Original Article

Match analysis of wheelchair padel players of different functional level

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ABSTRACT

The aim of this study was to quantify the kinematic demands of wheelchair padel and to examine the activity profiles in professional players according to their functional level. Twenty-two elite players classified in functional level groups (from 1 to 4) were video-analysed with a two-dimensional DLT corrected video system across seven matches of a professional tournament. The results showed players covered 729.6 ± 369.9 meters and 238.45 ± 129.45 turns per match during 1128.9 ± 583.04 second of effective playing time at a mean speed of 0.53 ± 0.49 m/s per rally. The WCP players' functional classification had heavy influence on their activity profiles during matches, with a large association with time spent in speed zones. However, WCP players spent most of the effective playing time in low and very low speed zones, regardless of functional groups. The players ranking, playing experience, years in daily ambulation and wheelchair manoeuvrability seemed to be other key determinants in wheelchair padel performance. **Keywords:** Time motion; Disability; Racket sport; Performance analysis.

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INTRODUCTION

Wheelchair padel (WCP) is a new adapted racket sport that emerged in 2010 before the great rise of its homologous discipline of Conventional Padel (CP), one of the most practiced sports in South America with a rapid international expansion in up to 27 countries around the world (Courel-Ibañez, Sánchez-Alcaraz & Muñoz, 2017). WCP is played in pairs (2 vs. 2) as best of 3 sets into a small-sized grass court (20 x 10 m) and surrounded by glass and mesh wall. In the same way like wheelchair tennis (WCT), the playing dynamics are limited by a double bounce of the ball before players must return it. During last years, WCP has grown professionally on court and institutionally off court with an increasing number of federal licenses as well as number of tournaments within the professional circuit.

Currently, research in wheelchair sports is focused on describing the mobility performance of players by accurately determining court-movement variables, including the distance travelled, the wheelchair turns as well as the linear and angular velocities during competitive match play conditions. It is now well-stated that one of the key determinants of performance in all the wheelchair disciplines is the ability of the athlete to sprint, brake and turn with the wheelchair (de Witte et al., 2017). In wheelchair tennis (Filipcic & Filipcic, 2009a; Sindall, Lenton, Tolfrey, et al., 2013 and Sindall, Lenton, Whytock, et al., 2013) reported distances covered per match of 613,3191 and 3952 m of effective playing time (EPT) respectively, and mean speeds per rally and per match around 1 m/s for a total playing time between 50 and 80 minutes (Croft, Dybrus, Lenton & Goosey-Tolfrey, 2010; Filipcic & Filipcic, 2009b; Roy, Menear, Schmid, Hunter & Malone, 2006; Sánchez-Pay, Sanz-Rivas & Torres-Luque, 2015; Sánchez-Pay, Torres-Luque & Sanz-Rivas, 2015; Sindall, Lenton, Tolfrey, et al., 2013). In wheelchair basketball (WCB), de Witte, Hoozemans, Berger, Berger, van der Woude, & Veeger, (2016), quantified the chair turns during competitive games indicating that players performed between 250 and 390 turns, depending on the players position, for a total playing time between 80 and 90 minutes. At the moment, there is only one pilot study that quantifies the players' kinematic demands in WCP (Navas, Ramón-Llín & Veiga, 2017) which would facilitate the prescription of training programs specific to the demands of the sport (Rhodes et al., 2015a).

In order to standardize the participants' impairments in wheelchair sports, players are classified according to their functional level in different groups. In general terms, the factors that determine the functional classification are functionality of the trunk, function of the lower limbs, upper limbs and hands. This functional classification influences the kinematic demands of players as previously reported in WCR and WCT, as players with highest classification level usually achieve greater velocities and distances during matches (Rhodes et al., 2015a; Rhodes, Mason, Malone & Goosey-Tolfrey, 2015b; Sindall, Lenton, Cooper, Tolfrey & Goosey-Tolfrey, 2014). In last years, the analysis of the players' activity profiles in wheel chair sports has evolved by the use of specific speed zones for analysis, where the match-play intensity is standardized in relation to an individual's peak speed for each functional group. The functional classification in WCP is established in groups from 1 (the lowest functional level) to 4 (the highest) in such a way that the total punctuation of the pair of players cannot exceed 5 points. However, at the moment, there is little information about the impact of functional classification on the performance of WCP players and their activity profiles (Rhodes et al., 2015a).

According to this, the aims of the present study were to quantify the kinematic demands of WCP and to examine the activity profiles of professional players according to their functional level. We hypothesized that players of a higher functional classification level could achieve greater kinematic values and a higher activity profile than those with a lower level.

METHODS

Participants

Twenty-two male WCP players (age = 39 ± 7 years) were analysed during seven official matches in the second tournament of the 2015 Spanish Professional WCP circuit (Table 1). Players were categorized into four groups according to a professional medical committee, from the lowest to the highest functional level (groups 1 to 4). Approval for the study was gained from University Research Ethics Committee and all participants provided their written informed consent to participate in the current investigation.

Table 1. Characteristics of the professional wheelchair padel players participating in the 2015 Spanish Professional WCP circuit

Functional classification	N	Ages (years)	Body mass (kg)	Playing experience (years)	WCP user for daily ambulation (years)
I	6	38 ± 4	74 ± 12	4 ± 2	11 ± 5
II	8	39 ± 9	71 ± 9	8 ± 5	18 ± 13
III	4	47 ± 5	79 ± 7	7 ± 5	11 ± 6
IV	4	35 ± 6	81 ± 8	4 ± 2	8 ± 4
Total	22	40 ± 8	75 ± 10	6 ± 4	13 ± 9

Data acquisition and processing

The matches were filmed using two digital video cameras JVC® GZ-MG recording at 25 Hz, each located at the top of each front wall court (four meters above and right in the middle of the court), and each recording half court (Figure 1). Matches footage was analysed with a two-dimensional DLT corrected (Abdel-Aziz & Karara, 1971) video system that allowed calculating the players 2D real coordinates (in meters) from the 2D screen coordinates (in pixels). This methodology has been extensively employed for performance analysis in different able-bodied sports such as football (Mallo, Veiga, Lopez de Subijana & Navarro, 2008) or swimming (Veiga, Cala, Frutos & Navarro, 2013).

Figure 1. Location of the camera in the padel court

Using the software Photo23D (Cala, Veiga, García & Navarro, 2009), the video images were footage were processed by an experimented observer who manually digitized (at a sampling frequency of five frames per second) the point of contact of the two wheels of each player's wheelchair with the grass throughout the effective playing time (EPT). This EPT was considered as the playing time of each rally from a player hitting the ball until point has ended (according to the WCP regulations). Once the two-dimensional coordinates of the players' trajectories were obtained, they were smoothed using quantic splines functions with the Cross Generalized Validation procedure as a method for evaluating the adjusting factor (Woltring, 1985).

Before the commencement of matches, five control points in each court, represented by field markers and uniformly distributed along the playing court were filmed and were employed for calibration purposes. The validity of the measurement system was checked by calculating the root mean square error when reconstructing the distance between two control points (less than 2%). To determinate the reliability of the method, the experimented observer repeated 30 times the digitization of the same rally sequence. The intra-reliability (Bland & Altman, 1986) tests did not reveal any significant differences ($p < 0.05$) between observations, with total differences in the measurements consistently less than 1%.

Total distance (m) calculated as the linear trajectory of the middle point between the two contact points of the wheelchair with the court, chair turns (360º) calculated as the angular displacement of the planar vector joining the same two contact points aforementioned, rally mean speed (m/s) and rally peak speed (m/s) were determined for each player during all matches. Using an approach similar to Venter, Opperman & Opperman, (2011) and Cahill, Lamb, Worsfold, Headey & Murray, (2013), calculating the mean peak speed of each classification group, five arbitrary speed zones were established specific to each functional classification group: very low (≤20% Vmax), low (>20–50% Vmax), moderate (>50–80% Vmax), high (>80–95% Vmax), and very high (>95% Vmax). Also, the time spent in each of the arbitrary speed zones was calculated for each classification group (Rhodes et al., 2015a).

Statistical Analyses

Kolgomorov - Smirnov and Levene were used to test normality and homogeneity of variances respectively. Descriptive statistics (mean ± SD) were used to check the normal distributions of data whereas median (IQR) was used for non-parametric results. To compare different functional standards a Kruskall Wallis test was used and then U the Mann Whitney post tests were employed for the pair comparison with Bonferroni p adjustment. Chi square tests were used to compare speed zones among standards, Z tests were used to compare standards proportions, and effect size were calculated with Cramer´s V, where 0.1 represents a small effect, 0.3 represents a medium effect and 0.5 represents a large effect (Cramer, 1999). Statistical significance was assigned by $p < 0.05$.

RESULTS

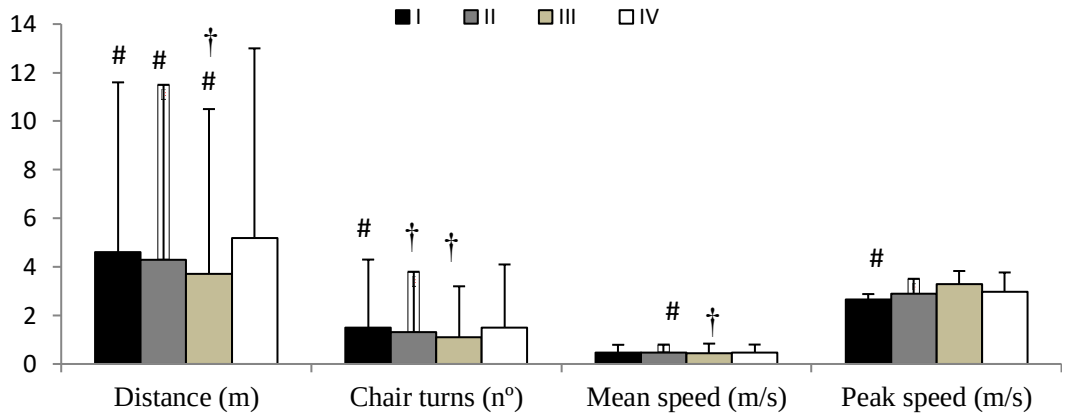
Kinematic Demands of WCP

The mean distance covered per match by professional WCP players (729.6 ± 369.9 m) was 2.3 times the distance covered per set (319.2 ± 143.6 m) which was 7.9 times the distance covered per game (40.5 ± 28.7 m) and 6.3 times the distance covered per rally (6.38 ± 6.41 m). WCP players performed also 238.45 ± 129.45 turns per match which corresponded to an average of 2.09 ± 2.25 turns per rally. Regarding the time variable, it should be noted that only the effective playing time (EPT) was analysed. Mean time spent per match (1128.9 ± 583.04 s) was 2.3 times greater than per set (493.9 ± 215.26 s) which was 7.9 greater than per game (62.7 ± 39.27 s) and this was 6.3 times greater than rally (9.9 ± 8.03 s). The peak distance covered and time spent per match (EPT) in the tournament was ~1456.6 m and ~1793.8 s, respectively. Players

moved at an rally mean speed of 0.53 ± 0.49 m/s, with a mean peak speed ranging from group I to IV of 2.65 ± 0.27 m/s, 2.89 ± 0.35 m/s, 3.28 ± 0.29 m/s and 2.97 ± 0.43 m/s), respectively.

Activity Profiles According to Functional Classification of WCP

The functional classification of the players affected the kinematic demands of WCP, such as the distance covered ($H = 22.4$; $p < 0.001$), the chair turns ($H = 27.8$; $p < 0.001$) and mean speed ($H = 11.1$; $p < 0.01$) but not the peak speed ($H = 7.56$; $p < 0.056$). However, there was no correlation between the player's functional level and the magnitude of distance, chair turns or mean speed. Players from functional group IV achieved the greatest values in distance covered and chair turns followed by groups I, II and III, respectively (Figure 2). For the rally mean speed, players from standard II were the fastest followed by IV, I and III.



 # Statistically different from group III (P < .0125) and †statistically different from group IV (P < .0125)

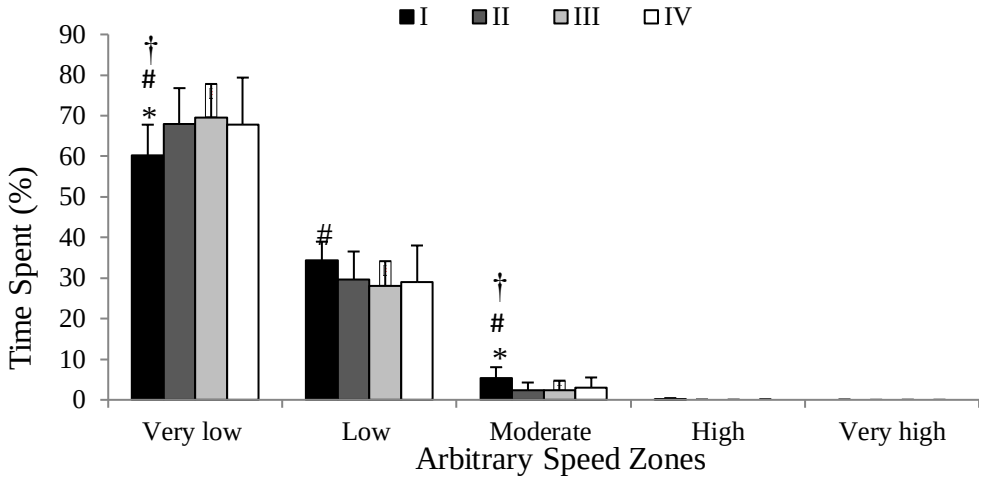
Figure 2. Descriptive statistics for kinematic variables per rally in professional wheelchair padel according functional standards

Arbitrary Speed Zones

According to the arbitrary speed zones (Table 2), wheelchair players spent 66.4% of total time in very low speed zones, 30.25% in low speed zone, and less than 5% in moderate zones. There was a large association (Figure 3) between functional classification and percentage of time spent in speed zones ($\chi^2_9 = 36.8$, $p < 0.001$, $V = 0.055$), indicating that players in group I spent a lower amount of time in very low but greater amount of time in low and moderate speed zones compared to the remaining groups.

Table 2. Arbitrary speed zones (m/s) relative to the peak speed in each functional group (Vmax) of professional WCP players participating in the 2015 Spanish Professional WCP circuit

	Functional Classification			
Zone	I	II	III	IV
Very low, ≤20% $_{Vmax}$	≤0.56	≤0.69	≤0.70	≤0.67
Low, >20-50% $_{Vmax}$	0.56-1.41	0.69-1.72	0.70-1.76	0.67-1.67
Moderate, >50-80% $_{Vmax}$	1.41-2.25	1.72-2.75	1.76-2.82	1.67-2.67
High, >80-95% $_{Vmax}$	2.25-2.67	2.75-3.27	2.82-3.34	2.67-3.17
Very high, >95% $_{Vmax}$	>2.67	>3.27	>3.34	>3.17



**Statistically different from group II (P < .0125), #statistically different from group III (P < .0125) and †statistically different from group IV (P < .0125)*

Figure 3. Time spent in five arbitrary speed zones between functional standards during professional wheelchair padel tournament

DISCUSSION

The WCP is a growing double racket sports discipline that has not been analysed yet in terms of kinematic demands or activity profile of players. The present study aimed to fill this knowledge gap by quantifying the match physical demands of WCP players during a professional tournament. According to our data, WCP performed an intermittent game mode with most of time at low and very low intensity playing. The functional group seemed to influence the activity profile but, unlike expected, kinematic demands did not increase with an increased player's functional class.

Compared to other wheelchair disciplines such as tennis (Sindall, Lenton, Tolfrey, et al., 2013 and Sindall, Lenton, Whytock, et al., 2013), basketball (Sporner et al., 2009) and rugby (Rhodes et al., 2015a; Sarro, Misuta, Burkett, Malone & Barros, 2010; Sporner et al., 2009) which reported distances between 2679 and 4540 m per match, WCP players in the present research covered shorter distances per match (729 m) during the EPT, due probably to the smaller dimensions of the padel court. When distances are presented by rally or game, values in the present research (6.38 and 40.5 m per rally and game, respectively) were not far from those presented in WCT matches (Filipcic & Filipcic, 2009a) (6.11 and 46.16 m). Players in the WCP tournament also performed 238.45 chair turns per match and 2.09 turns per rally to prepare themselves to receive or hit the ball and to get in an optimal position, lower values that reported in WCB (de Witte et al., 2016). These rotational data of professional WCP players are one of the main findings of the present research as no previous research in racket sports had been ever reported, despite being acknowledge as a key skill in wheelchair mobility (Sindall, Lenton, Tolfrey, et al., 2013).

In terms of EPT per match, WCP players in the present research spend more time (18.81 min) than previous studies in WCT (between 10 and 13 min) (Roy et al., 2006; Sánchez-Pay, Sanz-Rivas & Torres-Luque, 2015; Sánchez-Pay, Torres-Luque & Sanz-Rivas, 2015). Time differences may be related to the possibility of playing with the rebound of the ball on the wall and the double bounce of the ball before players must return

it. This aspect could clearly determine that the duration of the points was greater in WCP and the game more continuous.

For the speed values, WCP players moved at lower rally mean speed (0.53 m/s) compared to the other disciplines as WCR (between 1.14 and 1.33 m/s) (Rhodes et al., 2015a; Sarro et al., 2010; Sporner et al., 2009), WCT (between 0.93 and 1.00 m/s) (Filipcic & Filipcic, 2009a; Sindall, Lenton, Tolfrey, et al., 2013 and Sindall, Lenton, Whytock, et al., 2013) and WCB (1.48 m/s) (Sporner et al., 2009). The main explanation, other than the reduced dimensions of the court, is that WCP is played on a grass surface that slows the movements of the players down due to greater friction with the wheel of the chair (Chua, Fuss & Subic, 2010). Also, WCP and WCT players have the constraints of propelling the wheelchair while holding a racket, which considerably interferes in the player's mobility performance (Sindall et al., 2014; Goosey-Tolfrey & Moss, 2005). Generally speaking, the kinematic comparisons between wheelchair racket sports with WCT or WCP are problematic, as WCR and WCB playing time incorporates working and stopped-game-clock periods (compared to the EPT presented in WCP or WCT). In addition, in WCR and WCB, other opponents can directly influence the player's movements and force them to stop quite frequently which actually highlights the importance of acceleration in these disciplines. However, both WCP and WCT players do not have obstacles to avoid, they rarely have to come to a complete standstill and are more in control of their own movements. Therefore, the ability to effectively maneuverer with their wheelchair will probably represent a key skill to optimize performance (Mason, Porcellato, van der Woude & Goosey-Tolfrey, 2010; Rhodes et al., 2015b).

When comparing between different functional classification groups, the activity profiles of WCP in the present research did not increased according to the functional classification standard. Both for the distance and the chair turns, maximum values were observed in players of group IV followed by groups I, II, and III (in this order). The main explanation, according to the subjects' characteristics, was that players in group IV presented less wheelchair playing experience and fewer years in daily ambulation with respect to the rest of groups. This probably forced them to cover more distances and perform more chair turns to follow the rallies due to their lower manoeuvrability. Just like it happens in squash (Hughes & Frank, 1994), it is possible that successful playing strategies are associated with moving the opponent, thus forcing them to cover greater distances. Indeed, previous research in conventional padel CP (Ramón-Llín, Guzman, Vuckovic, Llana & James, 2010), reported that intermediate level covered more distances than elite level players. For the rally mean speeds, players in group II, with a better ranking, more wheelchair playing experience and more years in daily ambulation respect to the rest of groups (Table 1), achieved faster values (0.48 m/s) than players with the lowest ranking in group III. This could be expected for the aforementioned factors and it was also observed in the rally mean speed of top level (1.08 m/s) versus recreational (0.77 m/s) WCT players (Filipcic & Filipcic, 2009a) and for players of a higher functional level in WCR (Rhodes et al., 2015a; Rhodes et al., 2015b). The superior trunk function of players in higher functional groups that could play an important role in developing anaerobic power and, consequently, peak velocity (Goosey-Tolfrey & Moss, 2005).

Finally, according to the arbitrary speed zones, the WCP game was performed at low intensity, with 66% of EPT spent in the very low speed zone and 30% in the low speed zone, regardless of the players' functional classification. Differences were only observed in players with the greater functional capacity (group I) that spent less time in very low speed zones, probably helped by a better wheelchair manoeuvrability. Compared to other wheelchair disciplines like WCR (Rhodes et al., 2015a; Rhodes et al., 2015b) and WCT (Sindall, Lenton, Tolfrey, et al., 2013), the EPT spent by WCP players on high and very high-speed zones was very low and probably highlighted the importance of WCP game dynamics (WCP being played in pairs, shorter

dimensions of the court and longer EPT than other wheelchair disciplines) on determining the kinematical demands.

The current results indicate how that the WCP training sessions should be focused on obtaining aerobic demands sufficient to cope with match distances and time of up to ~1456.6 m and ~29.9 min (EPT), combined with the anaerobic demands of changes of rhythm and short periods of duration in very specific actions of the games. In addition, special attention should be given to the training of the wheelchair manoeuvrability (238.45 turns per match) as this could stand as an important factor that determines kinematic differences between players of different functional groups. Future research should examine the influence of the players' functional classification (and therefore their wheelchair manoeuvrability) on the effectiveness of their playing performance. Also, differences in physical demands between winners and losers of the matches could provide key information to interpret the games dynamics. The present study did not consider the type of wheelchair or the opponent court-movements that could influence the outcomes of the activity profile of players.

CONCLUSIONS

The results of the current study showed the kinematic demands of WCP and indicated that WCP players stayed very short time stopped conferring a more continuous game and spending most of the playing time in very low and low speed zones. Distances covered and speeds of WCP were lower compared to other wheelchair disciplines mainly due to the different court surface and dimensions and also to the fact that WCP must propel the wheelchair while holding the racket. The functional classification of WCP players had large influence in the kinematic performance variables, but no correlations were observed between functional standards and the players' activity profile. The actual ranking of players, the wheelchair playing experience, the years in daily ambulation or the manoeuvrability when traveling with the wheelchair seemed to be more important determinants of performance than functional classification.

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