between more specific sub-positions such as central defenders, full-backs, central midfielders, wide midfielders, wingers, forwards, and goalkeepers.

Practical Applications

The present findings support the use of multidimensional field-based testing batteries in Moroccan women's football. Coaches and strength and conditioning staff should monitor CMJ, DJ, 10 m and 20 m sprint performance, 20 m change-of-direction speed, and VMA to identify individual performance needs and guide training prescription. The 10 m and 20 m sprint tests appear particularly relevant for assess-

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ing short-distance acceleration, which differentiated first- and second-division players more clearly than 30 m sprint performance. CMJ and the 20 m change-of-direction speed test may be useful for monitoring sprint-related neuromuscular and locomotor qualities because they remained significant predictors of sprint performance in the multiple regression models. However, these tests should be used alongside direct sprint testing rather than as substitutes for sprint assessment. VMA should be considered a complementary marker of aerobic readiness and used mainly to guide aerobic training prescription rather than as a direct indicator of sprint ability. Overall, these assessments may help support individualized training prescription and player development monitoring, although their direct impact on long-term player development requires further longitudinal verification.

Conclusions

This study provides a multidimensional field-based physical profile of Moroccan female football players competing in the first and second divisions. First-division players demonstrated superior performance in dynamic jump tasks, 10 m and 20 m sprint performance, 20 m change-of-direction speed, and VMA, whereas SJ and 30 m sprint performance were less sensitive to competitive-level differences. CMJ and the 20 m change-of-direction speed test were the most consistent sprint-related indicators and remained significant predictors in the multiple regression models, while VMA did not independently predict linear sprint performance. These findings suggest that sprint performance in Moroccan female football players should be interpreted within a multidimensional profile, in which explosive jump performance, short-distance acceleration, change-of-direction speed, and aerobic readiness provide complementary information for training prescription and player monitoring.

Conflicts of Interest

The authors declare no conflict of interest.

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