



Article

Differences in Sprinting-Related Force–Velocity Mechanical Variables Between Under-19 and Senior Players: Physical Performance Readiness in Elite Youth Soccer

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Abstract

Objectives: This study compares linear sprint force–velocity (F – v) mechanical variables between elite Under-19 (U19) academy players and senior professional players. **Methods:** Thirty-eight senior players (SP; mean age 24.5 ± 4.3 y) and 214 U19 academy players (YP; mean age 17.4 ± 0.5 y) from 14 first-division club academies were tested during October 2023 using a motorized resistance device (1080 Motion). The following F – v variables were assessed: maximal theoretical force (F_0 , $\text{N} \cdot \text{kg}^{-1}$), maximal theoretical velocity (v_0 , $\text{m} \cdot \text{s}^{-1}$), maximal ratio of horizontal-to-resultant force ($\text{RF}_{\max}$, %), and decrease in the ratio of forces (DRF, %). Between-group comparisons were performed using the t -test, and Cohen's d effect sizes were reported. **Results:** Senior players outperformed U19 players across all F – v variables. F_0 exhibited a mean difference = $0.220 \text{ N} \cdot \text{kg}^{-1}$, with a 95% confidence interval (CI) [0.056, 0.384], $p = 0.0166$, and $d = 0.46$. v_0 exhibited a mean difference = $0.560 \text{ m} \cdot \text{s}^{-1}$, with a 95% CI [0.410, 0.710], $p < 0.0001$, and $d = 1.07$. $\text{RF}_{\max}$ exhibited a mean difference = 1.470% , with 95% CI [0.830, 2.110], $p = 0.0003$, and $d = 0.69$. DRF exhibited a mean difference = 0.260% , with a 95% CI [0.103, 0.417], $p = 0.0013$, and $d = 0.53$. **Conclusions:** U19 players demonstrated lower F_0 , lower v_0 , and reduced mechanical effectiveness compared with senior players. Regular monitoring of F – v profiles and individualized training interventions (force- or velocity-targeted) may be useful for training and monitoring strategies aimed at supporting physical preparation during the transition to senior soccer.

Keywords: speed; strength; performance; football; biomechanics; horizontal velocity



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1. Introduction

In elite soccer, youth players are increasingly assuming roles within senior teams and, in many cases, are being elevated from supporting roles to key contributors. Soccer-specific actions at high speeds are considered one of the main characteristics of elite performance [1]. Soccer preparation follows two main objectives: improving team and individual performances and reducing injury risk [2]. The two most frequent actions that precede goal-scoring opportunities are short accelerations and linear sprints [3]. Between the 2006/07 and 2012/13 Premier League seasons, the number of sprints and sprint distances increased

by 85% and 35%, respectively [4]. Modern soccer, therefore, demands higher mechanical and sprint capabilities from players because of the faster nature of the game. Match performance is influenced by contextual factors such as field position, competition level, match location, ball-in-play time, and weekly load [5–7]. High-speed actions, such as sprinting, require principles of specificity during training and preparation [8].

Therefore, it is necessary to investigate objective measures of speed quality and force production to better understand the biomechanical variables that determine the sprint performance. Force–velocity (F–v) profiling provides insight into neuromuscular mechanical capabilities [9]. The F–v relationship in sprinting is linear and inversely proportional, with determining variables such as maximal theoretical force (F_0), maximal theoretical velocity (v_0), and maximal power ($P_{\max}$) [10,11]. The ability to generate maximal power depends on both force and velocity, with changes in force having a more pronounced impact [10]. Hicks et al. [12] recommended understanding these mechanical variables (e.g., F_0 and v_0), which could provide valuable insights for optimizing training strategies to enhance the sprint performance and overall athletic capability. Additional parameters that assess the F–v relationship from technical perspectives can provide more information on linear sprinting. The ratio of the maximum forces ($RF_{\max}$) is determined as the proportion of the horizontal ground reaction force component averaged over subsequent steps to the corresponding resultant force. A higher percentage of $RF_{\max}$ signifies a larger portion of the total force production in the horizontal vector during the acceleration phase of the sprint. Conversely, a decrease in the ratio of forces (DRF) indicates a player's capacity to minimize the loss of mechanical effectiveness at higher running velocities. In the case of DRF, lower negative values indicate the better mechanical effectiveness of the player [13]. Based on these variables, we can identify players' limitations in the context of sprinting, and gain important information for creating individualized training programs.

With respect to age, it is important to define the differences in the mechanical variables of sprinting between youth and senior soccer players, to establish standards that support fluent and safe transition between competition levels. The Under-19 (U19) category in soccer, comprising players below 19 years of age, is extremely important in most clubs as it represents the last transition from youth to senior soccer. This group of players is closer to participating and competing with senior players, from the perspective of not only age (chronological and biological maturation) but also performance. Players at this level are frequently evaluated against senior performance standards within elite clubs. Consequently, comparing U19 players with established senior professionals may provide valuable descriptive insight into the mechanical characteristics of sprinting associated with senior-level competition with aim of providing performance benchmarks that may assist practitioners in contextualizing youth players' mechanical profiles during the transition phase. Research has shown the impact of the maturation status and peak height velocity (PHV) on the components of the F–v profile [14]. Authors have reported significant differences in the strength and acceleration components between the pre- and mid-PHV groups. In addition, the F–v profiles of jumping and sprinting exhibit correlations with biological and chronological age in youth soccer players [15]. Insufficient mechanical capabilities in sprinting can increase injury risk. Low horizontal force production during acceleration (F_0) is a potential risk factor for hamstring injuries [16]. Hamstring injuries are among the most common injuries in soccer [17,18], and can influence sprinting mechanics as well as affecting variables such as maximal velocity (v_0) and force production (F_0) [19,20]. Higher sprint velocities are associated with elevated hamstring strain risks [21]. This highlights the importance of monitoring and analyzing mechanical variables and explosive efforts in sprinting, helping clinical practitioners optimize the training load, with the aim of preventing excessive fatigue and musculoskeletal stress, and identifying players who are more prone to noncontact injury.

To date, no study with a large group of elite academy soccer players has provided a comprehensive comparison of mechanical variables pertaining to sprinting between U19 and senior players. Therefore, this study aims to (i) compare the mechanical variables of linear sprint performance of elite U19 and senior players to describe differences in mechanical characteristics between elite U19 and senior players in order to better characterize the physical demands associated with senior competition, and (ii) provide a large reference data pool for linear sprint mechanics in elite youth players. We hypothesize significantly higher performance in all sprinting-related mechanical variables in favor of professional senior players compared to elite youth soccer players.

2. Materials and Methods

2.1. Study Design

A cross-sectional design was used in this investigation. The study overview was explained prior to testing, and signed informed consent was collected from all players. The study was approved by the Institutional Ethics Committee of the Matej Bel University in Banská Bystrica and conducted in accordance with the Declaration of Helsinki. Written informed consent was obtained from the legal guardians, where applicable, and assent was obtained from all players under 18 years. All participants were informed of the benefits and risks of the investigation prior to testing.

2.2. Participants

Thirty-eight male senior professional players (SP; mean age 24.5 ± 4.3 y; body height = 180.1 ± 5.7 cm; body weight = 77.3 ± 5.6 kg) and 214 male U19 academy players (YP; mean age 17.4 ± 0.5 y; body height = 179.77 ± 6.35 cm; body weight = 71.78 ± 6.51 kg) from 14 first-division academies participated in the study (Table 1). All participants followed a structured weekly training typical of elite youth academies (4–5 training days, including 4–6 field and 1–2 gym sessions, and 1–2 competitive matches). The players competed at the highest national league in their age category. According to the participant classification framework [22], the subjects represented Tier 3–4: Highly Trained (academy players)/Elite Level (senior players). Players were not permitted to be included in the study if they had experienced a lower limb injury within the last six months.

Table 1. Anthropometric characteristics of senior and youth players.

Variable	SP n = 38 (Mean $\pm$ SD)	YP n = 214 (Mean $\pm$ SD)	SP (CV %)	YP (CV %)	SP (95% CI)		YP (95% CI)	
					Lower	Upper	Lower	Upper
Age (years)	24.5 ± 4.3	17.4 ± 0.5	17.6	2.9	23.1	25.9	17.3	17.5
Body Height (cm)	180.1 ± 5.7	179.8 ± 6.4	3.2	3.5	178.2	182	178.9	180.7
Body Weight (kg)	77.3 ± 5.6	71.8 ± 6.5	7.2	9.1	75.5	79.1	70.9	72.7

SP—senior players; YP—youth players; SD—standard deviation; CV—coefficient of variation; CI—confidence interval.

2.3. Data Collection

Linear sprint performance was measured with a motorized resistance device (MRD) 1080 Sprint (1080 Motion, Lidingö, Sweden), which provided external resistance and measured mechanical variables. Data were recorded at a sample frequency of 333 Hz. The 1080 Sprint device was positioned on the ground (artificial turf) and resisted loads were set to 1 kg in the no-flying-weight mode (NFW) [23]. The MRD provided valid and reliable data on force, velocity, and acceleration [24]. Specifically, it acted as a valuable tool for recording the maximal force production (F_0 , N·kg^{−1}), maximal velocity (v_0 , m·s^{−1}),

ratio of maximal forces ($RF_{\max}$, %), and decrease in the ratio of forces (DRF, %). Testing took place in October 2023, when two senior professional-league soccer teams were tested. Senior players were tested as part of their speed session 72 h after a competitive match. Players performed prescribed warm-ups according to the RAMP protocol [25] for linear speed sessions followed by two trials of 30 m linear sprints, which were measured by the 1080 Sprint device. Youth academy players were tested for a five-week period, as part of the national testing of 14 domestic academies. The examiners, device, starting position (standing with feet hip-width apart, dominant leg forward, and a forward lean to maximize acceleration) and conditions (artificial turf) were the same as those used for testing the senior players. The testing was conducted 72 h after a competitive game, with an identical RAMP protocol to minimize the influence of possible fatigue or other factors that could affect linear sprinting. For each player, the means values of sprint mechanical variables (F_0 , v_0 , $RF_{\max}$, and DRF) were calculated from two trials to enhance the reliability and minimize the influence of trial-to-trial variability. In addition, the F–v profile for each player was calculated as previously described by Morin and Samozino [9]. This served to identify the individual level of each variable, which could be used later for designing individual speed training protocols.

2.4. Data Processing

Descriptive data of the linear sprint mechanical variables (F_0 , v_0 , DRF, and $RF_{\max}$) were presented as means with 95% confidence intervals (95% CIs). The Shapiro–Wilk test revealed normal distributions for all measured variables. The homogeneity of variance was assessed using Levene’s test. When the equality of variances could not be assumed, between-group comparisons were performed using the Welch independent-sample *t*-test, applied to calculate the statistical significance between groups. The statistical significance was set at $p < 0.05$. The Cohen’s *d* effect size was calculated to evaluate the magnitudes of the differences, using the following scale: negligible (<0.2), small ($0.2–0.5$), moderate ($0.5–0.8$), and large (≥ 0.8) [26]. Reference values for all variables were calculated as percentile distributions for the cohort of youth players ($n = 214$). Statistical analyses were performed using the software JASP Team (2024) JASP (Version 0.19. 3).

3. Results

3.1. Differences in Linear Sprint Mechanical Variables

The descriptive statistics and between-group comparisons are summarized in Table 2. Senior players achieved higher values across the measured sprinting mechanical variables, compared with youth players. Senior players produced approximately 2.99% higher maximal F_0 , on an average ($p < 0.05$, $d = 0.46$), 6.02% higher maximal v_0 , ($p < 0.01$, $d = 1.07$), 2.88% higher $RF_{\max}$ ($p < 0.01$, $d = 0.69$), and 3.75% higher DRF ($p < 0.01$, $d = 0.53$). The moderate effect sizes of F_0 ($d = 0.46$), the effectiveness of force application $RF_{\max}$ ($d = 0.69$), and the capability to limit the decrease in mechanical effectiveness DRF ($d = 0.53$) indicated noticeable differences between senior and youth players. The medium-to-large effect size ($d = 0.46–1.07$) suggests a substantial difference between senior and youth players, which could also affect the ability of youth players to compete with senior players (Figures 1–4).

Table 2. Descriptive statistics of sprinting mechanical variables of senior and youth players.

Variable	SP (Mean $\pm$ SD)	YP (Mean $\pm$ SD)	Δ SP vs. YP	SP (CV %)	YP (CV %)	<i>p</i> -Value	<i>d</i> (Effect Size)
F_0 (N·kg ^{−1})	7.57 $\pm$ 0.46	7.35 $\pm$ 0.49	0.22	6.08	6.67	0.009	0.46
v_0 (m·s ^{−1})	9.86 $\pm$ 0.40	9.30 $\pm$ 0.55	0.56	4.06	5.91	<0.001	1.07

Table 2. Cont.

Variable	SP (Mean $\pm$ SD)	YP (Mean $\pm$ SD)	Δ SP vs. YP	SP (CV %)	YP (CV %)	<i>p</i> -Value	<i>d</i> (Effect Size)
RF _{max} (%)	52.50 $\pm$ 1.74	51.03 $\pm$ 2.20	1.47	3.31	4.31	<0.001	0.69
DRF (%)	−6.67 $\pm$ 0.43	−6.93 $\pm$ 0.52	−0.26	6.45	7.50	0.001	0.53

SP—senior players; YP—youth players; Δ SP vs. YP—differences between senior and youth players, F_0 , maximal theoretical force production; v_0 —maximal theoretical velocity; RF_{max}—maximal ratio of horizontal-to-resultant force; DRF—decrease in the ratio of forces; CV—coefficient of variation.

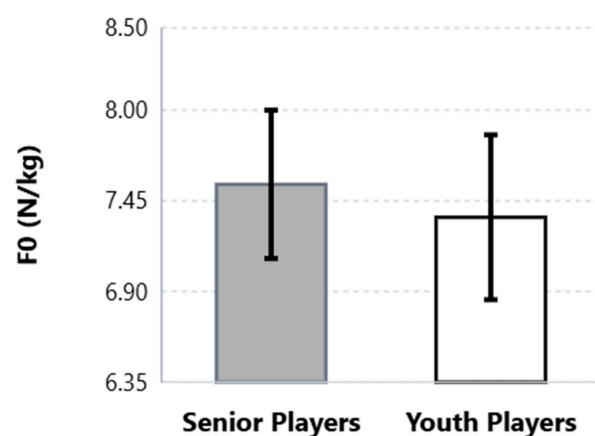


Figure 1. Differences between senior (SP) and youth (YP) players in maximal horizontal force production (F_0).

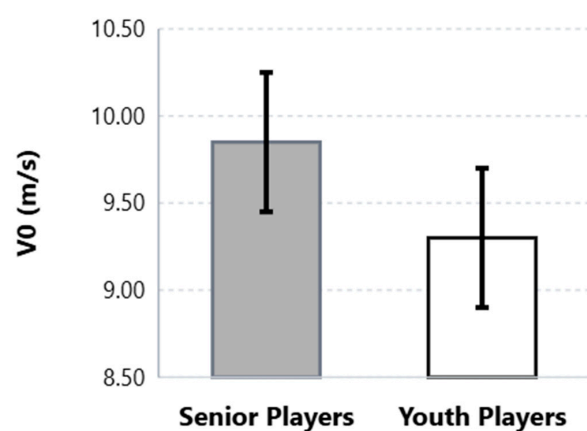


Figure 2. Differences between senior (SP) and youth (YP) players in maximal running velocity (v_0).

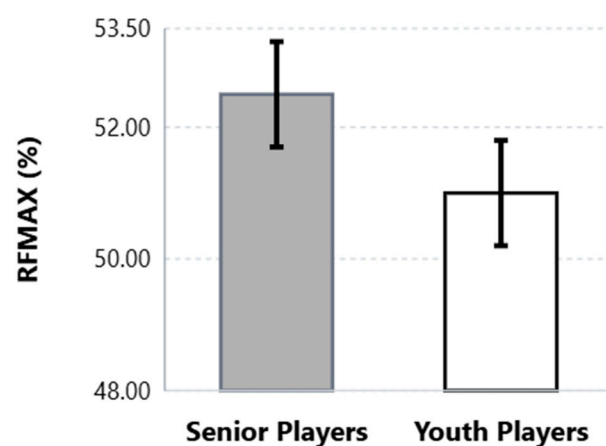


Figure 3. Differences between senior (SP) and youth (YP) players in ratio of maximal forces (RF_{max}).

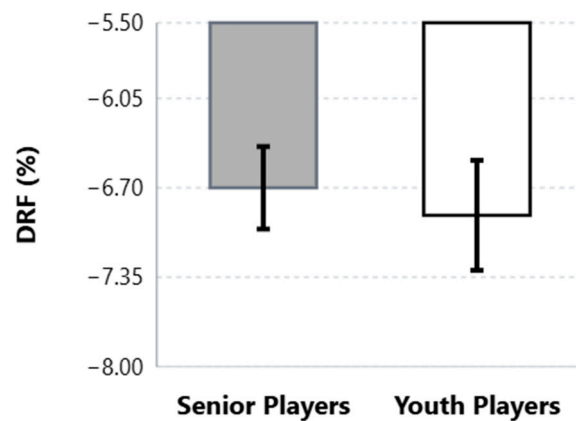


Figure 4. Differences between senior (SP) and youth (YP) players in decreasing forces ratio (DRF).

3.2. Reference Percentile Data for Linear Sprint Mechanical Variables

The percentile reference data for linear sprint mechanical variables of elite youth players ($n = 214$) are presented in Table 3. These percentiles provide a descriptive overview of the distribution of sprinting-related mechanical characteristics across the U19 cohort, allowing practitioners and researchers to contextualize individual player values, relative to a large elite youth sample.

Table 3. Reference percentile data for linear sprint mechanical variables of elite youth players.

	Percentiles										
	P ₅	P ₁₀	P ₂₀	P ₃₀	P ₄₀	P ₅₀	P ₆₀	P ₇₀	P ₈₀	P ₉₀	P ₉₅
F_0 (N·kg ⁻¹)	6.51	6.75	6.98	7.09	7.23	7.36	7.46	7.64	7.80	7.99	8.10
v_0 (m·s ⁻¹)	8.40	8.52	8.84	9.01	9.20	9.35	9.48	9.61	9.76	9.99	10.10
RF _{max} (%)	47.00	48.30	49.50	50.00	50.50	51.10	51.70	52.40	53.00	53.60	54.25
DRF (%)	-7.80	-7.60	-7.30	-7.20	-7.00	-6.90	-6.80	-6.70	-6.60	-6.30	-6.10

F_0 —maximal theoretical force production; v_0 —maximal theoretical velocity; RF_{max}—maximal ratio of horizontal-to-resultant force; DRF—decrease in the ratio of forces; P—percentile.

4. Discussion

This study found clear differences in the F–v mechanical variables in linear sprinting between senior and youth (U19) players. The largest observed difference was in v_0 , suggesting that the maximal theoretical velocity could be the most discriminative sprint characteristic when comparing late adolescent and senior players. Youth players were not able to reach the maximal sprinting speeds of senior players (v_0 : SP = 9.86 ± 0.40 m·s⁻¹; YP = 9.30 ± 0.55 m·s⁻¹, $p < 0.01$, $d = 1.07$). These differences could reflect a combination of factors related to training exposure and adaptation, competitive level, and age-related characteristics; however, biological maturation was not directly assessed in the present study and therefore could not be isolated as a contributing factor. This inability to reach and maintain adequate speed could lead to suboptimal performance, hampering the players' transition to senior soccer, and a potentially greater risk of injury from the higher physical demands and greater exposure to high-speed actions in senior-level soccer [19,20]. Differences in sprinting-related mechanical variables among youth soccer players could be influenced by the maturation status and different competition levels. Fernández-Galván et al. [15] showed that maturation stages impacted components such as F_0 , v_0 , P_{max} , and RF_{max}. Male players of higher competition levels exhibited superior values for all F–v variables ($d = 1.01$ – 1.97), when compared to the lower-level group [27]. The relationships among the jumping and sprinting F–v profiles and biological and chronological ages were

significant, with very large correlations ($r = 0.79\text{--}0.92$) [14]. Similar findings have been reported in Australian football, where differences in force-oriented sprint profiles across competition levels emphasize the impact of maturation on acceleration capacity [28]. Repeated sprints affected the F–v profile variables that described the production of force at high speeds, such as v_0 , DRF, and $P_{\max}$, which were more sensitive to fatigue [29]. Seasonal changes in the F–v profiles of elite male soccer players indicated that specific sprint capabilities could decline towards the end of the competitive season if not systematically trained, with F_0 and $P_{\max}$ showing more significant changes ($p \leq 0.006$) than v_0 ($p \geq 0.287$) [30]. Interestingly, Vigh-Larsen et al. [31] found that youth soccer players performed as many high-intensity activities as senior players, which does not indicate a discriminating physiological parameter between these two groups. Zhang et al. [32] identified two biomechanical sprinting patterns: “aerial” runners (more efficient force producers) and “terrestrial” runners (more effective at maintaining horizontal force production). Hassen et al. [33] also demonstrated position-specific differences, with forwards displaying higher maximal theoretical velocities ($v_0 = 8.8 \pm 0.4 \text{ m}\cdot\text{s}^{-1}$) and power outputs ($P_{\max} = 19.4 \pm 2.6 \text{ W}\cdot\text{kg}^{-1}$).

These findings highlight the need for position-specific and individualized sprint training approaches from early developmental stages. For strength and conditioning coaches working with youth players, understanding these speed benchmarks is essential. It is highly recommended that youth players should achieve senior-level speed criteria prior to transitioning to more competitive environments. If these benchmarks are not met, additional linear speed training should be provided to support their development. Additionally, according to our findings, the F_0 , $RF_{\max}$, v_0 , and DRF scores of youth players are lower than those of the senior group; therefore, adequate training stimuli must be incorporated into training. These variables are critical to enhancing the kinetic and kinematic aspects of linear sprinting variables in youth soccer players, particularly in terms of the horizontal force production and efficiency required to achieve higher running velocities.

Based on results from the F–v profiles, we can prescribe training programs that address individual needs. For better individualization in team sport settings, we can categorize players into groups (force deficit and velocity deficit groups), that identify specific strengths and weaknesses [12,34]. In the force deficit group, we can use modalities for enhancing the maximal horizontal force produced: acceleration/speedwork ($<7 \text{ s}$), resistance sprint training (50–75% velocity decrement, 10 m), improving hip–extensor strength, absolute/relative force qualities, and rate of force development [12]. The velocity deficit group should engage sprinting drills at higher velocities: acceleration/speedwork ($<7 \text{ s}$), resistance sprint training (25–50% velocity decrement, 10–20 m), flying sprints, assisted sprint training, improved stretch–shortening cycle, and reactive strength [12]. Proper periodization of sprint training and monitoring F–v profiles across the season can enable practitioners to make data-driven adjustments that optimize neuromuscular performance and reduce injury risk [31].

This study has certain limitations, particularly the imbalance between the number of senior and youth players considered, and the age difference (YP—17.4 years; SP—24.5 years). Monteiro et al. [35] tracked 3500 retired Portuguese players and found that the transition to senior status occurred typically in the late teenage years (17.94 years; SD—0.69). This supported the Elite Player Performance Plan (EPPP) implemented in England, which described the Professional Development Phase as being between the U17 and U23 age groups [36]. If the limitations of the youth players can be identified earlier, it may improve the scope for improvement of these players. Therefore, further studies are essential to validate and expand upon our findings and ensure that training interventions are grounded in robust evidence. Another limitation of this study is the fact that players were not distinguished based on their specific field positions. Finally, the lack of biological maturation assessment

limits the interpretation of the developmental differences between groups. Although the mean chronological age of the U19 players (~17.4 years) suggests that, on an average, this cohort is past the typical age of PHV, which in male soccer players has been estimated as ~13.6–13.7 years [37], the chronological age alone cannot capture the individual differences in the maturation timing and neuromuscular development. Particularly in youth populations, the residual variation in maturation status may still influence mechanical performance characteristics and exhibit inter-individual differences in neuromuscular adaptation and performance outcomes associated with maturation timing [38]. Future research should integrate maturation markers (e.g., PHV or hormonal profiles) and longitudinal designs to monitor mechanical adaptations across the youth-to-senior transition. Another limitation of this study is its cross-sectional design, which does not allow for causal inference or direct evaluation of successful transition outcomes. Therefore, the observed differences in sprinting-related mechanical variables should be interpreted as descriptive between-group differences, rather than predictors of individual transition success. Future longitudinal studies are required to determine whether these mechanical characteristics are associated with long-term progression to senior professional performance.

5. Practical Application

Based on the reference percentile data (Table 3), coaches can create training recommendations for youth players. These data consider different methods of force or velocity production. Players are divided into four groups with specific profiles: force dominant ($F_0 > P70$ ($>7.64 \text{ N}\cdot\text{kg}^{-1}$), $v_0 < P30$ ($<9.01 \text{ m}\cdot\text{s}^{-1}$)); velocity dominant ($v_0 > P70$ ($>9.61 \text{ m}\cdot\text{s}^{-1}$), $F_0 < P30$ ($<7.09 \text{ N}\cdot\text{kg}^{-1}$)); balanced profile (F_0 P30–70, v_0 P30–70); and underdeveloped profile ($F_0 < P30$, $v_0 < P30$). The detailed training recommendations for each profile are presented in Table 4.

Table 4. Training recommendations according to players' force–velocity profiles.

Profile	Velocity-Dominant (Low Force/High Velocity)	Force-Dominant (High Force/Low Velocity)	Balanced Profile (P30–70 for Both F_0 and v_0)	Underdeveloped (Both $< P30$)
Criteria	$F_0 < P30$ ($7.09 \text{ N}\cdot\text{kg}^{-1}$) $v_0 > P70$ ($9.61 \text{ m}\cdot\text{s}^{-1}$)	$F_0 > P70$ ($7.64 \text{ N}\cdot\text{kg}^{-1}$) $v_0 < P30$ ($9.01 \text{ m}\cdot\text{s}^{-1}$)	F_0 P30–70 ($7.09\text{--}7.64 \text{ N}\cdot\text{kg}^{-1}$) v_0 P30–70 ($9.01\text{--}9.61 \text{ m}\cdot\text{s}^{-1}$)	$F_0 < P30$ ($7.09 \text{ N}\cdot\text{kg}^{-1}$) $v_0 < P30$ ($9.01 \text{ m}\cdot\text{s}^{-1}$)
Focus	PRIMARY: Force/power development SECONDARY: Maintain velocity capacity	PRIMARY: Velocity-oriented development SECONDARY: Maintain force production	PRIMARY: Maintain and optimize power output SECONDARY: Position-specific adaptations	PRIMARY: Simultaneous force and velocity training. SECONDARY: Reduce DRF through RF_{max} optimization
Examples	- Resisted sprints (sled, uphill) - Heavy strength training - Plyometrics with resistance - Eccentric loading exercises	- Assisted sprints (1080 sprint, downhill) - Flying starts (30 m acceleration + 30 m maximal) - High-speed plyometrics	- Complex training (strength + plyometrics) - Max velocity training - Resisted sprint variations - Reactive strength training	- General strength training progressions - Plyometric exercises - Resisted sprints - Acceleration and Max velocity drills
Frequency	2–3 strength sessions + 1 velocity maintenance session	2–3 velocity sessions + 1 strength maintenance session	1–2 strength sessions + 1–2 velocity sessions	2 strength sessions + 2–3 velocity sessions + 1 plyometric session

6. Conclusions

This research provided novel insights into the linear sprint mechanical performance differences between youth (U19) and senior soccer players. The results reveal significant differences in the maximal theoretical speed (+6.02%), maximal force production (+2.99%), ratio of maximal forces (+2.88%), and decrease in ratio of forces (+3.75%) in favor of senior players. The results of the study show that an assessment of the F–v spectrum during linear sprinting could be a valuable tool for describing and benchmarking neuromuscular mechanical characteristics relevant to sprint performance in soccer players. Additionally, the research highlighted the increased demand on linear sprint mechanical variables for younger players transitioning to senior soccer. Consequently, we advise caution when youth players are not able to reach the specific speed and force thresholds required at the senior level. This study also provides reference percentile data for linear sprint mechanical variables from a large cohort of elite youth soccer players. Regular monitoring of F–v variables can guide individualized training interventions and support safe and progressive development toward professional competition.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study. Written informed consent has been obtained from the patient(s) to publish this paper.

Data Availability Statement: The original contributions presented in the study are included in the article; further inquiries can be directed to the corresponding author.

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Abbreviations

The following abbreviations are used in this manuscript:

F–v	Force–velocity
F0	Maximal theoretical force
v0	Maximal theoretical velocity
RFmax	Maximal ratio of horizontal-to-resultant force
DRF	Decrease in the ratio of forces
PHV	Peak height velocity
SP	Senior players
YP	Youth players

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