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Relationship between physical performance and match load and effects of two consecutive matches in cerebral palsy footballers

Relación entre el rendimiento físico y la carga de trabajo en partido y efecto de dos partidos consecutivos en futbolistas con parálisis cerebral

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Abstract. The aims of the present study were to analyse the relationship between the physical performance and the match load in cerebral palsy (CP) football players, and to analyse the possible impact of the Spanish League format (playing two matches on two consecutive days) on the players' match load. Data for a Spanish CP football team (n=10; age: 31.0 ± 8.9 years; weight: 66.1 ± 8.6 kg; height: 172.2 ± 7.8 cm; BMI: 22.5 ± 2.9 kg·m^{-2}) included anthropometric (weight, height and BMI), physical performance (CMJ, 5, 10 y 20-m sprint y MAT) and match load variables (distance covered, accelerations and decelerations, heart rate, speed and player load) from two official matches. The players' physical performance, but not their anthropometrical measurements, correlated to the match load variables (r = 0.76–0.95; *p* = 0.04–0.01), except for accelerations, decelerations and heart rate-related variables (*p* > .05). Players' match load data were not statistically different between matches. The results suggest that players' physical performance influences the match load variables, and these players' load variables in competition do not seem to be affected by the fact of playing two matches on two consecutive days. The way in which the players' physical performance and fatigue may affect the match load variables needs more research in CP football.

Keywords: CP football; modify agility T-test; player load; match analysis; dribbling.

Resumen. Los objetivos de este estudio fueron analizar la relación entre el rendimiento físico y la carga de partido en jugadores de fútbol con parálisis cerebral (PC), y analizar la posible influencia del formato de la Liga Española (en la que se juegan dos partidos en días consecutivos) en la carga de partido. Los datos obtenidos de un equipo español de fútbol PC (n=10; edad: 31.0 ± 8.9 años; peso: 66.1 ± 8.6 kg; altura: 172.2 ± 7.8 cm; IMC: 22.5 ± 2.9 kg·m^{-2}) incluyó variables antropométricas (peso, altura e IMC), de rendimiento físico (CMJ, 5, 10 y 20-m sprint y MAT) y variables de carga de partido (distancia recorrida, aceleraciones y deceleraciones, frecuencia cardiaca, velocidad y carga del jugador) en dos partidos oficiales. El rendimiento físico de los jugadores, pero no las variables antropométricas correlacionaron con la carga de partido (r = 0.76–0.95; *p* = 0.04–0.01), excepto para las aceleraciones, deceleraciones y variables relacionadas con la frecuencia cardiaca (*p* > .05). Los datos acerca de la carga de partido no fueron significativamente distintos entre partidos. Los resultados sugieren que el rendimiento físico de los jugadores de fútbol PC influyen en la carga en competición y esas variables de carga de partido no parecen estar afectadas por el hecho de jugar dos partidos en días consecutivos. La manera en la que el rendimiento físico de los jugadores y la fatiga puede afectar en la carga de partido necesita mayor investigación en fútbol PC.

Palabras clave: Fútbol PC; T-test modificado; carga del jugador; análisis de partido; dribbling.

Introduction

CP football is a 7-a-side football modality, played by athletes with cerebral palsy (CP) or acquired brain injury. The players are classified into three different sport classes (FT1 to FT3) according to their impairment profile and to the severity of their impairment. In the FT1 class are included players with a severe impairment profile, whereas in FT 2 and FT3 classes are included players with moderate and mild profiles respectively. This classification has an impact on the game since there must be at least one FT1 player and there can only be one FT3 player on the field at the same time per team. CP football is played according to the modifications of the International Federation of Cerebral Palsy Football (IFCPF) of the Fédération Internationale de Football Association (FIFA) rules. National federations have the competencies to organize their own national competitions. In this regard, the Spanish national competition is organized in a league format by the Spanish Federation of CP Sports (Federación Española de Deportes de personas con Parálisis Cerebral -

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FEDPC). Eight teams compete in this league and they all play against each other over a period of three weekends, which implies that each team must play at least a minimum of two matches within a two-day period. This league format may cause a player´s fatigue between matches which may have an impact on their performance.

In recent years, player tracking technology improvements (Rampinini, Coutts, et al., 2007) have upgraded the understanding of conventional football physical requirements in competition. The combination of global positioning systems (GPS), accelerometers and heart rate sensors, allows coaches and trainers to obtain a wide range of match load measures such as covered distances at different running intensities, acceleration and deceleration-related variables (Johnston et al., 2015) or heart rate measurements (Castillo-Rodríguez et al., 2020). The impact of the players' physical performance on these match load variables has been studied with conventional football players, showing a relationship between match load variables (such as total covered distance or high-intensity running) and players' physical performance (such as sprinting or endurance assessment using field tests) (Bradley et al., 2013; Mohr et al., 2003; Mooney et al., 2011). This suggests that physical performance field tests are valid as indicators of the players' capacity to perform activities at higher intensities in competition, and therefore to be able to produce a higher performance (Impellizzeri & Marcora, 2009). However, this relationship has not yet been looked into in CP football players.

Players' match load in CP football has been compared in competition between players from different sport classes, showing differences in the distance covered at high-intensity running and sprinting, as well as in the number of accelerations, decelerations and changes of directions in favour of those players with less severe impairment (Boyd et al., 2016; Yanci et al., 2019a). However, there is a lack of knowledge whether the physical performance level of players, as well as the Spanish League format, may influence the players' load variables registered during the match. The effect of congested periods (multiple matches with short periods of recovery) in conventional football has been recently studied due to professional teams are usually enrolled into various competitions and they must to compete more than one time per week (Clemente et al., 2021; Dellal et al., 2015). Similarly, the characteristics of the CP Spanish League format with two matches in only one weekend may impact players' recovery, reduce their physical performance in the second match and may increase their injury risk.

Thus, the aims of the present study were (1) to analyse the relationship between the players' physical performance and their match load variables in CP football, and (2) to analyse the impact of playing two matches on two consecutive days on the players' match load variables.

Materials and method

Participants

Ten players from a team belonging to the Spanish regular CP Football League participated in the study. Players' descriptive data is provided in Table 1. Both, coaching staff and players, were previously informed of the details of this study and its possible risks and benefits. The participation of the players was voluntary, and they were asked for their approval to participate through an informed consent. The study was developed based on the ethical provisions of the Declaration of Helsinki (2013), approved by the Bioethics Committee of the University (67/2017).

Table 1.
Descriptive data for the participants.

	n	Age (years)	Height (cm)	Weight (kg)	BMI ($kg \cdot m^{-2}$)	Experience (years)	Observations (n)
FT1	4	30.5 ± 6.1	169.3 ± 8.8	61.6 ± 8.7	21.7 ± 4.1	13.8 ± 5.3	8
FT2	5	28.5 ± 10.8	174.5 ± 8.1	69.9 ± 8.5	22.9 ± 2.4	5.5 ± 7.1	10
FT3	1	43	175	68.9	22.5	24	2
Overall	10	31.0 ± 8.9	172.2 ± 7.8	66.1 ± 8.6	22.5 ± 2.9	11.2 ± 8.3	20

BMI: Body mass index

Procedure

Anthropometric and physical performance assessments were carried out the same day for all players before the first competitive match. The players' match load variables were registered during two official matches, in this case separated by 17 hours, according to their competition calendar belonging to the Spanish CP Football League. Each player played a minimum of 30 minutes (one half) in each match and they played the same time in each match. The participants carried out a 10-minute standardized warm-up before the physical performance assessment. All players had performed these tests previously and no prior familiarization was required. Physical performance tests were carried out in the same field that the matches took place and players wore their usual football boots and equipment. Each test was performed twice, and a 2-minute rest between trials and a 3-minute rest between tests was set. The best repetition of each test was used for further analysis. Players were verbally encouraged throughout the tests and they were asked to perform at their maximal effort.

Anthropometrics and Physical Performance

Body height was measured using a fixed stadiometer (± 0.1 cm, SECA LTD., Germany) and body mass was measured using a digital scale (± 0.1 kg, Oregon scientific® GA101/GR101, Spain). The Body Mass Index (BMI) was calculated as *weight (kg) / height² (m²)*. The jump height in the countermovement jump (CMJ) was recorded using a contact platform (Globus Ergotester®, Italy). The time used to cover 5, 10 and 20-m in a sprint as well as the time used to complete an agility and a dribbling test were obtained using photoelectric cells (Witty System Microgate, Bolzano, Italy). The modified agility test with free displacements (MAT) (Arcos et al., 2020; Yanci et al., 2014). In addition, dribbling ability was performed using the same modified MAT, in which the player had to drive the ball around the cones.

Match Load Variables

For the purpose of recording the players' match load variables during competition, each player was equipped with a WIMU® inertial device (RealTrack Systems, Almería, Spain) (10 Hz), which was fixed to each player using an anatomically adjusted harness. This method has been shown as a valid and reliable tool to measure the players' match load (Pons et al., 2019; Principe et al., 2020). After the recording, the data was analysed using the SPRO® software (RealTrack Systems, Almería, Spain). The following variables were recorded and analysed as the players' match load variables: Distance (m) was the total number of meters covered during the match; Explosive Distance (m) was the number of meters covered at a speed greater than 16 $km \cdot h^{-1}$; Accelerations (n) and $Accelerations \cdot min^{-1}$ were the positive increase in speed during the game, total and per minute; Decelerations (n) and Decelerations/min were the negative increase in speed during the game, total and per minute; Maximal (Max) and Average (Avg) heart rate (HR) (bpm) were maximal value and the average value of the heart rate during the game; Maximal Speed ($km \cdot h^{-1}$) was the maximum value of travel speed reached during a given period of time; and the Player Load was the vectorial magnitude derived from the triaxial accelerometer data. Accelerations and decelerations are used to build a cumulative measure of the rate of change in acceleration in the three axes. This indicates the stress rate to which players subject their body for a certain period of time (i.e. in a match) (Barreira et al., 2017).

Statistical Analysis

Relative and absolute reliability among trials for the MAT and dribbling tests were assessed using ICC and TE, respectively. ICC values > 0.90 were considered as excellent (Portney & Watkins, 2002). Pearson's correlation analysis was used to establish the relationship between anthropometrical data, physical performance tests and the players' load variables in the two matches. Pearson' values were interpreted as trivial (< 0.09), small (0.10–0.29), moderate (0.30–0.49), high (0.50–0.69), very high (0.70–0.89) and almost perfect (> 0.90) (Hopkins et al., 2009). Negative correlations between match load variables and physical performance tests measured in seconds were expressed as positive, because a lower value in these tests means a higher performance, so the relationship between these variables is positive. Shapiro-Wilk test was used for testing the normality of the data, which presented non-significant values. As the sample distribution was normal, Student's paired *t* test and the effect size (ES) were used to compare the match load variables between the two matches. ES were expressed in Cohen's d units (at 90% of the confidence interval [CI]) and they were interpreted as trivial (< 0.24), small (0.25–0.49), moderate (0.50–0.79) and large (> 0.80) (Cohen, 1992). All calculations were carried out using SPSS Statistics® (version 25.0 for Windows; SPSS Inc, Chicago, IL, USA). The level of statistical significance to reject null hypotheses was set at $p < 0.05$.

Results

Both MAT and Dribbling tests presented good reliability values in the present study (MAT: ICC = 0.97 and typical error (TE) = 2%; Dribbling: ICC=

Table 2.
Pearson correlational analysis [r (p)] between anthropometrical and physical performance tests and players' match load variables.

Players' match load variables	Physical Performance Tests								
	Weight	Height	BMI	CMJ	5 m sprint	10 m sprint	20 m sprint	MAT	Dribbling
Distance	0.48 (0.23)	0.27 (0.57)	0.22 (0.64)	0.87* (0.01)	0.90** (< 0.01)	0.93** (< 0.01)	0.95** (< 0.01)	0.85* (0.02)	0.69 (0.09)
Explosive Distance	0.41 (0.36)	0.09 (0.85)	0.29 (0.52)	0.91** (< 0.01)	0.90** (< 0.01)	0.93** (< 0.01)	0.93** (< 0.01)	0.84* (0.02)	0.67 (0.10)
Accelerations	-0.52 (0.22)	0.53 (0.22)	0.94** (< 0.01)	0.07 (0.88)	0.11 (0.82)	0.19 (0.68)	0.31 (0.50)	0.78 (0.87)	0.55 (0.20)
Decelerations	-0.53 (0.23)	0.53 (0.22)	0.94** (< 0.01)	0.07 (0.88)	0.11 (0.82)	0.20 (0.67)	0.31 (0.50)	0.08 (0.86)	0.55 (0.20)
accel/min	-0.66 (0.11)	0.14 (0.77)	-0.71 (0.07)	0.71 (0.07)	0.72 (0.07)	0.79* (0.04)	0.88** (0.01)	0.74 (0.05)	0.19 (0.69)
decel/min	-0.66 (0.11)	0.14 (0.77)	-0.71 (0.07)	0.71 (0.08)	0.72 (0.07)	0.79* (0.04)	0.88** (0.01)	0.74 (0.05)	0.19 (0.69)
Max HR	-0.24 (0.61)	-0.81* (0.03)	0.38 (0.41)	0.25 (0.59)	0.39 (0.39)	0.39 (0.39)	0.37 (0.41)	0.56 (0.20)	0.15 (0.75)
Average HR	0.16 (0.74)	-0.57 (0.18)	0.56 (0.19)	0.55 (0.20)	0.63 (0.13)	0.67 (0.10)	0.70 (0.08)	0.78* (0.04)	0.27 (0.56)
Max Speed	0.61 (0.15)	0.43 (0.34)	0.27 (0.57)	0.70 (0.08)	0.78* (0.04)	0.83* (0.02)	0.83* (0.02)	0.36 (0.43)	0.48 (0.27)
Player load	0.47 (0.29)	0.13 (0.78)	0.31 (0.49)	0.76* (0.04)	0.81* (0.03)	0.89** (< 0.01)	0.89** (< 0.01)	0.67 (0.10)	0.64 (0.12)

BMI: Body mass index, CMJ: countermovement jump, MAT: Modified Agility Test, HR: heart rate.
* $p < 0.05$, ** $p < 0.01$

0.68 and TE = 10%). The correlational analysis between the players' anthropometrics and physical performance and the match load variables are presented in Table 2. The results for paired *t* test and ES analysis revealed no statistical differences in any player's load variables between matches. In addition, low ES values were shown, except for maximal HR and maximal speed, which presented moderate ES values (Table 3).

Table 3.
Load variables comparison between matches.

Match external load variables	Descriptive data		Comparison		ES (90% CI)
	Match 1	Match 2	t	*p*	
Distance (m)	3891.1 ± 2133.4	3680.4 ± 2340.0	0.39	0.71	0.09 (-0.79; 0.97)
Explosive Distance (m)	475.8 ± 355.8	352.9 ± 323.4	1.21	0.28	0.35 (-0.54; 1.23)
Accelerations (n)	2253.1 ± 706.3	2144.4 ± 699.2	0.33	0.76	0.15 (-0.73; 1.03)
Decelerations (n)	2254.7 ± 709.4	2145.1 ± 698.1	0.33	0.76	0.15 (-0.73; 1.03)
Accelerations/min	38.1 ± 6.3	38.3 ± 6.6	-0.10	0.92	-0.03 (-0.90; 0.85)
Decelerations/min	38.1 ± 6.4	38.3 ± 6.7	-0.11	0.92	-0.03 (-0.90; 0.85)
Max HR (bpm)	185.6 ± 15.1	172.9 ± 27.9	1.09	0.33	0.54 (-0.35; 1.43)
Average HR (bpm)	154.4 ± 21.7	143.1 ± 29.3	0.98	0.37	0.42 (-0.47; 1.31)
Max Speed (km·h^{-1})	22.5 ± 4.1	18.7 ± 6.8	2.12	0.09	0.65 (-0.25; 1.54)
Player load	51.6 ± 27.7	42.4 ± 29.8	1.30	0.25	0.31 (-0.57; 1.19)

ES (90%CI): Effect size at 90% of confidence interval.

Discussion

This study firstly aimed to analyse the relationship between the players' physical performance and their match load variables in competition in CP football, and secondly, to discriminate the possible impact of playing two matches on two consecutive days on the players' match load variables. The main findings for the present study were the existence of a relationship between the players' physical performance and their match load in competition, as well as the absence of statistical differences between two matches played on two consecutive days on the players' match load variables.

The results in this study provide coaches and teams with descriptive data of CP football players' physical demands in two official matches. This data shows a very high standard deviation for some match load parameters, as the total distance covered, the distance covered at high velocity and accelerations and decelerations. This variability may be because CP players with a lower level of impairment cover more distance at a higher intensity and perform more accelerations and decelerations than players with a higher level of impairment (Yanci et al., 2018). However, it is usual that CP teams have players from the three sport classes on the field. In addition, the field positions also influence this match load variability in conventional football (Bloomfield et al., 2007) and therefore the same is expected to happen in CP football, but there is no previous study that analyses this aspect.

Anaerobic physical performance of CP football players has been considered as a crucial factor to improve match performance, since high intensity actions as sprinting, jumping or rapid change of direction have been described as determinants in this sport (Daniel et al., 2020; Reina et al., 2016; Yanci et al., 2016, 2019b). Football researches consider these kinds of actions as determinants in competition (Peña-González et al., 2019; Stølen et al., 2005), and they are even more important in CP football, in which the impairment is mainly associated with the central nervous system and thus, with the performance in high intensity actions. Additionally, these high intensity actions are especially important in CP football because of the reduced field size and hence the reduced length of displacements compared to conventional football. The results in this study indicated, in a general way, that players' match load variables in competition are related to their ability to perform these anaerobic physical performance tests, suggesting that a higher physical condition of a player may have an impact on their match load parameters in competition. These results are in line with the literature in conventional football which shows that both, aerobic and anaerobic physical condition of players are related to their match performance (Bradley et al., 2013; Mohr et al., 2003; Rampinini, Bishop, et al., 2007). Similarly, other team sports modalities as Australian football or rugby also report similar relationships between players' physical capacities and their physical performance in competition (Gabbett & Seibold, 2013; Mooney et al., 2011; Piggott et al., 2015).

Specifically, the main associations in this study were seen for physical performance tests (except for the dribbling ability) and for the players' capacity to cover more distance in the match and to do so at high velocity, which is in accordance with the results shown in conventional football (Rampinini, Bishop, et al., 2007). Additionally, accelerations and decelerations per minute and the maximal speed in competition seem to be related to the players' capacity to perform better in linear sprint. A higher relationship between these match load variables and the players' abilities to accelerate in a short distance (5-m sprint) and to change of direction (MAT) were also expected a priori, although they showed a very high but non-significant correlation (r = 0.72–0.74; p = 0.05–0.08). The player load, which has been previously shown to be a valid and reliable unit load data for trainings and matches in conventional football (Barreira et al., 2017), also showed very high and significant correlations with jumping and sprinting linearly ability. In this regard, the players' physical performance in field tests (i.e. short [5-m] or long [30-m] sprint ability or intermittent endurance [yo-yoIR1 test], among others) have been shown as a determinant factor to show higher values in match load, especially for high-intensity actions, in conventional football (Black et al., 2018; Buchheit et al., 2010; Castagna et al., 2010; Castillo et al., 2019). Nevertheless, other match load variables did not seem to be related to any physical performance tests, for example, the total number of accelerations and decelerations and heart rate-related variables. As regards to this, the maximal and average heart rate of a football match have shown some limitations as indicators of the exercise intensity, and thus, do not seem to be good indicators of players' physical performance in a match (Alexandre et al., 2012).

Anthropometrical variables (i.e., height, weight and BMI) correlated neither to physical performance nor to match load variables in this study. However, although anthropometrical characteristics have been shown to be a predictor of success in several conventional sports (Bidaurrazaga-Letona et al., 2019; Hoare, 2000; Keogh, 1999), the results of this study suggest that these characteristics may be not an important factor to perform better both in physical performance tests and in competition in CP football.

The secondary aim of the present study was to analyse the possible fatigue effects on the players' match load variables in a second official match (with 17 hours rest between matches). To the authors' knowledge, there is no previous study that has shown how the previous match fatigue impacts on CP football players´ performance. The paired *t* test analysis showed that the match load variables were not different between matches, which suggests that players´ physical performance in the second match is not influenced by the fatigue generated in the first match. These results, specially for the covered distance, are in accordance to the results from able-bodied football players, in which there were not differences in the overall distances between normal and congested fixtured periods (Clemente et al., 2021; Dellal et al., 2015). However, a trend with a small to moderate ES (d = 0.31–0.65) was observed except for total distance covered and the absolute and relative number of accelerations and decelerations (Table 3). This trends seems to be in line with the findings shown by previous studies in conventional football, which show that HR responses during the match are affected by fatigue in elite adult, junior, university and recreational football (Alexandre et al., 2012), and that the muscle damage (seen 40 and 60 hours after the match) is related with the distance covered at high velocity, accelerations and sprints (Varley et al., 2017). Due to the small sample size involved in this study and its heterogeneity, the results of this study did not show a significant difference between matches. However, the previous literature and the trend seen in this study suggest the possibility of a fatigue effect in the current Spanish competition system. Therefore, future research aimed at seeing how fatigue may affect CP football players is required.

The present study has some limitations that should be considered. The results from this study should be taken with caution since the sample is small and there are not a similar number of players in each FT class. In this regard, previous research have shown physical performance differences between FT classes and it may influence the results of this study. Similarly, the clinical type of CP may explain the lack of significance in the results but there are not sample enaugh to create groups and compare between them (i.e. only one player with diplegia). Future research with larger sample may compare the relationship between physical performance and match load in CP footballers and the effect of fatigue in two consecutive matches according to players' FT class and/or players' clinical type of CP.

Finally, the present study provides some practical implications for CP football technical staffs that it could be considered in practical field. Since the players' physical performance in field test correlated to players' match load in competition, coaches and conditioning trainers may infer their players performance in the match using simple, efficient and reliable field tests. In addition, previous research suggest that these field test could be used for tatlent identification and players' selection processses due to its relationship with the players' demands in competition (Castagna et al., 2010).

Conclusions

This study provides CP football coaches and professionals with descriptive data on players' physical demands in competition for two official matches. Additionally, this study showed that the CP football players' physical performance mainly in jumping and sprinting ability is related with their match load variables, especially for the total distance covered in a match, the distance covered at high velocity, the maximal speed and the player load. In addition, the match load variables show a trend to decrease between matches on two consecutive days (separated by 17 hours), which suggests that players may be in a fatigue status to compete in the second match.

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