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# Important performance characteristics in elite clay and grass court tennis match-play.

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# Important performance characteristics in elite clay and grass court tennis match-play.


## Abstract

The performance characteristics of elite tennis match-play differ depending on court surface. However, the performance characteristics (e.g. aces, first serve points won, forced errors) most associated with success on different surfaces are currently unknown. With three weeks typically separating Roland Garros and Wimbledon, the transition from clay to grass courts, whereby players must adapt their game style between surfaces, is crucial to understand. Using the recently validated PWOL method, we analysed 984 singles matches across the 2016 and 2017 Roland Garros and Wimbledon tournaments, to identify the most important performance characteristics in clay and grass court tennis. Results revealed that *points won of 0-4 shot rally length*, *first serve points won* and *baseline points won* were most strongly associated with success for both sexes; serve-related performance characteristics (*aces*, *double faults* and *average first serve speed*) were among the least associated with success. Furthermore, winning short points (points of 0-4 shots) was more closely associated with success than winning medium-length (5-8 shots) and long points (9+ shots). To be representative of match-play, findings suggest that players should afford sufficient practise time to short rallies and point-ending strategies during the clay and grass court seasons, rather than over-emphasising long rallies.



Keywords: Elite tennis strategy; court surface; match statistics; winning performance; tennis coaching

## Introduction

Grand Slams are regarded as the most prestigious tennis events of the annual calendar (International Tennis Federation, 2019). As of 2019, the four Grand Slams are each contested on a different outdoor court surface; the Australian Open on Plexicushion Prestige hard courts, Roland Garros on clay courts, Wimbledon on grass courts and the US Open on DecoTurf hard courts (International Tennis Federation, 2019). Court surfaces are characterised by two main properties: their coefficient of restitution and their coefficient of friction (Fernandez-Fernandez, Sanz-Rivas, & Mendez-Villanueva, 2009), and it is these two key environmental constraints that help shape match-play on different surfaces. For example, investigations of match-play have demonstrated that more points are contested at the net on grass courts than hard and clay court surfaces, and that rally lengths are longest on clay courts (Brown & O'Donoghue, 2008; O'Donoghue & Ingram, 2001). Additionally, the serve has been shown to be most dominant on grass and least dominant on clay, with more points won as a direct result of the serve (i.e. either an ace or an unreturned serve) on grass than on any other surface (Brown & O'Donoghue, 2008; Sogut, 2019).

Elite tennis players are required to adapt to different court surfaces during the year, while attempting to maintain optimal performance levels. Therefore, understanding what influences success on different surfaces would guide coaches to better prepare their players for competition (Over & O'Donoghue, 2008) and help to ensure smooth, efficient transitions between surfaces. While several studies have compared the performance characteristics of match-play on difference court surfaces (e.g. Cui, Gomez, Goncalves, & Sampaio, 2018, O'Donoghue & Ingram, 2001; Unierzyski & Wieczorek, 2004), few have attempted to identify which performance characteristics are important and/or most associated with success. In this context, O'Donoghue (2002), reported that the number of

61 break points won best distinguished between winning and losing players during match-play
62 on hard courts at the Australian Open. Sogut (2019) recently examined associations
63 between match-play characteristics and men's world ranking on three different court
64 surfaces. The percentage of total serve points won, first serve points won and break points
65 saved were most positively correlated with world ranking on hard, clay and grass courts,
66 respectively, while the percentage of first serve points won was significantly correlated
67 with world ranking on all three court surfaces. Reid, McMurtrie and Crespo (2010),
68 reported that the percentage of second serve (and second serve-return) points won were
69 most strongly associated with world ranking (i.e. success) in men's tennis. However, Reid,
70 McMurtrie and Crespo (2010) incorporated data from multiple tournaments, played on a
71 variety of surfaces over a 12-month period. Although it is well-documented that court
72 surface influences match-play (Takahashi et al., 2009; Sogut, 2019; Vaverka, Nykodym,
73 Hendl, Zhanel & Zahradnik, 2018), effects of court surface were not examined by Reid,
74 McMurtrie and Crespo (2010), which may contribute to the discrepancy between their
75 results and those reported by O'Donoghue (2002) and Sogut (2019). Sogut (2019), Reid,
76 McMurtrie and Crespo (2010) and O'Donoghue (2002) further differed in their
77 methodological approaches, in terms of the performance characteristics selected for
78 inclusion and their respective operational definitions. Consequently, it is currently unclear
79 within the literature which performance characteristics are important in terms of winning
80 for elite tennis players. This issue is apparent for both sexes, but particularly for female
81 players, as Reid, McMurtrie and Crespo (2010) and Sogut (2019) focused on men's tennis.

82 Previous studies have demonstrated that the differences in match-play
83 characteristics (e.g. rally length, percentage of first serve points won, number of net-points
84 played), between Roland Garros and Wimbledon are greater than between all other pairs of
85 Grand Slams (Brown & O'Donoghue, 2008; Cui et al., 2018; Takahashi et al., 2006).

Furthermore, with only 3 weeks typically separating Roland Garros and Wimbledon, players must adapt their training strategies and attempt to reach optimal performance levels in a short time frame, so the surface transition from clay to grass is arguably the most important to understand. Despite this, we do not currently know which match-play characteristics are important in terms of winning on these two surfaces. Establishing this would enable more informed training for players during this critical surface-change period. It would also support the periodisation of training according to court surface, whereby sub-seasons (e.g. the clay court season, the grass court season) are characterised by surface-specific training methods (Over & O'Donoghue, 2008; Reid, Morgan & Whiteside, 2016). For example, if winning baseline rallies is most strongly associated with success on clay courts, this should be reflected in training sessions, with groundstrokes afforded more practice time than net-play during the clay court season. Therefore, the aim of this study was to identify important match-play characteristics on clay and grass court surfaces, for male and female elite tennis players.

## Method

### *Matches*

With institutional ethics approval, performance characteristics for the 2016 and 2017 Roland Garros (men n=244 and women n=250) and Wimbledon (men n=241 and women n=249) singles matches were obtained from the Roland Garros (2017) website and the Wimbledon Information System (IBM, 2019). Permission to use the Roland Garros data was granted by the Fédération Française de Tennis; access to the Wimbledon data was provided by IBM, with permission granted by The All England Lawn Tennis Club. Data from incomplete matches (i.e. those involving retirements, walkovers or defaults) were

excluded from the study; 23 men's matches and 9 women's matches were excluded accordingly.

### *Performance characteristics*

The following commonly used performance characteristics were obtained for winning and losing players in each match: number of aces, number of double faults, number of first serves in, average (i.e. mean) first serve speed, number of first serve points won, number of second serve points won, number of first serve-return points won, number of second serve-return points won, number of baseline points won, number of net points won, number of break points won, number of winners, number of forced errors, number of unforced errors, and number of points won of 0-4, 5-8 and 9+ shot rally length, respectively.

### *Reliability Testing*

The organisation committee for each Grand Slam is responsible for recruiting and training their own data entry teams; therefore, as different data entry teams collected data at each event, the reliability of the data collected at each Grand Slam had to be evaluated separately. To enable inter-rater reliability testing between the researchers and the data entry teams at each event, video recordings of eight matches (two men's matches and two women's matches from each Grand Slam) were observed and coded independently by the lead researcher, using a NacSport (NacSport Elite, Las Palmas de Gran Canaria, Spain) custom-notational analysis system. Cohen's kappa coefficient was calculated, based on analysis of over 200 match-play points per Grand Slam (comparing the lead researcher's results with those recorded by the Grand Slams' respective data collection teams). Cohen's kappa coefficient was $k = 0.97$ for Roland Garros data and $k = 0.99$ for Wimbledon data, identified as excellent (Fleiss, 1981).

133 ***Data Processing***

134 Data were normalised using the equations in Table 1 for each match, then reduced
135 to mean (± *sd*) for male and female winning and losing players, respectively.

136 [Table 1 near here]

137 ***Data analysis***

138 In each match, the winning player's performance was compared to that of the
139 losing player (i.e. their opponent) for each performance characteristic, to identify which
140 player 'outscored' the other. Then, the number of matches in which the winning player
141 outscored the losing player was tallied for each performance characteristic. Next, the
142 *Percentage of matches in which the Winner Outscored the Loser* (PWOL; Fitzpatrick,
143 Stone, Choppin & Kelley, 2019) was calculated, by dividing the number of matches in
144 which the winning player outscored the losing player for each performance characteristic
145 by the total number of matches in the respective sample. This provided PWOLs for each
146 performance characteristic for men and women at each Grand Slam.

147 The PWOL of each performance characteristic was interpreted to indicate their
148 importance in terms of winning. PWOL analysis produces a result between 0% and 100%
149 for each performance characteristic. A PWOL of 50% for a particular performance
150 characteristic means that players who outscored their opponent on this characteristic won
151 the match in 50% of cases; this equates to no association with success. As the PWOL
152 increases towards 100%, this indicates a stronger positive association with success (a
153 stronger association with winning); as the PWOL decreases towards 0%, this indicates a
154 stronger negative association with success (i.e. a stronger association with losing)
155 (Fitzpatrick et al., 2019). Accordingly, performance characteristics with either a high

PWOL or a low PWOL are considered important, whereas those with a PWOL close to 50% (i.e. between 40% and 60%) are considered less important (Fitzpatrick et al., 2019). For example, if the winning player hit more aces than the losing player in 150 out of 200 matches at Roland Garros, the PWOL for *aces* on clay would be 75.0%.

The PWOL method was developed as a more user-friendly alternative (to point-biserial correlations and *t* tests) for coaches, to facilitate their understanding of match-play data analysis; for a detailed validation against Student's t-tests and point biserial correlation methods, see Fitzpatrick et al., 2019. It is important to note that statistical significance can be calculated for PWOL values, using a binomial distribution with parameters n and *p*, with n being the sample size and *p* being the probability of the winning player outscoring the losing player in a single match.

To aid interpretation of results, the mean percentage of points played (per match) within each rally length category was also calculated for both sexes on clay and grass. Mann-Whitney *U*-tests were used to identify court surface differences in the mean percentage of points played within each rally length category for men and women, respectively.

**Results**

Table 2 displays the mean values for winning and losing male players at Roland Garros and Wimbledon, as well as the PWOL for each associated performance characteristic. The shaded areas illustrate the characteristics with the highest (top four) and lowest (bottom two) PWOLs.

[Table 2 near here]

Table 2 shows that for male players on clay and grass, the four performance characteristics with the highest PWOLs were *points won of 0-4 shot rally length, first serve*

179 *points won*, *baseline points won* and *second serve points won*. *Forced errors* and *unforced*
180 *errors demonstrated the lowest PWOLs on both surfaces*. *Aces*, *double faults*, *successful*
181 *first serves* and *average first serve speed* exhibited PWOLs between 44% and 59% at
182 Roland Garros, and between 33% and 68% at Wimbledon.

183 Table 3 displays the mean values for winning and losing female players at Roland
184 Garros and Wimbledon, and PWOLs for the associated performance characteristics. The
185 shaded areas illustrate the characteristics with the highest (top four) and lowest (bottom
186 two) PWOLs.

187 [Table 3 near here]

188 Table 3 shows that for female players, *points won of 0-4 shot rally length*, *baseline*
189 *points won*, *first serve points won* and *second serve points won* had the highest PWOLs on
190 clay and grass. *Forced errors* and *unforced errors* exhibited the lowest PWOLs on both
191 surfaces. The serving characteristics *Aces*, *double faults*, *successful first serves* and
192 *average first serve speed*) all exhibited PWOLs between 46% and 58% at Roland Garros,
193 and of these serving characteristics, only *double faults* demonstrated a PWOL outside of
194 this range (35%) at Wimbledon.

195 Table 4 displays the mean percentage of points (per match) played within each rally
196 length category for men and women on clay and grass courts.

197 [Table 4 near here]

198 Table 4 shows that, for men, the mean percentage of points of 0-4 shot rally length
199 was 3.1% higher at Wimbledon than Roland Garros; accordingly, the mean percentage of
200 points of 9+ shot rally length was 3.0% lower at Wimbledon. For women, the mean

percentage of points of 9+ shot rally length was 1.5% lower at Wimbledon than Roland Garros.

## Discussion

The aim of this study was to identify important match-play characteristics on clay and grass court surfaces, for both sexes. Analysis showed that the same performance characteristics exhibited the highest and lowest PWOLs, respectively, on both court surfaces. *Points won of 0-4 shot rally length*, *first serve points won*, *baseline points won* and *second serve points won* exhibited the highest PWOLs (i.e. were most closely associated with success) for both men and women, at Roland Garros and Wimbledon; hence, these four performance characteristics are important in terms of winning matches on clay and grass courts. *Forced errors* and *unforced errors* exhibited the lowest PWOLs for both sexes, demonstrating that these are also important as they were associated with losing matches on both surfaces. Often demonstrating PWOLs between 40% and 60%, serve-related performance characteristics are considered less important, however several serve-related characteristics were more important on grass than on clay, particularly for male players. While previous research has suggested that match-play characteristics differ depending on court surface, results here show that these differences do not necessarily translate to differences in the *importance* of each performance characteristic.

### *Performance characteristics associated with winning*

For both sexes, *points won of 0-4 shot rally length*, *first serve points won*, *baseline points won* and *second serve points won* were most closely associated with winning on clay and grass courts. However, approximately 60% of points in elite tennis are ‘first serve points’ and 40% of points are ‘second serve points’ (Brain Game Tennis, 2014), so it is understandable that both *first serve points won* and *second serve points won* are important.

It is also well documented that baseline play has dominated the game since the turn of the century, in contrast to the 1980s and 1990s, when net play was more prevalent (Crespo & Reid, 2007). For this reason, the importance of *baseline points won* is understandable. Additionally, all four of these performance characteristics pertain to 'points won', so it follows that they are likely to be somewhat associated with success.

Despite each pertaining to 'points won', of the three rally length performance characteristics, *points won of 0-4 shot rally length* was considerably more important than *points won of 5-8 shot rally length* and *points won of 9+ shot rally length*, irrespective of surface and sex. Grass courts have often been shown to exhibit the shortest rally lengths compared to other court surfaces (Brown & O'Donoghue, 2008; O'Donoghue & Ingram, 2001), so high PWOLs might be expected for *points won of 0-4 shot rally length* on grass courts. However, the importance of winning short rallies on clay was not expected, as rally lengths and durations have consistently been shown to be longest on clay courts (Martin et al., 2011; O'Donoghue & Ingram, 2001; Takahashi et al., 2006; although since the mid-2000s, the differences between rally lengths on different surfaces have reduced somewhat (Brown & O'Donoghue, 2008; Lane, Sherratt, Hu, & Harland, 2017; Martin & Prioux, 2016). In this analysis, male players who won more short rallies (points of 0-4 shot rally length) than their opponent won the match in 89% of cases at Roland Garros. Despite clay courts typically being associated with long rallies, the data presented in Table 4 reveals an underlying prevalence of short rallies on both surfaces. While perhaps unexpected, this helps explain why short points are so important on clay, as well as on grass, as they comprised a large proportion of total points played on both surfaces. In turn, this also indicates that the outcome of a large proportion of points may be determined by the quality of the serve and/or the serve-return. Future work to identify how points of 0-4 shot rally length are won would be beneficial and provide further insight here, particularly as this

250 performance characteristic was the most important in 3 of the 4 instances. In a coaching
251 context, the importance of short points and their prevalence on the two surfaces are
252 relevant. Pinder, Davids, Renshaw and Araujo (2011) explained that to optimise learning,
253 athletes' training sessions should be representative of the performance environment (i.e.
254 match-play). Therefore, results here suggest that elite players' practice sessions should not
255 have an over-emphasis on long rallies and consistency during the clay and grass court
256 seasons, but instead afford sufficient time to practising serves, serve-returns and point-
257 ending strategies, in order to be representative of match-play.

258 ***Performance characteristics associated with losing***

259 For both sexes, *forced errors and unforced errors* were the performance
260 characteristics most closely associated with losing on clay and grass. For male players,
261 *forced errors* exhibited a lower PWOL (closer to 0%) than *unforced errors* at Roland
262 Garros and Wimbledon, suggesting that forced errors are more important than unforced
263 errors for men on both surfaces. For female players on grass courts, *unforced errors* were
264 more important (with a PWOL closer to 0%) than *forced errors*. The higher unforced error
265 rate (compared to forced errors) exhibited by women here may be related to the tendency
266 for female players to adopt a one-dimensional 'power' gamestyle (Rutherford, 2017),
267 hitting the ball earlier and flatter in an attempt to apply pressure and out-hit their opponents
268 from the baseline (Antoun, 2007); a tactic that presents an inherent risk of 'over-hitting'
269 (i.e. committing an unforced error). In contrast, male players, who are naturally able to hit
270 the ball harder and typically have more tactical variety than women (Antoun, 2007), tend
271 not to adopt the risky power-hitting strategy. Instead, they attempt to exploit free space on
272 the court, using different spins and ball speeds to put their opponent under pressure
273 (Antoun, 2007), in turn inducing more forced errors. In this context, it is important for

coaches to be aware of and understand the differences in tennis strategies between men and women, so any expectations and goals set are realistic and sex-specific.

***Performance characteristics least associated with match outcome***

For male players, four serve-related performance characteristics (*aces*, *successful first serves*, *double faults* and *average first serve speed*) exhibited PWOLs between 44% and 59% on clay (indicating that serving is not important in terms of winning), but outside of this range on grass (*double faults* - 33%, *average first serve speed* - 60%, *successful first serves* - 61%, *aces* - 68%). This suggests men's serving is more important on grass than on clay. This also corresponds with the differences in rally lengths between the two events (see Table 4); the fact that more short rallies were played by men at Wimbledon than at Roland Garros may be a reflection of the greater importance of the serve on grass than on clay. On grass courts, the lower coefficients of friction and restitution (compared to clay) mean that, after a serve lands, the ball loses less horizontal velocity and bounces lower, respectively (Miller, 2006). Accordingly, the ball approaches the returning player faster, affording them less time to prepare for and perform the serve-return (Filipcic, Caks, & Filipcic, 2011). The returner is therefore less likely to successfully return the serve into play, so the server may win a higher proportion of points directly from their serve. If players recognise this, intuitively or otherwise, it could also explain the faster serve speeds at Wimbledon, where a fast serve may be more likely to be rewarded with a 'cheap' point than on the slower, higher bouncing clay courts at Roland Garros (Giampaolo & Levey, 2018).

For female players, *aces*, *successful first serves* and *average first serve speed* exhibited PWOLs between 46% and 58% on both surfaces, with *double faults* exhibiting a PWOL outside of that range (35%) only at Wimbledon. So, it appears that serving is not

important in terms of winning matches on clay or grass for women. This supports previous observations that the serve is a more effective weapon for male players than female players (Furlong, 1995), and that tactically, women tend to use their serves as a means of starting a point, rather than gaining an advantage or winning points directly (Filipcic et al., 2011). With female players typically producing lower serve speeds than male players, returners are afforded more time to plan and perform the serve-return, so points are less likely to be won directly from the serve.

In a practical context, these serve-related results indicate that enhancing a player's serve performance should not be a priority for coaches during the clay court season, and that only male players should afford serving additional practice time during the grass court season. Interestingly, though, *first serve points won* and *second serve points won* exhibited high PWOLs (73%+) irrespective of court surface and sex. So, perhaps the serve allows players to gain somewhat of a 'lasting' advantage in the rally, even though the more 'immediate' serving characteristics (*aces*, *double faults*, *first serve percentage* and *average first serve speed*) do not appear to be of great importance, particularly on clay. If this is the case, it may be prudent for coaches to focus on integrating the serve into a player's holistic match strategy rather than aiming to win points directly from their serve.

## Conclusion

*Points won of 0-4 shot rally length*, *first serve points won*, *baseline points won* and *second serve points won*) were most closely associated with winning for both sexes on clay and grass court surfaces. Accordingly, short points and point-ending strategies should be a focus for players during grass and clay court season training. *Forced errors* and *unforced errors* were most closely associated with losing on both surfaces, and serve-related characteristics were only somewhat important for male players on grass. These results

suggest that training need not drastically differ for either sex when transitioning from clay courts to grass courts, but that male players may wish to afford extra practice time to serving during the grass court season. Accordingly, players may wish to prioritise getting used to the surface (e.g. modifying their movement patterns and adapting to the different ball-court surface interactions), rather than specific areas of their game, such as approach shots or net-play, when transitioning from clay to grass before Wimbledon. Future work analysing short rallies in more detail would enhance our understanding, revealing how such points are won by elite male and female players.

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*Declaration of Interest*

The authors report no conflict of interest.

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Table 1. Normalised performance characteristic calculations, derived from O'Donoghue and Ingram (2001) and O'Donoghue (2005).

| Performance characteristic | Equation |
|---|---|
| Aces | (Number of aces/number of serves performed) x 100 |
| Double faults | (Number of double faults/number of points served) x 100 |
| Successful first serves | (Number of first serves in/number of first serves attempted) x 100 |
| First serve points won | (Number of first serve points won/number of first serve points played) x 100 |
| First serve-return points won | (Number of first serve-return points won/number of first serve-return points played) x 100 |
| Second serve points won | (Number of second serve points won/number of second serve points played) x 100 |
| Second serve-return points won | (Number of second serve-return points won/number of second serve-return points played) x 100 |
| Break points won | (Number of break points won as returner/number of break points played as returner) x 100 |
| Net points won | (Number of net points won/number of net points played) x 100 |
| Baseline points won | (Number of baseline points won/number of baseline points played) x 100 |
| Winners | (Number of winners/number of rally points played) x 100 |
| Forced errors | (Number of forced errors/number of rally points played) x 100 |
| Unforced errors | (Number of unforced errors/number of rally points played) x 100 |
| Points won of 0-4 shot rally length | (Number of points won of 0-4 shot rally length/number of points played of 0-4 shot rally length) x 100 |
| Points won of 5-8 shot rally length | (Number of points won of 5-8 shot rally length/number of points played of 5-8 shot rally length) x 100 |
| Points won of 9+ shot rally length | (Number of points won of 9+ shot rally length/number of points played of 9+ shot rally length) x 100 |

Table 2. Mean (± *sd*) for each performance characteristic for winning and losing male players at Roland Garros and Wimbledon, and associated PWOLs.

| Performance characteristic | Roland Garros | | | Wimbledon | | |
|---|---|---|---|---|---|---|
| | Winning players | Losing players | PWOL | Winning players | Losing players | PWOL |
| Number of points won of 0-4 shot rally length | 83.1 ± 23.6 | 70.2 ± 25.8 | 89% | 81.8 ± 25.4 | 67.9 ± 28.5 | 92% |
| Number of first serve points won | 48.9 ± 14.7 | 44.3 ± 15.6 | 85% | 56.4 ± 17.0 | 50.8 ± 18.3 | 85% |
| Number of baseline points won | 69.6 ± 20.0 | 56.7 ± 22.3 | 82% | 55.2 ± 18.0 | 45.3 ± 18.7 | 79% |
| Number of second serve points won | 22.8 ± 7.4 | 20.6 ± 8.2 | 77% | 22.5 ± 7.5 | 21.7 ± 8.0 | 73% |
| Number of break points won | 5.5 ± 2.0 | 2.5 ± 2.1 | 71% | 4.5 ± 1.7 | 1.7 ± 1.6 | 68% |
| Number of points won of 9+ shot rally length | 12.3 ± 7.6 | 10.3 ± 7.3 | 66% | 8.7 ± 6.1 | 7.0 ± 5.8 | 61% |
| Number of points won of 5-8 shot rally length | 23.2 ± 8.2 | 20.1 ± 8.9 | 65% | 22.4 ± 8.4 | 18.9 ± 8.2 | 69% |
| Number of winners | 39.0 ± 13.7 | 33.6 ± 14.5 | 64% | 29.2 ± 10.6 | 25.0 ± 11.1 | 61% |
| Number of net points won | 14.1 ± 8.0 | 13.8 ± 8.4 | 62% | 21.2 ± 9.8 | 19.8 ± 11.0 | 57% |
| Number of aces | 7.5 ± 6.4 | 5.7 ± 4.7 | 59% | 12.5 ± 8.5 | 9.1 ± 7.9 | 68% |
| Number of successful first serves | 66.2 ± 21.3 | 67.6 ± 21.3 | 56% | 72.0 ± 22.3 | 73.0 ± 21.7 | 61% |
| Average first serve speed (km/h) | 181.8 ± 9.7 | 180.9 ± 10.7 | 51% | 188.6 ± 8.8 | 185.2 ± 10.2 | 60% |
| Number of double faults | 3.4 ± 2.5 | 3.8 ± 2.7 | 44% | 3.4 ± 2.5 | 4.5 ± 2.6 | 33% |
| Number of unforced errors | 30.9 ± 14.9 | 37.4 ± 14.8 | 33% | 21.9 ± 10.5 | 25.7 ± 10.6 | 34% |
| Number of forced errors | 36.2 ± 13.2 | 42.2 ± 12.8 | 22% | 44.5 ± 14.8 | 50.0 ± 13.4 | 27% |

Table 3. Mean (± *sd*) for each performance characteristic for winning and losing female players at Roland Garros and Wimbledon, and associated PWOLs.

| Performance characteristic | Roland Garros | | | Wimbledon | | |
|---|---|---|---|---|---|---|
| | Winning players | Losing players | PWOL | Winning players | Losing players | PWOL |
| Number of points won of 0-4 shot rally length | 52.8 ± 15.8 | 43.7 ± 17.3 | 85% | 48.4 ± 14.2 | 39.0 ± 16.3 | 87% |
| Number of baseline points won | 49.8 ± 14.4 | 40.4 ± 16.0 | 84% | 44.0 ± 13.2 | 35.6 ± 15.7 | 90% |
| Number of first serve points won | 30.5 ± 9.3 | 25.8 ± 10.1 | 83% | 32.0 ± 9.9 | 28.0 ± 11.3 | 84% |
| Number of second serve points won | 12.5 ± 4.9 | 11.0 ± 5.4 | 76% | 13.3 ± 5.0 | 11.5 ± 5.3 | 79% |
| Number of winners | 25.3 ± 9.5 | 20.6 ± 11.3 | 68% | 20.3 ± 9.0 | 16.6 ± 8.9 | 64% |
| Number of points won of 5-8 shot rally length | 17.1 ± 7.2 | 14.8 ± 7.6 | 68% | 17.9 ± 7.2 | 14.5 ± 7.1 | 72% |
| Number of break points won | 5.1 ± 1.7 | 2.8 ± 1.9 | 66% | 4.5 ± 1.4 | 2.1 ± 1.7 | 63% |
| Number of successful first serves | 46.3 ± 15.6 | 45.4 ± 14.6 | 58% | 45.5 ± 16.3 | 45.8 ± 15.9 | 57% |
| Number of aces | 2.5 ± 2.4 | 1.8 ± 2.2 | 57% | 3.4 ± 3.0 | 2.5 ± 2.6 | 57% |
| Number of points won of 9+ shot rally length | 8.7 ± 5.7 | 7.6 ± 5.6 | 56% | 7.4 ± 5.5 | 6.2 ± 4.9 | 58% |
| Number of net points won | 8.2 ± 5.0 | 7.8 ± 5.9 | 54% | 10.9 ± 6.8 | 9.0 ± 5.6 | 66% |
| Average first serve speed (km/h) | 155.3 ± 10.5 | 154.7 ± 9.9 | 52% | 159.4 ± 9.5 | 158.4 ± 8.4 | 51% |
| Number of double faults | 2.8 ± 2.4 | 3.1 ± 2.3 | 46% | 2.8 ± 2.2 | 3.6 ± 2.3 | 35% |
| Number of forced errors | 21.9 ± 9.3 | 25.4 ± 9.0 | 34% | 25.5 ± 10.3 | 30.7 ± 10.0 | 35% |
| Number of unforced errors | 22.8 ± 10.2 | 27.7 ± 11.0 | 34% | 17.0 ± 9.3 | 20.5 ± 9.7 | 21% |

Table 4. Mean percentage of points played within each rally length category for men and women at Roland Garros and Wimbledon.

| Percentage of points played | Men | | Women | |
|---|---|---|---|---|
| | Roland Garros | Wimbledon | Roland Garros | Wimbledon |
| 0-4 shot rally length | 69.0% | 72.1%* | 65.1% | 65.9% |
| 5-8 shot rally length | 20.2% | 20.1% | 23.4% | 24.1% |
| 9+ shot rally length | 10.8% | 7.8%* | 11.5% | 10.0%+ |

* Different to men at Roland Garros ($p < 0.001$). + Different to women at Roland Garros ($p < 0.05$).