Activity limitation and match load in para-footballers with cerebral palsy: An approach for evidence-based classification

Abstract

Classification is a hot topic in Paralympic sport, making the development of evidence-based and sport-specific classification systems mandatory. However, the development of measurements for exploring the relationships between the athletes' impairment and their activity limitation is a considerable scientific challenge in team Paralympic sport such as 7-side football (ie, CP Football). The aims of this study were 1) to describe the activity limitation and external match load (ML) differences among impairment profiles (FT) in international level footballers with cerebral palsy (CPFP) and 2) to analyze the relationship among the activity limitation and external ML variables. Forty-eight international male CPFP (23 ± 7 y; 174.7 ± 7.2 cm; 69.4 ± 9.2 kg; 22.7 ± 2.6 kg·m^{-2}) participated in this study and were divided according to their impairment profile (FT5/6, FT7, and FT8). Significant differences ($P < .05$) have been observed among FT profiles in the activity limitation tests (ie, static balance, coordination, vertical jump, horizontal jump, acceleration capacity, and change of direction ability). Additionally, significant differences have been observed among FT profiles in certain ML values (ie, Vel_{max}, High Acc and in Mod and High Dec), where generally, FT8 players reported the best performance values. On the other hand, especially in the FT5/6 and in the FT8 profiles, a large-to-very large significant relationship was observed between the CPFP activity limitation and the ML values. In general, the results of the present study show that players with a lower impairment have less activity limitation and better ML. This study concludes that the potential relationships between the impairments of hypertonia, ataxia, or athetosis and performance in this para-sport might be impairment-specific.

Keywords: Paralympic sport, training load, brain impairment, coordination impairment, cerebral palsy, proficiency

Introduction

Classification is a defining feature of Para-sport, especially in Paralympic sport. Classification systems aim to promote participation in para-sport by people with disabilities by controlling for the impact of impairment on the outcome of competition,1 grouping the athletes into sport classes. Cerebral Palsy (CP) Football is a team para-sport where players are classified in sport classes according to what extent a motor control impairment of a cerebral nature causes a permanent and verifiable activity limitation,2 affecting the performance of the main football skills. Traditionally, CP Football comprised four sport classes (FT5: moderate spastic diplegia, FT6: moderate ataxia or athetosis, FT7: moderate spastic hemiplegia; and FT8: minimal impairment criteria for hyperthonia, ataxia, or athetosis (HAA)), so the sport class allocation is strongly based on the type/severity of the impairment and the body area involved. After the 2016 Rio Paralympic Games, the technical rule about the number of players considering their sports class was modified, lining up at least two players of the class FT5 or FT6 and no more of one FT8 player on the field of play during the game.2 Then, general performance of a team could be influenced by the classification of their players.2 Nevertheless, Tweedy, Beckman, and Connick3 suggest a sequential 4-step process that outlines how to develop evidence-based methods of classification, that is: (a) specification of impairment types that are eligible for the sport; (b) development of valid measures of impairment(s); (c) development of standardized, sportspecific measures of performance; and (d) assessment of the relative strength of association between measures of impairment and measures of performance.

Studies in para-athletics with runners with brain impairments analyzed the strength of association of lower limb strength,4 coordination (using tapping tests), and range of movement (ROM)5 with sprint performance (top speed reached at 30 m in a 60 m straight sprint). Considering the model suggested by Tweedy et al,3 impaired strength, coordination or ROM, but also the performance outcome (time or speed, in s or km/h), are clearly identifiable. However, the development of sport-specific measurement is a considerable scientific challenge in team Paralympic sport such as wheelchair basketball, wheelchair rugby, or 7-a-side football (ie, CP Football).6 To the best of the authors' knowledge, in team sports, only a couple of studies in wheelchair rugby have addressed step 4 of the Tweedy et al3 model, assessing the relationship between trunk strength impairment and three activities (tilting the chair, acceleration, and sprint momentum) that determine performance in wheelchair rugby players7; and the relationships between trunk function and arm impairment and performance in real games using an indoor tracking system.8 Additionally, Van der Slikke et al9 recently suggested that the use of inertial sensors in match play and in field testing could enhance evaluation of classification guidelines as well as individual athlete's performance in wheelchair basketball.

Specifically in football players with CP (CPFP), few studies have analyzed sport proficiency, including jumping ability,10,11 change of direction ability (CODA),12,13 sprint/ acceleration/deceleration,13 endurance,14 and dribbling skills.13 Several of these studies evidenced the validity, feasibility, and reliability of the tests used,11-13 especially to evaluate the activity limitation caused by the eligible impairment (ie, FT8 players vs regular football players) and the discrimination capability between moderate vs mild impairments of HAA (ie, FT5/FT6/FT7 vs FT8). On the other hand, in CPFP the external match load (ML) indicators have also been analyzed such as distance covered at different speeds,15 accelerations, decelerations, player load (PL), peak metabolic power (PMP), and changes of direction (CODs),16 comparing between the current sport classes and/or the playing time.15-17 However, there are no previous studies in para-athletes with coordination/brain impairments analyzing the strength of the relationships among the tests that evaluate the activity limitation caused by the eligible impairment and performance during a real team game. Knowing the association between the activity limitation and the real game (ie, external ML) would allow CP Football classifiers to better understand the sport proficiency required in this para-sport for each sport class or player profile.

Therefore, the aims of this study were as follows: (a) to describe proficiency in several activity limitation tests (ie, static/dynamic balance, coordination, vertical/horizontal jump, acceleration, and CODA) and the external ML (ie, maximum velocity reached, distance covered at different speeds, distance covered in short-term actions, PL, and PMP) in CPFP and (b) to analyze the strength of the association among the activity limitation and the ML variables.

Material and methods

Participants

Forty-eight international male CPFP (23 ± 7 y; 174.7 ± 7.2 cm; 69.4 ± 9.2 kg; 22.7 ± 2.6 kg·m−2) from five national teams, who played eight official matches during a World Championships Qualification Tournament (Vejen, Denmark) participated in this study. All CPFP trained a minimum of three times a week and had at least five years of playing experience at the international level. The inclusion criteria were to have a valid license from the International Federation of Cerebral Palsy Football (IFCPF) and play regularly as outfield player. The exclusion criteria were having any type of injury in the three months before data collection took place or playing regularly as a goalkeeper due to their sport-specific role during the match. Due to playing restrictions on class distribution and the smaller outfield player sample size of these FT classes, data from FT5 and FT6 were pooled (FT5/6, n = 9, 24 ± 8 y; 177.9 ± 5.0 cm; 70.2 ± kg; 22.1 ± kg·m−2). Conversely, FT7 (n = 32, 22 ± 5 y; 175.0 ± 7.9 cm; 68.6 ± 9.7 kg; 22.4 ± 11.0 kg·m−2) and FT8 (n = 7, 27 ± 11 y; 169.3 ± 2.9 cm; 72.0 ± 11.0 kg; 25.1 ± 3.6 kg·m−2) players tend to be outfield players and so no such sampling issues were of concern.15 All participants gave their written informed consent to take part in this study. This investigation was approved by the Ethics Committee of the principal investigator's university (reference number DPS. RRV.01.14).

Procedures

A cross-sectional (ie, correlational) design was used to examine the relationships between proficiency during test sessions with external match responses during the real competition. With a minimum of 72 hours prior to official matches, FPCP's activity limitation was assessed by static balance (ie, one leg stance with dominant and non-dominant leg [OLSD and OLSND]), dynamic balance (ie, tandem walk [TW]), coordination (ie, split jumps [SJ] and sidestepping [SideStep]), vertical jump (ie, countermovement jump [CMJ]), horizontal jump (ie, standing broad jump [SBJ], triple hop for distance with dominant [THD] and non-dominant legs [THND], 4 bounds for distance [4B]), acceleration (ie, 5 m [S5m], 10 m [S10m], 15 m [S15m] and 20 m sprint [S20m]), and CODA (ie, modified agility test [MAT] and 505) tests.[2] All these activity limitation tests are described in Annex 1.

CPFP did not perform any type of intense physical exercise during the 36-hours period before the test sessions, and the participants were advised to ensure they were fully hydrated and energized. Participants performed a standard warm-up consisting of 7 minutes of slow jogging followed by 6 minutes of progressive sprints. After that, each footballer performed the balance, coordination, jumping, acceleration, and CODA tests in order to assess their proficiency. The tests took approximately one hour to complete and were performed in the same order throughout and in the same indoor facilities for all players (17-22ºC, 60-70% humidity).

Regarding match analysis, measures of external match responses (ie, maximum velocity reached during the match [Velmax], distance covered at different speeds, distance covered in short-term actions, PL, and PMP) were collected for both halves during the official matches. Prior to the start of each match, CPFP performed a 20-25 minutes warm-up with their team including running, progressive sprints, and stretching; however, these data were not included in the overall analysis. The between-halves interval data (ie, 15 min) were also excluded from the analysis. External match responses were collected for both halves during every official match (n = 48 CPFP, 8 matches). All official matches analyzed were played in the same sports facilities (70 × 50 m, natural grass). Footballers' external ML was assessed using GPS devices (MinimaxX v4.0; Catapult Innovations, Melbourne, Australia) operating at a sampling frequency of 10 Hz. The GPS device has been validated for high levels of reliability and low levels of measurement error.[18] Participants wore a fitted body vest, and the device was inserted into a purpose-built harness prior to the warm-up for their respective matches. The Velmax,[19] distance covered at high intensities (high-intensity running: 13.0-18.0 $km \cdot h^{-1}$ [HIR] and sprinting: >18.0 $km \cdot h^{-1}$ [SPR]),[20] number of moderate (1.00-2.78 $m \cdot s^{-2}$) or high (>2.78 $m \cdot s^{-2}$) accelerations/ decelerations, PL, and PMP[16,17,21-23] were calculated from GPS-derived data. Considering that the CPFP did not play the same amount of time during matches (mean playing time = 47.77 ± 21.02 min), all variables were relativized according to the real playing time of each player.[17,24]

Data analysis

Results are presented as mean and standard deviation (SD). Kolmogorov-Smirnov and Levene's tests were applied to evaluate the normal data distribution and the homogeneity of variances. All examined variables had a normal distribution, and parametric statistics were used. A one-way analysis of variance (ANOVA) with a least significant difference post hoc comparison (Bonferroni correction) was used to examine the activity limitation and external ML mean differences among FT groups (ie, FT5/6, FT7 and FT8). Practical significance was assessed by calculating Cohen's effect size.25 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.25 Pearson's product-moment correlation coefficient (r) with 90% confidence limits (CL) was used to examine the relationship between the results in the activity limitation tests and the external ML. The following scale of magnitudes was used to interpret the correlation coefficients: <0.1, trivial; 0.1-0.3, small; 0.3-0.5, moderate; 0.5-0.7, large; 0.7-0.9, very large; and >0.9, nearly perfect.26 Magnitude-based inferences were subsequently applied to qualify the uncertainty in the correlation estimates, using the following probabilistic terms: 25 %-75%, possibly; 75%-95%, likely; 95%-99.5%, very likely; and >99.5%, most likely (Hopkins et al26). Data analysis was performed using the Statistical Package for Social Sciences (version 24.0 for Windows; SPSS Inc, Chicago, IL, USA). Statistical significance was set at $P < .05$.

Results

Table 1 shows the activity limitation test results (ie, static and dynamic balance, coordination, vertical and horizontal jump, acceleration, and CODA) for all the CPFP and according to their FT classes (FT5/6, FT7, and FT8). Significant differences ($P < .05$) were observed between FT classes in static balance, coordination, vertical jump, horizontal jump, acceleration capacity, and CODA. In contrast, no significant differences were observed between FT classes in dynamic balance. According to static balance, vertical jump (CMJ), and horizontal jumps (SBJ and 4B), the FT7 and FT8 players reported better performance values than FT5/6. However, in the coordination tests (SJ and SS), THND and S5m, only the FT8 group attained better values than FT5/6 and FT7. In this respect, while previous tests did not discriminate among all the FT classes, acceleration (S10m, S15m, and S20m) measurements and MAT were the only tests discriminating all the FT classes (significant or practical differences).

External ML results obtained during official CP Football matches are presented in Table 2. Significant or practical differences were observed between FT classes in Velmax, High Acc and in Mod and High Dec, where generally, FT8 class reported the better performance values. Moreover, FT8 players reported more distance covered in SPR than FT5/6 group ($P < .05$, ES = 0.80, large).

Low or moderate relationships were observed among activity limitation test values and the external load variables for all players. A significant relationship was found between THND and Velmax values during the matches ($r = .63$; ±0.15 CL, $P < .01$, 100/0/0, most likely). However, the analysis of associations by FT classes showed that relationships were not equal in all the classes. Specifically, in the FT5/6 class, the players who showed a better performance in the THD reported a higher number of High Acc during the match ($r = .92$; ±0.13 CL, $P < .01$, 100/0/0, most likely). Also, the FT5/6 players that had better acceleration capacity showed a higher number of High Acc ($r = -.74$; ±0.33 CL, $P < .01$, 0/2/98, very likely to $-.76$; ±0.31 CL, $P < .01$, 1/1/98, very likely) and a greater number of High Dec ($r = -.74$; ±0.33 CL, $P < .01$, 0/2/98, very likely to $-.76$; ±0.31, $P < .01$, 1/1/98, very likely). Furthermore, the players with a better performance in the MAT and in the 505 completed a greater number of High Acc (r = −.82; ±0.25 CL, P < .01, 0/0/100, most likely to −0.92; ±0.11 CL, P < .01, 0/0/100, most likely) (Figure 1A,B) and High Dec (r = −.77; ±0.30 CL, P < .01, 0/1/99, very likely).

Regarding the FT7 class, no high associations were observed among activity limitation variables and the external load during the official football matches (P > .05). Only the players who performed better in the horizontal jump (SBJ) performed a higher number of High Acc during the matches (r = .61; ±0.19 CL, P < .01, 100/0/0, most likely) (Figure 2).

Finally, with respect to the FT8 class, the players with better results in the dynamic balance test performed more Mod Acc (r = .78; ±0.10 CL, P < .05, 100/0/0 most likely). In the same way, the FT8 players with the best result in the SJ coordination test achieved a higher Velmax during the matches (r = .79; ±0.36 CL, P < .05, 97/2/1, very likely) (Figure 3A) and those players with better performance in the THND or in 4B accomplished higher Mod Acc (Figure 3B) and Mod Dec (r = .78; ±0.37 CL, P < .05, 97/2/1, very likely to r = .97; ±0.07 CL, P < .01, 100/0/0, most likely). In addition, the players with a better performance in the S5m test reported more HIR distance (r = .94; ±0.13 CL, P < .01, 100/0/0, most likely).

Discussion

Paralympic sport allow the participation of para-athletes from ten eligible impairments, but recent literature on evidencebased classification have considered eligible impairments of HAA as a unique group4,5,27 to explore the relationships between impairment and sports performance. It should be noticed that the absence of valid ratio-scaled measures of the impairment is currently the most significant barrier to the development of evidence-based systems of classification and addressing this is the Paralympic Movement's most pressing scientific challenge,28 especially when combining different eligible impairments. While previous studies have described the ML in CPFP using GPS technology,15-17 this is the first study exploring the relationships between activity limitation caused by HAA impairments and performance during real competition. We have considered the players' profile of diplegia (FT5), ataxia/athetosis (FT6), or hemiplegia (FT7) to compare players' proficiency with regard to the mild form of impairment (FT8), but also to explore whether the potential relationships between activity limitation testing and ML is similar across the sport classes (ie, impairment profiles).

Previous studies demonstrated the differences in the performance of CPFP with particular profiles and impairment severity (ie, sport classes) when comparing their performance in changing direction,12 accelerating/decelerating/sprinting,13 and jumping horizontally or vertically.11 Recently, a study with 56 international para-footballers with HAA29 performed a Data Envelopment Analysis as a classification tool using a directional distance function model, demonstrating that five of the twenty proposed activity limitation tests discriminate the performance and magnitude of athletes' impairments.

The five tests suggested by Pastor et al29 include measurements of jumping (standing broad jump, four bounds for distance, and triple hop with the non-dominant leg), and acceleration (0-to-10m) and CODA (Illinois Agility Test) while dribbling a ball. The findings of this study reinforce the idea that jumping, accelerations, and CODA are determinant factors to discriminate among profiles and impairment severity in CPFP. Concretely, participants with mild forms of HAA (ie, FT8, "higher sport class") performed better than those considered as "lower sport classes" (ie, FT5/FT6)2 in all the activity limitation tests, excepting in dynamic balance (TW). In addition, FT8 players exhibit better performance than those with a moderate form of unilateral spasticity (ie, FT7) in many of the tests, excepting in OLSD, SBJ, 4B, and 505. While the absence of differences in OLSD is understandable because this test demands balance on a single leg that is not affected in the FT7 players, no differences in SBJ and 4B does not match with previous findings in this population.11 Regarding the CODA tests, the differences in MAT are comparable with the study by Reina et al,12 but the 505 test was not previously applied in this population. The 505 test is performed in a straight line (10 m), requiring a sudden 180º COD for sprinting again for 5 m, so heel strike is not required (limited on those with lower limb paresis) when running12 in addition to the fact that the athlete freely chooses the leg to perform the COD.

Other measurements of impaired coordination and balance also prove differences between CPFP profiles. Although measurements of impaired coordination have been applied in runners5 and swimmers30 with brain impairments, the analysis of the contribution to sports performance (ie, with classification purposes) of this kind of tests has not previously been addressed in CP Football. This study demonstrated that coordination tests such as SJ and SS can discriminate between different levels of impairment due to (a) a bilateral spasticity (ie, FT5) that causes velocity-dependent muscle resistance31 affecting inter-limb coordination and performance of shorter strides; (b) a profile of ataxia (impaired control of voluntary movement), athetosis (involuntary contractions of the muscles), or dystonia (sustained muscle contractions that cause twisting and repetitive movements or abnormal postures) (ie, FT6) that affects whole-body coordination;12 or (c) a reduced between-limbs synchronization due to an unilateral spasticity or hemiplegia.32 With regard to balance, it is well known that people with CP are characterized by the performance of mass instead of fine and individual movements, performing slow and effortful voluntary movements that affect their capacity to keep an upright weight-bearing position.33 Our measurement of static balance by the OLS test demonstrates that upper motor neuron signs associated with CP such as extensor plantar response for those with lower limb spasticity (ie, FT5 and FT7), impaired voluntary control due to ataxia or that the involuntary contractions of the muscles in athetosis constrains balance performance. Overall, all these activity limitation tests can be used as valid and ratio-scaled measurements of impairment in para-athletes with HAA with practical applications for classification purposes: (a) identification of minimal impairment criterion to be eligible in this para-sport and (b) suggesting future research addressing specific relationships for each type of impairment in paraathletes with HAA. Match analysis in CP Football, using GPS devices, has been addressed as a valid tool to describe game demands15,16 but also to describe players' proficiency according to their functional profile.15,17 This study demonstrates that those para-footballers considered as “lower classes” for the game2 exhibit less Velmax, cover shorter distances sprinting, also performing less High Acc and Moderate Dec than those with mild forms of impairment. Similar results were found comparing FT7 vs FT8, excepting for the distance covered sprinting, but with moderate effect size. These results are in line with those from previous studies in this population,15-17 confirming that FT8 players most notably perform best in very high-intensity activity associated with game-defining moments, while no differences are found between FT5/FT6 vs FT7 players. Among all the variables obtained by the GPS records, those related with high-intensity actions are particularly relevant in CP Football performance,17 so small-sided games replicating those actions have been recently included in the classification protocols for this para-sport.34 However, the variable demands of the real game situations probably biased our ML analysis, so a particular challenge for future research is the identification of the optimal time for game analysis, available space, the number of players involved, or the inclusion of specific rules (ie, goalkeeper, numerical superiority, and scoring method).

For developing evidence-based classification systems, the identification of the relationships among impairment and sports performance presents another particular challenge in team Paralympic sport,6 especially because there are several performance factors in team para-sports. Previous studies of para-athletes with CP or brain impairments (ie, HAA) identified these relationships between the ROM in four tests (ie, maximum thigh flexion, heel pull distance, maximum thigh extension, and dorsiflexion lunge) with regard to two performance outcomes in para-athletics sprint: acceleration (time up to 15 m) and maximal velocity (time between 30 m and 60 m).5 On the contrary, the study by Connick et al5 did not find these relationships with regard to one of the ROM tests (backward stepping lunge) and three coordination (tapping) tests. A study by Beckman et al4 with a similar sample of runners with brain impairments did not find significant correlations between three muscle isometric strength measurements (ie, leg flexors, leg extensors, and plantarflexors) and the same outcomes of the sprint performance. Another study in RaceRunning (ie, a para-sport for people with severe forms of HAA using a three-wheeled running bike) by Van der Linden et al27 found low-to-moderate correlations between several measurements of the impairments (ie, spasticity, selective motor control, maximum static step length, passive ROM, and manual muscle testing) and performance in real competition (100 m race official time). The abovementioned studies shared the fact that they have a unidimensional quantification of the sports performance, that is, the performance during a straight race or sprint. This approach was also recently applied in para-swimming, finding moderate-to-large correlations with the maximal freestyle swim speed in six of the eight proposed coordination (tapping) tests: upper vs lower limbs, dominant vs non-dominant sides, bilateral, and asymmetry scores).35 In addition, Hogarth et al30 also demonstrated low-to-moderate correlations for eight measurements of isometric strength (ie, dominant vs non-dominant hip/ shoulder extension/flexion) with the same swimming performance outcome (ie, the maximal freestyle swim speed). However, they found fewer correlations when para-swimmers with hypertonia were analyzed independently, highlighting the impairment-specific nature of the activity limitation.

However, sports performance in team Paralympic sport cannot be considered as a single dimension. To the best of the authors' knowledge, only the study by Mason et al,8 applied in wheelchair rugby, demonstrated the relationships between impairment (ie, trunk and arms) and physical (ie, distance covered, time in higher speed zones, and peak speeds) or technical (ie, possessions, scored goals, and passes received or made) variables. Therefore, this study is the first to be applied in a team para-sport involving para-athletes with HAA addressing the relationships of ratio-scale measurements of the impairment (ie, activity limitation tests) and the sports performance during a real game. For example, we found positive relationships between CODA performance (MAT and 505) and the high accelerations during the game in those with bilateral spasticity (FT5, affecting CODA performance because of muscles stiffness in the lower extremities, usually on the legs, hips, and pelvis) and ataxia/athetosis (FT6, having problems with balance and starting, stopping and turning when running),12 constraining their performance during the game. For those with unilateral spasticity (ie, FT7), positive relationships were found between high accelerations and SBJ performance. This result matches with a recent finding by Loturco et al,36 who demonstrated that hip-thrust jumps (ie, horizontal jumps such as SBJ) are more associated with the maximum acceleration phase in sports performance. In FT8 players, the positive relationship between SJ and Velmax is similar to that obtained by Beckman and Tweedy,37 who demonstrated that SJ had a low correlation with sprint performance (30 m sprint). That study was conducted with a group 17 non-disabled runners, also finding a high negative correlation between the 4B tests and sprint performance, while our study found a positive relationship between the 4B and moderate accelerations during the real game. Considering that FT8 are those with minimal impairment criteria to be eligible in this para-sport, in general, this study reinforces the fact that ML is more affected in those with more severe impairments, but the different relationships found according to the para-footballers profiles give rise to the hypothesis that evidence-based classification in athletes with HAA could be impairment-specific.

Perspective

This study found differences between para-footballers with different profiles of HAA when performing jumps, accelerations, decelerations, CODs, coordination, and static balance tests. In addition, para-footballers with mild forms of HAA impairments exhibit better performance in certain ML values such as Velmax, High Acc and in Mod and High Dec, while those with a more severe form of impairment performed worse during the game (ie, lower ML values). However, variables involving lower limb power are more related to real game performance such as Velmax or highto-moderate accelerations. The different relationships between activity limitation caused by the impairments and real performance suggest the hypothesis that the relationships between HAA impairments and sports performance could be impairment-specific. CP Football recently introduced a new categorization of the impairment profiles according to the muscle tone and the affected body region as bilateral spasticity, ataxia/dyskinesia, or unilateral spasticity.34 Therefore, more research is needed to explore the relationships between the measurement of these impairments and the resulting activity limitation with the sports performance determinants found in this

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Figure 1. Relationship between MAT and High Acc (A) and between 505 and High Acc (B) in FT5/FT6 players. 505, 505 Agility Test; Acc, accelerations performed in the match; CL, confidence limit; MAT, Modified Agility Test

Figure 2 Relationship between SBJ and High Acc in FT7 players. CL, confidence limit; High Acc, high acceleration; SBJ, standing broad jump

Figure 3 Relationship between SJ and Vel_{max} (A) and between 4B and Mod Acc (B) in FT8 players. 4B, four bounds for distance; CL, confidence limit; Mod Acc, moderate acceleration; SJ, split jump; Vel max, maximum velocity achieved in the match

Table 1. Activity limitation test results (ie, static and dynamic balance, coordination, vertical and horizontal jump, acceleration, and CODA) for all football players with cerebral palsy and according to sport classes (FT5/6, FT7, and FT8)

					Pair comparisons (ES)		
	Total sample	**FT5/6**	**FT7**	**FT8**	**FT5/6 vs FT7**	**FT5/6 vs FT8**	**FT7 vs FT8**
Static balance							
OLS_D (s)	18.54 ± 3.83	14.39 ± 7.20	19.39 ± 1.64	20.00 ± 0.00	3.05**	0.77**	0.37
OLS_{ND} (s)	9.08 ± 6.47	5.73 ± 2.83	8.56 ± 6.13	15.78 ± 7.21	0.46	1.39**	1.00*
Dynamic balance							
TW (s)	20.20 ± 8.41	17.31 ± 4.24	21.70 ± 9.52	17.11 ± 5.15	0.46	−0.04	−0.89
Coordination							
SJ (s)	21.35 ± 3.90	21.58 ± 5.73	22.29 ± 2.90	17.30 ± 2.01	0.24	−2.12	−2.48**
SS (s)	19.22 ± 3.04	19.34 ± 2.17	20.21 ± 2.65	15.09 ± 1.98	0.33	−2.14**	−2.58**
Horizontal jump							
SBJ (m)	1.68 ± 0.26	1.42 ± 0.17	1.76 ± 0.25	1.74 ± 0.19	1.33**	1.67*	−0.08
TH_D (m)	5.11 ± 0.66	4.24 ± 0.62	5.36 ± 0.53	4.98 ± 0.38	2.13**	1.93*	−1.00
TH_{ND} (m)	3.31 ± 1.04	3.38 ± 0.89	3.04 ± 0.97	4.24 ± 0.97	−0.36	0.88	1.24*
4B (m)	6.17 ± 0.86	5.34 ± 0.77	6.37 ± 0.76	6.49 ± 0.79	1.37**	1.47*	0.16
Vertical jump							
CMJ (m)	0.44 ± 0.06	0.37 ± 0.06	0.45 ± 0.04	0.47 ± 0.04	1.70**	2.38**	0.45
Acceleration/Sprint							
S5m (s)	0.94 ± 0.20	0.98 ± 0.27	0.95 ± 0.19	0.86 ± 0.05	−0.15	−2.18	−1.63
S10m (s)	1.72 ± 0.15	1.85 ± 0.23	1.70 ± 0.11	1.64 ± 0.07	−1.31*	−3.07*	−0.86
S15m (s)	3.19 ± 0.29	3.44 ± 0.49	3.15 ± 0.18	3.01 ± 0.05	−1.59**	−9.16**	−2.90
S20m (s)	4.71 ± 0.48	5.13 ± 0.85	4.65 ± 0.27	4.39 ± 0.11	−1.76*	−6.85*	−2.42
CODA							
MAT (s)	7.17 ± 0.88	8.28 ± 1.30	7.03 ± 0.48	6.44 ± 0.23	−2.63**	−7.91**	−2.51
505 (s)	2.65 ± 0.25	2.83 ± 0.39	2.62 ± 0.18	2.55 ± 0.25	−1.17	−1.14	−0.29

Abbreviations: 4B, 4 bounds for distance; 505, 505 Agility Test; CMJ, countermovement jump; CODA, change of direction ability; ES, effect size; FT, International Federation of Cerebral Palsy Football (IFCPF) functional classes; MAT, Modified Agility Test; OLS_D, dominant one leg stance; OLS_{ND}, non-dominant one leg stance; S5m, sprint 5 m; S10m, sprint 10 m; S15m, sprint 15 m; S20m, sprint 20 m; SBJ, standing broad jump; SJ, split jump; SS, sidestepping; TH_D, dominant leg triple hop
*$P < .05$; **$P < .01$.

Table 2 Maximum velocity (Vel_{max}) achieved, distance covered at different high intensities, number of moderate/high accelerations (Acc), decelerations (Dec), player load (PL), and peak metabolic power (PMP) by all football players with cerebral palsy and according to functional class groups (FT5/6, FT7, and FT8)

					Comparisons (ES)		
	Total Sample	**FT5/6**	**FT7**	**FT8**	**FT5/6 vs FT7**	**FT5/6 vs FT8**	**FT7 vs FT8**
Vel_{max} ($km.h^{-1}$)	22.95 ± 2.01	21.86 ± 2.04	22.94 ± 1.90	24.41 ± 1.83	0.57	1.40*	0.81*
Distance at different high intensities ($m.min^{-1}$)							
HIR (13.0-18.0 $km.h^{-1}$)	11.87 ± 4.71	11.34 ± 5.07	11.62 ± 4.53	13.70 ± 5.35	0.06	0.44	0.39
SPR (> 18.0 $km.h^{-1}$)	3.38 ± 2.01	2.65 ± 2.09	3.23 ± 1.60	4.97 ± 2.97	0.36	0.80*	0.59
Short-term actions (number. min^{-1})							
Moderate Acc (1.0/2.78 $m.s^{-2}$)	0.98 ± 0.50	1.08 ± 0.60	0.88 ± 0.33	1.29 ± 0.83	−0.61	0.25	0.49
High Acc (> 2.78 $m.s^{-2}$)	0.07 ± 0.07	0.03 ± 0.03	0.06 ± 0.05	0.15 ± 0.11	0.68	1.18**	0.86**
Moderate Dec (−1.0/-2.78 $m.s^{-2}$)	0.95 ± 0.42	0.86 ± 0.28	0.89 ± 0.32	1.37 ± 0.71	0.08	0.73*	0.69*
High Dec (> −2.78 $m.s^{-2}$)	0.11 ± 0.08	0.05 ± 0.03	0.12 ± 0.08	0.14 ± 0.09	0.83	1.02	0.26
PL ($AU.min^{-1}$)	10.49 ± 2.28	10.86 ± 1.83	10.39 ± 2.57	10.46 ± 1.43	−0.19	−0.28	0.05
PMP ($watt.min^{-1}$)	115.16 ± 38.04	106.91 ± 47.25	117.84 ± 36.31	113.51 ± 37.48	0.30	0.18	−0.12

Abbreviations: Acc, acceleration; AU, arbitrary units; Dec, deceleration; ES, effect size; FT, International Federation of Cerebral Palsy Football (IFCPF) functional classes; HIR, high-intensity running; SPR, sprinting; Vel_{max}, maximum velocity achieved in the match.

*$P < .05$;

**$P < .01$.