NOTATIONAL ANALYSIS IN FEMALE GRAND SLAM TENNIS COMPETITIONS

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Abstract:

Grand Slam tennis tournaments are played on different surfaces. The aims of the present study were to analyse the technical differences in the Grand Slam tournaments (Australian Open or AO, Roland Garros or RG, Wimbledon or W, and the United States Open or US), as well as to establish differences between winning and losing players. A total of 580 sets in 248 matches played in Grand Slams between 2017 and 2018 were analysed. To observe differences between the tournaments, a one-way analysis of variance (Kruskal Wallis) with the Bonferroni *post-hoc* test was performed. Univariate (Wilcoxon test) analysis of data was carried out to show the differences between the winning and losing performances of sets. Players who had more aces, points won on the 1st serve, winning shots and net points won more matches in the AO, W and US than in the RG ($p<.05$). However, in RG, players won more receiving points (43.56% of the points played) with chances to break the opponents' service game. The results also showed that the winning players were superior in both service and receiving, and the most influential variables on the outcome of the match were percentage of receiving points won, break points won, and percentage of points won on the first serve. Such knowledge may have implications for the design of appropriate game strategies and specific training sessions to improve performance in professional women's tennis.

Key words: *tennis, surfaces, performance, technical actions, women's singles*

Introduction

The US Open (US) and Australian Open (AO) tournaments were played on grass courts until 1978 and 1986, respectively, when they changed to synthetic surfaces (O'Donoghue & Ingram, 2001). The US and AO began to play on the same surface but in 2008 the AO changed the playing surface from Rebound Ace® to Plexicushion Prestige® so concurrently, all the four Grand Slam tournaments are played on different surfaces. The International Tennis Federation (ITF) is responsible for testing and classifying the speed of the surface and the ball. In relation to the court pace rating, tennis regulation differentiates the following types of surface: 1 (slow pace), 2 (medium-slow pace), 3 (medium pace), 4 (medium-fast pace), and 5 (fast pace). Regarding the types of balls, the ITF recognises three types from 1 (fast) to 3 (slow) (Sánchez-Pay, Palao, Torres-Luque, & Sanz-Rivas, 2015). Court surface seems to be a determining aspect in the sport of tennis, since it determines speed of the game and players' strategy (Du Bois & Heyndels, 2007). However, game speed is best understood as the relationship between the speed of the surface and the ball (Miller, 2006).

Likewise, the influence of the court surface is reflected in the competition statistics, showing significant differences between the four major tournaments (Cross & Pollard, 2009; Cui, Gómez, Gonçalves, & Sampaio, 2018). Coaches can use these data in order to improve their training programmes, players can make better tactical decisions, sports organisations can manage athletes more effectively, and researchers can develop a better understanding of sports performance (O'Donoghue, 2015).

In addition, players can modify their tactical configuration by adapting to the characteristics of the court to achieve victory (Katić, Milat, Zagorac, & Đurović, 2011). Notation analysis is especially important and useful when it is carried out on tournament data (Ortega, Villarejo, & Palao, 2009). In this regard, weekly updated player and competition statistics can be found on the official websites of the ITF, the Association of Tennis Professionals (ATP) and the Women's Tennis Association (WTA) (Fernández-García, Giménez-Egido, & Torres-Luque, 2021).

However, most of the research are focused on the men's singles. Few studies have conducted

an exhaustive analysis of the professional female players' performance in the four Grand Slam events. Also, studies that analyses performance differences according to court surface are scarce (Cui, et al., 2018). Some studies have compared tennis performance between male and female category. For example, Del Corral and Prieto-Rodríguez (2010) analysed how the differences in the male and female players' ranking could predict the match outcome of the Grand Slam tournaments. Fitzpatrick, Stone, Choppin, and Kelley (2019) analysed the competition statistics of male and female players at Roland Garros and the percentage of points played with 0-4 shots (short points or short rally length), then with 5-8 and with more than 9 strokes in both tournaments. Finally, the study by Fitzpatrick, Stone, Choppin, and Kelley (2021) showed statistical performance differences between men and women in short points during Wimbledon.

Moreover, it seems that, among the four major events, Roland Garros is a tournament with the longest rallies and the lowest shot rate, while Wimbledon is the Grand Slam with the shortest rallies and the highest shot rate (Cui, et al., 2018; O'Donoghue, 2002; O'Donoghue & Brown, 2008; O'Donoghue & Ingram, 2001). Furthermore, players had better service statistics at the Australian Open, the US Open and Wimbledon, they spend more time in the baseline zone at Roland Garros, they approach the net more frequently and perform more winning shots at Wimbledon (Cui, et al., 2018; O'Donoghue & Ingram, 2001).

Filipčič et al. (2008) analysed the statistics in male and female categories at Roland Garros 2005, highlighting that the female winning players achieved better percentages and won more points when serving, made fewer unforced errors, approached the net more, and won more break points. A recent study using the PWOL method (percentage of matches in which the winner outperformed the loser), showed that for female players, points won of 0-4 shot rally length, baseline points won, first serve points won and second serve points won had the highest PWOLs at Roland Garros, while forced errors and unforced errors showed the lowest PWOLs at both (Fitzpatrick, Stone, Choppin, & Kelley, 2019).

Information about female professional players' performance in the Grand Slam tournaments is still limited. This study responds to this lack of data through an analysis that compares the performance of the players in the four events. This knowledge is vital for planning specific and effective training and design strategies for better performance. Therefore, the aims of this study were to analyse and compare the performance of elite female tennis players in the Grand Slam tournaments, and to determine the differences between the winning and losing players.

Method

Sample

The sample was composed of 580 sets from a total of 248 matches. It included 149 sets from the Australian Open (Plexicushion Prestige® acrylic hard surface), 134 from Roland Garros (clay surface), 146 from Wimbledon (grass surface), and 151 from the United States Open (DecoTurf® hard surface), all of them in the women's category. All the matches included in each tournament were recorded and analysed from the second round. The data of four matches were not included in the analysis, three of them due to a player injury and one for not having data available on the web. The study was undertaken according to the Data Protection Law, and all procedures were approved by the Local University Bioethics Committee. In addition, the USTA approved the use of the data for publication.

Variables

Table 1 shows the variables of this study, divided in seven categories: general, match, serve, net, return, winners and errors, and total points.

Procedure

The data were obtained from the official statistics of the tournament websites, following the methodology of previous studies (Cui, Gómez, Gonçalves, Liu, & Sampaio, 2017; Cui, et al., 2018; Sánchez-Pay, et al., 2015). Match statistics were included for the players who played on the court covered with the Hawk-Eye camera system (Hawk-Eye Innovations, Southampton, United Kingdom). This system uses fixed and synchronised cameras to track the ball with a reported measurement mean error between 2 and 5mm (Cui, et al., 2017; Griffiths, Evans, & Griffiths, 2005). Moreover, the system allows the generation of metadata associated with the point (e.g. server name, player on the court, score, and point outcome) stored in a file (Whiteside & Reid, 2017). In addition, some studies have calculated the reliability of the data by comparing them with expert observations with high accuracy validity (Cui, et al., 2017, 2018; Fernández-García, Blanca-Torres, Nikolaidis, & Torres-Luque, 2019). Following these investigations, the reliability of the data was confirmed. In this case, two experienced performance analysts in tennis and other racquet sports observed and collected the data of five sets that were randomly selected but played in different locations (Centre Court, Court 1, Court 2, and so on). Afterwards, comparisons were made between inter-observers (experienced performance analysts and website data) for all the variables (excluding ratio variables) after a database treatment process. The minimum Cohen's kappa value for all the vari-

Table 1. Variables analysed in the Grand Slam tournaments in the women's category

Variable group	Game statistics
General variables	Tournament, winner of the match
Variables related to match	Games won, game difference, games per set, sets played, match time (minutes)
Variables related to serve points	Aces (AC), double faults (DF), points played on 1st serve, total points played on serve, 1st serve (%), points won on 1st serve, points won on 1st serve (%), points won on 2nd serve, points played on 2nd serve, points won on 2nd serve (%)
Variables related to net points	Net points won, net points played, net points won (%)
Variables related to return points	Break points won, break points played, break points won (%), receiving points won, receiving points played, receiving points won (%)
Variables related to winners and errors	Winners (WS), unforced errors (UE), WS:UE ratio
Variables related to total points	Total points won, total points played on serve, total points won on serve

ables exceeded 0.90 (the minimum value was for the unforced error variable), while the intra-class coefficients (ICC) ranged from 0.95 to 1 and standardised typical errors varied from 0.03 to 0.11, supporting high inter-rater reliability (Hopkins, 2000). All the matches were played according to the International Tennis Federation rules (International Tennis Federation, 2020). Data collection took place one month after the end of each tournament from their official websites (https://www.ausopen.com; https://www.rolandgarros.com; http://www.wimbledon.com/index.html and https://www.usopen.org/index.html).

The sample was divided into sub-groups for its analysis. The first division was by tournament: Australian Open (AO), Roland Garros (RG), Wimbledon (W) or US Open (US). Each tournament was played on a different surface and with different balls. The AO was played on a hard court (category 4) with type 2 balls. Roland Garros was played on a clay court (category 1) with type 1 balls. Wimbledon was played on a grass court with type 2 balls, although no information was found in the ITF website related to the pace category (commonly as category 5). The US was played on a hard court (category 3) with type 2 balls. The second division was by set outcome: winning or losing player.

Statistical analysis

A descriptive analysis of each variable (mean and standard deviation) was carried out. The Kolmogorov-Smirnov test was used to calculate the normality of the variables. The results showed Kolmogorov-Smirnov being $p<.05$, so Wilcoxon test (non-parametric) was used to compare the differences between winners and losers. To observe the differences in the variables between the four tournaments, the non-parametric Kruskal-Wallis test and *post-hoc* pairwise comparison were performed. Differences between different pairs of tournaments were assessed with the Bonferroni *post-hoc* test. Significance was set at $p<.05$. All data were analysed with the statistical package IBM SPSS 20.0 for Windows (Armonk, NY: IBM Corp.).

Results

Table 2 shows the descriptive statistics (mean and standard deviation) of the different Grand Slam statistics of the female professional tennis players. Roland Garros and Wimbledon were the tournaments with the greatest number of statistically significant differences ($p<.05$). On the other hand, the Australian Open and Wimbledon were the most similar events. There was also a high number of statistically significant differences between the Australian Open and Roland Garros and between Wimbledon and the US Open. In addition, there were some significant differences between the Australian Open and the US Open (receiving points won and receiving points won [%], and between Roland Garros and the US Open (sets played, match time [minutes] and aces).

Table 3 shows the statistical differences between the winning and losing players in each Grand Slam tournament. The winners achieved better statistical records than the losers at all the Grand Slam tournaments. In this way, they obtained statistically higher values ($p<.05$) in points won on service, points won on first serve, points won on first serve (%), points won on second serve, and points won on second serve (%). They achieved more aces (especially at the Australian Open [$Z=1.81$, $p<.001$]) and performed fewer double faults. Likewise, the winners were significantly better on receiving points. Also, the values of the winning players at Wimbledon were higher than those obtained at the other tournaments ($Z=67.05$, $p<.001$). On the other hand, the winners performed statistically significantly better in the points won at the net and Wimbledon was the Grand Slam where the winners had the highest scores in the net variables ($Z=4.69$, $p<.001$) and ($Z=73.74$, $p<.001$), respectively. In addition, there were signifi-

Table 2. Average values (M), standard deviation (SD) and differences between the Grand Slam tournaments

	AO	RG	W	US
	M (SD)	M (SD)	M (SD)	M (SD)
Sets played	**2.46 (0.50)***	**2.27 (0.44)+%**	2.49 (0.50)	2.50 (0.50)
Match time (minutes)	**104.54 (34.6)***	**93.43 (29.43)+%**	102.81 (32.51)	105.79 (35.45)
Games won	4.76 (2.12)	4.61 (2.00)	4.82 (1.90)	4.69 (1.92)
Games per set	9.51 (2.56)	9.22 (1.99)	9.64 (2.10)	9.38 (1.94)
Aces (AC)	**1.44 (1.53)***	**0.83 (1.20)+%**	1.43 (1.42)	1.25 (1.41)
Double faults (DF)	1.44 (1.36)	1.37 (1.42)	1.34 (1.25)	1.34 (1.40)
Points played on 1st serve	19.68 (7.74)	19.14 (6.94)	19.95 (6.59)	19.26 (6.44)
Total points played on serve	30.95 (10.57)	30.02 (9.58)	31.26 (9.03)	30.59 (9.26)
1st serve (%)	63.26 (9.84)	63.74 (10.68)	63.74 (10.22)	63.16 (10.71)
Points won on 1st serve	12.64 (5.58)	11.82 (4.64)	13.32 (4.85)	12.26 (4.57)
Points won on 1st serve (%)	63.91 (14.23)	**62.04 (13.83)+**	67.02 (14.41)	63.86 (14.86)
Points won on 2nd serve	5.09 (2.57)	5.00 (2.59)	5.34 (2.61)	5.15 (2.89)
Points played on 2nd serve	11.31 (4.65)	10.88 (4.63)	11.27 (4.39)	11.32 (4.77)
Points won on 2nd serve (%)	45.74 (16.99)	46.85 (18.64)	47.69 (17.32)	44.63 (17.67)
Net points won	ND	**3.12 (2.23)+**	**4.15 (3.35)ç**	3.34 (3.07)
Net points played	ND	**5 (3.46)+**	**6.28 (4.69)ç**	5.23 (4.55)
Net points won (%)	ND	**64.28 (27.80)**	**67.65 (24.37)ç**	59.73 (29.17)
Break points won	**1.59 (1.15)^**	**1.63 (1.18)+**	1.34 (1.19)	1.56 (1.07)
Break points played	3.49 (2.57)	3.43 (2.55)	3.08 (2.18)	3.41 (2.23)
Break points won (%)	47.90 (33.79)	49.22 (35.02)	45.91 (71.22)	46.68 (33.80)
Receiving points won	11.78 (5.15)*#	13.20 (5.65)	12.59 (4.87)	13.17 (5.04)
Receiving points played	30.99 (10.58)	30.03 (9.58)	31.25 (9.03)	30.58 (9.25)
Receiving points won (%)	**38.05 (11.91)*#**	**43.56 (13.14)+**	**40.22 (11.81)ç**	43.05 (12.32)
Winners (WS)	**9.82 (4.58)***	**8.78 (4.29)+**	9.91 (4.77)	9.20 (4.71)
Unforced errors (UE)	ND	**12.33 (5.71)+**	**8.76 (4.76)ç**	11.68 (5.29)
WS:UE ratio	ND	**0.85 (0.68)+**	**1.49 (1.38)ç**	0.93 (0.71)
Total points won	30.99 (10.63)	30.02 (9.60)	31.25 (9.10)	30.58 (9.32)
Total points won on serve	17.73 (6.93)	**16.82 (5.89)+**	18.65 (6.10)	17.41 (6.03)

Note: AO: Australian Open; RG: Roland Garros; W: Wimbledon; US: US Open.

The following symbols indicate significant differences between the Grand Slams in pairs: *=AO vs. RG; ^=AO vs. W; #=AO vs. US; +=RG vs. W; %=RG vs. US; ç=W vs. US. ND=no data.

cant differences between both groups of players in the number of winners and unforced errors, and Roland Garros was the tournament where more shot mistakes were made by the losing players ($Z=14.01$, $p<.001$). Finally, regarding general variables, the winners were significantly better in the number of games won, the game's difference, the total points won with serve and the total points won.

Discussion and conclusion

The aims of this study were to analyse the performance of elite female tennis players in the Grand Slam tournaments, and to observe the differences between the winning and losing players. Main results showed significant differences in performance variables between the games played at the four Grand Slams, and these statistics could predict match outcome in professional tennis. This information allows coaches and players to design better training sessions adapted to the demands of the competition (Ortega et al., 2009).

Differences between the tournaments

The results obtained confirm that the surface of the court had a great influence on the performance of the players and the strategies they adopt (Barnett & Pollard, 2007; Cui, et al., 2018; O'Donoghue & Ingram, 2001). It was observed that the average of aces and double faults was similar in all the tournaments, with the exception of Roland Garros, the event where a lower number of direct serve points was achieved. This reflects difficulty players have of

Table 3. Statistical differences between the losers and winners of the Grand Slam tournaments

	AO			RG			W			US		
	Loser	Winner		Loser	Winner		Loser	Winner		Loser	Winner	
	M (SD)	M (SD)	Z	M (SD)	M (SD)	Z	M (SD)	M (SD)	Z	M (SD)	M (SD)	Z
Games won	3.21 (1.86)	**6.30 (0.87)#**	-13.960	3.06 (1.73)	**6.16 (0.46)#**	-13.285	3.42 (1.73)	**6.23 (0.55)#**	-13.378	3.19 (1.63)	**6.20 (0.40)#**	-14.415
Game difference	-3.08 (1.36)	**3.08 (1.36)#**	-15.025	-3.10 (1.56)	**3.1 (1.56)#**	-14.026	-2.81 (1.47)	**2.81 (1.47)#**	-14.728	-3.01 (1.37)	**3.01 (1.37)#**	-15.126
Aces (AC)	1.07 (1.31)	**1.81 (1.65)#**	-4.421	0.72 (1.11)	0.95 (1.28)	-1.223	1.27 (1.42)	**1.59 (1.41)***	-2.334	0.87 (1.08)	**1.63 (1.59)#**	-4.243
Double faults (DF)	1.56 (1.38)	1.33 (1.33)	-1.635	**1.55 (1.47)***	1.19 (1.34)	-2.219	**1.50 (1.25)***	1.18 (1.23)	-2.515	1.34 (1.22)	1.34 (1.55)	-0.864
P. played on 1st serve	19.36 (7.69)	20.01 (7.80)	-0.773	19.57 (7.10)	18.71 (6.78)	-0.891	19.84 (6.60)	20.06 (6.60)	-0.194	18.57 (6.41)	**19.95 (6.42)***	-1.967
T. P. played on serve	31.06 (10.64)	30.85 (10.55)	-0.186	31.16 (9.86)	28.88 (9.18)	-1.82	31.36 (8.95)	31.16 (9.14)	-0.114	30.00 (9.06)	31.17 (9.44)	-0.991
1st serve (%)	61.77 (9.71)	**64.75 (9.78)***	-2.191	62.77 (10.71)	64.71 (10.60)	-1.585	63.05 (10.57)	64.44 (9.84)	-1.164	61.97 (10.91)	64.34 (10.41)	-1.589
P. W. on 1st serve	11.10 (5.53)	**14.19 (5.22)#**	-5.208	10.83 (4.72)	**12.81 (4.35)#**	-3.627	12.03 (5.03)	**14.6 (4.32)#**	-4.542	10.52 (4.58)	**14.00 (3.85)#**	-6.531
P. W. on 1st serve (%)	55.80 (12.57)	**72.02 (10.77)#**	-10.16	54.54 (12.25)	**69.55 (10.98)#**	-9.02	59.92 (14.17)	**74.13 (10.69)#**	-8.288	55.48 (13.25)	**72.23 (11.25)#**	-10.023
P. W. on 2nd serve	4.60 (2.46)	**5.58 (2.59)#**	-3.219	4.55 (2.84)	**5.45 (2.24)#**	-3.328	4.79 (2.66)	**5.88 (2.45)#**	-3.635	4.54 (2.79)	**5.76 (2.88)#**	-3.931
P. played on 2nd serve	**11.70 (4.58)***	10.91 (4.71)	-2.008	**11.59 (4.92)***	10.17 (4.22)	-2.013	11.53 (4.46)	11.01 (4.31)	-0.834	11.43 (4.77)	11.21 (4.77)	-0.242
P. W. on 2nd serve (%)	38.78 (14.44)	**52.70 (16.53)#**	-7.009	37.73 (16.19)	**55.97 (16.35)#**	-8.207	40.62 (16.17)	**54.75 (15.50)#**	-7.018	37.92 (15.21)	**51.35 (17.45)#**	-6.99
Net points won	ND	ND	ND	2.90 (2.33)	**3.35 (2.1)***	-2.085	3.62 (3.11)	**4.69 (3.50)^**	-3.014	2.72 (2.49)	**3.97 (3.45)%**	-3.07
Net points played	ND	ND	ND	5.09 (3.82)	4.90 (3.08)	-0.261	6.10 (4.81)	6.47 (4.58)	-0.865	4.67 (3.83)	5.78 (5.11)	-1.4
Net points won (%)	ND	ND	ND	57.71 (29.64)	**70.84 (24.21)#**	-3.647	61.72 (25.45)	**73.74 (21.65)#**	-4.355	52.58 (28.94)	**66.88 (27.69)#**	-4.596
Break points won	0.87 (0.85)	**2.32 (0.93)#**	-11.191	0.89 (0.92)	**2.38 (0.91)#**	-10.518	0.64 (0.77)	**2.03 (1.13)#**	-11.009	0.87 (0.85)	**2.25 (0.79)#**	-11.211
Break points played	2.59 (2.22)	**4.39 (2.59)#**	-6.767	2.22 (2.19)	**4.64 (2.30)#**	-8.345	2.32 (2.08)	**3.83 (2.01)#**	-6.437	2.78 (2.26)	**4.03 (2.01)#**	-5.171
Break points won (%)	34.29 (35.24)	**61.33 (26.17)#**	-7.3	37.62 (38.67)	**60.83 (26.35)#**	-5.591	24.77 (32.98)	**67.05 (90.5)#**	-9.175	29.77 (32.62)	**63.59 (25.55)#**	-8.995
R. points won	9.82 (4.96)	**13.73 (4.56)#**	-7.386	10.63 (5.38)	**15.78 (4.68)#**	-7.751	10.66 (4.81)	**14.53 (4.12)#**	-7.17	11.39 (5.27)	**14.94 (4.10)#**	-5.948
R. points played	30.91 (10.55)	31.06 (10.64)	-0.107	28.88 (9.18)	31.18 (9.88)	-1.829	31.14 (9.13)	31.36 (8.95)	-0.13	31.15 (9.43)	30.00 (9.06)	-0.972
R. points won (%)	30.64 (8.37)	**45.45 (10.20)#**	-11.193	35.23 (9.58)	**51.89 (10.72)#**	-10.827	32.97 (7.66)	**47.47 (10.73)#**	-10.896	34.92 (8.72)	**51.18 (9.77)#**	-12.013
Winners (WS)	8.91 (4.75)	**10.72 (4.21)#**	-3.826	7.69 (4.18)	**9.87 (4.12)#**	-4.342	8.82 (4.45)	**11.00 (4.84)#**	-3.342	7.50 (4.30)	**10.9 (4.49)#**	-6.009
Unforced errors (UE)	ND	ND	ND	**14.01 (5.49)#**	10.65 (5.44)	-5.006	**9.78 (4.69)#**	7.74 (4.63)	-3.674	**12.64 (4.68)#**	10.72 (5.7)	-3.622
WS:UE ratio	ND	ND	ND	0.58 (0.32)	**1.13 (0.82)#**	-9.046	1.06 (0.80)	**1.92 (1.68)#**	-6.686	0.60 (0.29)	**1.25 (0.84)#**	-9.511
T. P. won	26.85 (11.03)	**35.13 (8.04)#**	-7.507	26.01 (10.17)	**34.03 (7.01)#**	-6.887	27.49 (9.67)	**35.01 (6.65)#**	-7.48	26.45 (9.85)	**34.70 (6.56)#**	-7.463
T. P. played on serve	31.06 (10.64)	30.91 (10.55)	-0.107	31.16 (9.86)	28.88 (9.18)	-1.82	31.36 (8.95)	31.12 (9.14)	-0.165	30.00 (9.06)	31.15 (9.43)	-0.972
T. P. won on serve	15.7 (7.16)	**19.77 (6.07)#**	-5.592	15.38 (6.49)	**18.25 (4.82)#**	-4.067	16.83 (6.47)	**20.48 (5.10)#**	-5.285	15.06 (6.13)	**19.76 (4.93)#**	-6.519

Note. AO: Australian Open; RG: Roland Garros; W: Wimbledon; US: US Open; M: mean; SD: standard deviation; P: points; T: total; W: won; R: receiving.
*Statistical differences (Wilcoxon): *=p<.05; %=p<.01; #=p ≦.001. ND=no data.

achieving an ace on the slower surface, which coincides with the results of previous studies (Filipčič, Filipčič, & Berendijaš, 2008).

The percentage of first serves is similar across all the surfaces (≈ 63%), which is consistent with other studies with similar characteristics (Cui, et al., 2018; Hizan, Whipp, & Reid, 2011; Reid, Morgan, & Whiteside, 2016; Torres-Luque, Blanca-Torres, Cabello-Manrique, & Fernández-García, 2019). However, regarding the percentage of points won on the first serve, the highest values were recorded at Wimbledon, while the lowest were at Roland Garros, with statistically significant differences between them ($p<.05$). With regard to the percentage of points won on the second serve, there were no statistically significant differences, which may be due to the fact that the players opt for the 'fast-weak' service strategy in the Grand Slams with the idea of committing fewer double faults (Barnett, Meyer, & Pollard, 2008; Carboch, 2017; Cui, et al., 2018; O'Donoghue & Ingram, 2001).

On the other hand, the court surface had an influence on the percentage of receiving points won. On slower courts players have more time for the preparation of the shot, so return-of-serves are especially important in the matches played at Roland Garros. However, it was interesting how the percentage of receiving points won at the US Open (which was played on the DecoTurf court), were very similar to those of the French tournament. One possible explanation is that, although the surface of the US Open event is listed as a medium speed surface (International Tennis Federation, 2020), the court conditions were slower than in other seasons. In this sense, it is common that the surface characteristics are modified every year, printing different layers of resin that modify speed of the surface (Barnett & Pollard, 2007).

Likewise, there were significant differences in the number of winning strokes between the four Grand Slams. While the Australian Open, Wimbledon, and the US Open all exceed nine winning strokes per set, at Roland Garros that figure is not reached (Table 2). This could be due to slow speed of the clay court, allowing players to have more reaction time to recover and return more shots from the opponent player (Carboch, Placha, & Sklenarik, 2018; Cui, et al., 2018; O'Donoghue & Ingram, 2001; Sánchez-Pay, et al., 2015).

Regarding break points won, although there were no significant differences between each Grand Slam, the percentages were higher at Roland Garros (Cui, et al., 2018). In this sense, the dominance of the serving players on the fast and medium courts should be noted here. In addition, the percentage of net points won were significantly higher at Wimbledon and Roland Garros than at the other two tournaments. At Wimbledon, it may be because court conditions make approaching the net a very effective tactic, especially when the serve-volley strategy is used (O'Donoghue, 2002; O'Donoghue & Ingram, 2001). As for Roland Garros, although it is a tournament where fewer approaches to the net were recorded, the performance percentages in this area of the court were also high. One possible explanation is that the players have more time to prepare the point by taking shots that flow laterally to the opponent, thus getting to the net in a more advantageous position.

Winners vs. losers

The results of this study showed that the winning players achieved higher values in all serve performance statistics. They had a higher percentage of first serves and they won more points with the first and second serves in all the competitions. As other research have showed, these differences may be due to a greater technical and tactical efficiency of their service (Gillet, Leroy, Thouvarecq, & Stein, 2009).

The dominance of the winners when serving were reflected in a higher number of aces and less double faults than those of the losers in all the tournaments. However, at Roland Garros, the statistical differences between the winning and losing players were lower, which was consistent with previous studies (Filipčič, et al., 2008). This could be explained by the fact that the conditions of the court (slow surface) reduced the advantage of the winner players when serving.

Moreover, data showed that, in all the Grand Slams, the winners achieved a significantly higher percentage of receiving points than the losers, probably because the winner players played more aggressive when returning the opponents' serves (Fernández-García, et al., 2019), so they had a higher number of break points played and break points won.

Likewise, the results showed significant differences between the winners and losers in net game statistics. These results suggest that elite tennis players carefully build the point before approaching the net to have a better chance of success (O'Donoghue & Ingram, 2001). Other studies also highlighted the players' high level of performance when they play in the net zone (Cui, et al., 2018). Furthermore, the results showed that the winner players had a significantly higher number of winner shots and a lower number of unforced errors in all the Grand Slam tournaments. This could be due to better tactical decisions and technical performance of the winners (Fernández-García, et al., 2019).

The current study adds novel insights into notational analysis in female tennis players' play. However, some limitations to the study should be noted. First, although the data analysed showed how the tennis point has started and been finished, it would be interesting that future studies perform a point-by-point analysis. On the other hand, the

court pace rating is modified almost every year, mainly for synthetic surfaces, so future studies could observe the evolution of competition statistics over time. Finally, although these data constitute a useful guide for training design, future studies are warranted to confirm these results, focusing on the statistical differences between the winners and losers of Grand Slam matches. This study presents new contributions to shot statistics in female tennis players. Results showed that the court surface determined the game style and the female players' strategies in the Grand Slam tournaments. Similar values were found for the Australian Open and Wimbledon, while at Roland Garros the most different results were obtained. The winning players showed a more aggressive game style than the losing players and they made better tactical decisions in their shots. Also, they performed more winning shots and less unforced errors and showed higher net game statistics. Finally, the winning players showed higher effectiveness when they serve and return.

Practical application

The information of this study may have important implications for the design of appropriate game strategies and specific-training sessions to improve performance in female tennis players, based on the different characteristics of each Grand Slam tournament. Players should adapt their behaviour and tactics considering aspects such as surface resistance at the Australian Open and US Open, where longer matches were played, importance of the serve at Wimbledon, or the ability to perform good returns-of-serve at Roland Garros. Finally, following the results obtained in this research we encourage coaches to use these values during training sessions through goal setting exercises. For example, during a clay season, coaches should use drills focusing on defensive shots, with the aim to reduce unforced errors. On the other hand, during grass and hard courts seasons, players should introduce time reaction exercises and return of serves due to a higher number of aces on these courts.

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