QUALITATIVE TEMPORAL STRUCTURE AND PERFORMANCE IN BADMINTON COMPETITION

Abstract

The temporal structure of badminton has been studied for the past 2 decades. Changes in the scoring system, as well as sex or level of the players have been proven to yield different results. However, it is not clear yet how key factors in badminton such as score, set, criticality and last but not least, relative quality of opposition influence not only the temporal structure but also the outcome of the rallies.

We investigated men's singles (N=46) and women's singles matches (N=56) from the BWF Super Series circuit and World Championships in order to see whether these variables have an impact on how the game is played. We found that all variables have a certain impact on both the temporal structure of the rallies and the outcome. These differences stand true for men and women badminton players.

Additionally, we propose a profiling technique so that we can evaluate predicted versus observed performances based on the relative quality of opposition. All results yielded by the study may be used for practical coaching purposes.

Keywords: badminton, performance analysis, temporal structure, outcome, relative quality of opposition

Introduction

Badminton is an opposition indoor racket sport played either one against one (women and men's singles) or two against two (women, men and mixed doubles). One of the particularities of this sport is that it is the only racket sport not played with a ball but with a shuttlecock, that is made by a cork and sixteen feathers from the left wing of the goose. Although the aerodynamics of the shuttlecock suffers a drastic deceleration after the stroke due to air friction (Darbois-Texier, Cohen, Quéré and Claneta, 2012), badminton remains the fastest racket sport in the world.

The duration of a match is variable, and it is characterized by alternative periods of moderate to high intensity efforts with resting periods for a particular number of rallies that determine the temporal structure of the sport (Cabello, Tobar, Puga and Delgado, 1997; Cabello-Manrique and Gonzalez-Badillo, 2003; Cabello, Padial, Lees and Rivas, 2004. Variables such as match duration, rally and rest times, work density, real time played, number of rallies played, shots per rally and shot frequency have been studied through notational analysis (Barrera, Chiminazzo and Fernandes, 2016; Gawing, Beyer and Seidler, 2015). The use of notational analysis to understand the temporal structure at the highest level in men's and women's singles, in both scoring systems, has received some attention (Abian-Vicen, Castanedo, Abian and Sampedro, 2013; Abian, Castanedo, Xing Qiao, Sampedro and Abian-Vicen, 2014; Barrera, et al.,, 2016; Cabello-Manrique, Carazo-Prada, Ferro-Sanchez, Oña-Sicilia and Rivas-Corral, 2004; Cabello et al., 2003; Cabello et al., 2004; Ming, Keong and Ghosh, 2008; Gawing et al., 2015; Laffaye et al., 2015; Phomsoupha and Laffaye, 2015)

These characteristics make badminton a quick, complex and dynamic sport (both physically and mentally) in which each player tries to destabilize the opponent's balance and in turn generate disorder, while trying to maintain its own stability and self-organization when leading the rallies (Chow, Seifert, Hérault, Chia and Lee, 2014; see also Vilar, Araújo, Davids and Travassos, 2012). In fact, badminton is a sport into constant adaptation (Abian et al., 2014; Laffaye et al., 2015) and evolving due to its dynamical temporal structure.

Specifically, Cabello et al. (2004) studied the time structure of badminton competition in tournaments of 5 different levels: junior national, junior international, senior national, senior international and world championships). The authors found, over a sample of 79 male and female players with the old scoring system, that the greater the level of the competition was the fewer the differences between men and women's singles were. That is, unlike national and intermediate international tournaments (junior and senior), world class level shows no significant differences in the total playing time, total work and rest times. In contrast, Abian et al. (2013), claim that under the current scoring system during the 2008 Beijing Olympic Games, men's singles players significantly played longer matches, longer rallies, rest more between rallies, played more rallies per match and shots per rally at a higher frequency than the women's singles players who have in turn a greater work density and percentage of time played. A more recent study (Gawin et al., 2015), using top 10 players shows that, like Cabello et al's. (2004) study, there are no significant differences between men's and women's singles concerning the temporal structure of the matches. It appears to be much discrepancy about the time structure of badminton, and it seems to rely on the level of the sample and the kind of match measured (Abian et al., 2014; Cabello et al., 2004; Ming et al., 2008; Tu, 2007; see also Gawin et al., 2015). Assuming that Cabello et al.'s (2004), Abian et al.'s (2013) and Gawin et al.'s (2015) studies match each other concerning the level of the competitors engaged in different competitions (World Championships - Olympic Games - World Series), and the best players in the world are in the draw[1], they fail to prove how the quality of opposition may influence these findings and mask their interactive effects (see O'Donoghue, 2013).

It has been demonstrated that quality of opposition is the largest source of variability in sports performance (McGarry & Franks, 1994) and one of the most critical factors in sports performance research (Gómez, Lago, & Pollard, 2013; O'Donoghue, 2013). For instance, O'Donoghue (2008) distinguished three performance groups in women's singles tennis at Grand Slam tournaments: group A (Top 20), group B (Top 21-75) and group C (Top 76-on). However, this kind broad grouping, as well as Cabello et al.'s (2004) and Abian et al.'s (2013) in badminton, have been shown to hide under or overestimated performances2 inside the mean performance (O'Donoghue, 2008; O'Donoghue, 2013). O'Donoghue and Cullinane (2011) were able to account for the relative quality (RQ) between the two players in contest by using a regression-based approach to evaluate performance indicators in tennis (see also Cullinane, 2011).

Thus, the aim of the present study was to show that the both the temporal structure of badminton and the outcome, for both men and women are influenced by the relative quality between the players as well as other variables such as, match status, score and game period. It was hypothesised that the profiling technique that accounts for quality of opposition equation will solve any kind of controversy/discrepancy to yield proper results to be used for practical purposes. Additionally, we intend to generalize a new method to gather new qualitative and useful temporal information in badminton matches for all the levels of competition.

Methods

All matches from the Super Series circuit and World Championships were considered for analysis. In order to select a number of them we proceeded to set the following criteria:

1. Calculate the median and percentiles 25 and 75 of the match duration. A total of 114 selectable (from a total of 446) matches for men's singles and 126 (from a total of 434) for women's singles filled into the values used as criteria.
2. Matches were grouped as follows:
    - Top10 vs Top 10
    - Top10 vs Top20
    - Top10 vs >Top20
    - Top20 vs Top20

[1] Qualification systems for both BWF sanctioned events that gather the best players in the world, but also the lower ranked players. For instance, in the last World Championships the last qualified in men's singles and women's singles were respectively ranked number 214 and number 104 in the world. In the last Olympic Games (London 2012), the last qualified in men's singles and women's singles were respectively ranked number 226 and number 109 in the world. That may determine a very uneven quality of opposition.

[2] One may assume that the best level of performance, and hence the most reliable performance profile of a player should appear against opponents of their own level or very similar. It might be that a match confronting two players ranked 123 and 124 in the world yields similar results than a match confronting players ranked 1 and 2. However, a match between world ranking 124 and 1 may be a different story in terms of temporal structure.

- Top20 vs >Top20
- >Top20 vs >Top20

3. 20% of the matches of each condition with a minimum of 6 matches. If there are not 6 matches, then 5, 4, 3, 2, 1.
4. After highlighting the selectable matches, we used a random application to select the matches to be analysed.

To avoid world ranking variability through the 2015 season, these 9 players were ranked by their Super Series standing and World Championships results. That is, Ranking built up exclusively on Super Series (SS), Super Series Premier (SSP) and World Championships (WC) points. These are the highest classed tournaments for the 2015 season by the Badminton World Federation (BWF).
Videos were either recorded directly from behind the court using a video camera Sony handycam or downloaded from the BWF YouTube channel (www.badmintonworld.tv). Dartfish software (Dartfish Connect Plus 8.0) was used to analyse the videos of all matches.

After above mentioned criteria, we obtained 46 matches from men's singles and 56 from women's singles.

Variables

The independent variables are:

1. Sex
2. Quality of opposition
3. Set (1, 2, 3)
4. Game period (First 11, Last 11, Setting)
5. Match status (0-2 points, 3-4 points and 5-more points of difference).

The dependent variables are defined as follows:

1. Rally Time: time elapsed from the current serve until the shuttle hits the ground.
2. Rest Time: time elapsed from the moment the shuttles hits the ground until the racket impacts on it on the following serve.
3. Shots per Rally: the total number of times the shuttle is hit by both players from the serve until it hits the ground.
4. Shot frequency: time elapsed between two consecutive shots.

This Project has been carried out by validating an observation scale and creating a tool on a video analysis program (Dartfish) on which 4 observers could be trained on the analysis of the relevant variables. Find below the inter-observer reliability test.

Table 1. Inter-observer reliability tests

	Rallies	Duration	Type of Serve	Rally Outcome Player	Rally Outcome Opponent
Kappa	-	-	0.94	0.81	0.82
STE	0.05	0.14	0.10	0.46	0.39
r	1.0	1.0	0.98	0.86	0.89
ICC	0.99	0.98	0.98	0.85	0.90

Concerning the quality of opposition we will use the O'Donoghue and Cullinane's (2011) regression-based approach. The relative quality (RQ) between two players (A and B) is defined as the difference between the quality ratings of both players (R_A and R_B) engaged in a match. As an indicator of performers' quality the 2015 world ranking will be used ($Rank_A$ and $Rank_B$). #matches indicates the estimation of the round the players would reach based on their ranking. For a Super Series or Super Series Premier, player ranked 1, who is expected to win the tournament, needs to win 5 matches, whereas player ranked 2, who is expected reach the final, needs to win 4 matches.

$$R_A = \#matches - \log_2 (Rank_A);$$

$$R_A = 5 - \log_2 (1)$$

$$R_B = \#matches - \log_2 (Rank_B);$$

$$R_B = 5 - \log_2 (2)$$

$$QR = R_A - R_B$$

Results

The table 1 presents the descriptive statistics of Strokes, Rally Time, Rest Time and Frequency for men and women players. Also, the differences were presented using the student t-test with significant differences between genders in all the variables ($p<0.001$).

Table 1. Descriptive statistics and differences by sex of strokes, rally time, rest time and frequency.

	SEX	N	Mean	SD	t	p
Strokes	Men	2849	10.30	7.8	9.15	0.001
	Women	3272	8.61	6.6		
Rally Time	Men	2849	9.40	7.41	4.97	0.001
	Women	3272	8.53	6.23		
Rest Time	Men	2849	26.19	56.80	2.10	0.036
	Women	3272	23.98	18.71		
Frequency	Men	2824	.88	0.14	-22.50	0.001
	Women	3203	1.02	0.29		

Differences in all variables can be observed between male and female players. That is, men would play longer rallies containing more number of strokes at a highest pace, they also rest for longer. However, a student t-test reveals differences by sex during the first, second and third sets according to the first 11 points, the last 11 points or deuce from 19 points. The results show differences between men and women players for strokes and frequency all the sets (first and last 11 points $p<0.05$) but not during the deuce conditions. Additionally, rally time was significant during the first and second sets in the first 11 points, and during the last 11 points of the third set. Rest time was only significant during the last 11 points of the third set. No significance was identified during deuce situations (19-19 points). The lack of differences when the set or match is in maximal equality (deuce situation) is particularly interesting for coaching since it appears that women match the men's structure of the game in all the four variables.

Table 3. Descriptive statistics and differences by sex of strokes, rally time, rest time and frequency according to quality of opposition.

	SEX	Mean	SD	p		SEX	Mean	SD	p
Top 10 vs Top 10					**Top 20 vs Top 20**				
Strokes	Men	11.14	8.30	0.001	Strokes	Men	8.04	5.71	0.804
	Women	9.72	7.18			Women	8.21	5.75	
Rally Time	Men	10.18	8.02	0.272	Rally Time	Men	7.89	5.76	0.057
	Women	9.71	7.12			Women	9.16	5.89	
Rest Time	Men	25.78	18.42	0.946	Rest Time	Men	23.50	22.30	0.276
	Women	25.85	18.86			Women	25.97	18.44	
Frequency	Men	0.88	0.11	0.001	Frequency	Men	0.95	0.12	0.001
	Women	1.06	0.30			Women	1.25	0.38	
Top 10 vs Top 20					**Top 20 vs >Top 20**				
Strokes	Men	9.39	7.27	0.120	Strokes	Men	10.75	8.20	0.001
	Women	8.60	6.58			Women	6.94	5.13	
Rally Time	Men	8.54	6.81	0.929	Rally Time	Men	9.93	7.80	0.001
	Women	8.58	6.30			Women	7.29	5.02	
Rest Time	Men	25.51	19.37	0.863	Rest Time	Men	24.06	19.19	0.037
	Women	25.27	18.72			Women	20.59	18.41	
Frequency	Men	0.90	0.12	0.001	Frequency	Men	0.90	0.12	0.001
	Women	1.06	0.36			Women	1.09	0.36	
Top 10 vs >Top 20					**>Top 20 vs >Top 20**				
Strokes	Men	10.29	7.74	0.001	Strokes	Men	10.11	7.49	0.002
	Women	8.28	6.25			Women	8.65	7.11	
Rally Time	Men	9.34	7.36	0.001	Rally Time	Men	9.02	6.92	0.031
	Women	8.18	6.10			Women	8.15	5.86	
Rest Time	Men	27.86	89.07	0.214	Rest Time	Men	27.00	55.25	0.016
	Women	24.28	19.55			Women	21.85	17.43	
Frequency	Men	0.88	0.18	0.001	Frequency	Men	0.88	0.14	0.001
	Women	0.99	0.25			Women	0.96	0.20	

Table 3 presents the differences of strokes, rally time, rest time and frequency between men and women players (student t-test) according to quality of opposition. The results show differences in all the variables between sex in contexts that involve **Top 20 vs > Top 20** and **>Top 20 vs >Top 20** players. That means that the lower the ranking is the more differences we find between men and women in all the variables. In addition, there were significant differences for strokes during **Top 10 vs Top 10** and **Top 10 vs >Top 20**; rally time in **Top 10 vs Top 20**; and for frequency in the **Top 10 vs Top 10**, **Top 10 vs Top 20**, **Top 10 vs >Top 20**, and **Top 20 vs Top 20**. Apparently there is one variable that differs always between men and women which is the frequency; men hit the shuttle at a higher pace than women in all conditions.

Furthermore, as we dig deeper into this the differences for each sex in each game condition (quality of opposition) there are significant differences for men's players in strokes (F=4.696; p<0.001; ES= 0.01; differences between **Top 10 vs Top 10** and **Top 10 vs Top 20** and **Top 20 vs Top 20**, rally time (F=3.994; p=0.001; ES=0.008; differences between **Top 10 vs Top 10** and **Top 10 vs Top 20** and **Top 20 vs Top 20**), and frequency (F=4.802; p<0.001; ES=0.011; differences between **Top 20 vs Top 20** and the other contexts). However the rest time remained stable for men.

On the other hand, women's players showed significant differences for strokes (F=6.520; p<0.001; ES=0.02; differences between **Top 10 vs Top 10** with all the contexts and **Top 20 vs Top 20** with all the contexts), rally time (F=7.720; p<0.001; ES= 0.013; differences between **Top 20 vs >Top20** with all the contexts and **Top 10 vs Top 10** with **Top 10 vs Top 20**, **Top 10 vs >Top20** and **Top 20 vs Top 20**), rest time (F=5.609; p<0.001; ES=0.009; differences between **Top 10 vs Top 10** and all the contexts and **>Top 20 vs >Top20** with all the contexts), and frequency (F=46.227; p<0.001; ES=0.067; differences between **Top 20 vs Top 20**, **Top 10 vs Top 10**, **Top 10 vs >Top 20**, **>Top 20 vs >Top20**, and **Top 20 vs Top 20** with all the contexts).

The results showed above that the game structure of badminton is different depending upon the relative level of the contenders for both men and women and therefore this data could be used as a plan to where the players (men or women) should aim in training. That is, considering the top group as a reference, the lower ranking groups should train in such a way that progressively match the characteristics of the top group. Coaches should create a training environment that facilitates this.

Besides the temporal structure of badminton, which is clearly affected by relative quality of opposition we have looked into the rallies outcome and how the points are achieved by the players. In order to do so, we have separated service and service return situations (hereafter C1 and C2 respectively). We were interested in how variables like set, game criticality (first 11 points, last 11 points, and setting), score line and relative quality of opposition influence the differences between men and women badminton players.

Table 5 includes the relationships between Rally Outcome according to the sex (Crosstab command analysis: Pearson's Chi-square). The main results showed more winners in C1 for men players (C1 W) and more unforced errors in C2 for women players (C2 UE). Furthermore, the results for each gender showed significant differences for men players in C1 and C2. For instance, they make more forced errors in C1 than in C2. The women's players, in turn showed differences between winners in C1 and C2 (more winners in C2), C1 and C2 forced errors (more errors in C1) and C1 and C2 unforced errors (more errors in C2). That means that serving or returning also have an impact on the outcome of the rally and that it is different distributed for men and women; in comparison to women men get more points by directly winning and women tend to gain points from opponent's mistakes.

Table 5. Frequency distribution of point outcome (C1 winners, C1 forced errors, C1 unforced errors, C2 winners, C2 forced errors, and C2 unforced errors) according to the sex of the players.

	POINT OUTCOME							
SEX	**C1 W**	**C1 FE**	**C1 UE**	**C2 W**	**C2 FE**	**C2 UE**	**X2**	**p**
Men								
N	544	397	506	540	370	464		
Outcome %	19.3%	14.1%	17.9%	19.1%	13.1%	16.4%		
Total %	8.9%	6.5%	8.3%	8.9%	6.1%	7.6%	57.505	<.001
Adjusted Residual	5.0	-1.9	.6	.5	1.7	-5.6		
Women								
N	474	516	567	610	382	723		
Outcome %	14.5%	15.8%	17.3%	18.6%	11.7%	22.1%		
Total %	7.8%	8.5%	9.3%	10.0%	6.3%	11.9%	126.241	<.001
Adjusted Residual	-5.0	1.9	-.6	-.5	-1.7	5.6		
	x2	**df**	**p**	**EFD**	**ES**			
	51.657	5	0.001	348.17	0.092			

Table 6 shows the relationships between frequency distributions of point outcome and sex according to the game criticality during the first set of the match. The results reflect the importance of more C1 winners for men's players compared with women's players during the first and last 11 points. Also, the men's players did less C1 forced errors during the first 11 points and C2 unforced errors during the last 11 points than women. The third set did not show any significant difference. The interesting part of these results is that men keep having more winners and less mistakes (unforced or forced) during the whole set until reaching the setting situation which is a key point to equalize the performance between men and women.

Table 6. Frequency distribution of point outcome (C1 winners, C1 forced errors, C1 unforced errors, C2 winners, C2 forced errors, and C2 unforced errors) according to the sex of the players and the criticality during the first set.

	First set	**POINTOUTCOME**					
Sex		**C1W**	**C1FE**	**C1UE**	**C2W**	**C2FE**	**C2UE**
	First 11 points						
Men	N	143	88	128	136	89	108
	%	20.7%	12.7%	18.5%	19.7%	12.9%	15.6%
	Adjusted Residual	4.3	-3.1	-.2	.3	.4	-1.7
Women	N	102	151	154	155	100	154
	%	12.5%	18.5%	18.9%	19.0%	12.3%	18.9%
	Adjusted Residual	-4.3	3.1	.2	-.3	-.4	1.7
		x2	**df**	**p**	**EFD**	**ES**	
		25800.0	5.0	0.001	86.73	0.13	
	Last 11 points						
Men	N	104	71	105	110	70	110
	%	18.2%	12.5%	18.4%	19.3%	12.3%	19.3%
	Adjusted Residual	2.4	-1.9	1.5	.4	.9	-3.0
Women	N	93	113	106	128	74	184
	%	13.3%	16.2%	15.2%	18.3%	10.6%	26.4%
	Adjusted Residual	-2.4	1.9	-1.5	-.4	-.9	3.0
		x2	**df**	**p**	**EFD**	**ES**	
		17562.0	5.0	0.003	61.06	0.11	
	Deuce						
Men	N	1	1	3	0	0	0
	%	20.0%	20.0%	60.0%	.0%	0%	.0%
	Adjusted Residual	-.2	.4	1.8	-1.2	0	-1.2
Women	N	2	1	1	2	0	2
	%	25.0%	12.5%	12.5%	25.0%	0%	25.0%
	Adjusted Residual	.2	-.4	-1.8	1.2	0	1.2
		x2	**df**	**p**	**EFD**	**ES**	
		4902.0	5.0	0.297	0.77	0.61	

Further results in table 7 show that second set has a different performance structure; no more winners for men, however women tend still to make more mistakes in the first half of the set. These differences disappear in the rest of the set.

Table 7. Frequency distribution of point outcome (C1 W, C1 FE, C1 UE, C2 W, C2 FE, and C2 UE) according to the sex of the players and the criticality during the second set.

	Second set	**POINTOUTCOME**					
Sex	**First 11 points**	**C1W**	**C1FE**	**C1UE**	**C2W**	**C2FE**	**C2UE**
Men	N	136	101	122	126	92	111
	%	19.8%	14.7%	17.7%	18.3%	13.4%	16.1%
	Adjusted Residual	1.8	1.0	.0	.2	.8	-3.4
Women	N	124	99	137	138	92	179
	%	16.1%	12.9%	17.8%	17.9%	12.0%	23.3%
	Adjusted Residual	-1.8	-1.0	.0	-.2	-.8	3.4
		x2	**df**	**p**	**EFD**	**ES**	
		13471.0	5.0	0.019	96.52	0.09	
	Last 11 points						
Men	N	104	90	87	111	76	98
	%	18.4%	15.9%	15.4%	19.6%	13.4%	17.3%
	Adjusted Residual	1.2	-.5	-1.4	.4	1.1	-.7
Women	N	109	117	126	129	78	130
	%	15.8%	17.0%	18.3%	18.7%	11.3%	18.9%
	Adjusted Residual	-1.2	.5	1.4	-.4	-1.1	.7
		x2	**df**	**p**	**EFD**	**ES**	
		4637.0	5.0	0.462	62.18	0.06	
	Deuce						
Men	N	2	1	3	4	2	2
	%	14.3%	7.1%	21.4%	28.6%	14.3%	14.3%
	Adjusted Residual	-.2	-.8	-.4	1.3	.8	-.6
Women	N	3	3	5	2	1	4
	%	16.7%	16.7%	27.8%	11.1%	5.6%	22.2%
	Adjusted Residual	.2	.8	.4	-1.3	-.8	.6
		x2	**df**	**p**	**EFD**	**ES**	
		2912.0	5.0	0.714	1.20	0.30	

Table 8 shows the relationships between sex and point outcome according to the points range (criticality) during the third set. Significant effects were identified by sex during first11 points with more C1 UE for men and C2 UE for women players. However, when reaching the final stage of the match the only difference between men and women was still a big amount of C2 UE for women.

Table 8. Frequency distribution of point outcome (C1 winners, C1 forced errors, C1 unforced errors, C2 winners, C2 forced errors, and C2 unforced errors) according to the sex of the players and the criticality during the third set.

	Third set	**POINTOUTCOME**					
Sex	**First 11 points**	**C1W**	**C1FE**	**C1UE**	**C2W**	**C2FE**	**C2UE**
Men	N	28	23	33	29	19	18
	%	18.7%	15.3%	22.0%	19.3%	12.7%	12.0%
	Adjusted Residual	.6	.7	2.2	-.8	.8	-3.1
Women	N	23	18	18	33	14	38
	%	16.0%	12.5%	12.5%	22.9%	9.7%	26.4%
	Adjusted Residual	-.6	-.7	-2.2	.8	-.8	3.1
		x2	**df**	**p**	**EFD**	**ES**	
		13553.0	5.0	0.019	15.47	0.21	
	Last 11 points						
Men	N	24	21	24	24	22	15
	%	18.5%	16.2%	18.5%	18.5%	16.9%	11.5%
	Adjusted Residual	1.0	1.2	.6	.3	-.1	-2.8
Women	N	18	14	20	22	22	32
	%	14.1%	10.9%	15.6%	17.2%	17.2%	25.0%
	Adjusted Residual	-1.0	-1.2	-.6	-.3	.1	2.8
		x2	**df**	**p**	**EFD**	**ES**	
		8842.0	5	0.011	15.39	0.18	

The independent results for men's players showed no significant differences between sets for first 11 points (χ^2=10.830; p=0.761), last 11 points (χ^2=3.887; p=0.952) and deuce (χ^2=6.376; p=0.783) conditions. The women's players showed no significant relationships during first 11 points (χ^2=16.997; p=0.074), last 11 points (χ^2=9.841; p=0.455) or deuce conditions (χ^2=8.900; p=0.542).

Outcome and temporal structure share the same pattern; differences between men and women vanish when reaching the latest stages of the matches.

Further analysis in table 9 show that for all conditions, the score line has an impact on the performance of the rallies: more C1 W for men players compared with women players during all the conditions (0-2 points; 3-4 points; or more than 5 points). Additionally, the women's players showed more C2 unforced errors than men's players during all score-line conditions. Additionally, the way both men and women earned their points differ significantly on the score difference between the contenders.

Table 9. Frequency distribution of point outcome (C1 winners, C1 forced errors, C1 unforced errors, C2 winners, C2 forced errors, and C2 unforced errors) according to the sex of the players and the score-line (points differences in the score).

		POINT OUTCOME					
Sex	**Score-line**	**C1 W**	**C1 FE**	**C1 UE**	**C2 W**	**C2 FE**	**C2 UE**
	0-2 points						
Men	N	221	193	276	288	154	197
	%	16.6%	14.5%	20.8%	21.7%	11.6%	14.8%
	Adjusted Residual	3.0	-1.5	1.2	1.2	.7	-4.4
Women	N	190	249	283	298	161	317
	%	12.7%	16.6%	18.9%	19.9%	10.7%	21.2%
	Adjusted Residual	-3.0	1.5	-1.2	-1.2	-.7	4.4
		x2	**df**	**p**	**EFD**	**ES**	
		27.859	5.00	0.001	148.08	0.10	
	3-4 points						
Men	N	145	103	115	133	103	119
	%	20.2%	14.3%	16.0%	18.5%	14.3%	16.6%
	Adjusted Residual	2.4	-.5	-.9	.4	1.5	-2.6
Women	N	128	126	146	146	97	179
	%	15.6%	15.3%	17.8%	17.8%	11.8%	21.8%
	Adjusted Residual	-2.4	.5	.9	-.4	-1.5	2.6
		x2	**df**	**p**	**EFD**	**ES**	
		12.953	5.00	0.024	93.25	0.09	
	5 or more points						
Men	N	177	101	115	119	113	148
	%	22.9%	13.1%	14.9%	15.4%	14.6%	19.1%
	Adjusted Residual	3.4	-1.0	.2	-1.1	1.0	-2.4
Women	N	156	141	138	166	124	227
	%	16.4%	14.8%	14.5%	17.4%	13.0%	23.8%
	Adjusted Residual	-3.4	1.0	-.2	1.1	-1.0	2.4
		x2	**df**	**p**	**EFD**	**ES**	
		16.534	5	0.005	106.20	0.10	

The results separated for each sex showed significant differences for men players (χ^2=42.976; p<0.001; ES=0.09) with less C1 winners during 0-2 points of difference (adjusted errors= -3.3), more C1 unforced errors during 0-2 points (adjusted errors= 3.7) and less during more than 5 points (adjusted errors= -2.6). More C2 winners occur during 0-2 points of differences (adjusted errors= 3.2) and less C2 winners during more than 5 points of difference (adjusted errors= -3.1). Lastly, less C2 forced errors and C2 unforced errors occur during 0-2 points of difference (adjusted errors= -2.3 and -2.2, respectively) and more C2 unforced errors occur during more than 5 points score-lines (adjusted errors= 2.4).

On the other hand, women players showed differences (χ^2=21.248; p=0.019; ES=0.06) with less C1 winners during 0-2 points of difference (adjusted errors= -2.7) and more C1 winners during more than 5 points of difference (adjusted errors= 2.0). Lastly, more C1 unforced errors occurred during 0 to 2 points (adjusted errors= 2.7) and less C1 unforced errors during more than 5 points of difference (adjusted errors= -2.2).

The results present in the Table 10 show the relationships between point outcome and sex according to quality of opposition. The main results identified no significant differences in **Top 10 vs Top 10**, **Top 10 vs >Top 20**, and **Top 20 vs Top 20** matches.

Table 10. Frequency distribution of point outcome (C1 winners, C1 forced errors, C1 unforced errors, C2 winners, C2 forced errors, and C2 unforced errors) according to the sex of the players and the score-line (points differences in the score).

			POINT OUTCOME					
Quality Opposition	**Sex**		**C1 W**	**C1 FE**	**C1 UE**	**C2 W**	**C2 FE**	**C2 UE**
Top 10 vs Top 10	**Men**	N	108	85	104	97	76	103
		%	18.8%	14.8%	18.2%	16.9%	13.3%	18.0%
		Adjusted Residual	1.0	-1.3	1.5	1.2	.2	-2.3
	Women	N	105	112	95	92	82	148
		%	16.6%	17.7%	15.0%	14.5%	12.9%	23.3%
		Adjusted Residual	-1.0	1.3	-1.5	-1.2	-.2	2.3
			x2	**df**	**p**	**EFD**	**ES**	
			9.519	5.00	0.90	75.01	0.09	
Top 10 vs Top 20	**Men**	N	77	62	61	72	58	61
		%	19.7%	15.9%	15.6%	18.4%	14.8%	15.6%
		Adjusted Residual	2.1	.5	-1.1	-1.2	1.9	-1.8
	Women	N	52	54	69	81	38	76
		%	14.1%	14.6%	18.6%	21.9%	10.3%	20.5%
		Adjusted Residual	-2.1	-.5	1.1	1.2	-1.9	1.8
			x2	**df**	**p**	**EFD**	**ES**	
			11.657	5.00	0.040	46.68	0.12	
Top 10 vs >Top 20	**Men**	N	180	125	169	200	115	172
		%	18.7%	13.0%	17.6%	20.8%	12.0%	17.9%
		Adjusted Residual	1.8	-2.6	-.4	1.3	.5	-.7
	Women	N	159	173	184	186	114	194
		%	15.7%	17.1%	18.2%	18.4%	11.3%	19.2%
		Adjusted Residual	-1.8	2.6	.4	-1.3	-.5	.7
			x2	**df**	**p**	**EFD**	**ES**	
			10.293	5	0.067	115.07	0.07	
Top 20 vs Top 20	**Men**	N	19	17	25	19	14	20
		%	16.7%	14.9%	21.9%	16.7%	12.3%	17.5%
		Adjusted Residual	.7	.0	.6	.2	.5	-1.6
	Women	N	32	35	45	37	24	59
		%	13.8%	15.1%	19.4%	15.9%	10.3%	25.4%
		Adjusted Residual	-.7	.0	-.6	-.2	-.5	1.6
			x2	**df**	**p**	**EFD**	**ES**	
			3.040	5.00	0.694	12.52	0.09	
Top 20 vs >Top 20	**Men**	N	85	67	91	89	63	71
		%	18.2%	14.4%	19.5%	19.1%	13.5%	15.2%
		Adjusted Residual	.8	1.8	-.3	1.2	1.8	-4.6
	Women	N	28	16	37	27	15	56
		%	15.6%	8.9%	20.7%	15.1%	8.4%	31.3%
		Adjusted Residual	-.8	-1.8	.3	-1.2	-1.8	4.6
			x2	**df**	**p**	**EFD**	**ES**	
			24.457	5.00	0.001	21.60	0.19	0.00
>Top 20 vs >Top 20	**Men**	N	75	41	56	63	44	37
		%	23.7%	13.0%	17.7%	19.9%	13.9%	11.7%
		Adjusted Residual	5.2	-.8	.6	-.8	.5	-4.1
	Women	N	98	126	137	187	109	190
		%	11.6%	14.9%	16.2%	22.1%	12.9%	22.4%
		Adjusted Residual	-5.2	.8	-.6	.8	-.5	4.1
			x2	**df**	**p**	**EFD**	**ES**	
			38.056	5	0.001	42.52	0.18	

The main significant results reflected more C1 winners for men players during **Top 10 vs Top 20** and **>Top 20 vs >Top 20** matches. Also, the women players committed more C2 unforced errors than men players during **Top 20 vs >Top 20**, and **>Top 20 vs >Top 20** matches. Lastly, the results showed more C1 forced errors in women's players during **Top 10 vs >Top 20** matches.

The results also showed that men were not significantly difference in the frequencies displayed according to the quality of opposition (χ^2= 21.963; p=0.638). The women players showed difference trends among quality of opposition (χ^2= 55.005; p<0.001; ES=0.06). The results reflected that less C1 winners occur during **>Top 20 vs >Top 20** (adjusted residuals= -2.8), less C1 forced errors during **Top20 vs >Top 20** (adjusted residuals= -2.6), more C2 winners during **>Top 20 vs >Top 20** (adjusted residuals= 3.0), less C2 unforced errors during **Top 10 vs >Top 20** (adjusted residuals= -2.7) and more C2 unforced errors during **Top20 vs >Top 20** (adjusted residuals= 3.0).

These results show again that, not only the game structure is affected by the relative quality of the players but also the outcome. Specifically, the lower the ranking is the more differences appear between men and women in the outcome of the rallies. Interestingly enough is the fact that the outcome in the women's rallies fluctuates along the ranking, however men remain stable.

To finish off with the results of the performance, we introduce an example on what the analysis/evaluation of relative quality of opposition would be. As it was introduced above, O'Donoghue and Cullinane's (2011; O'Donoghue, 2013) used a regression-based approach in which the relative quality (RQ) between two players (A and B) is defined as the difference between the quality ratings of both players (R_A and R_B) engaged in a match. We chose two top players to see how they perform with opponents of different world ranking. These two players are fow women singles Ratchanok Intanon and for men singles Chen Long. The analyses of the performance profile (O'Donoghue, 2013) concerning their outcome (C1 and C2 winners, forced errors and unforced errors) were analyzed. Results for Ratchanok Intanon (see table 1) and Chen Long (see table 2) show that the adjusted values for quality of opposition are highly important to control for individual players' performance during each match. In fact, the predicted values allowed indicating whether the player performed better or worse than expected. The evaluation score percentage (ES%) allows to improve the quality of this information. For example, values around 50% would indicate a performance close to the median (percentile 50) of the player's performance. However, when these values are greater or lower to the median, they would indicate better/ poorer performances based on the normal distribution of their performance according to each opponent and the expected performance. The results presented in tables 1 an 2 for men's and women's players, respectively, are clear due to the significant differences of the expected values for each indicator depending on the ranking or quality of opposition. This model is very useful when accounting for match to match characteristics and the dependent performance of the opponent.

Table 1. Performance profiling according to quality of opposition for women's players (Ratchanok Inthanon analysis).

C1 Forced errors	**QO**	**Observed**	**Predicted**	**Residual**	**Z**	**ES%**
NOZUMI OKUHARA	7	30,8	34,47069	-3,67069	-0,59818	27,4859917
CHEUNG NGANYI	28	35	41,5565	-6,5565	-1,06846	14,2656532
SAINA NEHWAL	2	33,3	28,06741	5,23259	0,85271	80,3089928
SAYAKA SATO	14	35,3	38,0136	-2,7136	-0,44221	32,9168625
YAO XUE	68	53,8	46,0918	7,7082	1,25614	89,5467392
C1 unforced errors	**QO**	**Observed**	**Predicted**	**Residual**	**Z**	**ES%**
NOZUMI OKUHARA	7	61,5	31,32295	30,17705	1,4357	92,4456137
CHEUNG NGANYI	28	30	22,82046	7,17954	0,34157	63,3662741
SAINA NEHWAL	2	16,7	39,00646	-22,30646	-1,06125	14,4288151
SAYAKA SATO	14	29,4	27,07171	2,32829	0,11077	54,4100632
YAO XUE	68	0	17,37841	-17,37841	-0,82679	20,4178049
C1 winners	**QO**	**Observed**	**Predicted**	**Residual**	**Z**	**ES%**
NOZUMI OKUHARA	7	7,7	34,20635	-26,50635	-1,60707	5,40195067
CHEUNG NGANYI	28	35	35,62304	-0,62304	-0,03777	48,4935532
SAINA NEHWAL	2	50	32,92612	17,07388	1,03518	84,9707571
SAYAKA SATO	14	35,3	34,91469	0,38531	0,02336	50,9318444
YAO XUE	68	46,2	36,52979	9,67021	0,5863	72,1163034
C2 forced errors	**QO**	**Observed**	**Predicted**	**Residual**	**Z**	**ES%**
NOZUMI OKUHARA	7	17,4	15,98433	1,41567	0,13544	55,3868
CHEUNG NGANYI	28	0	8,64136	-8,64136	-0,82671	20,4200726
SAINA NEHWAL	2	29,4	22,62001	6,77999	0,64864	74,1714453
SAYAKA SATO	14	0	12,31284	-12,31284	-1,17796	11,9406277
YAO XUE	68	16,7	3,94146	12,75854	1,2206	88,8881247
C2 unforced errors	**QO**	**Observed**	**Predicted**	**Residual**	**Z**	**ES%**
NOZUMI OKUHARA	7	69,6	34,7007	34,8993	1,7239	95,7637051
CHEUNG NGANYI	28	41,7	46,77224	-5,07224	-0,25055	40,1081021
SAINA NEHWAL	2	5,9	23,79193	-17,89193	-0,88379	18,8404793
SAYAKA SATO	14	33,3	40,73647	-7,43647	-0,36733	35,668644
YAO XUE	68	50	54,49867	-4,49867	-0,22222	41,2071313
C2 winners	**QO**	**Observed**	**Predicted**	**Residual**	**Z**	**ES%**
NOZUMI OKUHARA	7	13	49,31497	-36,31497	-1,58924	5,60031095
CHEUNG NGANYI	28	58,3	44,58641	13,71359	0,60014	72,5793532
SAINA NEHWAL	2	64,7	53,58806	11,11194	0,48629	68,6619216
SAYAKA SATO	14	66,7	46,95069	19,74931	0,86428	80,6282953
YAO XUE	68	33,3	41,55987	-8,25987	-0,36148	35,8870327

Table 2. Performance profiling according to quality of opposition for men's players (Chen Long analysis).

C1 Forced errors	QO	Observed	Predicted	Residual	Z	ES%
HSU JEN HAO	25	4,3	7,2633	-2,9633	-0,32355	37,3139374
KENTO MOMOTA	3	14,3	27,32871	-13,02871	-1,42256	7,74318733
LIN DAN	4	36,4	24,6062	11,7938	1,28772	90,1078276
TOMMY SUGIARTO	11	15	15,03277	-0,03277	-0,00358	49,857179
VIKTOR AXELSEN	6	25	20,76902	4,23098	0,46196	67,7944997
C1 unforced errors	**QO**	**Observed**	**Predicted**	**Residual**	**Z**	**ES%**
HSU JEN HAO	25	39,1	39,66709	-0,56709	-0,05709	47,7236751
KENTO MOMOTA	3	28,6	17,05366	11,54634	1,16235	87,7453338
LIN DAN	4	4,5	20,1219	-15,6219	-1,57262	5,79034169
TOMMY SUGIARTO	11	35	30,91101	4,08899	0,41163	65,969468
VIKTOR AXELSEN	6	25	24,44634	0,55366	0,05574	52,2225533
C1 winners	**QO**	**Observed**	**Predicted**	**Residual**	**Z**	**ES%**
HSU JEN HAO	25	56,5	52,9961	3,5039	0,85009	80,2362475
KENTO MOMOTA	3	57,1	55,6356	1,4644	0,35528	63,8810081
LIN DAN	4	59,1	55,27747	3,82253	0,92739	82,313796
TOMMY SUGIARTO	11	50	54,01813	-4,01813	-0,97484	16,4819816
VIKTOR AXELSEN	6	50	54,77271	-4,77271	-1,15791	12,3450383
C2 forced errors	**QO**	**Observed**	**Predicted**	**Residual**	**Z**	**ES%**
HSU JEN HAO	25	0	-0,22807	0,22807	0,02366	50,9438094
KENTO MOMOTA	3	33,3	21,08772	12,21228	1,26677	89,7381229
LIN DAN	4	7,8	18,19555	-10,39555	-1,07832	14,0445487
TOMMY SUGIARTO	11	14,5	8,02555	6,47445	0,67159	74,9077627
VIKTOR AXELSEN	6	5,6	14,11926	-8,51926	-0,8837	18,842909
C2 unforced errors	**QO**	**Observed**	**Predicted**	**Residual**	**Z**	**ES%**
HSU JEN HAO	25	0	7,31721	-7,31721	-0,6111	27,056669
KENTO MOMOTA	3	11,1	27,22208	-16,12208	-1,34643	8,90819407
LIN DAN	4	38,4	24,52134	13,87866	1,15907	87,6786173
TOMMY SUGIARTO	11	23,1	15,02451	8,07549	0,67442	74,9977835
VIKTOR AXELSEN	6	22,2	20,71487	1,48513	0,12403	54,9354239
C2 winners	**QO**	**Observed**	**Predicted**	**Residual**	**Z**	**ES%**
HSU JEN HAO	25	100	92,56807	7,43193	0,77733	78,151795
KENTO MOMOTA	3	55,6	51,62573	3,97427	0,41568	66,1177911
LIN DAN	4	53,8	57,18088	-3,38088	-0,35362	36,1811842
TOMMY SUGIARTO	11	61,5	76,71491	-15,21491	-1,59137	5,57631659
VIKTOR AXELSEN	6	72,2	65,01042	7,18958	0,75198	77,3968457

Conclusion

These results show that in order to establish a performance and temporal structure of badminton there are many variables to be accounted for. As it was stated in the introduction the relative quality of opposition is a great source of variability, and so it has been proven in our study. Previous results missed these differences in such a straight forward fashion. Furthermore, we can state that temporal and performance structure of badminton not only depends on the level of the players engaged in action but also on another variables such as score line, criticality and set. We can conclude, as well as Cabello et al., (2004) and Gawin et al., (2015) that the higher the level is the fewer the differences found between men and women. That contrast with Abian et al's., (2014) results who claimed that there were differences between men and women. Further studies will be needed in order to apply this methodology in junior tournaments and lower level BWF sanctioned tournaments.

Last but not least, the regression based model appears to be a useful tool, to be explored in a deeper way to monitor players' performances, throughout tournaments or during the whole season. This model in extremely important to compare what the actual performances are with the kind of training conducted and more importantly how they are expected to perform with opponent of different level.

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