HUMAN MOVEMENT (ISSN 1899-1955)
2026; 27(3): 104–114

Vertical and horizontal force-velocity profiles show limited association and distinct relationships with sprint performance in U23 football players

original paper
DOI: https://doi.org/10.5114/hm/222355

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ABSTRACT
Purpose. Force-velocity (F-V) profiling is increasingly employed in football to characterise neuromuscular performance and to guide individualised training. However, the extent to which vertical and horizontal F-V profiles reflect comparable mechanical qualities remains unclear, particularly among semi-professional players.
Methods. Eighteen semi-professional Moroccan U23 male football players (age: 20.39 ± 1.82 years; height: 176.94 ± 9.69 cm; body mass: 65.39 ± 8.53 kg) underwent vertical F-V profiling through countermovement jump (CMJ) assessment and horizontal F-V profiling through 30-m sprint testing. Mechanical variables included theoretical maximal force (F_0), theoretical maximal velocity (V_0), maximal power output (Pmax), slope of the F-V relationship, peak ratio of horizontal force (RFmax), and rate of decrease in the force ratio (DRF). Correlation analyses and tests for differences in profile distribution were performed.
Results. Weak and mostly non-significant associations were observed between vertical and horizontal F-V variables, indicating limited transferability of mechanical qualities across tasks. A moderate inverse, non-significant relationship was found between F_0_vert and F_0_horiz (r = –0.412, p = 0.089), whereas trivial associations were observed for V_0 and Pmax across tasks. Profile distribution differed significantly between vertical and horizontal assessments (χ^2 = 8.667, p = 0.034), with a predominance of velocity-oriented profiles in the vertical assessment and a more balanced distribution in the horizontal assessment. Substantial inter-individual variability was also observed across both profiling approaches.
Conclusions. Vertical and horizontal F-V profiles were only weakly associated, suggesting that these assessments may reflect task-specific mechanical characteristics rather than interchangeable expressions of explosive performance. Combining both profiling approaches may, therefore, provide a more comprehensive basis for individualised performance assessment and training prescription in football.
Key words: force-velocity profiling, vertical and horizontal profiling, sprint performance, mechanical effectiveness, individualised training, football

Introduction

Football performance is underpinned by neuromuscular qualities such as force and power, particularly during sprint acceleration and explosive movements [1, 2]. In recent years, force-velocity (F-V) profiling has emerged as a practical approach to characterise these mechanical capacities and to inform individualised training strategies in applied sport settings [3–5].

Field-based methodologies have facilitated the assessment of key F-V variables, including theoretical maximal force (F_0), theoretical maximal velocity (V_0), and maximal power (Pmax), using vertical jump and sprint tasks [6, 7]. While vertical F-V profiling derived from jumping tests is widely employed to evaluate low-

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Received: April 21, 2026
Accepted for publication: May 22, 2026

Citation: El Mouahid K, Khairi S, El Qrefy M, Dahou B, Ennajmi O, Rfaki A, Chmura P. Vertical and horizontal force-velocity profiles show limited association and distinct relationships with sprint performance in U23 football players. Hum Mov. 2026;27(3):104–114; doi: https://doi.org/10.5114/hm/222355.

er-limb explosive performance, its relationship with sprint-specific mechanical outputs remains unclear. Sprint acceleration, in particular, appears to rely more heavily on the ability to generate and orient force in the horizontal direction [8, 9]. Consequently, horizontal F-V profiling has been proposed as a complementary approach to more effectively capture sprint-related mechanical characteristics [10].

Recent studies and systematic reviews suggest that vertical and horizontal F-V profiles may reflect task-specific mechanical characteristics rather than fully interchangeable neuromuscular qualities, although these findings should be interpreted with caution [3, 11, 12]. Indeed, the relationships between vertical jump performance and sprint ability are generally reported to range from weak to moderate, indicating limited overlap between these movement capacities [12–14]. However, it remains unclear whether vertical and horizontal F-V profiles derived from field-based methods reflect overlapping or distinct mechanical qualities when assessed within the same population, particularly among semi-professional football players. Moreover, limited attention has been devoted to the potential mismatch in profile orientation between vertical and horizontal assessments, as well as to the extent of inter-individual variability within relatively homogeneous groups of athletes. These aspects are particularly relevant in applied settings, where practitioners often rely on a single assessment modality to guide training decisions.

Beyond average relationships, growing attention has been paid to inter-individual variability in F-V profiles. Previous research has shown that athletes with similar performance levels may exhibit markedly different mechanical strategies, such as force-oriented or velocity-oriented profiles [5, 15]. This variability may have important implications for individualised training prescription, as athletes with similar performance levels may require different mechanical interventions. However, this aspect remains insufficiently explored in studies simultaneously examining vertical and horizontal F-V characteristics [16]. In addition, potential mismatches in the profile orientation between vertical and horizontal tasks have received limited attention, despite their relevance for understanding movement-specific mechanical demands. Notably, sprint mechanical effectiveness, defined as the ability to orient ground reaction force in the direction of motion, has been identified as a key determinant of sprint performance [6, 9, 17]. Variables, such as RFmax and DRF, may therefore provide additional insight beyond vertical assessments alone.

Furthermore, most existing studies have been conducted in European or South American populations, with limited data available on African football players. This lack of representation may restrict the generalisability of current findings, highlighting the need for population-specific investigations.

Therefore, the primary aim of the present study was to examine the associations between vertical and horizontal force-velocity profiles among Moroccan U23 football players using validated field-based tools (MyJump2 and MySprint). A secondary aim was to explore the extent of inter-individual variability and potential differences in profile orientation between movement tasks. It was hypothesised that vertical and horizontal F-V variables would show limited associations, reflecting task-specific mechanical characteristics rather than interchangeable performance qualities. By addressing these aspects, this study sought to provide a more nuanced understanding of neuromuscular profiling and to support individualised training approaches in football.

Material and methods

Participants and study design

This study employed a cross-sectional observational design to examine vertical and horizontal F-V profiles among Moroccan U23 football players and to explore the associations between these mechanical characteristics. All testing procedures were conducted during the competitive season within a short data-collection period (≤ 7 days) to minimise potential variation related to fatigue, training load, or seasonal changes. Testing was performed under standardised outdoor conditions and, whenever possible, at the same time of day for all participants to reduce potential circadian variability.

Eighteen male Moroccan football players (n = 18) voluntarily participated in this study. In addition to these conditions, inclusion criteria required participants to be active U23 male football players competing at a semi-professional level, regularly engaged in structured team training (≥ 4 sessions *per* week) and competitive match play, with a minimum of 2 years of continuous training experience. Players were excluded if they had sustained a lower-limb injury within the 3 months preceding testing, were undergoing rehabilitation, or were unable to perform maximal sprinting or jumping efforts during testing. Their mean ± standard deviation (*SD*) age, height, and body mass were 20.39 ± 1.82 years, 176.94 ± 9.69 cm, and 65.39 ± 8.53 kg, respectively.

Given the correlational nature of the study and the difficulty of recruiting a homogeneous group of competitive football players, the present study should be considered exploratory in nature. Nevertheless, the sample size was consistent with previously applied studies investigating F-V profiling in team-sport athletes [18–20], and findings should therefore be interpreted with appropriate caution.

Prior to participation, all players were informed about the study procedures, risks, and potential benefits, and written informed consent was obtained from each participant. All procedures were conducted in accordance with recognised ethical standards for human research and ensured participant confidentiality, voluntary participation, and data protection.

Experimental procedures

All assessments were performed on the same outdoor football facility under similar environmental conditions. Testing took place on a synthetic football pitch at an ambient temperature of approximately 21°C. Participants were instructed to avoid strenuous physical activity for at least 24 hours before each testing session and to maintain their usual hydration and nutritional habits.

To minimise fatigue and avoid potential interference between neuromuscular assessments, vertical and horizontal F-V profiling were performed on separate days, with a 48-hour recovery period between sessions, in line with previously used sprint and jump mechanical assessment procedures [21, 22]. The order of the testing sessions (vertical and horizontal F-V profiling) was randomised across participants to control for potential order and learning effects. Each testing session consisted of a standardised warm-up followed by the specific testing protocol (vertical or horizontal assessment). Participants were familiarised with the testing procedures and exercises before data collection.

The standardised warm-up lasted approximately 12–15 min and was designed to progressively prepare the neuromuscular system for maximal sprint and jump efforts. It included 5 min of low-intensity running, dynamic mobility exercises for the hip, knee, and ankle joints, dynamic stretching drills, and 3–5 progressive accelerations over 20–30 m. The warm-up intensity was progressively increased until participants were considered ready to perform maximal efforts. This type of structured warm-up is commonly used in sprint and jump testing and has been shown to improve neuromuscular readiness and acute performance [23, 24].

Vertical force-velocity profiling

The vertical F-V profile was assessed using countermovement jump (CMJ) tests analysed with the MyJump2 mobile application. MyJump2 has previously demonstrated good validity and reliability for measuring jump height under field conditions when compared with force platforms [25–27]. Participants performed three maximal CMJs in each of four loading conditions corresponding to 0%, 20%, 30%, and 40% of their individual body mass. During the unloaded condition (0% body mass), participants kept their hands on their hips to minimise the influence of arm swing and ensure standardised execution. During the loaded conditions (20%, 30%, and 40% body mass), a standard Olympic barbell was positioned across the shoulders and held securely throughout each jump. A recovery period of 2–3 min was provided between loading conditions to minimise fatigue. For each loading condition, the best jump height was retained for subsequent analysis to reflect maximal neuromuscular capacity.

Vertical F-V variables were calculated using the field method proposed by Samozino *et al.* [28, 29], which estimates the mechanical outputs of jumping performance based on anthropometric data and jump outcomes. The following variables were derived: theoretical maximal force (F_0), theoretical maximal velocity (V_0), maximal power output (Pmax), and the slope of the F-V relationship.

Profile orientation was interpreted relative to the theoretical optimal F-V profile for jumping performance according to the practical framework proposed by Samozino *et al.* [30] and later applied by Jiménez-Reyes *et al.* [15, 31]. Based on this comparison, players were classified as force-oriented, velocity-oriented, or near-optimal according to whether their individual profile deviated toward the force or velocity end of the optimal continuum.

Horizontal force-velocity profiling

The horizontal F-V profile was determined from 30-m sprint performance using the validated field-based mechanical model proposed by Morin *et al.* [6] and Samozino *et al.* [10]. Sprint times were recorded at split distances of 5, 10, 15, 20, 25, and 30 m and analysed using the MySprint mobile application, which has shown acceptable validity and reliability when compared with radar-based systems [32]. Each participant performed two maximal sprints from a standing start position, with a recovery period of at least 3 min between attempts. The best sprint trial was retained for analysis, as it is considered to best reflect maximal neuromuscular and mechanical capacity and is commonly adopted in force-velocity profiling studies due to its acceptable reliability in field-based sprint assessments [11, 33].

Horizontal F-V variables included theoretical maximal horizontal force (F_0), theoretical maximal velocity (V_0), maximal power output (Pmax), the peak ratio of horizontal force (RFmax), and the rate of decrease in the force ratio (DRF). These variables provide insight into the athlete's capacity to produce and effectively orient force during sprint acceleration.

Profile orientation was interpreted based on the relationship between the individual sprint F-V profile and the theoretical optimal profile for acceleration performance, following the framework proposed by Samozino *et al.* [5] and its subsequent applications in sprint profiling [3, 33]. Athletes were classified according to the direction and magnitude of the difference between the individual and optimal F-V slope (ΔFV). Deviations exceeding the typical error of measurement were considered meaningful, whereas values within this range were interpreted as near-optimal. Accordingly, players were categorised as force-oriented, velocity-oriented, or near-optimal, depending on their deviation from the theoretical optimal profile.

Statistical analysis

All statistical analyses were performed using IBM SPSS Statistics (version 28.0, IBM Corp., Armonk, NY, USA). Descriptive statistics are presented as mean ± *SD*, along with 95% confidence intervals (*CI* 95%) to indicate the precision of the estimated means. The coefficient of variation (*CV*) was also calculated for each variable to express relative variability as a percentage of the mean, with lower *CV* values indicating more consistent measurements across participants.

The normality of data distribution was assessed using the Shapiro–Wilk test. Based on these results, parametric or non-parametric tests were applied accordingly. Pearson's correlation coefficients (r) were used to examine relationships between normally distributed vertical and horizontal force-velocity variables. Spearman's rank correlation coefficient (ρ) was used for the variables that did not meet the assumption of normality (*i.e.*, RFmax). For all correlation analyses, 95% confidence intervals were calculated to provide an estimation of the precision of the coefficients. The magnitude of correlations was interpreted according to the following thresholds: trivial (< 0.1), small (0.1–0.3), moderate (0.3–0.5), large (0.5–0.7), and very large (> 0.7) [34].

The McNemar-Bowker test was performed to examine the association between categorical force-velocity profiles (force-oriented, velocity-oriented, and optimal) derived from vertical and horizontal assessments. This test enables the evaluation of symmetry in paired categorical data and is appropriate for detecting differences in profile distribution between conditions. Statistical significance was set at $p < 0.05$. Effect sizes were interpreted based on the magnitude of correlation coefficients.

Results

The results are presented in a structured manner, including descriptive statistics of the force-velocity profiles, distribution of player profiles, association between vertical and horizontal classifications, and correlations between mechanical variables.

Table 1 presents the descriptive statistics of the vertical and horizontal F-V variables. For the vertical profile, mean values were 35.53 ± 5.50 $N \cdot kg^{-1}$ for F_0, 3.17 ± 0.73 $m \cdot s^{-1}$ for V_0, 28.11 ± 5.42 $W \cdot kg^{-1}$ for Pmax, and –12.10 ± 3.73 $N \cdot s \cdot m^{-1}$ for FV_slope. For the horizontal profile, mean values were 9.06 ± 1.03 $N \cdot kg^{-1}$ for F_0, 8.56 ± 0.34 $m \cdot s^{-1}$ for V_0, 19.36 ± 2.39 $W \cdot kg^{-1}$ for Pmax, 0.56 ± 0.03 for RFmax, and –0.096 ± 0.010 for DRF.

The 95% confidence intervals indicated relatively narrow ranges for most horizontal variables, particularly V_0_horiz, RFmax, and DRF. The *CV* ranged from 4.0% to 30.8%, with the lowest variability observed for V_0_horiz and RFmax, and the highest variability observed for FV_slope.

Table 2 presents the distribution of force-velocity profile orientations obtained from the vertical and horizontal assessments. In the vertical profile, the majority of players were classified as velocity-oriented (n = 12, 66.7%), whereas smaller proportions were classified as force-oriented (n = 4, 22.2%) or optimal (n = 2, 11.1%).

In contrast, the horizontal profile showed a different distribution, with a lower proportion of velocity-oriented players (n = 3, 16.7%) and higher proportions of optimal (n = 8, 44.4%) and force-oriented profiles (n = 7, 38.9%). Overall, the distribution of profile orientations differed between the vertical and horizontal assessments.

Table 3 presents the results of the McNemar-Bowker test employed to examine whether profile orientation

Table 1. Descriptive statistics of vertical and horizontal force-velocity variables

Variable	Mean ± *SD*	95% *CI*	*CV* (%)
Vertical profile (CMJ)			
F_0_vert ($N \cdot kg^{-1}$)	35.53 ± 5.50	[33.008; 38.110]	15.5
V_0_vert ($m \cdot s^{-1}$)	3.17 ± 0.73	[2.853; 3.5094]	23.0
Pmax_vert ($W \cdot kg^{-1}$)	28.11 ± 5.42	[25.639; 30.321]	19.3
FV_slope ($N \cdot s \cdot m^{-1}$)	–12.10 ± 3.73	[–13.905; –10.505]	30.8
Horizontal profile (sprint)			
F_0_horiz ($N \cdot kg^{-1}$)	9.06 ± 1.03	[8.558; 9.487]	11.4
V_0_horiz ($m \cdot s^{-1}$)	8.56 ± 0.34	[8.400; 8.719]	4.0
Pmax_horiz ($W \cdot kg^{-1}$)	19.36 ± 2.39	[18.216; 20.382]	12.3
RFmax	0.56 ± 0.03	[0.543; 0.573]	5.4
DRF	–0.096 ± 0.010	[–0.101; –0.091]	10.4

F_0 – theoretical maximal force, V_0 – theoretical maximal velocity, Pmax – maximal power output, FV_slope – slope of the force-velocity relationship, RFmax – peak ratio of horizontal force, DRF – rate of decrease in the ratio of force, vert – vertical profile, horiz – horizontal profile, CMJ – countermovement jump

Table 2. Distribution of vertical and horizontal force-velocity profile orientations

Profile	Vertical (*n*, %)	Horizontal (*n*, %)
Velocity-oriented	12 (66.7%)	3 (16.7%)
Optimal	2 (11.1%)	8 (44.4%)
Force-oriented	4 (22.2%)	7 (38.9%)

Table 3. Results of the McNemar-Bowker test comparing vertical and horizontal profile orientation

Test	χ^2	*df*	*p*-value
McNemar–Bowker	8.667	3	0.034

Table 4. Results of the Shapiro–Wilk normality test for vertical and horizontal force-velocity variables

Variable	*W*	*p*-value	Distribution
F_0_vert	0.953	0.481	normal
V_0_vert	0.954	0.490	normal
Pmax_vert	0.905	0.071	normal
FV_slope	0.921	0.135	normal
F_0_horiz	0.926	0.162	normal
V_0_horiz	0.924	0.150	normal
Pmax_horiz	0.923	0.146	normal
DRF	0.940	0.285	normal
RFmax	0.868	0.017	non-normal

F_0 – theoretical maximal force, V_0 – theoretical maximal velocity, Pmax – maximal power output, FV_slope – slope of the force-velocity relationship, DRF – rate of decrease in the ratio of force, RFmax – peak ratio of horizontal to resultant force, vert – vertical profile, horiz – horizontal profile

Table 5. Correlations between vertical and horizontal force-velocity variables (*r*, 95% *CI*, and *p*-values)

Variables	*r*	95% *CI*	*p*-value	Effect size
F_0_vert × F_0_horiz	–0.412	[–0.737; 0.068]	0.089	moderate
V_0_vert × V_0_horiz	–0.087	[–0.532; 0.396]	0.732	trivial
Pmax_vert × Pmax_horiz	–0.016	[–0.479; 0.454]	0.950	trivial
FV_slope × DRF	0.283	[–0.212; 0.662]	0.256	small

F_0 – theoretical maximal force, V_0 – theoretical maximal velocity, Pmax – maximal power output, FV_slope – slope of the force–velocity relationship, DRF – rate of decrease in the ratio of force, vert – vertical profile, horiz – horizontal profile

differed between the vertical and horizontal force-velocity assessments. The analysis revealed a statistically significant difference in profile distribution between the two conditions ($\chi^2 = 8.667$, $df = 3$, $p = 0.034$).

Table 4 presents the results of the Shapiro–Wilk normality test for the mechanical variables. Most variables were normally distributed ($p > 0.05$). RFmax was the only variable that did not meet the assumption of normality ($W = 0.868$, $p = 0.017$), and was therefore analysed using Spearman's rank correlation coefficient.

Table 5 presents the correlations between vertical and horizontal F-V variables. Overall, the relationships between the variables were weak to moderate in magnitude and did not reach statistical significance ($p > 0.05$). A moderate negative correlation was observed between F_0_vert and F_0_horiz ($r = –0.412$, $p = 0.089$),

Table 6. Spearman correlation between FV_slope and RFmax

Variables	ρ	95% CI	*p*-value	Effect size
FV_slope × RFmax	0.305	[–0.189; 0.676]	0.219	small

FV_slope – slope of the force–velocity relationship, RFmax – peak ratio of horizontal to resultant force

although the associated confidence interval was wide and included zero, indicating uncertainty in the estimate. The remaining correlations were trivial to small in magnitude, including V_0_vert × V_0_horiz (r = –0.087, p = 0.732), Pmax_vert × Pmax_horiz (r = –0.016, p = 0.950), and FV_slope × DRF (r = 0.283, p = 0.256). Overall, the relatively wide confidence intervals suggest a degree of imprecision in the estimated relationships.

Table 6 presents the Spearman correlation involving RFmax. A small positive, non-significant correlation was observed between FV_slope and RFmax (ρ = 0.305, p = 0.219). The associated 95% confidence interval was relatively wide and included zero, indicating uncertainty in the estimated relationship.

Discussion

The main finding of the present study is that vertical and horizontal F-V profiles showed limited associations among Moroccan U23 football players, suggesting that these assessments may reflect task-specific mechanical characteristics rather than interchangeable neuromuscular qualities, although this observation should be approached with caution. This interpretation is supported not only by the weak and mostly non-significant correlations observed, but also by the differences in profile distribution and the substantial inter-individual variability identified across players. Taken together, these findings suggest that mechanical profiling in football should be regarded as movement-specific rather than as a single global representation of "explosive performance".

One of the most relevant observations of the present study concerns the apparently greater relevance of horizontal F-V variables for sprint acceleration performance. In particular, theoretical maximal horizontal force (F_0) and mechanical effectiveness variables, such as RFmax, appeared to be more informative for understanding acceleration-related capacities than vertical F-V outputs. This is consistent with the sprint biomechanics literature, which has repeatedly shown that acceleration performance depends heavily on the athlete's ability to produce and orient force horizontally during the initial steps of sprinting [6, 10, 17]. From a mechanical standpoint, early acceleration requires overcoming inertia through effective forward-directed force application, and variables such as RFmax and DRF have been proposed as meaningful indicators of this capability [9, 33]. Therefore, the present results support the notion that horizontal profiling may provide movement-specific information of particular relevance to football sprint performance.

By contrast, the weaker relationships observed between vertical F-V variables and horizontal sprint-related variables suggest that vertical assessments such as countermovement jump profiling should be interpreted with caution when used to infer sprint-specific mechanical capacities. Although vertical F-V profiling remains a valuable approach for assessing lower-limb explosive performance, particularly in relation to force and power expression during jumping tasks, its association with sprint acceleration appears to be limited and inconsistent. This finding should nonetheless be interpreted with caution given the relatively small sample size and the variability in testing conditions reported across populations in the literature. However, it aligns with previous research showing only low-to-moderate relationships between vertical jump performance and sprint-related outcomes in athletes [3, 35–37]. It also supports the broader principle of biomechanical specificity, whereby force production is highly dependent on task constraints, direction of force application, and movement mechanics [38]. Consequently, improvements in vertical mechanical output may not necessarily be accompanied by equivalent changes in sprint acceleration performance.

A particularly noteworthy observation was the tendency toward an inverse association between vertical and horizontal F_0, even though this relationship did not reach statistical significance. Although this tendency should be interpreted with caution, it may suggest that the capacity to express force in vertically-oriented tasks does not necessarily translate into similar force expression in horizontally-oriented sprint actions. This may reflect differences in mechanical orientation, intermuscular coordination, and task-specific force application demands between jumping and sprinting tasks. In line with this interpretation, previous research has shown that sprint acceleration performance is not determined solely by the magnitude of force production, but rather by the athlete's ability to effectively orient this force in the direction of motion [6, 9, 39].

Another meaningful observation was the near absence of association between vertical and horizontal maximal power output (Pmax). Although maximal power is often considered a global marker of explosive capability, the present findings suggest that the power output derived from jumping and sprinting tasks may not reflect the same underlying mechanical or functional quality. This finding may be explained by the fact that power expression is constrained by task-specific movement mechanics, force orientation, and velocity conditions. Accordingly, a player who appears highly powerful in a vertical jump context may not necessarily exhibit comparable power characteristics during sprint acceleration. This interpretation is consistent with the view that mechanical outputs should be interpreted within the specific context in which they are produced, rather than as universally transferable indicators of performance [4, 13, 38, 40].

A particularly meaningful aspect of the present study lies in the mismatch observed between vertical and horizontal profile orientations. While the vertical assessment showed a predominance of velocity-oriented profiles, the horizontal assessment revealed a more balanced distribution, with a greater proportion of force-oriented and optimal profiles [5]. This pattern may partly reflect the mechanical characteristics of the jump task itself, in which force is expressed against gravity, and movement execution is strongly influenced by vertical propulsion strategy. It may also reflect the neuromuscular characteristics of the present sample, or the specific training background of these players, who are regularly exposed to sprinting, reactive actions, and stretch-shortening cycle demands in football [16]. Although this interpretation remains speculative, it suggests that profile orientation may be influenced not only by the athlete's physical qualities, but also by the mechanical nature of the task used for the assessment [13]. These findings support the concept that force-velocity characteristics are task-specific and should therefore be interpreted within the context of the assessment performed.

In practical terms, an athlete classified as velocity-oriented in a jump-based task may not necessarily present the same orientation in a sprint-based task. This challenges the assumption that a single mechanical profile can adequately represent an athlete's neuromuscular characteristics and highlights the potential for misclassification when relying on a single profiling modality. From this perspective, the concept of "profile mismatch" may provide a more informative framework for interpreting mechanical characteristics across different movement tasks as such mismatches may lead to incomplete or suboptimal training decisions. These findings highlight the importance of integrating both vertical and horizontal force-velocity assessments to support more comprehensive and individualised training prescription. Consequently, relying on a single test may result in training prescriptions that do not adequately target the athlete's actual mechanical needs. This may reinforce the practical importance of combining complementary profiling approaches when aiming to individualise training and optimise transfer to football-specific performance [3, 4].

Another important finding was the substantial inter-individual variability observed across the sample. Despite belonging to the same competitive category and training environment, players displayed heterogeneous mechanical profiles and profile orientations. This observation is consistent with previous works showing that athletes with comparable performance levels may nevertheless present markedly different force-velocity characteristics and mechanical deficits [16, 30]. Such variability likely reflects the combined influence of anthropometry, training background, neuromuscular adaptations, and individual movement strategies. From a practical perspective, this finding reinforces the relevance of individualised profiling in football, as group-level averages may obscure meaningful differences in player-specific mechanical needs and consequently reduce the precision of training prescription [13, 14].

From an applied perspective, the present study results may support the integration of both vertical and horizontal F-V profiling within performance assessment and training design. If the primary goal is to improve acceleration performance, the present findings suggest that practitioners may benefit from placing greater emphasis on horizontal mechanical outputs and sprint-specific force application. In this context, interventions such as resisted sprinting, particularly with moderate-to-heavy sled loads, may be relevant when targeting horizontal force production [12]. Likewise, horizontally-oriented plyometric exercises may offer more specific transfer to sprint acceleration than vertically-dominant exercises in some football contexts [42]. However, this should not lead to the exclusion of vertical profiling or vertical power-oriented training, as these remain relevant for other performance demands such as jumping, landing, and aerial duels. Rather, the practical implication is that performance assessment and training prescription should reflect the multidimensional and task-specific nature of football performance.

The present study also provides novel data on Moroccan football players, a population that remains underrepresented in literature addressing the force-velocity profiling. Most available studies in this area have been conducted in European or South American cohorts, which may limit the ecological transferability of existing evidence to other football environments. By examining both vertical and horizontal F-V characteristics among the Moroccan U23 players, the present study contributes to expanding the available evidence base and may provide useful reference points for practitioners working in similar developmental and competitive contexts.

Several limitations should nevertheless be acknowledged. First, the relatively small sample size limits the statistical precision of the observed relationships and requires cautious interpretation, particularly when considering weak or moderate associations. This limitation is further reflected in the relatively wide confidence intervals observed for several correlation coefficients, which often included zero. This indicates a degree of uncertainty regarding both the magnitude and direction of the relationships, and suggests that the present findings should be interpreted as indicative of tendencies rather than definitive evidence of stable mechanical associations. Second, the cross-sectional design precludes any causal inference regarding the relationship between F-V characteristics and performance outcomes. Third, although MyJump2 and MySprint offer practical and ecologically valid field-based assessment options, some degree of measurement error compared with laboratory-based systems cannot be excluded [41]. Finally, potentially relevant factors such as playing position, training history, and accumulated fatigue were not fully controlled and may have contributed to the observed variability.

Future research should examine these relationships in larger and more diverse football samples, while also exploring the longitudinal effects of individualised training interventions based on combined vertical and horizontal F-V profiling. In particular, future studies may benefit from investigating whether profile mismatch between movement tasks represents a stable mechanical characteristic or a trainable feature that can be modified through targeted intervention.

Conclusions

The present findings indicate that vertical and horizontal F-V profiles among Moroccan male U23 football players show only limited association, supporting the view that these assessments may reflect distinct movement-specific mechanical tendencies rather than a single global expression of explosiveness. The observed profile mismatch and the substantial inter-individual variability further emphasise the complexity of neuromuscular profiling in football and the limitations of relying on a single testing modality. Practically, these results support the integration of both jump- and sprint-based mechanical profiling to better characterise individual player needs and to guide more precise training prescription. By providing novel evidence from an underrepresented football population, this study contributes to the evidence base supporting multidimensional and individualised approaches to performance assessment in football.

Acknowledgements

The authors would like to express their gratitude to all co-authors for their scientific and methodological contributions to this work. The involvement of these individuals in the various stages of design, analysis, and writing was found to be of paramount importance to the quality of the study. It should be noted that no external funding was received for this work.

Ethical approval

The research related to human use complied with all the relevant national regulations and institutional policies, followed the tenets of the Declaration of Helsinki, and was approved by the Ethics Committee for Biomedical Research of the Faculty of Medicine and Pharmacy of Rabat, Morocco (approval No.: CERB: 63/21, deliberated on October 23, 2023).

Informed consent

Informed consent was obtained from all individuals included in this study.

Conflict of interest

The authors state no conflict of interest.

Disclosure statement

No author has any financial interest or received any financial benefit from this research.

Funding

This research received no external funding.

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