

Breaking down success: Game-related statistical analysis in tennis grand slams

🔟 Shiny Raizada 🖂 . Symbiosis School of Sports Sciences. Symbiosis International (Deemed University). Pune, India.

Anurag Reddy. Applied Data Science. Indiana University. Indianapolis, United States of America.

5 Souhardya Biswas. Symbiosis School of Sports Sciences. Symbiosis International (Deemed University). Pune, India.

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ABSTRACT

The data-driven insights and examination of key performance indicators (KPI) in professional tennis is becoming increasingly popular and are now deemed important for player development and coaching strategies. The aim of the study was to analyse game-related KPIs differentiating winners from losers in the 2023 US Open and French Open tournaments. A total of 253 matches (127 men's singles matches from US Open and 126 men's singles matches from Roland Garros tournament) were included in the study. An independent t-test was employed to compare the differences between winners and losers for all indicators in 2023 French Open and US Open Grand Slams. For the variables that did not follow a normal distribution, the Mann–Whitney U test was used. Variables that showed significant differences between two groups were selected for discriminant analysis. It was found that winners outperformed losers in several key indicators, including Aces, Break Points Won %, First Serve % In, Net Points Won %, Receiving Points Won %, Second Serves In, Win % First Serve, and Win % Second Serve (p < .01, Cohen's d: 0.06-0.1, r: 0.02–0.85). In the context of the French Open, winners demonstrated a significantly higher percentage of win on First Serve (mean- 73.02, p < .01, Cohen's d:1.272), as compared to their counterparts who did not succeed and recorded a lesser percentage of win on First Serve (mean- 63.25, p < .01, Cohen's d:1.272). In conclusion, Serve quality, return performance, and error minimization are critical KPIs for success in Grand Slams. Surface dynamics play a significant role in shaping match strategies.

Keywords: Performance analysis, Game-related statistics, Tennis grand slams, Discriminant analysis, Coaching strategies.

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Corresponding author. Symbiosis School of Sport Sciences. Symbiosis International (Deemed University). 412115 Pune, India. E-mail: shiny.raizada@ssss.edu.in

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INTRODUCTION

The data-driven insights and examination of key performance indicators (KPI) in professional tennis is becoming increasingly popular among coaches and practitioners (Filipcic, Zecic, Reid, Crespo, Panjan, & Nejc, 2015;). Indeed, these data and KPIs are now deemed important for player development and coaching strategies (Klaus, Bradshaw, Young, O'Brien, & Zois, 2017; Cui, Gómez, Gonçalves, & Sampaio, 2018; Fitzpatrick, Stone, Choppin, & Kelley, 2019). The increasing demand of data and KPIs has led to numerous researches being conducted within the field of data analytics. Previous studies have investigated the player performance on varied surfaces (Cui et al., 2018), between different levels of players (Hizan, Whipp, & Reid, 2011; Klaus et al., 2017; Söğüt, 2017).sex ,age groups (R Cross, 2014; Hizan, Whipp, & Reid, 2015; Stare, Zibrat, & Filipcic, 2015), physiological responses (Reid and Duffield, 2014; Smith et al., 2018), stroke and movement characteristics (Hizan et al., 2015; Reid et al., 2016), and some aspects of performance (such as serving speed, serving efficiency, serving return) (Cross and Pollard, 2009; Hizan, Whipp, & Reid, 2011).

Amongst the various KPIs available, some KPIs are helpful in identification of success (i.e., winning), such as serve speed, return, net play, shot placement etc. (Filipčič, Filipčič, & Berendijaš, 2008; Fitzpatrick et al., 2019; Fernandez-Garcia et al. 2019), monitoring the parameters of a sport over time, on different surfaces (Cui et al., 2018), for varying playing positions (O'Donoghue P, 2004) and for long term development (Filipcic et al. 2021).

The annual four Grand Slam tennis tournaments—Australian Open, French Open, Wimbledon, and US Open bring together the top-ranked tennis players in the world. These elite athletes compete in a best-of-five sets format for men, navigating a challenging draw of 128 players. Analysing matches from these events provide a deeper understanding about the evolution of tennis tactics and strategies at the highest level, as well as the factors that contributes to match success. (Gillet et al., 2009; Reid et al., 2016; Woods et al., 2018, 2019, Cui et al. 2020).

Previous studies investigated the effectiveness of tennis players on different surfaces like clay and hard courts that influence the player performances (Fitzpatrick et al., 2019; Martin and Prioux, 2016; Lage et al., 2022). It was observed that fast surfaces like hard court induce shorter rally length leading to an aggressive style of play whereas slow surfaces like clay have longer rally and allow a more defensive style of play (Fitzpatrick et al., 2019) suggesting varying playing tactics. Therefore, identifying the performance indicators that contribute to success in a match is important to inform players, coaches and sports scientists about tactical, technical, and physical requirements of the most competitive situations and optimize training and match strategies (Fernandez-Garcia et al. 2019; Carlisle, 2021).

Given that the performance at the elite level can provide valuable insights for optimizing training and match preparation processes, it is essential to explore the competitive match-play characteristics. This understanding can offer practical implications, particularly for the players who are not succeeding, in this highly competitive game (Cui et al., 2017). It was hypothesized that winners would outperform losers in serve-and-return performance, break point conversions, net play, and overall efficiency.

METHODOLOGY

Sample and data

The study included a total of 253 matches from two Grand Slams tennis tournaments during the 2023 season. It included 127 men's singles matches from US Open and 126 men's singles matches from Roland Garros

tournament. One match was excluded from the study due to the unavailability of complete match statistics on the web. The data were collected from the official website (https://www.rolandgarros.com and <u>https://www.usopen.org/index.html</u>) of the tournament following the process of previous studies (Cui, Gómez, Gonçalves, Liu, & Sampaio, 2017; Cui, et al., 2018). The game-related statistics for the matches played on the court covered with the Hawk-Eye camera system (Hawk- Eye Innovations, Southampton, United Kingdom) were included in the study. All the matches were played in accordance with the rules by International Tennis Federation (International Tennis Federation, 2020).

Performance indicators

The Key performance indicators (KPIs) selected for this study were adopted from the past literature (Gillet et al., 2009; Reid et al., 2016; Cui et al., 2018, 2019a). The raw match data were cleaned, organized, and evaluated to avoid misinterpretation of the player's performance and were divided into four categories representing the technical and tactical efficiency of the tennis players. Table (1) displays each performance indicator according to the following categories: serve points, return points, net points and winners and unforced errors.

The match outcome (win or lose) was the dependent variable and the performance indicators were selected as the independent variables for this study.

Group	Indicators
Serve points	Ace (%), Double faults (%), First Serve In (%), Second Serve In (%), Win on
	first serve (%), Win on second serve (%)
Return points	Receiving points won (%), Break Points Won, Break Pts Attempt, Break Pts
	Won (%)
Net points	Net Points Won, Net Points Won (%)
Winners and unforced errors	Winners, Unforced Errors

Table 1. List of variables analysed in grand slam tournaments in men's category.

Statistical analyses

Descriptive statistics (mean and standard deviation) were calculated for each performance indicator of winners and losers of the match, across different tournaments. The normality of the data was verified using Kolmogorov-Smirnov test, after which an independent t test was employed to compare the differences between winners and losers for all indicators in 2023 French Open and US Open Grand Slams. For the variables that did not follow a normal distribution, the Mann–Whitney U test was used instead.

To understand the differences for t-test, the standardized mean differences i.e. Cohen's d effect size was calculated and interpreted as d less than 0.2 trivial, d between 0.2 to 0.5 small, d between 0.5 to 0.8 medium and greater than 0.8 large effect (Hopkins et al., 2009). Whereas effect size for Mann–Whitney U test was calculated using the formula $r = z/\sqrt{n}$. The effect size was small if r is less than 0.3, r between 0.3 and 0.5 indicates medium effect, r greater than 0.5 means large effect (Karadimitriou, S. M., Marshall, E. & Knox, C. Mann-Whitney U Test (Sheffield Hallam University, 2018, Volker, 2006).

Variables that showed significant differences between two groups were selected for discriminant analysis. In a significant discriminant function, if the absolute value of the structural coefficient (SC) was greater than 0.30 (Sampaio et al., 2006), then a performance indicator was considered a meaningful contributor to differentiating winners from losers. The alpha level was set at p < .01 for all tests. All analyses were conducted using Statistical Package for the Social Sciences 24 (SPSS Inc., Chicago, IL, United States).

RESULTS

Table 2. Descriptive statistics.

וסע	French	n Open	US Open		
KFI	Win Loss		Win	Loss	
Aces	6.07 ± 4.06	5.04 ± 4.92	10.36 ± 5.67	7.38 ± 6.36	
Break Points Won	5.99 ± 1.82	3.08 ± 2.21	5.3 ± 1.74	2.09 ± 1.73	
Break Pts Attempt	13.56 ± 4.55	8.74 ± 5.04	11.96 ± 4.69	6.23 ± 4.43	
Break Pts Won %	46.45 ± 13.77	36.84 ± 23.08	47.92 ± 17.52	34.98 ± 27.78	
Double Faults	3.78 ± 2.66	5 ± 3.15	3.68 ± 2.75	4.97 ± 3.08	
First Serve % In	62.29 ± 6.67	60.38 ± 6.11	104.95 ± 33.92	110.08 ± 31.87	
First Serve Attempts	113.32 ± 34.96	116.65 ± 32.23	64.67 ± 22.52	66.09 ± 20.5	
First Serves In	70.52 ± 22.85	70.31 ± 20.27	49.54 ± 16.1	44.51 ± 16.55	
Net Points Won	19.04 ± 8.95	18.46 ± 9.46	18.16 ± 9.25	15.59 ± 8.86	
Net Points Won %	70.17 ± 11.53	63.59 ± 11.37	70.26 ± 9.63	61.32 ± 11.3	
Net Pts Attempt	27.39 ± 12.82	28.71 ± 13.67	26.04 ± 13.22	25.26 ± 12.91	
Receiving Pts Won%	45.9 ± 14.31	34.18 ± 5.6	42.76 ± 6.18	31.09 ± 5.44	
Receiving Pts Attempt	115.46 ± 33.51	113.32 ± 34.96	110.08 ± 31.87	104.95 ± 33.92	
Receiving Pts Won	50.55 ± 11.7	39.58 ± 15.87	45.88 ± 10.83	33.71 ± 14.56	
Second Serves In	42.81 ± 15.43	46.35 ± 15.01	40.29 ± 14.63	43.99 ± 14.08	
Total Pts. Won	NA	NA	117.12 ± 28.93	97.9 ± 35.6	
Unforced Errors	36.18 ± 15.74	44.24 ± 14.84	31.91 ± 13.95	38.6 ± 12.88	
Win % First Serve	73.02 ± 7.14	63.25 ± 8.19	77.65 ± 6.78	66.4 ± 7.9	
Win % Second Serve	53.95 ± 9.44	44.42 ± 9.45	55.34 ± 9.36	43.66 ± 8.27	
Win on First Serve	50.84 ± 15.36	45.03 ± 15.84	61.58 ± 7.26	59.87 ± 6.35	
Win on Second Serve	22.93 ± 8.59	21.08 ± 8.98	21.91 ± 7.74	19.7 ± 8.4	
Winners	39.47 ± 13.5	33.42 ± 15.67	39.12 ± 14.3	31.21 ± 15.46	

Table 3. Results of independent t-test and Mann-Whitne	ey U test along with its effect size.
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Como Dolatod	Independent t-test		Mann Whitney U Test		Effect Size	
Statiatica	Sig. value		Sig. value		("Cohens d" or " <i>r</i> ")	
Statistics	French Open	US Open	French Open	US Open	French Open	US Open
First Serve % In	.019	.042	NA	NA	0.298 ^s	0.256s
Win % First Serve	.000	NA	NA	.000	1.272 ⁱ	0.632
Win % Second Serve	.000	.000	NA	NA	1.010 ⁱ	1.323 ^ı
Aces	NA	NA	.007	.000	0.170 ^s	0.296 ^s
Double Faults	NA	NA	.001	.000	0.206 ^s	0.234s
Win on First Serve	NA	NA	.002	.013	0.194⁵	0.157 ^₅
Win on Second Serve	NA	NA	NA	.016	NA	0.151 ^s
Second Serves In	NA	NA	.042	.035	0.128⁵	0.133⁵
Net Points Won	NA	NA	NA	.016	NA	0.152⁵
Net Points Won %	NA	NA	.000	.000	0.277 ^s	0.401 ^m
Break Points Won	NA	NA	.000	.000	0.609 ⁱ	0.692 ¹
Break Pts Attempt	NA	NA	.000	.000	0.467 ^m	0.550 ⁱ
Break Pts Won %	NA	NA	.000	.000	0.301 ^m	0.314 ^m
Receiving Pts Won	NA	.000	.000	NA	0.373 ^m	0.949 ⁱ
Receiving Pts Won%	NA	NA	.000	.000	0.657 ¹	0.757 ¹
Winners	NA	NA	.000	.000	0.242s	0.302 ^m
Unforced Errors	NA	.000	.000	NA	0.288 ^s	0.499 ^m

Note: Effect Size "Cohens d" – for independent t-test; Effect size "r" – for Mann Whitney U Test; s – Small Effect Size; m – Medium Effect Size; I – Large Effect Size; NA – Not Applicable.

Tables 2 and 3 shows the descriptive statistics and comparison of the game related performance indicators between the winners and losers during the 2023 French and US Open.

It was found that winners outperformed losers in several key indicators, including Aces, Break Points Won %, First Serve % In, Net Points Won %, Receiving Points Won %, Second Serves In, Win % First Serve, and Win % Second Serve (p < .01, Cohen's d: 0.06-0.1, r: 0.02–0.85).

In the context of the French Open, winners demonstrated a significantly higher percentage of win on First Serve (mean- 73.02, p < .01, Cohen's d:1.272), as compared to their counterparts who did not succeed and recorded a lesser percentage of win on First Serve (mean- 63.25, p < .01, Cohen's d:1.272).

On the other hand, players in the US Open who emerged victorious recorded an average of 61.58 win on first serve, surpassing their opponents who won first serve with an average of 59.87.

The players who did not succeed (losers) committed more double faults and unforced errors. In the US Open, losers averaged 4.97 (r = 0.234) double faults per match, whereas winners averaged 3.68 (r = 0.234) double faults. Meanwhile, in the French Open, losers averaged 4.99 (Cohen's d = 0.206) double faults, while winners recorded an average of 3.78 (Cohen's d = 0.206) double faults per match.

Game related statistics	French Open	US Open
First Serve % In	-0.426	-0.105
Win % First Serve	0.337	0.280
Win % Second Serve	0.399	-0.402
Aces	-0.171	0.148
Double Faults	-0.066	-0.035
Win on First Serve	0.806	0.631
Win on Second Serve	#	-0.402
Second Serves In	-0.863	-2.271
Net Points Won	#	0.026
Net Points Won %	-0.121	0.200
Break Points Won	0.863	0.676
Break Pts Attempt	0.019	0.062
Break Pts Won %	-0.069	-0.174
Receiving Pts Won	-0.389	-0.560
Receiving Pts Won%	0.211	0.542
Winners	0.356	-0.065
Unforced Errors	-0.274	-0.076
Eigenvalue	1.658	2.692
Wilks Lambda	0.376	0.271
Canonical Correlation	0.790	0.854
R ²	62.41	72.93
Chi-Square	237.071	318.044
Significance	<.001	<.001
Reclassification	90.9%	94.1%

Table 4. Discriminant function Structure Coefficients	(SC) and tests	of statistica	significance.
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Note. *SC discriminant value $\ge |.30|$ # means that variable was non-significant and was not used in discriminant analysis.

The discriminant functions (see Table 4) recorded in this study were highly effective in distinguishing winners from losers, as evidenced by the reclassification rates of 90.9% for the French Open and 94.1% for the US

Open. The high r2c values (0.62 for the French Open and 0.73 for the US Open) reflects the robustness of these functions.

The indicators that significantly contributed to the discriminant functions during the French Open included: First Serve %, Win % First Serve, Win % Second Serve, Win on First Serve, Second Serves In, Break Points Won, Receiving Pts Won, and Winners with |SC (Structural Coefficient) | values ranging from 0.33 to 0.86.

Conversely, across the US Open, the indicators that contributed to the discriminant functions were Win on First Serve, Win on Second Serve, Second Serves In, Win % Second Serve, Break Points Won, Receiving Pts Won, and Receiving Pts Won%, with |SC| values ranging from 0.40 to 2.27.

DISCUSSION

Tennis is evolving rapidly because of the advancement of technology in tennis equipment (Allen et.al. 2016; Haake & Coe, 2000) and scientific sports training which has enabled the players to hit faster strokes and improve fitness. Therefore, it is important to constantly analyse the variables that affect performance. The primary objective was to identify key performance indicators that distinguish winners from losers across various matches in 2023 French and US open tournaments. The results of this study illuminate critical performance differentials between winners and losers in the 2023 French and US Open tennis tournaments. Notably, the superior performance of winners across several key indicators underscores the multifaceted nature of success in high stakes matches.

Serve performance

Winners significantly outperformed losers in metrics related to serving, such as Aces, First Serve % In, Win % First Serve, and Win % Second Serve. This research underscores the crucial role of serve quality in determining match outcomes (Cui et al. 2018), which indicates the control of the serve situation, effects, direction and hitting power.

O'Donoghue and Brown (2008) reported that servers in men's singles Grand Slam matches won 62.4% of points lasting shorter rallies, compared to 49.7% for points with 5 or more shots. This advantage was most notable in points comprising 3 to 4 shots on the first serve and 1 to 2 shots on the second serve (O'Donoghue & Brown, 2008). Ziagkas et al. (2017) also emphasized on the accuracy of the first serve at the French Open from 2002 to 2009 that increased from 60.2% to 64.2%. Furthermore, an increase in the percentage of first serves won by one unit makes a player 1.27 times more likely to win the match, while an increase in the percentage of second serves won by one unit increases the likelihood of winning by 1.17 times (Ma, Liu, Tan, & Ma, 2013). Additionally, a player who serves, on average, more than 5 aces is likely to win the match. However, the number of Aces did not contribute significantly to the discriminant functions in this study. This suggests that players at the highest level adopt more consistent and similar approach to serve performance. The high effectiveness of first serves, both in terms of landing in and winning points, suggests that a robust first serve not only initiates play favourably but also sets a psychological tone. Similarly, consistent second serves reduce the risk of double faults, thereby maintaining pressure on the opponent.

Serve return

Studies consistently highlights the critical role of serve return in determining competitive success (Cui, 2010; Elliott, & Saviano, 2001). The significant difference in Receiving Points Won % (0.389-0.560) highlights the comprehensive skill set of winning players. Statistically, increases in the percentage of points won on first and second serve returns significantly correlate with higher likelihoods of winning matches. An increase in

the percentage of first serve return points won by one unit corresponds to a 1.16-fold higher likelihood of winning the match. Similarly, an increase in the percentage of second serve return points won by one unit correlates with a 1.15-fold higher likelihood of winning the match. The reason for this could be firstly, the losers are not consistent and show dominance in the first serve performance and secondly, there is a loss of efficiency in the second serve (Lage et al., 2023), which make the winners play more offensive strokes and take the initiative in setting the point in their favour.

In tennis, research has consistently shown that servers typically hold a substantial advantage over receivers in point-winning opportunities (O'Donoghue and Brown, 2008; Gillet et al., 2009). However, studies indicate that effective return of serves can mitigate this advantage and neutralize its benefits (Gillet et al., 2009; Ma et al., 2013).

Break points performance

The ability to convert break points is often a decisive factor in match outcomes, as it directly influences the scoring opportunities and pressure dynamics. The marked advantage of winners in Break Points Won (SC = |0.863| r = .301 in French Open and SC = |0.676|, r = .314 in US Open) indicates that winners were able to convert more break point opportunities and saved more break points on their serves. Furthermore, the discriminant analysis underlines the importance of Break point opportunities in influencing the likelihood of winning matches and putting a psychological pressure on the opponents while serving. A one-unit increase in break point conversions correlates with a 1.032-fold higher likelihood of winning the match. Similarly, a one-unit increase in break point conversions correlates with a 1.032-fold higher likelihood of winning the match (Ma et al., 2013; Cui et al., 2018). The results of this study also correspond to the other studies on grass courts (Katić et al., 2011) and all Grand Slam surfaces for men (Ma et al., 2013). It will be useful for the players to incorporate more varied break point situations in their training in order to cope up with the stress and improve their game tactics.

Net performance

Net Points Won % was not able to discriminate between the winners and losers in the two Grand Slam tournaments. However, the winners in the US Open has shown exceptional net performance with higher Net Points Won % (p < .005, r = 0.40). Previous studies by Cui et al. (2017 and 2020) and Djurovic et al. (2009) reported that many professional players heavily rely on net play strategies on fast courts. Proficiency at the net reflects versatility and adaptability in play, allowing winners to disrupt opponents' rhythm and shorten points effectively.

Winners and unforced errors

The finding suggests players who served fewer than two double faults demonstrated a higher likelihood of winning matches compared to those who served between three to five and more than six double faults (Ma, Liu, Tan, & Ma, 2013). Filipcic et al. (2009) observed that losers in both genders tend to commit more unforced errors than winners, who also achieved a greater number of winners. These studies identified playing errors, such as unforced errors and double faults, as critical factors influencing match outcomes (Martínez-Gallego et al., 2013; Djurovic et al., 2009). Cui (2018) has also reported that the ability to hit more winners and making less unforced errors is basis for technical and tactical efficiency, physical fitness and mental toughness.

The discriminant functions developed in this study were highly effective in distinguishing winners from losers, as evidenced by the reclassification rates of 90.9% for the French Open and 94.1% for the US Open. The higher |SC| values observed in the US Open compared to the French Open suggest that the variability and impact of these indicators are more pronounced on the faster hard courts of the US Open. This disparity may

be attributed to surface-specific dynamics, where aggressive play and serve effectiveness are more rewarded compared to the slower clay courts of the French Open (Collinson & Hughes, 2000; O'Donoghue & Ingram, 2001).

Implications for training and strategy

These findings have practical implications for coaching and player development. Emphasizing serve and return drills, particularly focusing on first serve accuracy and second serve reliability, can yield substantial competitive advantages. Drills to enhance the service consistency can be designed and decision-making under pressure situations should be incorporated in the training (Reid et al., 2013). Additionally, strategies aimed at improving break point conversion and net play could be integral to transitioning from competitive parity to dominance. Furthermore, analysing the shot patterns on different surfaces and opponent's game play can guide match preparation and make the player more adaptable to uncertainty (O'Donoghue, 2002). These findings can refine strategies, tactical approaches especially in high pressure situations like tie-breaks.

CONCLUSION

In conclusion, the study reaffirms the critical importance of serving, receiving, and error minimization in determining match outcomes at elite tennis tournaments. By elucidating the performance indicators that most significantly distinguish winners from losers, this research provides a nuanced understanding of competitive dynamics and offers actionable insights for enhancing player performance. Future research could further explore the interplay of these indicators across different surfaces and player styles, thereby enriching the strategic framework for achieving success in professional tennis.

AUTHOR CONTRIBUTIONS

Conceptualization, S.R, S.B and R.S; methodology, S.R.; data collection, S.B. and R.S.; formal analysis, S.R. and A.R; investigation, S.R. and A.R.; writing—review and editing, S.R. and A.R; project administration, S.R., S.B. and R.S. All authors have read and agreed to the published version of the manuscript.

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