Sprint mechanical force–velocity profiles in Portuguese football and futsal players: A cross-sectional pilot study

Perfis de força- velocidade no sprint em jogadores portugueses de futebol e futsal: um estudo piloto transversal

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RESUMO

Enqudramento – O sprint é um fator determinante para o desempenho em desportos coletivos como o futebol e o futsal. As relações força-potência-velocidade e eficácia mecânica têm sido recentemente utilizadas para analisar perfis de força-velocidade (F-V). O objetivo deste estudo era duplo: (1) quantificar os perfis biomecânicos F-V do sprint em jogadores de futebol e futsal portugueses; (2) analisar diferenças entre sexos, níveis competitivos e desportos nas variáveis em estudo.

Métodos – 4 jogadores de futebol (2 homens) e 4 jogadores de futsal (2 homens), com 26 ± 4,24 anos, realizaram 3 sprints máximos de 30 m a partir de uma posição de pé com 4 min de descanso entre sprints sucessivos. Foram recolhidos dados de vídeo com um Go Pro Hero (Full HD 1080p, 30 fps). O perfil de força-velocidade foi obtido com: F_0 (N/kg), V_0 (m/s), P_{max} (W/kg), Sfv, RF_{max} (%), DRF (%), V_{opt} (m/s) e velocidade máxima (m/s).

Results – Os jogadores masculinos mostraram um V_0 (t = - 7,12; p < 0,001, d = 5,04), V_{opt} (t = - 2,90; p ≤ 0,05, d = 2,05) e velocidade máxima (t = - 5,09; p ≤ 0,05, d = 3,60) mais alta do que nas jogadoras femininas. Não foram observadas diferenças com significado estatístico entre os níveis competitivos e o desporto.

Conclusão – Estes resultados mostraram que os perfis mecânicos de sprint (F-V) são capazes de diferenciar entre jogadores masculinos e femininos de futebol e jogadores de futsal. Nenhuma diferença entre os níveis competitivos pode dever-se ao baixo nível competitivo da amostra. A investigação futura deve incluir diferentes níveis competitivos, tais como elite, subelite e recreativo.

Palavras-chave: força, condicionamento, avaliação, velocidade, futebol, futsal.

ABSTRACT

Background: Sprint running is a key factor of performance for team sports as football and futsal. Force-power-velocity relationships and mechanical effectiveness have been recently used to analyse force-velocity (F-V) profiles. The aim of this study was two-fold: (1) to quantify the sprint mechanical F-V profiles in Portuguese football and futsal players; (2) to analyse differences among sexes, competitive levels and sports on sprint mechanical variables in Portuguese football and futsal players.

Methods: Four football players (2 mens) and four futsal players (2 mens), aged 26 ± 4.24 years, performed a 3 maximal sprints of 30 m from a standing position with 4 min of rest between successive sprints. Video data was collected with a Go Pro Hero (Full HD 1080p, 30 fps). Force-velocity profile was obtained with time motion data: F_0 (N/kg), V_0 (m/s), P_{max} (W/kg), Sfv, RF_{max} (%), DRF (%), V_{opt} (m/s) and max speed (m/s).

Results: Men's players showed a higher V_0 (*t* = - 7.12; *p* < 0.001, d = 5.04), V_{opt} (t = - 2.90; *p* ≤ 0.05, d = 2.05) and max speed (*t* = - 5.09; *p* ≤ 0.05, d = 3.60) than women players. No differences with statistical significance were observed among competitive levels and sports.

Conclusion: These results showed that the sprint mechanical F-V profiles is able to distinguish between men and women football and futsal players. No differences among competitive levels could be due to the low competitive level of the sample. Future research should include different competitive level such as elite, sub-elite and recreational.

Keywords: Strength, conditioning, assessment, speed, football, futsal.

INTRODUCTION

Sprint running is a key performance factor for many sport activities, notably in invasion team sports as football and futsal (Sweeting et al., 2017; Taylor et al., 2017). Both football codes can be characterized by intermittence within high demanding movements and rest periods with low intensity (Bangsbo, 1994; Stølen et al., 2005). Straight sprint and vertical jumps have reported as the two most frequent actions in football and futsal competitive matches (Agras et al., 2016; Faude et al., 2012). Consequently, force-power-velocity relationships and mechanical effectiveness of force application have been recently used to analyse power-force-velocity profiles in sprint running (Morin et al., 2011; Morin & Samozino, 2015; Samozino et al., 2016). In this sense, Samozino et al. (2016) have proposed a straightforward method, convenient for field settings, to determine theoretical maximal velocity (V_0), theoretical horizontal force (F_0), horizontal power (Pmax) and force-velocity profile (i.e., the slope of the force-velocity relationship; Sfv). Ratio of force (RF_{max}) and index of force application technique (DRF) can also be calculated from the Samozino' method.

The importance of power-force-velocity profiles in football codes were supported in previous studies (Manson et al., 2021; Marcote-Pequeño et al., 2018; Simperingham et al., 2016; Sweeting et al., 2017). Specifically, in football and futsal have been showing differences in force-velocity-power variables on sprint and jump performance (Devismes et al., 2019; Jiménez-Reyes et al., 2019; Manson et al., 2021; Marcote-Pequeño et al., 2018). Upon that, an influence has been reported amongst sprint mechanical and F-V profiles, according to sex, competitive levels and various sports (Jiménez-Reyes et al., 2018, 2019). It is suggested that trained futsal players have a higher F0 and lower V0 than football players. Pmax, Sfv and DRF is similar for both sports (Jiménez-Reyes et al., 2019; Marcote-Pequeño et al., 2018). Additionally, men and high-level players presented an overall enhanced F-V profile compared to women and their lower-level counterparts, respectively. As well as know, there are no studies comparing the F-V profiles in Portuguese football and futsal players. Thus, it is crucial to explore the magnitude of the differences amongst Portuguese population in the F-V profile between sexes, competitive levels and sports.

The aim of this study was two-fold: (1) to quantify the sprint mechanical F-V profile in Portuguese football and futsal players; (2) to analyse differences among sexes, competitive levels and sports on sprint mechanical variables in Portuguese football and futsal players. Based on previously published evidence, it was hypothesized that men presented higher values of F_0, V_0, P_{max}, DRF and RF_{max} than women. High-level players revealed larger values of F_0, V_0, P_{max} and RF_{max} than their low level counterparts. Futsal players have a higher F_0 and lower V_0 than football players. P_{max}, Sfv and DRF is similar for players of both sports.

MATERIAL AND METHODS

2.1. Participants and design

Eighth football and futsal players were analysed (4 men and 4 women) from amateur's and semi-professional levels. Only players without health problems or musculoskeletal injuries during the three months preceding data collection were included in the current research. The study was conducted according to the guidelines of the Declaration of Helsinki. Informed consent was obtained from all subjects involved in the current investigation. Table 1 presented the means for all baseline characteristics according to sex, competitive level and sports.

Table 1 – Baseline characteristics of the sample

Variables	Women (n=4)		Men (n=4)	
	Football (n=2)	Futsal (n=2)	Football (n=2)	Futsal (n=2)
Age (years)	26 ± 1.41	24 ± 1.56	23.64 ± 0.40	23.64 ± 1.23
Heigh (m)	174.01 ± 1.41	168.09 ± 1.56	186.35 ± 2.60	182.09 ± 1.68
Weight (kg)	68.01 ± 1.65	71.02 ± 1.43	82.02 ± 1.32	78.43 ± 2.15
Experience (years)	6.6 ± 1.65	8.8 ± 1.70	10.6 ± 1.65	8.9 ± 0.21

2.2. Data collection and procedure

Participants performed a 10-minutes (min) warm-up consisting of 5 min of jogging and 5 min of lower limb dynamic stretching. As part of the specific warm-up, subjects performed 3 of 30 meters (m) at 50% effort. After 4 min of rest, participants performed 3 maximal sprints of 30 m from a standing position (semi-tandem stance) with 4 min of rest between successive sprints (Jiménez-Reyes et al., 2018, 2019; Marcote-Pequeño et al., 2018). Video data was collected with a Go Pro Hero Full HD 1080p 30 fps (GoPro, Inc., San Mateo, Calif) attached to a tripod at a height of 1 m, corresponding approximately to the height of subject's centre of mass (Graves et al., 2015). Figure 1 presents the data collection and camera parallax to assess power-force-velocity profiles.

2.3. Variables

Force-velocity profile was obtained with time motion data based on previous researches (Jiménez-Reyes et al., 2018, 2019; Manson et al., 2021; Marcote-Pequeño et al., 2018; Samozino et al., 2016). The dependent and independents variables analysed were: (1) Dependent variables: F_0 (N/kg), V_0 (m/s), P_{max} (W/kg), Sfv, RF_{max} (%), DRF (%), V_{opt} (m/s) and max speed (m/s); (2) Independent variables: age (years), sex (male/female); height (m), weight (kg) and competitive level (years). Dependent variables were obtained using appropriate routines in Microsoft Excel® Spreadsheet (Microsoft Corporation, Redmond, WA, USA) based on Samozino et al.'s equations (Samozino et al. 2015).

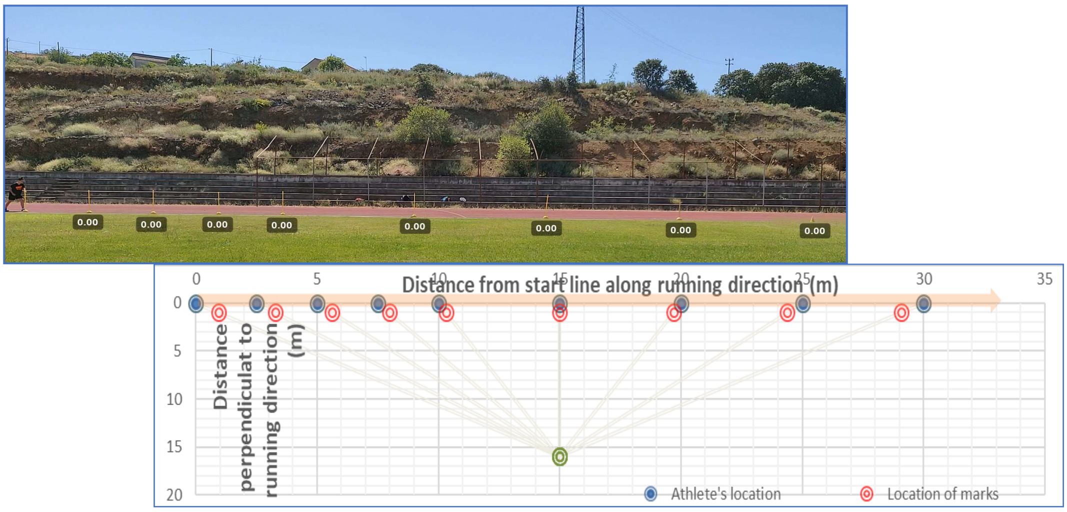

Figure 1 – Data collection and camera parallax to assess power-force-velocity profiles

The calculation accounts for camera parallax was: (i) perpendicular distance from camera to the line of movement (16 m); (ii) separation between marks and line of movement (1 m); and (iii) camera location from the start line in the direction of movement (15 m) (Royer et al., 2019). A good intra- and inter-observer reliability for total sprinting time were obtained (ICC = 0.93).

2.4. Statistical analysis

Standardized effect sizes (ES) were calculated with Cohen's *d*, classified as: negligible (<0.2), small (0.2–0.5), moderate (0.5–0.8), and large (≥0.8) (Ferguson, 2009). A good intra- and inter observer reliability for total sprinting time for all players for one trial were obtained by intra-class correlation coefficient (ICC). Statistical significance was set at $p < 0.05$. Data were analysed using SPSS for Windows Version 22.0 (SPSS Inc., Chicago, IL, USA). All statistical analysis was conducted using SPSS for Windows Version 22.0, IBM SPSS AMOS 23.0 (SPSS Inc., Chicago, IL, USA) and JASP software (JASP Team, 2019; jasp-stats.org).

RESULTS

Descriptive statistics for mean sprint mechanical F-V profile are presented in table 2 according to sexes, competitive levels and sports.

Table 2 - Descriptive statistics for mean sprint mechanical F-V profile according to sex competitive levels and sports.

Variables	Women (n=4)				Men (n=4)			
	Football (n=2)		Futsal (n=2)		Football (n=2)		Futsal (n=2)	
	Amateur (n=1)	Professional (n=1)	Amateur (n=1)	Professional (n=1)	Amateur (n=1)	Professional (n=1)	Amateur (n=1)	Professional (n=1)
F_0 (N/kg)	12.92 ± 1.15	14.64 ± 2.32	9.41 ± 1.52	9.94 ± 0.18	10.33 ±	11.02 ± 4.18	11.62 ± 0.25	12.38 ± 2.59
V_0 (m/s)	6.43 ± 0.06	7.43 ± 0.03	6.24 ± 0.07	6.92 ± 0.08	7.93 ±	8.26 ± 0.43	8.29 ± 0.08	8.33 ± 0.49
P_{max} (W/kg)	20.49 ± 1.95	28.29 ± 3.66	14.68 ± 2.27	17.19 ± 0.36	20.03 ±	22.31 ± 7.22	24.05 ± 0.77	25.65 ± 3.65
FVSlope	-2.00 ± 0.16	-1.90 ± 0.33	-1.53 ± 0.24	-1.43 ± 0.05	-1.30 ±	-1.37 ± 0.60	-1.43 ± 0.00	-1.50 ± 0.41
RF_{max} (%)	42.33 ± 1.41	28.49 ± 1.89	40.33 ± 1.70	43.67 ± 0.47	43.67 ±	46.33 ± 2.49	49.67 ± 0.47	50.33 ± 0.82
DRF (%)	-19.58 ± 1.57	-17.96 ± 3.51	-14.45 ± 2.40	-13.57 ± 0.33	-12.35 ±	-12.66 ± 5.48	-12.92 ± 0.11	-13.78 ± 4.02
Vopt (m/s)	3.16 ± 0.03	3.71 ± 0.01	3.12 ± 0.03	3.46 ± 0.05	3.93 ±	4.13 ± 0.21	4.14 ± 0.04	4.16 ± 0.25
Max speed (m/s)	6.28 ± 0.04	7.27 ± 0.06	6.12 ± 0.05	6.75 ± 0.08	7.48 ±	7.92 ± 0.27	8.05 ± 0.08	8.12 ± 0.39

*Correlation is significant at the 0.05 level (2-tailed) **Correlation is significant at the 0.01 level (2-tailed). Abbreviations: Δ – Mean difference; Cohen *d* – Cohen difference; DRF – index of force application technique; F_0 – theoretical horizontal force; P_{max} – horizontal power; RF – ratio of force; Sfv – slope of the force-velocity relationship; *t* – *t* test; V_0 – theoretical maximal velocity; Vopt – optimal velocity.

Men's players showed a higher V_0 (t = - 7.12; p < 0.001, d = - 5.04), V*opt* (t = - 2.90; p ≤ 0.05, d = - 2.05) and max speed (t = - 5.09; p ≤ 0.05, d = - 3.60) than women players. No differences with statistical significance were observed among competitive levels and sports (p ≥ 0.05). Table 3 presented the comparison mean differences among sexes using independent sample t-test.

Table 3 - Independent sample t-test for mean differences among sexes.

Variables	Woman (n=4)	Men (n=4)	Total (n=8)	*t*	Δ	*Cohen's d*
F_0 (N/kg)	11.84 ± 2.63	11.33 ± 0.82	11.59 ± 1.59	0.37	0.51	0.26
V_0 (m/s)	6.65 ± 0.37	8.08 ± 0.16	7.37 ± 0.81	-7.12**	-1.43	-5.04
Pmax (W/kg)	20.09 ± 5.78	22.92 ± 2.44	21.51 ± 4.38	-0.90	-2.83	-0.64
FVSlope	-1.74± 0.39	-1.34 ± 0.47	-1.54 ± 0.42	-1.43	-0.40	-1.01
RFmax (%)	38.50 ± 7.13	47.58 ± 3.18	43.04 ± 7.05	-2.33	-9.08	-1.65
DRF (%)	-16.50 ± 3.00	-13.00 ± 0.82	-14.75 ± 3.63	-2.25	-3.50	-1.59
Vopt (m/s)	3.28 ± 0.48	3.98 ± 0.03	3.63 ± 0.49	-2.90*	-0.70	-2.05
Max speed (m/s)	6.47 ± 0.48	7.85 ± 2.25	7.16 ± 0.82	-5.09*	-1.39	-3.60

*Correlation is significant at the 0.05 level (2-tailed) **Correlation is significant at the 0.01 level (2-tailed). Abbreviations: Δ – Mean difference; Cohen *d* – Cohen difference; DRF – index of force application technique; F_0 – theoretical horizontal force; P_{max} – horizontal power; RF – ratio of force; Sfv – slope of the force-velocity relationship; *t* – *t* test; V_0 – theoretical maximal velocity; Vopt – optimal velocity.

Figure 2 presented the significantly mean difference between both sexes for each mechanical sprinting measures. Mean differences between competitive levels and sports are not represented due to insignificance differences.

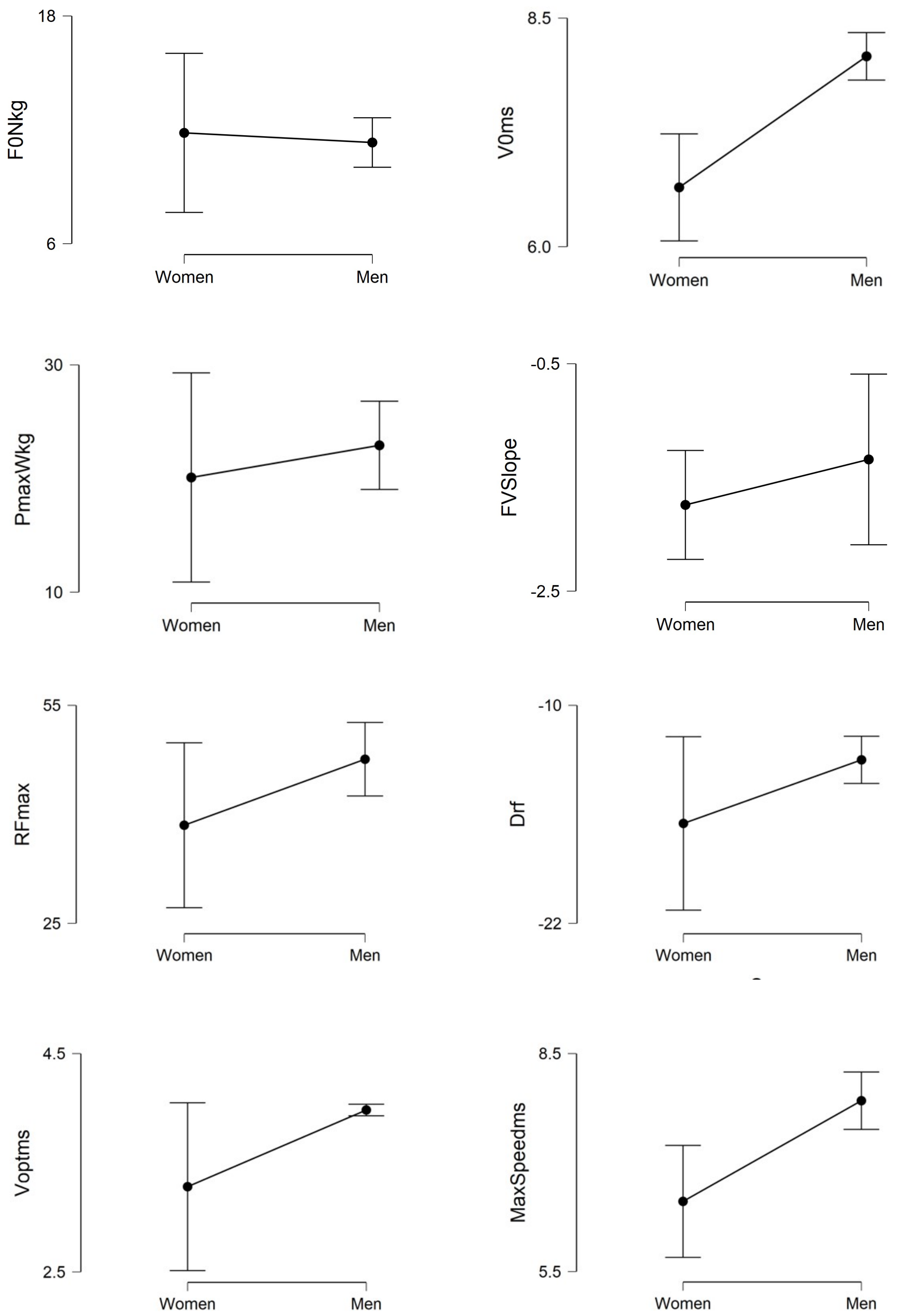

Figure 2 – Mean difference between both sexes for each mechanical sprinting measures. *Abbreviations*: DRF – index of force application technique; F_0 – theoretical horizontal force; P_{max} – horizontal power; RF – ratio of force; Sfv – Slope of the force-velocity relationship; V_0 – theoretical maximal velocity; Vopt – optimal velocity.

DISCUSSION

The present study findings supported that sprint mechanical F-V profile is able to distinguish between men and women, as well amongst soccer and futsal players. Complementary comparison between sex, competitive levels and sports revealed that the sprint mechanical F-V profile (i.e., F_0, V_0, P_{max}, DRF and RF_{max}) was generally higher for men (compared to women) and for players competing at higher levels of practice (compared to their lower-level counterparts) (Morin et al., 2011; Morin & Samozino, 2015; Samozino et al., 2016). Nonetheless, very large correlations between F-V and jumping/sprinting performance variables has been described in both sexes in previous studies (Jiménez-Reyes et al., 2018, 2019; Marcote-Pequeño et al., 2018; Morin & Samozino, 2015; Simperingham et al., 2016). Study data does not confirm these differences in the sprint mechanical F-V profile among competitive level and sports. Higher F_0 and lower V_0 of futsal players could be caused by the specific game's demand (larger number of accelerations but of shorter distances compared to soccer). Jiménez-Reyes et al. (2019) reported differential F-V profiles between football and futsal players. The authors observed a higher F_0 and lower V_0 on futsal players as result of the larger number of accelerations and shorter distances covered in futsal comparting soccer. Likewise, Jiménez-Reyes et al. (2018) showed that a decrease in the magnitude of the correlations for higher-level athletes.

Thus, the research hypotheses were partially confirmed, however some limitations of the study should be taken into consideration due to the exploratory nature of this pilot experimental design. Sample size was rather small, which reduces the understanding about competitive levels and sports specific features. Also, future researches should include different competitive level such as elite, sub-elite and recreational, considering the significant differences present in these sub-tiers (Teixeira et al., 2021b). Additionally, mainly studies must be focused on the adjustment thresholds for elite and sub-elite football players (Ade et al., 2014; Akubat et al., 2012; Castagna et al., 2010; Osgnach et al., 2010). Indeed, speed and acceleration thresholds have been commonly determined by physical and on-field tests, nonetheless a limited research exists on the classification high-intensity data in female and youth environments (Sweeting et al., 2017; Teixeira et al., 2021a). Pacing strategies and recovery times should also be considered to obtain an F-V profile with greater reliability and transfers to the demands of the game in more ecological contexts (Branquinho et al., 2020, 2021; Ferraz et al., 2017, 2018). F-V profiles are also dependent on the level of strength and neuromuscular fatigue, so these variables should be assessed in future studies (Branquinho et al., 2020; Ferraz et al., 2012; Forte et al., 2017, 2021; Teixeira et al., 2021d). Study F-V profiles variations across different teams, competitions and season phases are another important research-practice gap for further researches (Teixeira et al., 2021a). Match-related contextual factors should also be monitored to assess their influence on variations in F-V profiles variations over time (Teixeira et al., 2021d).

CONCLUSIONS

Sprint mechanical F-V profile as a sensitive method of assessing the capacities of the neuromuscular system to produce maximal levels of force, velocity, and power as well as the mechanical effectiveness in force application (assessed by DRF and RF_{max}) during sprint running. These results showed that the sprint mechanical F-V profile is able to distinguish between men and women soccer and futsal players. No differences among competitive levels could be due to the low competitive level of the sample. Future research should include different competitive level such as elite, sub-elite and recreational.

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