Performance analysis in wheelchair para-badminton matches

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Abstract

Para-badminton has performance classes which consider the impairment degree of each athlete; two of them use a wheelchair and are identified as Wheelchair 1 (WH1) and Wheelchair 2 (WH2). Due to the difference in functionality of players between the classes, the match characteristics of WH1 and WH2 games are expected to be different. Therefore, the objective of our study was to describe and compare the temporal and technical characteristics of classes WH1 and WH2. Twenty-three matches covering both WH1 and WH2 classes for men's singles performed during the first phase of Brazil Para-badminton Championship 2018 were filmed and assessed. There were differences between all temporal characteristics, except in relation to the rally time and frequency of strokes, which suggested that the WH2 matches were more intense and more prolonged. Both clear and net-lift strokes were the techniques most used by the two classes. The WH2 class showed a higher frequency of total strokes, net-shot, smash, block and non-forced errors ($p<0.05$) than the WH21 class. Regarding the winning of points, the net-lift and service led to higher wins in WH1. Drop-shot and clear (WH1), and net-shot and drop-shot (WH2) were the highest occurring shots leading to winning points.

Keywords: *Paralympic Sport, Para-badminton, Performance, Match Analysis*

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Cite this article as:

Mota-Ribeiro, W., & Bezerra de Almeida, M. (2020). Performance analysis in wheelchair para-badminton matches. *International Journal of Racket Sports Science, 2*(1), 22-31.

Introduction

The Tokyo Summer Paralympics (scheduled for 2020, but now expected to take place in 2021) marks the official debut of Para-badminton. Para-badminton events encompass performance classes aiming at assuring a fair competition based on impairment degree of each athlete (BWF, 2017). There are six sport classes according to each kind and/or level of impairment, including two that use wheelchairs - Wheelchair 1 (WH1) and Wheelchair 2 (WH2). The former group of athletes presents a higher degree of functional impairment (BWF, 2017; Strapasson Duarte, & Pereira, 2015).

Elaboration of practice planning must take into account the typical demands of the modality (Abian-Vicen, Castanedo, Abian, & Sampedro, 2013; Álvarez, 2001). Therefore, in order to properly determine these demands, coaching staff should perform match analysis. Scouting and match statistics are the most common strategies for analyzing team performance in competitions (Rodrigues, Eduardo, Gois, & Almeida, 2016). However, the notational analysis by video recording can provide more accurate and practical information of each event, player and competition, due to the possibility of reviewing the plays that occurred during the match (Abian-Vicen et al., 2013).

In racket sports, performance analysis usually records number and type of strokes performed through each point, game or match. Afterwards, these data provide indicators for training prescription (Fernandez, Sanz, & Mendez-Vill, 2009). In this regard, some analyses on badminton matches have been carried out (Abian-Vicen et al., 2013; Cabello & Padial, 2002; Cabello, Prada, Sanchez, Sicilia, & Corral, 2004; Cabello-Manrique & Gonzalez-Badillo, 2003), however, considering the recent para-badminton history, studies on match analysis are still scarce (Strapasson et al., 2014, 2018; Straparsson, Baessa, Borin, & Duarte, 2017).

In this regard, it is worth mentioning that these studies narrowed the analysis to a few matches of each para-badminton class, which reduces the generalization of the results. Thus, studies with a broader range of matches are necessary to reinforce data about match characteristics in each class. It is expected that, due to the functionality between the classes, the game characteristics between WH1 and WH2 will be different. Therefore, the objective of our study was to describe and compare the temporal and technical characteristics of classes WH1 and WH2.

Method

Experimental Problem Approach

This is a descriptive and inferential study with two independent groups. All games of the single men's WH1 and WH2 categories held during the Brazilian Para-badminton 2018 Championship were filmed. Subsequently, a notational analysis was performed to compare the two classes in relation to temporal and technical characteristics.

Ethical aspects

The Brazilian Badminton Confederation authorized the researchers to record the matches. This project was approved by the Institutional Research Ethics Committee of the Federal University of Sergipe (protocol nº 2573727).

Sample

All 25 matches of men's singles event performed during the 2018 Brazilian Para-badminton Championship were filmed (WH1: n = 10; WH2: n = 15). Matches would be excluded from analysis if any unexpected event that could affect natural time course of match occurred, or if athletes needed medical care during the game (which did not happen). Besides, matches that lasted more than 2 games were excluded in order to keep similarity with other studies (two matches out) (Abian-Vicen et al., 2013; Fernandez-Fernandez, Tellez, Moya-Ramon, Cabello-Manrique, & Villanueva, 2013). Therefore, the sample comprised 23 matches (10 WH1, and 13 WH2). All participants represented the best players in the country and had already participated in at least one international tournament.

Data Collection and Research Instrument

All matches were recorded by a GoPro Hero 4 Silver camera (GoPro, USA), 4k resolution, and 12 megapixels. The camera was placed baseline, 3 m apart and 1.60 m height, in order to monitor the entire playing area, thus, enabling to identify which strokes were being executed. Further reproduction was performed by using the Windows Media Player software (Microsoft, USA), and the time structure was measured with a digital timer (Casio, Japan). It is worth mentioning that all measurements and observations were carried out by the same researcher who had had extensive training on the methods and procedures of the present study.

Reliability Study

Data collection was performed by a badminton trainer with experience in performance analysis. However, a subsample of 3 matches was randomly selected to analyze intra-rater reliability using the Fleiss Kappa test. The results showed a kappa value of 0.91, considered almost perfect agreement.

Temporal Characteristics

The temporal variables assessed were based on research related to conventional badminton (Abian-Vicen et al., 2013; Chen & Chen, 2008; Faude et al., 2007; Laffaye, Phomsoupha, & Dor, 2015; Cabello-Manrique & Gonzalez-Badillo, 2003) and defined in Table 1.

Table 1.
Operational definition of the variables related to the time characteristics of the para-badminton performance analysis

Variables	Definition
Total playing Time (TT)	Time between the first game service to the last point of the game, recorded in minutes
Rally Time (TR)	Time between contact with shuttle during service and end of point, recorded in seconds
Effective Time (ET)	Time accounted for the sum of rallies, recorded in minutes
Rest time (RT)	It is the sum of the intervals between rallies and the official intervals, recorded in seconds
Frequency of Strokes (FS)	Corresponds to the ratio between the total number of strokes and the actual playing time (TS / ET), strokes per second
Working Density (WD)	Ratio between the effective time and the rest time (ET / RT)
Work load (WL)	Ratio between the total playing time and the effective time (TT / ET) and displays the working relationship during the game. The lower the value, the greater the intensity of the game.

Technical characteristics

The technical characteristics assessed were based on research related to conventional badminton (Abian-Vicen et al., 2013; Cabello-Manrique & Gonzalez-Badillo, 2003) were Rally, Stroke, Total Strokes (TS), Unforced Error (nFE), Winning Points (WP), Block (BL), *Clear* (CL), *Drop* (DS), *Drop* (DS), *Net-Lift ou Lob* (NL), Services (Sv), Short Backhand Service (SBS), Forehand Short Service (SFS), Long Backhand Service (LBS), and Long Service Forehand (LFS) and are defined in appendix 1.

Data Analysis and Interpretation

Means and standard deviation of all the temporal and technical variables were calculated, in addition to the percentages of strokes, services and types of scoring. Normality of the continuous variables was assessed by using Shapiro-Wilk test, which is indicated for samples from 4 to 30 units, in order to reduce the chances of type I error (Miot, 2017). Classes were compared by using the t-test for independent samples (normal distribution) or Mann-Whitney U-test (non-normal distribution). The analysis considered a 95% confidence interval (95% CI), a significance level of 5%, in addition to calculating the effect size (ES) based on Pearson's r. The reference values of the effect size were <0.30 (small effect), 0.30-0.49 (moderate effect) and ≥0.50 (large effect). All calculations were performed by using the SPSS statistical analysis software version 22 (IBM, USA), except for the effect size (Excel, Microsoft, USA).

Results

Temporal Characteristics

There were differences in all temporal characteristics, except for RT and FS. In this sense, WH2 matches were more intense (ES: large for WL, and moderate for WD), and more prolonged (ES: large for ET, and moderate for TT) (Table 2).

Table 2.
Time characteristics of the games of classes WH1 and WH2. Data are presented as mean and standard deviation

Variables	WH1	WH2	*p*	95% CI	ES
WL	3.9 ± 0.7	3.3 ± 0.4 [a]	0.030	-	0.56
TT (min)	21.6 ± 3.5	24.6 ± 3.0*	0.037	-5.82 a -0.20	0.44
ET (min)	5.7 ± 1.6	7.7 ± 1.7*	0.009	-3.49 a -0.55	0.53
TR (s)	5.7 ± 1.3	6.7 ± 1.3	0.073	-2.21 a 0.10	0.38
RT (s)	15.6 ± 1.9[a]	15.0 ± 0.8	0.026	-	0.23
FS (strokes/s)	0.72 ± 0.05	0.72 ± 0.03	0.705	-0.27 a 0.04	0.08
WD	0.36 ± 0.08	0.45 ± 0.09*	0.009	-0.17 a -0.02	0.48

WL: work load; TT: total playing Time; ET: effective time; TR: rally time; RT: rest time; FS: frequency of strokes; WD: work density; ES: *effect size*. *$p < 0.05$ (t test); [a]$p < 0.05$ (Mann-Whitney test).

Technical Characteristics

Regarding the several types of strokes executed, WH2 demonstrated a higher usage of net-shot, smash, and block, besides a higher number of TS (ES: large for all). Moreover, clear and net-lift were the type of stroke most used on both classes (no statistical difference between classes), whereas drive and block were the least used (Table 3).

Players in the WH2 class performed more services during the matches (ES: large), although no differences concerning the specific types of services were found. In that matter, the short backhand service was the most used service, while long backhand service was the least used service (Table 4).

Table 3.

Number of strokes carried out in the classes WH1 and WH2. Data are presented as mean and standard deviation, and as a total number (n) per class with percentage (%).

	WH1		WH2		*p*	95% CI	ES
	Mean ± SD	n (%)	Mean ± SD	n (%)			
TS	189.0 ± 60.8	1890 (100)	266.0 ± 68.2*	3459 (100)	0.007	-146.5 a -25.7	0.54
NL	42.0 ± 12.7	420 (22.2)	52.9 ±14.8	688 (19.9)	0.077	-23.1 a 1.3	0.38
DR	0.8 ± 1.1	8 (0.4)	2.1 ± 1.6	27 (0.8)	0.053[a]	-	0.40
DS	31.2 ± 16.9	312 (16.5)	39.5 ± 9.7	513 (14.8)	0.155	-19.9 a 3.4	0.30
NS	16.4 ± 6.6	164 (8.7)	33.1 ± 11.0*	431 (12.5)	<0.001	-25.0 a -8.5	0.68
CL	91.6 ± 32.3	916 (48.5)	119.9 ± 45.7	1559 (45.1)	0.112	-63.8 a 7.1	0.34
SM	5.2 ± 1.4	52 (2.7)	13.0 ± 4.2*	169 (4.9)	<0.001	-10.7 a -4.9	0.77
BL	1.8 ± 1.9	18 (0.9)	5.5 ± 2.3*	72 (2.1)	<0.001	-5.6 a -1.9	0.67

TS: total strokes; NL: *net lift;* DR: *drive;* DS: *drop shot;* NS: *net shot*; CL: *clear*; SM: *smash;* BL: block. *$p < 0.05$ (t test); [a] Mann-Whitney test.

Table 4.

Number for each types of service performed in games of classes WH1 and WH2. Data are presented as mean and standard deviation, and as a total number (n) per class with percentage (%).

	WH1		WH2		*p*	95% CI	ES
	Mean ± SD	n (%)	Mean ± SD	n (%)			
Sv	58.3 ± 8.7	583 (100)	67.3 ± 6.4*	875 (100)	0.009	-15.60 a -2.45	0.53
SFS	13.1 ± 10.7	131 (22.5)	12.8 ± 11.9	167 (19.1)	0.958	-9.71 a 10.22	0.01
SBS	25.5 ± 20.2	255 (43.7)	26.7 ± 16.1	347 (39.7)	0.876	-16.90 a 14.51	0.03
LFS	13.2 ± 10.5	132 (22.6)	17.5 ± 4.3	227 (25.9)	0.388	-14.32 a 5.80	0.20
LBS	6.5 ± 4.3	65 (11.1)	10.3 ± 11.9	134 (15.3)	0.141	-9.00 a 1.40	0.32

Sv: services, SFS: Forehand Short Service, SBS: Short Backhand Service, LFS: Long Service Forehand, LBS: Long Backhand Service *p < 0.05 (t test).

Table 5.

Number for several performance characteristics in the games of classes WH1 and WH2. Data are presented as mean and standard deviation, and as a total number (n) per class with percentage (%).

	WH1		WH2		*p*	95% CI	ES
	Mean ± SD	n (%)	Mean ± SD	n (%)			
NL	4 ± 2.0*	40 (12.9)	2.3 ±1.6	30 (8.9)	0.04	0.09 a 3.30	0.43
DR	0.1 ± 0.3	01 (0.3)	0.1 ± 0.4	2 (0.6)	0.710[a]	-	0.08
DS	8.6 ± 4.7	86 (27.7)	5.9 ± 3.5	77 (23)	0.135	-0.90 a 6.25	0.32
NS	3.8 ± 2.4	38 (12.2)	6.1 ± 4.4	79 (23.6)	0.153	-5.50 a 0.92	0.30
CL	5.8 ± 2.8	58 (18.7)	3.6 ± 2.6	47 (14)	0.068	-0.20 a 4.54	0.39
SM	2.3 ± 2.1	23 (7.4)	4.4 ± 3.6	57 (17)	0.119	-4.75 a 0.60	0.33
BL	0.6 ± 0.7	06 (1.9)	1.1 ± 0.9	14 (4.2)	0.220[a]	-	0.25
Sv	5.8 ± 2.7*	58 (18.7)	2.2 ± 1.8	29 (8.6)	0.01	1.60 a 5.55	0.63
WP	31.1 ± 3.5	310(53)	30.9 ± 5.7	335(43)	0.933	- 4.12 a 4.48	0.02
nFE	27.6 ± 7	276(47)	37.2 ± 4.9*	444(57)	<0.001	-14.80 a -4.46	0.64

NL: *net lift;* DR: *drive;* DS: *drop shot;* NS: *net shot*; CL: clear; SM: smash; BL: block; Sv: services; WP: Winning Points; nFE: Unforced Error. *$p < 0,05$ (t test); [a] Mann-Whitney test.

Discussion

The present study aimed at identifying and comparing technical and time characteristics of 23 para-badminton matches of WH1 and WH2 classes. It was previously clear that effective time (ET), frequency of strokes (FS) and work load (WL) are extremely important variables to qualify intensity of the match in conventional badminton (Phomsoupha & Laffaye, 2015). Thus, in the present study we used them in a similar way for para-badminton analysis. The main reason for this study was to create a body of knowledge for the competition characteristics that helps to improve training methods and provides information on the total amount of work, rest periods, series or repetitions required with training, especially in sports for people with disabilities (Sánchez-Pay, Sanz-Rivas, & Torres-Luque, 2015).

Temporal characteristics

When comparing the temporal characteristics between the classes, some statistical differences were found, mainly considering the variables that determine match intensity, that is, WL and WD, which indicates that the WH2 class match is more intense than WH1. In addition, WH2 class matches were longer when compared to WH1 class, according to TT and ET mean values.

These characteristics provide coaches with important information when working with both classes, since it is necessary to differentiate the exercises based on time characteristics according to the intensity of each class. Exercises, such as multi-shuttle, in which the coach launches several shuttles in sequence to the athlete to simulate a rally, should be performed with greater times and greater speed for class WH2, including with less rest time for the same.

The mean TT of WH1 class match lasted 21 min, and the WH2 one was 24 min long. Similar results were found in worldwide elite athletes, in which the TT in WH2 class (30 min) was longer than WH1 class (21 min), and even longer than in WH2 matches on the present study. However, it is worth mentioning that the study with athletes of the Para-badminton World Championship was carried out based on only one match of each class (Strapasson et al., 2017).

Mean ET found in the present study was 6 min in the WH1 class and 7 min in WH2 class, which shows a longer shuttle playing time in WH2 class, which correspond approximately to 28% and 30% of TT, respectively. These results are in agreement with what was observed previously on conventional badminton matches, ranging between 27% (Abian-Vicen et al., 2013) and 32% (Phomsoupha & Laffaye, 2015). Sánchez-Pay et al. (2015) denoted lower values than these with wheelchair tennis athletes, with an average of 20%. This difference in tennis could be explained by a larger court size, faster strokes, and the use of a ball instead of a shuttle. These three factors favor a less dynamic style of playing, since the distance covered by player/ball is larger. At the end of a play, the shuttle hardly falls down more than one meter apart from the wheelchair, which makes the resting interval shorter.

The ET/RT ratio is used in tennis (ITF, 2012) and badminton to characterize the WD, and has an important role for determining the intensity of the match, that is, the higher the value, the higher the intensity (Cabello-Manrique & Gonzalez-Badillo, 2003; Phomsoupha & Laffaye, 2015). In the present study, RT showed a higher value for WH2 class. WD values below 1.0 corroborate with a modality of an intermittent nature, similar to conventional badminton, whose RT values are higher than ET, which enables enough time for players to be prepared for the next point.

The FS can be used in both, conventional badminton and para-badminton, to provide useful information related to the match speed. Notwithstanding, to the best of our knowledge, this is the first study to analyze this performance indicator. Values slightly above 0.72 were found for both classes, which are lower than those found in conventional badminton athletes, whose means ranged from 0.92 to 1.09 (Abián, Castanedo, Feng, Sampedro, & Abian-Vicen, 2014; Faude et al., 2007). The lower FS for these para-badminton classes when compared to conventional badminton is explained by the most commonly used types of strokes, such as clear and net-lift, which are characteristically slower, and the lower incidence of faster strokes, such as drive and smash. This is due to the net height in

relation to the height of the athletes when seated, which limits the performance of these strokes. Another preponderant factor for a higher FS in conventional badminton is the lower displacement speed of WH1 and WH2 athletes when compared to the badminton ones.

WL is an important tool to quantify the external load of the para-badminton match, i.e., the rate between total and effective match time (TT/ET), which represents the working rate during the game. The lower the WL value, the higher the workload and intensity of the match. Considering this variable, WH2 class showed a higher match intensity, which corroborates with the other temporal characteristics already addressed.

Technical Characteristics

Among the technical characteristics, strokes present the most common techniques used by the athletes and can provide support for training program elaboration, aiming at maximizing the specific skills demands of each class. The clear was the most used stroke, and along with net-lift respond for 70% of the strokes in WH1 class and 65% in WH2 class (Table 4). These strokes reveal the intention to make the opponent go to the back of the court, in addition to allow more time for the attacking player to move and prepare himself for the next stroke. Another relevant tactical aspect associated with the high prevalence of these actions is that the opponent's response also tends to be a stroke to the back of the court in order to protect himself from SM or DS counter-strokes.

Another relevant tactical aspect associated with the high prevalence of these actions is that the opponent's response also tends to be a stroke on the back of the court to protect against smash or drop-shot counterattacks. This tactical intension to conquer points can be justified by the difficulty that athletes of both classes have in their antero-posterior displacement.

Athletes of both classes predominantly performed SBS. In this kind of service, athletes try to throw the shuttle in the frontcourt of the opposing player, as close as possible to the service line. That is the most elemental service technique in para-badminton, due to its teaching-learning ease (Table 5) (Strapasson, 2016). The service importance in WH1 class is decisive, since it is the second technical characteristic that scores the most during the match (Table 6).

The WH2 class showed statistically higher values for the net-shot, smash and block strokes (Table 4). The block in para-badminton is closely associated with an opposing smash, which makes smash a determining factor when considering the possibility of increasing or not block execution. Therefore, it was expected that the class that obtained the highest amount of smash could produce a greater number of block, which happened. It is worth mentioning that, although there is a statistical difference associated with the strokes between these classes, the rational value between smash and block, which is of approximately 2.8 smash/block, shows that there is no significant practical difference between the use of these actions, thus, a differentiate work is not necessary when training these strokes in both classes.

The two scoring forms (nFE and WP) are widely used in conventional badminton and can indicate the quality of the strokes (Blomqvist, Luhtanen, & Laakso, 1998). Regarding the comparative analysis on the types of scoring during the matches, the nFE were more frequent in WH2 class (Table 6). This is due to the greater body control capacity of WH2 class athletes to perform a more intense and aggressive match.

As shown by the time characteristics, the athletes executed riskier plays to score the points; consequently they made more errors in the strokes. This does not mean that the classes had differences in technical quality, but rather a greater risk requirement for scoring the points. This information focuses on the performance of the athletes and the final results of the match (Chiminazzo, Ferreira, Castanho, Barreira, & Fernandes, 2017).

The WPs that occurred most in WH1 and WH2 classes were drop-shot and net-shot, respectively (Table 6). Both strokes throw the shuttle at the opposing frontcourt, the area where most points occur (Strapasson et al., 2017). This factor and the greater occurrence of the clear and net-lift (Table 4) strokes in both classes characterize a type of match, in which the tactical purpose is inducing the opponent to move to the backcourt, thus, creating space for finishing the plays in the frontcourt. This strategy is justified by the difficulty of

anteroposterior displacement of the athletes of these classes.

This study has some limitations. We were not able to identify the detailing of each athlete's training program, such as weekly attendance and training load monitoring. So, It is not possible to know whether athletes with different training regimens can show different game characteristics. However, all the athletes in the sample had already participated in, at least, one international tournament, in addition to being considered the best athletes of this sport in the country. Therefore, it is believed that there might be some similarity among each other as regards to prepare for competitions.

Conclusions

Considering the temporal characteristics of the variables referred to as work load, work density, total playing time, rally time, the WH2 class showed a more intense match-play than WH1. The net-shot was the only stroke that showed a practical difference between classes, with a higher number for WH2 class. The clear and net-lift were the strokes most used by both classes, accounting for 70% (WH1) and 65% (WH2) of the actions. Regarding the scoring types, the nFE were more frequent in WH2 class. The highest winning points occurrences were the strokes executed at the opposing frontcourt, such as drop-shot (WH1) and net-shot (WH2).

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Appendix 1.

Operational definition of the variables related to the technical characteristics of the para-badminton performance analysis.

Variables	Definition
Rally	Set of actions performed between the beginning of a service and the completion of the point
Stroke	Technical gestures used to launch the shuttle by impact with the racket, to the opposing side during the rally
Total Strokes (TS)	Sum of the strokes of a game
Unforced Error (nFE)	The athlete has the control of the play and ends up losing the point by mistake, striking a shuttle or off the net, consequently the opponent's point
Winning Points (WP)	Points earned directly by the action of the scorer, hitting the opponent's body or ground of the court
Block (BL)	Basically defensive stroke, as it is the answer to a fast attack of the adversary, where the objective is to block the trajectory of attack only by positioning the racket to cushion the impact
Clear (CL)	A stroke executed above the head, the shuttle makes a parabolic trajectory from the bottom of the court (or middle) of who strikes to the bottom of the opposing court
Drop (DS)	Strike executed above the head, the shuttle is struck from the bottom (or middle) of the striker's court with downward trajectory near the service line of the opposing court
Smash (SM)	Strike executed from the bottom or middle of the court, the shuttle performs a descending and faster trajectory, so that it falls in the middle or the bottom of the opposing court
Drive (DR)	Strike executed at head or shoulder height, with trajectory parallel to the ground and accelerated to the opposing court
Net-Shot (NS)	Strike performed in the front zone of the court, the athlete strikes the shuttle so that it falls in the front zone of the opponent's court, passing as close to the net as possible
Net-Lift ou Lob (NL)	Strike performed in the front zone of the court, below the upper edge of the net, with a parabolic trajectory to the bottom of the opposing court
Services (Sv)	Technical actions to start a rally, the server must touch the shuttle with the racket passing the same to the opposing side
Short Backhand Service (SBS)	Service executed with the palm of the hand holding the racket backwards, aiming to strike the shuttle to the front of the opponent's court
Forehand Short Service (SFS)	Service executed with the palm of the hand holding the racket facing forward, aiming to strike the shuttle to the front of the opponent's court
Long Backhand Service (LBS)	Service performed with the palm of the hand holding the racket facing back, aiming to strike the shuttle to the bottom of the opponent's court
Long Service Forehand (LFS)	Service executed with the palm of the hand holding the racket facing forward, aiming to strike the shuttle to the bottom of the opponent's court