

Gender differences in squash performance and strategy at the elite level: a notational analysis

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Abstract

There are various strategic and tactical situations during every point of a squash match, where either male or female players need to make quick decisions. Performance analyses can provide important data for scientists, coaches and players. However, there are few studies on squash compared to other sports games. The aim is to compare the game characteristics and rally pace in the elite level of men's and women's squash matches at Professional Squash Association (PSA) tournaments. We watched video recordings of men's and women's matches at the elite level of squash. We analysed 18425 shots in 14 men's matches and 10014 in 11 women's matches. We found a significant difference in the point duration of men's matches $25,1\pm 3,5s$ compared to women's matches $17,2\pm 3,9s$ ($p<0,001$), and the men's matches were played at a significantly faster rally pace $1,34\pm 0,05s$ compared to women's matches $1,39\pm 0,05s$ ($p<0,05$). There was no statistical significance between winners and losers for the rally pace of specific shots. Regarding shot frequency, both male and female players hit more backhand shots than forehand shots in the ratio 2to1, the drive shot was the most frequent, and the most common error was when the players hit the ball too low onto the front wall. More than 50 % of all shots hit the lower third of the front wall in both genders. These observed game indicators show differences in the game characteristics and performance between the genders at the elite squash level. This information can help coaches and players to adopt gender-specific training strategies.

Key words: rally pace; tactics; men; women; performance analysis.

Introduction

Data from notational analyses can help coaches and players to better understand and prepare a training or match strategy. The two basic situations in squash are attack and defence. The offensive situations can be created by accurate shots to the side or back wall of the court, where the ball is the hardest to hit. When accurate and good-quality shots, players can reach advantageous offensive situations in which scoring is easiest. In addition, players try to provide the opponent with as little time as possible so that the player does not have time to return to the "T" zone. Conversely, in defensive situations where the opponent has gained the advantage in the rally, it is necessary to slow down the rally pace play with a slow high ball to the back of the court to gain time to return to the "T" zone (Langhammer et al., 1999). Rally pace (i.e. how quickly the ball travels between the opposing players, in other words, how much time the player has since the opponent hit the ball) has been analysed between the genders in tennis (Carboch et al., 2018). In tennis, the rally pace is often related to the quality of the serve. Vučković et al. (2013) showed the time between shots in squash of 1.1-1.6s depending on what court area was the shot taken. There are different serve types in squash, however, the squash serve is not as deciding as e.g. the tennis serve, because in elite matches a squash player rarely wins the rally by the serve winner (Carboch & Strnad, 2017), and there are on average around 13 shots in a squash rally at the elite level (Huges et al., 2007).

Notational analysis and performance indicators in sports games attract the attention of the scientist (e.g. Abdullah et al. 2016; Abian-Vicen et al., 2013; Carboch et al., 2019; Clemente et al. 2012; Laffaye et al., 2015). or studies in squash itself, however not very frequently in this sport (Hong et al., 1996; Hughes & Francks, 1994; or Hughes & Barlett, 2002;). In sport games, Kokstejn & Musalek (2019) show the importance of fundamental motor skills development in young football players and Mohammed (2013) shows differences in the body composition and trunk flexibility between squash and football players. The squash performance analysis studies dealt with shot combinations, or placement and types of all shots during the match indicating the most common shot is a straight drive into the backhand back corner (Vučković et al., 2013). From a strategic perspective between the genders, women tend to play long rallies in a defensive style usually ending with an attacking shot (Ghani et al., 2016). Men can cover more space on the court during play (Reid et al., 2016). Differences between the genders affecting the game performance and strategy in sports games are further determined by physiological, anatomical, and psychological differences (e.g. Crespo and Miley, 1998; Mavvidis et al., 2008; Ong, 2017; Paces et al., 2016).

A notational analysis allows players and coaches to diagnose and evaluate individual elements of game performance in squash, including tactical and strategic components that help to improve the game performance. Moreover, there are usually differences in these game characteristics between men and women in the sports games. The aim is to compare the game characteristics and rally pace in the elite level of men's and women's squash matches at PSA (The Professional Squash Association) tournaments.

Methods

Participants

We observed matches from the elite-level squash tournaments organized by PSA using convenience sampling. The total of 18425 shots were analysed in 14 men's matches (from the PSA tournaments Allam British Open 2018, Black Ball Squash Open 2018, El Gouna 2019, Grasshopper Cup 2019, Qatar World Championship 2019, Windy City Open 2020) and 10014 shots in 11 women's matches women's tournaments (El Gouna 2018, Allam British Open 2018, CIB Egyptian Open 2020, World Tour Finals 2019, PSA World Championship 2020). The mean men's world ranking was $12,5 \pm 6,2$ with a mean age of $27,7 \pm 5,0$ years. For female players, the mean ranking in the world rankings was $7,5 \pm 6,7$ with a mean age of $27,3 \pm 4,5$ years. All the players were right-handed. This study was approved by the Ethics Committee at the Faculty of Physical Education, at Charles University in accordance with the Declaration of Helsinki.

Measures and procedures

Data were obtained from video recordings taken at tournaments that were publicly available on the internet at youtube.com or psaworldtour.com. Video quality was assessed as completely suitable for the analysis. All the matches had a camera placed behind the back wall of the court so that the actions of both players in each match could be seen very clearly. Notational analysis was performed from the observed matches. To do this, a notation sheet was created in Microsoft Office Excel, where the specified variables were recorded. The sheet contained the following variables: match number, shot number, gender of players, the total number of rally shots, time of the shot, who played the shot (player A, B), player name, shot type, serving player, score, type of error, and location of the ball impact on the front wall. For the rally pace (i.e., how long the ball travels from the opponent's to the player's racket-ball contact), the time of each shot for each player was measured and this interval was recorded by pressing the keyboard button, which recorded the intervals directly to the Excel sheet. Each action was replayed twice. During the second observation the shot type was assigned to the measured values and error type was noted. In unclear situations, the video recording was slowed down or replayed to define the action correctly. From this obtained data, we then gathered the frequencies of specific and total rally shots.

Data evaluation

The recordings were evaluated by one evaluator, a long-time player and expert squash coach. The observed variables were defined as follows. Type of shots (Ghani et al., 2016): Serve - the first shot of the point. Drive - player hit the ball straight along the side wall to the back of the court. Cross court shot - the ball was played to the back corner from the opposite court side; Drop shot - player hits a ball to the front area of the court; Boast - the player hit the ball to the side wall first before hitting the front wall; Volley shot - player hit the ball before the ball touched the ground; Kill shot - offensive shot, which touches the front wall very low near the Tin, and usually bounces 2 times before the short line; Lob shot - higher and curved shot played into the back of the court. We selected possible error outcomes and determined them as follows: 1. Out - Tin and below: the ball hit the Tin or the area below on the front wall. 2. Front wall upper out - the ball was played above and including the out line on the front wall. 3. Left sidewall out - the ball hit over and including the out line on the left sidewall. 4. Right sidewall out - the ball hit over and including the out line on the right sidewall. 5. Back wall out - player shot over the back wall (glass) (including the out line). 6. Ball onto the floor first - the ball played from the racket did not reach the front wall but the ball touched the floor first. 7. Ball touch with the player body - player touched the ball with his body. 8. Foul shot - racket touched the ball twice.

Statistical analysis

Data were evaluated using basic descriptive characteristics, including relative and cumulative percentages. Independent samples T-tests and Cohen's d (Cohen, 1988) were performed to compare men and women, and paired samples T-tests were used to compare winners and losers. The evaluator had playing experience of more than 15 years in competitive squash and 5 years as a coach evaluating and analysing the performance in squash. To quantify intra-rater error, the evaluator viewed and analysed 3 male and 3 female matches one more time for reliability testing. Data gathered from the second review were compared to the first observed evaluations using Intra-class correlation (ICC) and Cohen's Kappa reliability test. The intra-rater (ICC) reliability for the rally pace of all shots was 0,89 and Kappa for the agreement in shot type 0,85, front wall impact location 0,94, and error type 0,99. Therefore we consider the results for reliable.

Results

Game characteristics differed significantly in men's and women's matches (table 1). The men's mean point duration reached 7,8s longer than in the women's matches, and the rally length contained 6.2 more shots in

the men's matches. We defined the rally pace as the time between the racket-ball contact of both players. The men played at a significantly faster rally pace compared to the women, i.e. they played the ball 0.05s earlier.

Table 1. Basic match characteristics of male and female matches

	Male	Female	T-test	<i>p</i>	Cohen <i>d</i>
Point duration (s)	***25,1±3,5	17,2±3,9	5,29	<0,001	2,1
Rally length	***18,6±2,3	12,4±2,5	6,48	<0,001	1,65
Rally pace (s)	*1,34±0,03	1,39±0,05	2,58	0,017	0,99

Data are presented as Mean±SD. ***Significantly different $p < 0,001$. *Significantly different $p < 0,05$.

Next, we analysed the rally pace for the specific shots. We categorize the data for the genders and from the winner's and losers' perspectives. In table 2 we can see seven shot types. Paired samples t-tests didn't show any significant differences for any shots in both male and female matches. The greatest mean difference between winners and losers can be observed in men's serves – 0.09s ($d = 0.75$). We see comparable results between winners and losers in other shots for both genders. Only women winners played drive shot slower by 0.02s ($d = 0.4$). Men achieved a faster pace in drive and cross shots compared to women, but no statistically significant.

Table 2. Rally pace of male and female winners and losers

	Rally pace - specific shots			
	Male		Female	
	Winners	Losers	Winners	Losers
Boast	1,46±0,16	1,50±0,08	1,46±0,10	1,46±0,06
Drive	1,41±0,06	1,42±0,04	1,48±0,05	1,46±0,05
Drop shot	1,19±0,04	1,21±0,05	1,24±0,06	1,32±0,20
Kill	1,01±0,09	1,02±0,06	1,08±0,07	1,03±0,06
Lob	1,76±0,20	1,74±0,15	1,94±0,15	1,88±0,14
Cross	1,31±0,05	1,31±0,06	1,39±0,05	1,43±0,11
Serve	1,29±0,12	1,38±0,12	1,34±0,13	1,35±0,12
All shots	1,33±0,06	1,36±0,04	1,38±0,07	1,39±0,06

No statistically significant differences between winners and losers.

The men played 34% of the forehand shots and 66% of the backhand shots. The women's ratio reached 64% backhands to 36% forehands. Table 3 shows the frequency of all shots for both genders. The most frequent shot was the drive for both men and women and predominantly played with the backhand. The distribution of all shots is comparable between genders, both overall and for forehand and backhand shots.

Volley shots represented 20% and 19% of shots for men and women, respectively. The most common volley shots were the Volley Drive, Cross, and Drop shot, again more often hit with a backhand shot for both genders. Women also had more unclassified shots (other), such as rally errors and referee decisions. Table 5 shows more details.

Table 3. Frequencies of shot types between the genders.

Shot frequencies	Male			Female		
	Backhand	Forehand	Total	Backhand	Forehand	Total
	Boast	2,0%	1,7%	3,6%	2,0%	2,5%
Drive	28,5%	8,7%	37,2%	24,3%	8,9%	33,2%
Drop shot	5,6%	3,2%	8,8%	5,3%	3,1%	8,4%
Kill	0,6%	0,6%	1,2%	0,9%	0,8%	1,6%
Lob	2,3%	1,1%	3,5%	2,0%	0,9%	2,9%
Cross	7,4%	8,1%	15,5%	7,7%	7,9%	15,6%
Serve	3,7%	2,1%	5,8%	5,0%	3,2%	8,2%
Volley	13,0%	6,7%	19,7%	12,0%	6,5%	18,6%
Other	-	-	4,8%	-	-	7,1%
Total	63,1%	32,1%	100,0%	59,1%	33,8%	100,0%

Table 4. Frequencies of volley shot types between the genders.

Volley shot frequencies	Male			Female		
	Backhand	Forehand	Total	Backhand	Forehand	Total
Volley Boast	0,2%	0,1%	0,3%	0,2%	0,2%	0,3%
Volley Drive	5,1%	1,7%	6,8%	4,4%	1,5%	5,9%
Volley Drop shot	4,1%	1,2%	5,3%	3,1%	1,2%	4,3%
Volley Kill	0,5%	0,7%	1,2%	0,7%	0,7%	1,4%
Volley Lob	0,1%	0,0%	0,2%	0,3%	0,0%	0,3%
Volley Cross	3,0%	3,0%	6,0%	3,3%	3,0%	6,3%
Total	13,0%	6,7%	19,7%	12,0%	6,5%	18,6%

The shot impact location on the front wall, divided into the lower, middle and upper third, the shows Figure 1. From the shots that landed on the front wall, we found that more than half of the shots landed in the bottom third of the front wall. Men used this third 3.6% more than women did; however, these data are comparable between the genders.

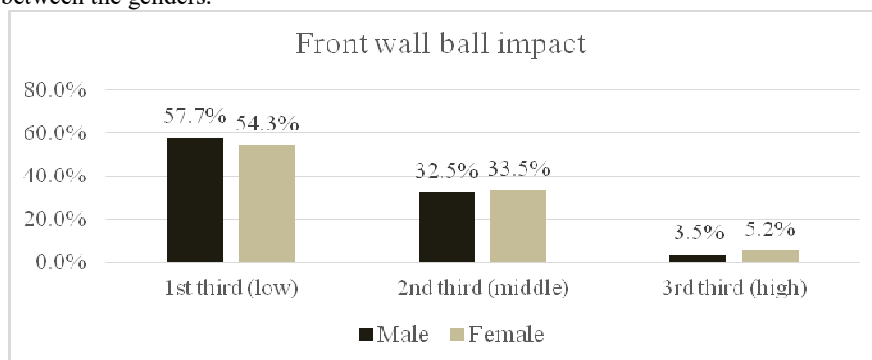


Figure 1. Location of shot impact on the front wall.

In Table 5, we can see the percentage of individual errors committed by the players in the matches. Errors were recorded in 3.2% of all analysed shots. They were divided into 8 categories. The most frequent error was hitting the ball into the Tin or below. This constituted about two-thirds of all errors for both genders (7% less for women). The second most common error was hitting the ball directly on the floor after it was played in 27 % of cases, seemingly being a forced error.

Table 5. Analysis of error shots outcome.

Error type	Male	Female
Out - Tin and below	69,5%	62,7%
Front wall upper out	1,0%	2,2%
Left sidewall out	1,4%	2,5%
Right sidewall out	1,4%	4,1%
Backwall out	0,0%	0,6%
Ball onto floor first	25,3%	26,9%
Ball touch with player body	0,5%	0,3%
Foul shot	1,0%	0,6%
Total	100,0%	100,0%

Discussion

The aim was to compare the game characteristics and rally pace in the elite level of men's and women's squash matches at PSA tournaments. The results showed statistically significant differences in game characteristics of play between men and women. The largest and statistically significant difference was the mean point length and duration between genders at the elite level of squash. Women's point length was comparable to that of elite men at national tournaments in the Czech Republic (Dušek, 2018). This difference from the results presented by us for elite men at PSA tournaments, where the best players in the world are present, may be longer

due to the better quality and more accurate shots. These shots make it much more difficult for an opponent to hit a winner. In addition, the physical preparation and movement is probably much better among top players, who are much able to reach difficult shots, thus lengthening the rallies. The shorter mean point length in women's matches could be due to a higher frequency of errors and other physiological and biomechanical prerequisites.

In terms of rally pace, men played at a significantly faster pace compared to women. This can be attributed to biomechanical and fitness differences between the sexes, with men being able to hit the ball faster and being able to cover more space on the court. Although the male winners played at a faster rally pace compared to the losers, these results are statistically insignificant. This is likely because men play in a more offensive style, which gives them an advantage on the court and overall match victory, while women have been shown to have a lower tendency to take risks at the expense of their own errors (Ghani et al., 2016). In addition, the slower rally pace in women's matches may be due to playing defensive shots more often. Vučković et al. (2010) found that winners ran a significantly smaller distance than losers. This may be related to the faster rally pace of the winners. Winners controlled more of the "T-zone", therefore they ran fewer meters. Players who control the central court area are usually in a better position (and can quicker take the position to hit the next shot) to attack and therefore can play their shots faster. A notable comparison is that the rally pace at the squash elite level is comparable to elite tennis matches on clay surfaces (Carboch et al., 2019). Of course, the ratio of work/rest ratio and load is different as the mean point duration in tennis is 5s, and also due to more frequent errors in tennis because of the absence of the walls that prolong the point in squash.

Both genders played more backhand shots than forehands at a ratio of 2 to 1. This can be attributed to the players' strategy to aim the shots at this courtside. Players can attack with the forehand shot more easily and therefore playing into the opponent's backhand is usually safer. Shots, such as volleys and drop shots, are also indicative of the more attacking play. Hong (1996) also confirms that the style of play of male squash players has a character of 'pressure and attack'. Volley play is generally more characteristic for men who play more often the drive volley and drop volley shots.

In terms of shot frequency, the drive is still the most frequent shot for both genders. We found a higher frequency of volleys in women's matches compared to the results of Ghani et al. (2016). This may indicate a slight tendency for the female game to approach the male game in terms of aggression and attack. From the perspective of ball placement on the front wall, we found that men hit the ball to the bottom third of the front wall more often compared to women. This is probably due to the more powerful shots and more aggressive style of play. It is likely that the bottom third of the front wall is used more because of the attacking playing style. This corresponds to a higher frequency of errors when hitting the tin and below in men's matches. This suggests that women attack mostly in prepared positions and do not take more risks. This is supported by Ghani et al. (2016), that a female attacking player only hits the winner if her opponent provides her with an opportunity because of a poor shot quality.

Conclusion

We have shown differences in game characteristics between men's and women's matches at the elite squash level. Men had a significantly longer point length and duration and played at a faster pace compared to women. Together with other game indicators such as shot frequency, hitting location on the front wall, and error type, these results indicate different game characteristics and more aggressive and offensive play in men's matches. The information gained in this research can help to design training units and strategic plans that can more effectively target the phenomena that lead to winning in the game of male and female players on the PSA tour. Thus, in terms of practical application in training sessions and strategy development, we need to reflect on these differences. Considering the gender-specific aspects of game performance when creating training plans and strategies for matches, identical strategies for men and women do not seem to be the most appropriate choice in practice.

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