Muscle strength and anaerobic performance in football players with cerebral palsy

Javier Yanci, Ph.D.[a,*], Carlo Castagna, Ph.D.[b], Asier Los Arcos, Ph.D.[a], Alfredo Santalla, Ph.D.[c], Ignacio Grande, Ph.D.[d], Joaquín Figueroa, Ph.D.[e], and Jesús Camara, Ph.D.[a]

[a]*Faculty of Physical Activity and Sports Science, University of the Basque Country, UPV/EHU, Spain*
[b]*Football Training and Biomechanics Laboratory, Italian Football Federation (FIGC), Technical Department, Coverciano, Florence, Italy*
[c]*Faculty of Physical Activity and Sports Science, Pablo de Olavide University, Sevilla, Spain*
[d]*Faculty of Physical Activity and Sports Science, Universidad Politécnica, Madrid, Spain*
[e]*Faculty of Physical Activity and Sports Science, Alfonso X El Sabio University, Madrid, Spain*

Abstract

Background: This is the first study that quantified the anaerobic performance in football players with cerebral palsy (CP).

Objective: This study aimed to examine anaerobic fitness in a population of football players with CP using vertical jumping (VJ) and Wingate tests.

Methods: Twelve players (age 26.8 ± 4.8 yr, body mass 66.2 ± 4.8 kg, height 173.7 ± 6.4 cm, body mass index 22.2 ± 1.9 kg m^{-2}) from the Spanish National Football Team with CP which had 9.4 ± 3.7 years of playing experience performed the VJ and Wingate anaerobic tests.

Results: Vertical jump height was 20.0 ± 1.2 cm for squat jump (HSJ) and 23.9 ± 5.4 cm for countermovement jump (HCMJ). Wingate test peak power (PPOW) was 490.6 ± 125.8 W (7.35 ± 1.53 W kg^{-1}). HCMJ was largely ($r = -0.631$, $p = 0.028$) and very-largely ($r = -0.710$, $p = 0.01$) associated with PPOW (W kg^{-1}) and mean power output (MPOW) (W kg^{-1}), respectively. Squat jump test peak power (W) showed a large association ($r = -0.656$, $p = 0.021$) with MPOW (W and W kg^{-1}). The CMJ height resulted 19.5% higher than SJ.

Conclusions: Results showed low VJ and anaerobic capacity of football players with CP compared to national players without CP and the general population. In football players with CP the difference (19.5%) between VJ with or without countermovement (CMJ-SJ) was higher than reported for national players without CP. Further studies examining the effect of football practice on neuromuscular performance in subjects with CP are warranted.

Keywords: Physical impairment; Muscle function; Vertical jump; Physical performance; Wingate test

Cerebral palsy (CP) is the third most common major developmental disability, after autism and intellectual impairment.[1] Its manifestations are the result of a non-progressive brain lesion, injury, or malformation occurring prenatally or in the first 2 years of life.[1] CP is characterized by a heterogeneous group of neuromotor conditions, involving muscle weakness and disordered movement or posture.[2]

Football is one of the most popular sports among participants with CP, and the number of football players with CP at a competitive level has increased in recent years.[3] Football for people with CP is a 7-a-side game with two 30 min halves; all players must have an International Federation of Cerebral Palsy Football (IFCPF)[3] classification ranging from class (FT) 5 to 8.[4,5] Football players in class FT 5 have a diplegic impairment with athletes in class FT 6 reporting quadriplegic impairment, with moderate to severe athetoid, ataxic, spastic, or mixed involvements. Football players in class FT 7 have hemiplegia, with moderate hyperthonia and, finally, athletes in class FT 8 are minimally impaired and can be monoplegic, hemiplegic, or diplegic, with spasticity, athetosis, or both.[6,7]

Football is considered an intermittent activity; the game takes place over an extended time period and is characterized by numerous short periods of high or maximum intensity exercise, interspersed with brief recovery periods.[8,9] Both aerobic and anaerobic energy systems must be activated to meet the energy demands of the muscles during play.[8,9] Therefore, many studies have reported the need to

* Corresponding author. Faculty of Physical Activity and Sports Science, University of the Basque Country, UPV/EHU, Lasarte 71, 01007 Vitoria-Gasteiz, Spain.

E-mail address: javier.yanci@ehu.es (J. Yanci).

assess both systems to determine the fitness level of elite football players.[9,10] Anaerobic fitness is considered equally as important as aerobic capacity (endurance) in football performance.[11] Indeed during a football match, players perform several dynamic movements (i.e. kicks, sprints, tackling, and jumps), which require high strength and power of the lower limbs.[12] Therefore, measurements of muscle power are usually included in the evaluation of anaerobic fitness in football players.

The Wingate anaerobic test and the vertical jump (VJ) test are most often used to assess anaerobic capacity and power respectively.[13] The Wingate 30 s all-out test is considered as one of the most popular and reliable anaerobic tests.[8,14] It has been used in recreational and elite football[8,15,16] and was validated in children with CP[17] and in individuals with spastic CP.[18] The VJ tests have also been shown to be a suitable tool to determine anaerobic fitness.[19] Indeed VJ tests have been widely used to assess lower-limb power level of football players, either as the only characterization test,[10,20–23] or in combination with the Wingate test.[13,24,25]

Previous studies have described the anaerobic capacity in children, adolescents and adults with CP[17,18,26–28] and in athletes with CP.[6,29] However, despite the importance of anaerobic capacity in elite football performance,[30] and the necessity of knowing the anaerobic capacity of people with CP who practice this sport,[5] we are unaware of any study that assessed the anaerobic capacity of football players with CP. Such information would be useful to describe the anaerobic fitness of football players with CP and for population-specific training prescription. Therefore the aim of the present study was to determine the anaerobic fitness (measured by VJ and Wingate test) of football players with CP, and to examine the relationship between the performance achieved in both tests. As CP is associated with a functional impairment, our work hypothesis was that football players with CP have a lower anaerobic fitness than football players without CP.

Methods

Participants

This study included 12 participants with the Spanish National Football Team with CP (age 26.8 ± 4.8 years, body mass 66.2 ± 4.8 kg, height 173.7 ± 6.4 cm, body mass index 22.2 ± 1.9 kg m^{-2}, 9.4 ± 3.7 years of playing experience). All participating athletes trained 4–5 days per week, and none performed specific strength training. All players had been assigned CPISRA and Spanish Sport Federation classifications for people with CP (Table 1).

Prior to involvement in the investigation, all participants gave their written informed consent, as outlined in the Declaration of Helsinki (2013). The participants had the option to voluntarily withdraw from the study at any time without penalty. The study was approved by the Ethics Committee of the Spanish Sports Federation for people with cerebral palsy.

Table 1
Participants' IFCPF classification and impairment characteristics

Player	CPC	Position	PA	TSST (yr)
P1	5	Goalkeeper	SD	9
P2	6	Goalkeeper	AT	12
P3	6	Defender	AT	2
P4	7	Defender	SH	9
P5	7	Defender	SH	1
P6	7	Defender	SH	5
P7	6	Midfielder	AT	2
P8	7	Midfielder	SH	2
P9	8	Midfielder	SD	4
P10	7	Striker	SH	11
P11	7	Striker	SH	3
P12	8	Striker	SH	7

IFCPF = International Cerebral Palsy Football Federation; CPC = IFCPF classification; PA = predominant affectation; SD = spastic diparesia; SH = spastic hemiplegia; AT = athetosis; TSST = time in the Spanish football team.

Procedure

Anaerobic fitness was considered as a relevant component of football performance with differences related to age, competitive level and fitness.[9] The ability to perform VJ was related to competitive level in professional male and female players.[31,32] Specifically the squat jump (SJ) and countermovement jump (CMJ) have been shown to possess construct-validity in professional football players and to be related to championship ranking.[31,32]

Recently maximal efforts over short exercise-periods (i.e. 30 s) were considered as a relevant component of match performance and training in competitive football.[33,34] This promoted interest in laboratory test like Wingate test (i.e. 30 s) for the evaluation of players' anaerobic capacity.

The tests considered in this study were carried out during the pre-season, while the Spanish National football Team with CP was in preparation for the final phase of the Football 7 World Cup for people with CP. Wingate tests and VJ tests were performed on alternate days. No strenuous exercises were performed during the 48 h immediately prior testing. Two days before the testing sessions, the participants underwent 45 min of test practice to master the VJ and Wingate test procedures. However all players were familiarized with the test procedures used in this study as they were part of test routines used during their previous competitive season.

In this study a descriptive-comparative design was used. Difference between the football players with CP and the reference populations of football players without CP were performed using a systematic revision of the limited literature available. The magnitude of the differences between this study's results and the literature data were assessed using the effect size method according to Cohen.[35]

Performance tests

During SJ, participants were instructed to bend their knees to approximately 90°, and to maintain that posture for 2 s before jumping.[36] For the CMJ, the maximal flexion of the knees during the take-off phase was required to be about 90°.[36] During both jumps, a minimal flexion of the trunk during take-off was permitted. In both jumps, the hands were placed on the hips during the take-off, flight, and landing phases. However players from class FT 7 that could not place either of their hands on the hips, were told to place their arms alongside their body. On the testing day, the participants performed a standardized 10 min warm-up, including jogging, lateral displacements, stretching, and jumping exercises. At the end of this preliminary session, all participants performed both tests correctly. The VJ tests were performed on a force platform (Quattro Jump, Kistler, Zurich, Switzerland) and data were recorded at a sampling frequency of 500 Hz. Each player performed three CMJ and SJ with 30 s of passive recovery between each jump[37] Data analysis was performed considering CMJ and SJ best performance.[10] The VJ considered variables were CMJ and SJ jumping height (HCMJ and HSJ, respectively) and the peak power output during the impulse phase (PPOCMJ and PPOSJ, respectively). The elastic index (EI) was obtained by the following formula EI = [(CMJ − SJ) × 100]/SJ,[38] where the EI is expressed in %, and the CMJ and SJ in cm.[32]

The Wingate test was performed on a mechanically braked cycle ergometer (Monark 828 E, Varberg, Sweden). The test was preceded by a warm-up phase consisting of 5 min of cycling with a constant cadence of 60 revolutions per minute, against a light load of 1 kg.[8] Two unloaded 3 s sprints were performed during the warm-up phase. For those players that had difficulties in pedaling, the cycle ergometer position of the pedals, saddle, and handlebar were adjusted to facilitate their pedaling. Whenever possible, the saddle height was set as described elsewhere.[39] The variables measured from the Wingate test were the peak power output (PPOW),[29] determined as the highest value, and the mean power (MPOW) throughout the 30 s test. The fatigue (F), fatigue index (FI)[29] and total work (W) were obtained as described elsewhere.[14] De Groot et al,[18] in a study with individuals with spastic CP, obtained good ICCs (0.98) and moderate SDDs (24%) values in this test.

Statistical analysis

Data are presented as mean ± standard deviation (SD). All the variables were normally distributed and satisfied equality of variances criteria according to the Shapiro-Wilk and Levene tests respectively. Pearson product-moment correlation coefficients (r) were calculated to determine the relationships among the parameters obtained from the VJ and Wingate tests. The results were interpreted using the magnitude threshold values for Pearson product-moment used by Hopkins[40]: trivial ($r < 0.1$), small ($0.1 < r < 0.3$), moderate ($0.3 < r < 0.5$), large ($0.5 < r < 0.7$), very large ($0.7 < r < 0.9$), nearly perfect ($r > 0.9$) and perfect ($r = 1.0$). Spearman rank-order correlation was computed to calculate the relationship of the players' CP class with the VJ and Wingate test. Statistical significance was set at $p < 0.05$. Magnitude of the differences between this study and the literature data were assessed using the Cohen d. Effect sizes (ES) of above 0.8, between 0.8 and 0.5, between 0.5 and 0.2 and lower than 0.2 were considered as large, moderate, small, and trivial respectively.[35] Data analysis was performed using the Statistical Package for Social Sciences (version 19.0 for Windows, SPSS Inc, Chicago, IL, U.S.A.).

Results

Parameters indicating the anaerobic performance of football players with CP, as measured by VJ and Wingate tests, are detailed in Table 2. The overall performance was markedly lower than that described in previous studies (Table 3). Indeed, the SJ (ES = from 3.6 to 8.86) and CMJ (ES = from 2.25 to 3.83) performance of football players with CP resulted largely lower than that reported for players without CP. Furthermore large difference were found between the players with CP and players without CP for PPOw (ES = 2.87) and MPOw (ES = 4.22).

There was a significant large negative correlation between HCMJ and PPOW (W kg^{-1}) ($r = -0.631$,

Table 2
Vertical jump and Wingate tests values of the study participants

Parameters	Mean	SD (range)
Vertical jump		
H_{SJ} (cm)	20.0	4.3 (14.4−28.1)
PPO_{SJ} (W)	2573.4	435.3 (1941.3−2979.2)
PPO_{SJ} (W kg^{-1})	38.8	5.4 (32.3−47.0)
H_{CMJ} (cm)	23.9	5.4 (17.3−31.9)
PPO_{CMJ} (W)	2835.2	512.5 (2263.1−3146.5)
PPO_{CMJ} (W kg^{-1})	42.8	6.8 (33.7−52.5)
EI (%)	18.9	13.8 (−0.9−55.1)
Wingate test		
PPO_W (W)	490.6	125.7 (339.0−731.0)
PPO_W (W kg^{-1})	7.3	1.5 (5.4−9.9)
MPO_W (W)	399.4	97.6 (269.0−586.0)
MPO_W (W kg^{-1})	6.0	1.3 (4.4−8.5)
FI (W s^{-1})	6.9	3.7 (1.6−12.8)
F (%)	31.8	14.1 (9.3−59.6)
W (J)	11971.7	2902.2 (8065.0−17390.0)
W (J kg^{-1})	177.5	37.4 (130.0−245.0)

SD = standard deviation; H_{SJ} = maximum height of the center of gravity during the flight phase of the squat jump; PPO_{SJ} = peak power output during the squat jump; H_{CMJ} = maximum height of the center of gravity during the flight phase of the countermovement jump; PPO_{CMJ} = peak power output during the counter movement jump; EI = elastic index; PPO_W = peak power output during the Wingate test; MPO_W = mean power output during the Wingate test; FI = fatigue index of the Wingate test; F = fatigue of the Wingate test; W = work during the Wingate test.

Table 3
Vertical jump and Wingate anaerobic tests results in previous studies (football players without CP) and present study (football players with CP)

Study	*N*	Sport	Performance	Age (yr)	H_{SJ} (cm)	PPO_{SJ} (W)	H_{CMJ} (cm)	PPO_{CMJ}	PPO_W (W kg^{-1})	PPO_W (W)	MPO_W (W kg^{-1})	MPO_W (W)
Al-Hazzaa et al, 2001	23	Football	Elite	25.2 ± 2.3	—	—	—	—	11.88 ± 1.3	873.6 ± 141.8	8.02 ± 0.5	587.7 ± 55.4
Chelly et al, 2009	22	Football	Recreational	17 ± 0.3	31.5 ± 4	—	33.8 ± 4	—	—	—	—	—
Davis et al, 1992	135	Football	Elite	24.4 ± 4.6	39.2	—	46.7	—	—	(1037−1273)	—	(841−684)
Magal et al, 2009	12	Football	Elite	20.0 ± 0.9	—	—	—	—	9.23 ± 1.2	—	6.96 ± 0.8	—
McLellan et al, 2011	23	Football	Amateur	23.0 ± 3.9	—	4054 ± 401 W	55.0 ± 1	4774 ± 722 W	—	—	—	—
Meckel et al, 2009	33	Football	Elite	17.4 ± 0.8	—	—	—	—	10.6 ± 0.9	—	8.7 ± 0.4	—
Miller et al, 2011	16	Football	Elite	19.6 ± 0.8	—	—	61.8 ± 7.2	—	10.9 ± 1.2	—	8.9 ± 0.6	—
Nuzzo et al, 2008	12	Football	Elite	19.83 ± 1.4	—	—	56.0 ± 8.0	72.6 ± 9.0 W kg^{-1}	—	—	—	—
Popadic et al, 2009	19	Football	Elite	23.21 ± 3.8	—	—	—	—	9.72 ± 1.3	—	6.78 ± 0.8	—
Ronnestad et al, 2008	21	Football	Elite	23 ± 20	30.3 ± 1.2	—	36.0 ± 0.9	—	—	—	—	—
Siegler et al, 2006	12	Football	Elite	20 ± 1.50	—	—	60.2 ± 5.7	—	11.3 ± 0.5	—	9.2 ± 0.3	—
Present study	12	CP football		26.8 ± 4.8	20.0 ± 1.2	2573 ± 435 W	23.92 ± 5.4	2835 ± 503 W 42.8 ± 6.8 W kg^{-1}	7.35 ± 1.53	490.6 ± 125.8	6.0 ± 1.3	399.41 ± 0.8

H_{SJ} = maximum height of the center of gravity during the flight phase of the squat jump; PPO_{SJ} = peak power during the squat jump; H_{CMJ} = maximum height of the center of gravity during the flight phase of the counter movement jump; PPO_{CMJ} = peak power during the counter movement jump; PPO_W = peak power output during the Wingate test; MPO_W = mean power output during the Wingate test; CP = Cerebral Palsy.

$p = 0.028$). Wingate MPOW (W kg^{-1}) showed significant very-large and large negative correlations with HCMJ (W kg^{-1}) ($r = -0.710$, $p = 0.01$), PPOCMJ (W) ($r = -0.683$, $p = 0.014$) (Table 4).

Finally, significant large relationships were observed between the participant's CP class and PPOW (W) ($r = 0.588$, $p = 0.044$) (Table 5).

Discussion

This is the first descriptive study that has examined anaerobic fitness in male football players with CP. The main finding was the evidence of a remarkably lower performance in the VJ and Wingate tests compared to those previously reported for elite football players without CP. These reported results confirmed this study work hypothesis.

Anaerobic metabolism is considered crucial in determining the outcome of a football match,[41] as it is utilized during sprints, jumps, tackles, and duel plays.[9] Therefore, it is considered essential to characterize the anaerobic fitness of football players. Many studies have reported the anaerobic fitness of football players of different performance levels[9,11,30] and in individuals with spastic CP[18] or Paralympic athletes.[29] The lower anaerobic performance of football players with CP in the present study was reflected in the much (ES > 0.8) lower values of the VJ test results. Indeed, compared to the values determined in the present study, previous studies (Table 3) have shown higher jumping heights during SJ and CMJ in elite football players[13,22–25] as well as for recreational and amateur football players.[20,21] Specifically the values of HSJ (20.0 ± 1.2 cm) and HCMJ (23.9 ± 5.4 cm) for our study participants are well below the range of mean values reported in different studies (HSJ of 31.5−41.5 cm and HCMJ of 33.8−61.8) (Table 3). These study values were ~49% lower than those from the study with the sample most similar to ours in competitive level, age, and anthropometric characteristics.[24] Similarly, the peak power, in both absolute (W) and relative values (W kg^{-1}), during both types of jumps was lower in the present study compared to those previously determined for both amateur[21] and elite football players.[22]

In this study football players with CP showed an EI that was remarkably higher than that recently reported by Castagna and Castellini[32] in male national-level professional football players (19% vs. 8%). The higher ability in taking advantage of the countermovement potential over the static start during SJ may be the result of differences in motor-unit pattern activation or lack of explosive strength in football players with CP.[32] Unfortunately, this study design did not enable a detailed analysis of the neuromuscular aspect of the VJ. Given the interest of the nature of muscle recruitment during VJ for training prescription and functional testing further studies are warranted.[32]

Table 4
Relationship between vertical jump and Wingate tests results

	PPOw (W)	PPOw (W kg^{-1})	MPO_W (W)	MPO (W kg^{-1})	FI (W s^{-1})	FI (%)	W (J)	W (J kg^{-1})
H_{SJ} (cm)	0.112	−0.513	0.125	−0.548	−0.004	−0.017	0.122	0.212
	0.730	0.088	0.698	0.065	0.990	0.959	0.705	0.507
H_{CMJ} (cm)	0.055	−0.631*	0.036	−0.710**	−0.019	0.065	0.031	0.013
	0.865	0.028	0.912	0.010	0.954	0.841	0.924	0.968
PPO_{SJ} (W)	0.117	−0.535	0.046	−0.656*	0.089	0.145	0.040	0.036
	0.717	0.073	0.887	0.021	0.783	0.653	0.902	0.912
PPO_{SJ} (W kg^{-1})	0.276	−0.240	0.142	−0.405	0.306	0.257	0.136	0.130
	0.386	0.452	0.660	0.191	0.334	0.419	0.673	0.688
PPO_{CMJ} (W)	0.090	−0.548	0.013	−0.683*	0.075	0.133	0.009	−0.056
	0.780	0.065	0.967	0.014	0.817	0.681	0.978	0.864
PPO_{CMJ} (W kg^{-1})	0.241	−0.278	0.084	−0.485	0.280	0.259	0.081	−0.054
	0.451	0.382	0.796	0.110	0.378	0.416	0.802	0.868

H_{SJ} = maximum height of the center of gravity during the flight phase of the squat jump; H_{CMJ} = maximum height of the center of gravity during the flight phase of the countermovement jump; PPO_{SJ} = peak power output during the squat jump; PPO_{CMJ} = peak power output during the counter movement jump; PPOw = peak power Wingate test; MPO_W = mean power Wingate test; FI = fatigue index Wingate test; F = fatigue percentage Wingate test; W = work mean Wingate test.
*$p < 0.05$, **$p < 0.01$.

The lower anaerobic performance of football players with CP obtained in this study was also reflected in much lower (ES > 0.8) values in the Wingate test, compared with the values of football players without CP. Indeed, the players with CP in our study exhibited a lower peak and mean power than those obtained in previous studies with football players without CP.[8,13,15,16,24,25] As in VJ tests, the Wingate relative PPOW of football players with CP (7.35 ± 1.53 W kg^{-1}) was largely below the range of mean values reported in different studies (9.23−11.88 W kg^{-1}) (Table 3). The reported performance differences were even larger when expressed in absolute terms. Indeed the PPOW (W) in our study participants (399.41 W) resulted approximately 50% lesser than the lower range data reported in the available published literature for the football players without CP (range 1037−1273 W).[24] Similarly, a study of elite athletes with CP and able-bodied (AB) athletes showed that Wingate test power output (W/kg) was significantly higher (5.7%) in the AB group than in the group with CP. Paralympic athletes[29] have better performance in the power output (25.5%) in comparison with our study football players (9.8 ± 0.5 vs. 7.3 ± 1.5 W/kg). This aspect shows that not only impairment, but also the practiced sport and the level of training can determine the Wingate test performance. The magnitude of these differences and the difficulty that some of our study participants experienced in performing the test, may question the applicability of the Wingate test (compared with the VJ test) for the assessment of the anaerobic performance in football players with CP. Unfortunately, in our study no reliability or validity values of the Wingate test were analyzed. In the one study that addressed the Wingate test performance in a population with CP (i.e. children) a high inter-individual variation was reported in performance especially when testing leg power.[42] However, a study in people with CP showed good and moderate ICC and SDD values.[18] Thus it would appear that the Wingate test warrants further studies before being routinely considered for the assessment of lower limb anaerobic fitness with sedentary and trained adults with CP (population validity).

These performance differences are similar to previous studies which observed a markedly lower strength performance[43] and low anaerobic fitness levels[29,42] in participants with CP. The functional impairments associated with CP, such as asymmetric and lower motor-unit recruitment during maximal voluntary contraction,[44] along with the coactivation of antagonist muscles,[45] may have at least partially contributed to the lower anaerobic capacity of football players with CP. This may suggest that the anaerobic capacity training should be included as a specific

Table 5
Relationship between participants' IFCPF classification with vertical jump and Wingate anaerobic tests results

	H_{SJ} (cm)	H_{CMJ} (cm)	PPO_{SJ} (W)	PPO_{SJ} (W kg^{-1})	PPO_{CMJ} (W)	PPO_{CMJ} (W kg^{-1})	PPO_W (W)	PPO_W (W kg^{-1})	MPO_W (W)	MPO_W (W kg^{-1})	FI (W s^{-1})	F (%)	W (J)	W (J kg^{-1})
CPC	0.078	0.221	0.351	0.309	0.479	0.253	0.588*	0.524	0.471	0.343	0.445	0.305	0.471	0.213
	0.811	0.489	0.264	0.328	0.115	0.428	0.044	0.080	0.122	0.275	0.147	0.334	0.122	0.507

IFCPF = International Federation of Cerebral Palsy Football; CPC = IFCPF classification; H_{SJ} = maximum height of the center of gravity during the flight phase of the squat jump; H_{CMJ} = maximum height of the center of gravity during the flight phase of the countermovement jump; PPO_{SJ} = peak power output during the squat jump; PPO_{CMJ} = peak power output during the counter movement jump; PPO_W = peak power output during the Wingate test; MPO_W = mean power output; FI = fatigue index; F = fatigue; W = work.
*$p < 0.05$.

component in training sessions for football players with CP. Furthermore, it would be of interest to examine the effects of different strength training programs on the anaerobic capacity of football players with CP in future studies.

Football practice was reported to positively affect the aerobic and anaerobic fitness of recreational players compared to sedentary individuals.[46,47] Unfortunately, with this study it was not possible to assess the benefit of football practice on populations with CP as no control group was considered. Due to the interest of the possible effect on a population with CP provided by regular football practice, future descriptive and training studies are warranted.

The present study reported a relationship between the VJ and Wingate test performances in football players with CP. Indeed HCMJ was largely and very-largely correlated with relative PPOw and MPOW, respectively. Similarly, there were inverse large correlations between absolute PPOSJ and relative MPOW and between absolute PPOCMJ and relative MPOW (Table 4). Our results differ from those previously obtained in college football players without CP, where no significant relationships were observed between the VJ and the Wingate test parameters.[13] The lack of relationship described in participants without CP[13] suggests distinctive natures and specificities of the different energy systems required in each type of test, which are determined mainly by the test duration,[14] and the different muscle groups involved in the VJ and Wingate tests.[48] Anaerobic testing procedures should consist of specific protocols that replicate the athlete's specific sports activity pattern.[8] The higher specificity of the jumping test to measure the anaerobic performance of football players[49] could at least partially explain the lack of a significant relationship between the two tests in participants without CP. Given that, the inverse relationship between Wingate and VJ tests found in this study, may be partially due to the difficulty experienced when pedaling on the cycle ergometer of football players with CP. These descriptive data may suggest the interest of further studies examining the population validity and applicability of anaerobic capacity tests in football players with CP. However due to the paucity of data reporting the applicability of VJ and Wingate tests in the results of populations with CP, interpretation should be performed with caution.

In this study no significant relationship between VJ parameters and the participant's IFCPF classification (Table 5) were found. This suggests that this classification does not take into account the VJ ability of football players with CP. While this ability is not the only determinant of performance in football, this fact is striking since the IFCPF classification is based on the signs of hyperthonia, ataxia, or athetosis.[4] The finding of a significant relationship between the absolute PPOW and the participant's IFCPF classification might suggest that this parameter is more indicative of the functional status associated with CP. However, the likelihood of this possibility is questionable, given the difficulty that football players with CP experienced in performing the Wingate test, and the fact that pedaling ability is not similar to the skills required for football.

Even though the VJ and the Wingate tests have been used in football players, they have not been used for football players with CP. Therefore, we have to be cautious interpreting these results. Due to the descriptive nature of this study, it would be interesting in future studies to include a control group with football players without CP or a sedentary group with CP and also use more specific tests to assess anaerobic capacity. In addition, because the competitive level of football for people with CP has been increasing in recent years, more studies are needed.

Conclusions

The results of this study showed that the VJ and Wingate test performance were largely lower in players with CP compared to players without CP or Paralympics athletes. Thus it would be of interest to analyze the effects of different strength training programs on football players with CP. The negative relationship between VJ and Wingate test in players with CP suggests that these capabilities can be as different performance in the population of football players with CP. This might suggest the need of specific training programs for the improvement of lower limb explosive strength and anaerobic capacity in players with CP. In this regard the EI found in the players with CP may suggest the need of training procedures stressing lower limb maximal strength in this population of football players.[32] In the light of this study evidence and associated reasoning more specific tests (i.e. change of direction ability, repeat sprint ability) and anaerobic-training for football players with CP are warranted.

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