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Section IV – Behavioural Sciences in Sport & Sport for the Disabled

Assessing the Sprint Force-Velocity Profile in International Football Players with Cerebral Palsy: Validity, Reliability and Sport Class' Profiles

by

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This study assessed and described the Sprint Force-velocity (SFv) profile, and its validity and reliability in international cerebral palsy (CP) football players. Twenty international male CP football players (age: 26.9±7.4) performed a 30-m sprint, a vertical jump (CMJ), a change of direction (MAT), a dribbling and an intermittent endurance (Yo-YoIR1) test. The SFv profile and physical performance variables were shown according to the players' sport class with the estimation of the effect sizes between classes. The SFv showed high reliability (ICC=0.77 to 0.99; SEM=0.89 to 8.66%). Validity for the SFv was provided by its positive correlation with the players' sport class (r=0.53 to 0.75; p=.02 to <.01) and the rest of the physical performance tests (r=0.45 to 0.99; p=.04 to <.01). The RF_{max} was the main SFv profile variable that explained players' performance in the rest of the tests (β=0.77 to 1.0; p<.05; R^2=0.59 to 0.99). The SFv profile seems to be an efficient test to assess international CP football players' physical performance. This provides information about the players' individual sprint mechanical characteristics and their sprint strengths and weaknesses, allowing coaches and conditioning trainers to individualize their training interventions to optimize sprint performance.

Key words: *CP football, para-sports, physical performance, disability.*

Introduction

Cerebral palsy (CP) football is a 7-a-side football modality played by people with CP or acquired brain injury with a minimum impairment of hypertonia, athetosis or ataxia (International Federation of Cerebral Palsy Football Classification Rulebook). It is played on a 70 x 50 m pitch during two halves of 30-min, and the rest of rules and adaptations are established by the International Federation of Cerebral Palsy Football (IFCPF). Eligible players for CP football are classified into three sport classes according to the severity of their impairment (FT1: severe profile, FT2: moderate profile, and FT3: mild profile).

As in conventional football, CP football is an intermittent sport with high anaerobic metabolism requirements alternated with recovery actions performed at low intensities (Yanci et al., 2016). A high performance in CP football is characterized by short high-intensity actions such as accelerations, linear sprints or jumps, among others, which are frequently the decisive actions in a match (Faude et al., 2012). In the last years, there has been an increase of research about the physical performance characteristics in CP football (Daniel et al., 2020; Peña-González et al., 2020; Reina et al., 2020; Tufekcioglu 2020). The linear sprint (Pastor et al., 2019), the vertical jump (Reina et al., 2018), change of direction (Reina et al., 2016) and dribbling (Reina et al., 2017), are the most commonly assessed abilities to evaluate physical performance in CP football. According to Yanci et

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al. (2019), CP football players cover an average of 186 m per sprint, while the number of medium and high-intensity accelerations is on average 66 and 4.5, respectively, in those players who play a minimum of 40-min. In addition, some studies have shown the importance of sprint and acceleration performance in CP football players' evaluation, for example, to discriminate between national and international football players (Peña-González et al., 2021). Under this perspective, sprint performance seems to be a discriminant factor to succeed in CP football and it has become a crucial ability to improve by coaches and conditioning trainers in their training programs.

Although the traditional assessment of sprint ability has been carried out by recording the time taken to run a given distance (i.e., 30-m sprint) (Jiménez-Reyes et al., 2020), there is an increasing interest in evaluating the players' force-velocity (Fv) profile to obtain more specific data about players' capability to produce horizontal force during the sprint (Marcote-Pequeño et al., 2019; Samozino et al., 2016). This assessment is based on the inverse and linear relationship between force and velocity (Samozino et al., 2016). The sprint Fv (SFv) profile assessment allows coaches and conditioning trainers to obtain information about the specific components of sprint performance, being able to implement a more specific and individualized training program to improve sprint performance (Morin and Samozino, 2016). The specific characteristics that influence sprint performance are the theoretical maximal capability of a player to produce horizontal force (F_0) and velocity (V_0), the associated maximal power output (P_{max}), the slope of the Fv relationship (Fv_{slope}), the theoretical maximal effectiveness of horizontal force application (RF_{max}), the players' capability to maintain the inevitable decrease in horizontal force production when the velocity increases (D_{RF}) and the maximal speed reached (V_{max}) (Morin and Samozino, 2016). With this information, coaches and conditioning trainers could analyse the players' specific components of the SFv profiles. It could be useful to determine the players' strengths and weaknesses in sprint performance and to individualize their training programs to be more effective and efficient in the conditioning of players (Morin and Samozino, 2016).

The SFv profile has been reported and characterized with regular football players in several studies (Jiménez-Reyes et al., 2020; Marcote-Pequeño et al., 2019; Mendiguchia et al., 2014). This literature from regular football has reported the correlation between the variables of the SFv profile and other physical performance determinants in football (jumping and sprinting abilities) (Marcote-Pequeño et al., 2019). Moreover, recent research has studied the usefulness of the SFv profile assessment to detect the possible decrease in players' physical performance at the end of the season (Jiménez-Reyes et al., 2020) and to control the "return-to-play" after a hamstring injury (Mendiguchia et al., 2014). However, the SFv profile has been not characterized in CP football, in which the players' disability has an impact mainly on their force production (Cans, 2000). As the main tests used to evaluate physical performance in CP football assess the players' ability to produce high levels of force in a reduced time (force-velocity relationship), the possible correlations between the SFv profile and the rest of physical performance tests could help coaches use a unique test to measure their players' physical performance efficiently. Under this perspective, the assessment of the SFv profile may shed some light on CP football players' sprint characteristics and may help coaches and conditioning trainers detect the specific features (i.e., initial horizontal force or power application in the acceleration phase or the maintenance of the force/power application at high velocities) to improve throughout the training process. Thus, the aims of the present study were to assess and describe the SFv profile in international football players with CP, to report the reliability of this test in this population and to show the relationship between the players' SFv profile and their physical performance in the linear sprint, the vertical jump, change of direction ability, dribbling ability and specific endurance.

Methods

Participants

Twenty male international football players (age: 26.9±7.4 years, body mass: 67.0±9.1 kg, body height: 1.74±0.07 cm, BMI: 22.0±2.1 kg·m^2) with CP (Bilateral Spasticity=5; Athetosis/Ataxia=3; Unilateral Spasticity=12) from the Spanish National Team (world ranked

12th of 84 national teams) participated in the study. All players were federated in the Spanish Sports Federation of People with Cerebral Palsy and were free of injury at the moment of the assessment. Each participant was informed about the study procedures and they signed an informed consent form according to the Declaration of Helsinki (2013). The protocol of this study was approved by the ethics committee of the hosting institution.

Measures

For anthropometrical measurements, players' body mass and height were assessed with a digital Body Composition Monitor (Tanita Bc 601 Ltd., India) and with a fixed stadiometer (SECA Ltd., Germany), respectively. The body mass index (BMI) was calculated as *body mass (kg) / (height (m))*^{2}. For the vertical jump assessment, players performed a "free" countermovement jump (CMJ) (Globus Ergotester®, Italia). Since most players were affected in their upper limbs by their disability, they were allowed to perform the CMJ without placing their hands on the hips. A 30-m sprint test with electronic timing and photocells (Witty System, Microgate, Bolzano, Italy) set every 5-m was used to assess the players' time in 30-m linear sprint performance and the players' Fv profile. The variables derived from the SFv profile (F_0, V_0, P_{max}, Fv_{slope}, RF_{max}, D_{RF} and V_{max}) were calculated according to Samozino et al. (2016) with the use of their specific spreadsheet (Samozino et al., 2016). Time in the modified agility test (MAT) (Sassi et al., 2009) was used to assess the players' change of direction ability. For measuring dribbling ability, players performed the MAT protocol while dribbling the ball. The specific procedures used for the MAT and the dribbling test were obtained from Peña-González et al. (2021). Finally, a Yo-Yo IR1 (Bangsbo et al., 2008) test (which is more specific for football) was used to assess players' intermittent endurance.

Design and Procedures

A cross-sectional study was designed to assess and compare the SFv profile (F_0, V_0, P_{max}, Fv_{slope}, RF_{max}, D_{RF} and V_{max}) and other football-specific physical performance characteristics (vertical jump, linear sprint, change of direction ability, specific endurance and dribbling ability) in international football players with CP. All tests were performed on the same day, in the same order, under the same conditions and at least 48h after players' last training session. The evaluation was performed in a competitive period and all players were familiarized with each test (they had been evaluated with the same tests periodically during the previous year).

After the physical performance tests, players performed a standardized warm-up consisting of 5-min jogging, 3-min dynamic stretching and 3-min high intensity activities including short accelerations, changes of direction and different jumps. Players carried out two attempts of the CMJ with a 2-min rest interval between the subsequent attempts and the best result obtained was recorded for further analysis. The rest of physical tests were performed on a synthetic grass pitch and players wore their usual football boots. Each player performed two attempts of the 30-m sprint test, the MAT and the dribbling test, and the best result of each test was recorded for each player. Players were verbally encouraged throughout the tests and asked to perform at their maximal effort.

Statistical Analyses

Data normality was assessed by a Shapiro-Wilk test. The intraclass correlation coefficient (ICC) and the standard error of measurement (SEM) were used to report the SFv profile relative and the absolute reliability, respectively, among trials. ICC values were considered as poor to moderate (<0.75), good (0.75 to 0.90) and excellent (>0.90) (Portney and Watkins, 2009). The SEM was shown in percentages and it was calculated as: SEM%=(SEM/mean)×100. The standardized differences or effect sizes (ES) at 95%CI between sport classes were expressed in Cohen's *d* units and they were interpreted as trivial (<0.19), small (0.20–0.49), moderate (0.50–0.79) and large (> 0.80) (Cohen, 1992). Pearson's correlation coefficients (*r*) were calculated to show the relationship between the SFv profile variables and the players' sport class, body mass, body height, BMI, as well as 30-m sprint, CMJ, MAT, dribbling test and Yo-Yo IR1 performance. Pearson's correlation coefficients were interpreted as trivial (*r*<0.09), small (*r*=0.10–0.29), moderate (*r*=0.30–0.49), high (*r*=0.50–0.69), very high (*r*=0.70–0.89) and almost perfect (*r*>0.90) (Hopkins et al., 2009). A stepwise regression analysis, in which all variables from the SFv profile were introduced as possible predictors, was carried out. The stepwise regression analysis showed, without collinearity biases, the best SFv variables that predicted each physical performance test. All calculations were performed using Microsoft Excel (Microsoft, Seattle, Washington, USA) and SPSS Statistics® (Statistical Package for the Social Sciences, Version 27.0), and the level of significance was set at $p<.05$.

Results

SFv profile reliability

The estimated measure of the theoretical players' maximal capability to produce horizontal force and velocity (F_0 and V_0) presented good to excellent reliability (ICC=0.79 and 0.96; SEM=7.68 and 2.37%, respectively). RF_{max} and V_{max} presented excellent reliability values (ICC=0.99 and 0.97; SEM=0.89 and 1.94%, respectively), while the rest of the SFv profile variables (P_{max}, Fv_{slope}, and D_{RF}) presented good reliability values (ICC=0.88, 0.77 and 0.77; SEM=6.89, 8.67 and 8.88%, respectively).

Relationship between SFv profile and physical performance

Descriptive data (mean ± standard deviation) for each sport class and the total sample, including the SFv profile and the rest of physical performance variables are shown in Table 1. In addition, although it was not possible to perform statistical analyses in each sport class due to the small sample size, the ES was presented in Table 2, to show the standardized differences among sport classes.

Table 1

Descriptive data for the Sprint Fv profile and other physical performance variables according to the sport class and the total sample.

	FT1		FT2		FT3		Total sample	
	M	SD	M	SD	M	SD	M	SD
Sprint Fv profile								
F_0 (N·kg^{-1})	10.23	2.13	13.58	1.71	14.77	1.47	12.86	2.34
V_0 (m·s^{-1})	5.96	0.30	7.43	0.35	7.34	0.03	7.05	0.72
P_{max} (W·kg^{-1})	15.36	3.90	25.24	3.64	27.12	2.80	22.95	5.70
FV_{Slope} (N·s·m^{-1}·kg^{-1})	-1.71	0.29	-1.83	0.22	-2.01	0.19	-1.82	0.24
RF_{max} (%)	39.45	2.46	47.60	1.64	47.52	0.12	45.56	4.01
D_{RF} (%)	-16.40	2.68	-17.05	2.11	-18.76	1.80	-17.06	2.22
V_{max} (m·s^{-1})	5.85	0.31	7.27	0.34	7.20	0.04	6.91	0.69
Physical performance variables								
30-m sprint (s)	5.71	0.35	4.65	0.20	4.65	0.06	4.92	0.52
CMJ (cm)	24.58	5.13	34.19	4.17	35.30	11.46	31.64	6.68
MAT (s)	7.49	0.41	6.14	0.34	5.76	0.13	6.44	0.72
Dribbling (s)	14.20	4.52	9.40	1.06	8.21	0.53	10.48	3.16
Yo-Yo IR1 (m)	344.00	125.22	1073.85	209.66	1540.00	28.28	938.00	418.01

M: mean; SD: standard deviation; F_0: theoretical maximal force production; V_0: theoretical maximal running velocity; P_{max}: theoretical maximal mechanical power in the horizontal direction; FV_{Slope}: force-velocity slope; RF_{max}: maximal value of the ratio of horizontal force; D_{RF}: decrease in the ratio of horizontal force; V_{max}: maximal velocity; CMJ: countermovement jump; MAT: modified agility test.

Table 2

Effect sizes (95%CI) for the Sprint Fv profile and the rest of physical performance variables between the different sport classes.

	FT1 vs. FT2	FT1 vs. FT3	FT2 vs. FT3
Sprint Fv profile			
F_0	-1.75(-2.93;-0.57)	-1.89(-3.81;0.02)	-0.66(-2.17;0.85)
V_0	-4.14(-5.84;-2.44)	-4.32(-7.11;-1.52)	0.25(-1.24;1.74)
P_{max}	-2.54(-3.86;-1.21)	-2.67(-4.82;-0.51)	-0.49(-1.99;1.01)
FV_{Slope}	0.48(-0.57;1.52)	0.92(-0.79;2.63)	0.78(-0.74;2.29)
RF_{max}	-4.13(-5.83;-2.43)	-3.08(-5.38;-0.78)	0.05(-1.44;1.54)
D_{RF}	0.27(-0.76;1.31)	0.78(-0.91;2.48)	0.77(-0.74;2.28)
V_{max}	-4.06(-5.74;-2.38)	-4.09(-6.78;-1.39)	0.20(-1.29;1.69)
Physical performance variables			
30-m sprint	4.10(2.41;5.79)	2.84(0.62;5.05)	0.00(-1.49;1.49)
CMJ	-2.07(-3.30;-0.83)	-1.31(-3.09;0.47)	-0.20(-1.69;1.29)
MAT	3.58(2.02;5.14)	3.92(1.29;6.54)	1.09(-0.45;2.63)
Dribbling	1.87(0.67;3.07)	1.24(-0.52;3.01)	1.08(-0.45;2.63)
Yo-Yo IR1	-3.62(-5.19;-2.05)	-8.92(-13.87;-3.97)	-2.18(-3.86;-0.50)

F_0: theoretical maximal force production; V_0: theoretical maximal running velocity; P_{max}: theoretical maximal mechanical power in the horizontal direction; FV_{Slope}: force-velocity slope; RF_{max}: maximal value of the ratio of horizontal force; D_{RF}: decrease in the ratio of horizontal force; V_{max}: maximal velocity; CMJ: countermovement jump; MAT: modified agility test.

Table 3

Pearson's correlation analysis (r [p]) between Sprint Fv variables and the players' sport class, anthropometrics and physical performance.

	Sport Class	Height	Body mass	BMI	30-m sprint	CMJ	MAT	Dribbling test	Yo-Yo IR1
F_0	0.53*(.023)	0.30(.202)	0.05(.822)	-0.16(.493)	-0.83**(<.001)	0.53*(.023)	-0.80**(<.001)	-0.69**(.001)	0.71**(<.001)
V_0	0.73**(<.001)	0.31(.186)	-0.02(.924)	-0.27(.255)	-0.98**(<.001)	0.77**(<.001)	-0.84**(<.001)	-0.70**(.001)	0.83**(<.001)
P_{max}	0.63**(.003)	0.30(.195)	0.02(.936)	-0.21(.377)	-0.93**(<.001)	0.64**(.004)	-0.86**(<.001)	-0.71**(<.001)	0.80**(<.001)
FV_{Slope}	-0.21(.383)	-0.22(.357)	-0.12(.625)	0.02(.922)	0.45*(.049)	-0.21(.393)	0.49*(.027)	0.49*(.027)	-0.38(.099)
RF_{max}	0.75**(<.001)	0.32(.170)	-0.04(.867)	-0.30(.194)	-0.99**(<.001)	0.76**(<.001)	-0.89**(<.001)	-0.78**(<.001)	0.85**(<.001)
D_{RF}	-0.13(.585)	-0.20(.406)	-0.13(.575)	-0.02(.951)	0.35(.129)	-0.14(.572)	0.41(.072)	0.432(.057)	-0.30(.203)
V_{max}	0.74**(<.001)	0.31(.178)	-0.02(.951)	-0.26(.267)	-0.98**(<.001)	0.77**(<.001)	-0.85**(<.001)	-0.70**(.001)	0.84**(<.001)

F_0*: theoretical maximal force production; V_0: theoretical maximal running velocity; P_{max}: theoretical maximal mechanical power in the horizontal direction; FV_{Slope}: force-velocity slope; RF_{max}: maximal value of the ratio of horizontal force; D_{RF}: decrease in the ratio of horizontal force; V_{max}: maximal velocity; CMJ: countermovement jump; MAT: modified agility test.*
**p<.05; **p<.01*

Table 4

Regression analysis models for each physical performance variable.

Physical performance test	Sprint Fv profile variable (predictor)	Model 1			Model 2		
		B	SEB	β	B	SEB	β
30-m sprint	RF_{max}	-0.13	<0.01	-1.0**	-0.11	0.01	-0.85**
	P_{max}				-0.02	<0.01	-0.17**
	R^2	0.991			0.997		
CMJ	V_{max}	7.51	1.57	0.77**			
	R^2	0.590					
MAT	RF_{max}	-0.16	0.02	-0.88**			
	R^2	0.781					
Dribbling	RF_{max}	-0.63	0.13	-0.77**	-3.0	0.64	-3.64**
	V_{max}				13.92	3.71	2.91**
	R^2	0.586			0.787		
Yo-Yo IR1	RF_{max}	95.42	13.84	0.87**			
	R^2	0.748					

P_{max}: theoretical maximal mechanical power in the horizontal direction; RF_{max}: maximal value of the ratio of horizontal force; V_{max}: maximal velocity; CMJ: countermovement jump; MAT: modified agility test.
**p<.05; **p<.01;*

Pearson's correlation analysis showed positive high and very high correlations between the SFv profile and the players' sport class (*r*=0.53–0.75, and *p*=.023-<.001) except for FV_{slope} and D_{RF} (*r*=-0.21, *p*=.383 and *r*=-0.13, *p*=.585, respectively) (Table 2). The SFv profile showed non-significant trivial to moderate correlations to anthropometric features (players' body mass, height and BMI) (*r*=0.02–0.32, *p*<.05). The SFv profile correlated positively with high to almost perfect values to the rest of physical performance variables (the 30-m sprint, the CMJ, the MAT, the dribbling test and the Yo-Yo IR1), except D_{RF} for all physical performance tests and FV_{Slope} for the CMJ and the Yo-Yo IR1. Linear regression analyses showed that the main factor to predict CP players' physical performance was RF_{max} with great adjustments (R^2=0.59 to 0.99) except for the CMJ. P_{max} and V_{max} were also included in some models of the analyses.

Discussion

The present study aimed to describe the SFv profile in international CP football players and to show its validity by comparing it to the players' performance in linear sprint, vertical jump, change of direction, dribbling and specific endurance tests. To the authors' knowledge, this is the first study that examines the SFv profile in CP football players, and the main findings revealed high positive correlations between SFv variables (F_0, V_0, P_{max}, RF_{max}, and V_{max}) and players' performance in the 30-m sprint, CMJ, MAT, dribbling and Yo-Yo IR1 tests. In addition, RF_{max} seemed to be the main predictor variable from the SFv profile of players' physical performance in the linear sprint, change of direction, dribbling and endurance tests. This study also showed good to excellent reliability for all the variables from the SFv profile (ICCs from 0.77 to 0.99) with low standard error in the measurement (SEMs from 0.86 to 0.89%). These reliability values are similar to those found in previous literature for other physical performance tests in CP football as the modified agility test (ICC=0.82-0.91; SEM=5.84-5.75%) and the dribbling test (ICC=0.85-0.92; SEM=6.30-4.66%) (Peña-González et al., 2020; Reina et al., 2017). These results reveal that the SFv profile is a reliable tool that may be used with CP football players.

CP football, as regular football, is an intermittent team sport in which players' high physical performance is determined by their capability to perform short and high-intensity activities such as sprinting, jumping and changing direction, among others (Stølen et al., 2005). Table 1 shows the SFv profile and other physical performance variables (mean and standard deviation) of international CP football players according to their sport class and for the total sample. As it was expected, these data suggest that CP footballers with lower impairment (i.e., FT3) were able to obtain higher values in the SFv profile variables, linear sprint, vertical jump, change of direction, dribbling and specific endurance tests than players with greater impairment (i.e., FT1). In spite of not including a statistical analysis to show differences between sport classes, main standardized differences can be observed between FT1 and FT2 (Table 2) for all variables and these differences are reduced between FT2 and FT3. Similarly, Peña-González et al. (2020) observed that FT1 players presented statistically lower performance in change of direction and dribbling tests than FT2 and FT3 players, without statistical differences between these last two sport classes. However, such an interpretation from this study should be taken with caution and it is necessary for future research to show whether these differences are significant between sport classes or not.

The Pearson's correlation analysis revealed a positive and significant relationship between the players' sport class and their SFv profile, except for the FV_{slope} and D_{RF} variables. Players with a lower impairment profile (i.e., FT3) seemed to be able to produce higher theoretical maximal horizontal force (F_0), reach higher theoretical maximal velocity (V_0) and higher theoretical maximal power output during the acceleration phase (P_{max}), obtain a higher maximal ratio of horizontal force (RF_{max}) and higher maximal velocity during the sprint (V_{max}) than their peers with higher impairment (i.e., FT1). All these variables from the SFv profile also correlated to the rest of physical performance tests (time during the 30-m sprint, the CMJ, the MAT, the dribbling test and the Yo-Yo IR1). This suggests that players who are able to produce higher levels of F_0, V_0, P_{max}, RF_{max} and V_{max} are also able to reach higher values of sprint, vertical jump, change of direction, dribbling and endurance performance than players with lower values in the SFv variables.

More interestingly, players' performance in the linear sprint, change of direction, dribbling and specific endurance tests may be explained by their effectiveness when applying horizontal force during the acceleration phase. RF_{max} is the direct measurement of the proportion of the total force production which is directed in the forward direction of motion at the beginning of the sprint (Morin and Samozino, 2016). This RF_{max} was the included variable by the stepwise regression analysis to explain players' performance in the 30-m sprint, MAT, dribbling and Yo-Yo IR1 tests. This indicates the importance of the horizontal force application in the acceleration phase in these physical tests as well as in CP football, in which players perform an average of 1.06 moderate (1.0–2.78m·s^{-1}) and 0.07 high (>2.7 m·s^{-1}) accelerations, and between 0.9 and 0.13 high intensity changes of direction per minute in a match (Yanci et al., 2018). In the same way, Jimenez-Reyes et al. (2020) observed that RF_{max} was one of the SFv profile variables that professional football players (without CP) improved during a season, and these changes correlated to 10-m sprint performance. Our results are also in line with Morin and Samozino (2016) who presented an example of two players with similar SFv profiles and identical time in a linear sprint and horizontal power output production, in which RF_{max} and the decrease in this ratio of force application in the horizontal vector (D_{RF}) are two crucial variables for coaches and conditioning trainers, as they provide information about the specific and individual needs of each player (Morin and Samozino, 2016). However, in the present study D_{RF} did not correlate, and it was not a predictor of any physical performance test, suggesting that the initial application of force in the horizontal vector is more important than the decrease in this ratio of force for performance in these tests and performance in a match, given the short distances covered by CP footballers (an average of 12.0-m at between 13.0 and 18.0km·h^{-1}, and 3.27-m at >18.0km·h^{-1}) (Yanci et al., 2018).

The SFv profile seems to be an efficient (easy to carry out and simple for athletes) test to assess international CP football players as it is related to players' physical performance and it provides information about the mechanical characteristics of players in the sprint, showing the players' strengths and weaknesses and allowing coaches and conditioning trainers to individualize the training programs. Nevertheless, this study presents some limitations that should be considered for the interpretation of the results and for future research. The SFv profile has been shown according to the CP football players' sport class, but the low sample size in some classes and the asymmetry in the sample size between sport classes did not allow statistical comparison between groups. In future research, it would be interesting to study the differences in the SFv profile between international CP football players according to their sport class, their impairment profile and their field position.

Sprint performance is one of the most important features in CP football, and players' performance in the linear sprint is commonly assessed by coaches and physical trainers to have information about their players' physical performance. Thus, the SFv profile can be used to test CP football players as it is valid, reliable, easy to carry out and time efficient. The SFv profile provides meaningful information about players' sprint characteristics (e.g., maximal force and power applied to move forward, the ability to maintain this force and power production at high velocities). With this information, it is possible to individualize the players' training program to impact their specific needs, allowing individual responses to training, maximizing improvements and reducing players' weaknesses in sprint performance.

Conclusions

This study describes the Sprint Force-velocity (SFv) profile according to the CP football sport classes. The analysis revealed high reliability for all the SFv profile variables and Pearson's correlation coefficients showed a significant relationship between the SFv profile, the CP football players' sport class and their physical performance in vertical jump, change of direction, dribbling and intermittent endurance tests. In addition, players' maximal ability to produce force in the horizontal vector (RF_{max}) was the main variable from the SFv profile that predicted players' performance in other physical performance tests. These findings could be interesting for CP football practitioners, coaches and physical trainers as they will allow them to assess the strengths and weaknesses in sprint performance and individualize the training stimulus to the optimization of sprint performance.

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