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Original Article

Differences in performance indicators of elite tennis players in the period 1991–2010

ALES FILIPCIC[1], MIROSLAV ZECIC[2], MACHAR REID[3], MIGUEL CRESPO[4], ANDREJ PANJAN[5], SARABON NEJC[5, 6]
[1]University of Ljubljana, Faculty of Sport, Ljubljana, SLOVENIA
[2]University of Zagreb, Faculty of Kinesiology, Zagreb, CROATIA
[3]Sport Science and Medicine Unit, Tennis Australia, and Department of Human Movement and Exercise Science, University of Western, AUSTRALIA
[4]International Tennis Federation, Tennis Development Department, London, GREAT BRITAIN
[5] S2P Ltd., Laboratory for Motor Control and Motor Behaviour, Ljubljana, SLOVENIA
[6]University of Primorska, Science and Research Center, Institute for Kinesiology Research, SLOVENIA

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Abstract:
The aim of this study was to compare differences in 15 tennis match variables between two groups of top 300 male ATP (Association Tennis Professionals) players. The groups consisted of the top 300 ATP players who had positive win-loss number of matches (G_1) and negative win-loss number of matches (G_2) in professional tennis tournaments at three different points in time, approximately 10 years apart (1991, 2000 and 2010). A t-test for independent samples and multivariate ANOVA (MANOVA – Wilks' lambda) assessed the differences between the two groups of players. The comparisons revealed that players in Group 1 achieved a significantly better statistical performance in selected aspects of the serve, the return and in general matchplay, independent of the year. The largest number of differences in the analysed match statistics was observed in 2010, where 12 match statistics varied significantly between the two groups. Some evidence also suggests that the efficiency of the serve and return of serve have improved over the past two decades, therein highlighting their important role in modern professional tennis. The present findings suggest that the observed performance indicators are sufficiently sensitive to discriminate between top 300 ATP players with variable number of win-loss matches.
Key words: ATP, tennis players, performance indicators.

Introduction

Tennis is an open-skill sport in which players constantly make tactical decisions related to specific game situations. Based on the knowledge of their own strengths and weaknesses, and those of their opponents, players apply different strategies and tactical concepts to maximise their chances of winning a match (O' Donoghue & Ingram, 2001).

'Performance analysis' is a term used exclusively for the analysis of performance in sports encompassing notational as well as biomechanical analysis (Hughes & Bartlett, 2002). 'Match analysis' is a field of sports science that describes athletes' performance in a particular match. Notational analysis (Downey, 1992) and computerised notational analysis (Hughes & Clarke, 1995) are methods of analysing dynamic and complex situations, including competition and training in sports, and have wider applications outside sports.

Researchers and coaches examine player movements, game patterns, tactics and traits without bias; all in an attempt to formulate ways in which players or teams can maximise their prospects of winning (Over & O'Donoghue, 2008). Indeed, in tennis, several studies (Gillet & Leroy, 2009; Takahashi, et al. 2009; Reid, McMurtrie & Crespo, 2010) have determined how match statistics describe and explain a player's success. Hughes and Clarke (1995) compared the match statistics of top players on different surfaces and showed that there were significant differences. Unierzyski and Wieczorek (2004) compared the serve and return-of-serve game patterns and tactical approaches adopted by players in the finals of two Grand Slam tournaments. They concluded that on fast courts players have better chances of winning a point if the serve is placed close to the T and the return of serve is played wide. On clay, players who placed serves wide had greater chances of winning a point. Verlinden, et al. (2004) showed similar conceptual and statistical significant differences between players' performances on fast and slow surfaces. Playing skill is also purported to affect game strategy, with top tennis players who play with high accuracy (a small number of unforced errors) are also reported to dictate matches, finishing points with their dominant shots (Kleinoder & Mester, 2000; O' Donoghue & Ingram, 2001; Brody, 2006; Stoinska, Unierzyski & Hurnik, 2008).

Corresponding Author ALES FILIPCIC, E-mail: ales.filipcic@fsp.uni-lj.si

Players' performances are defined by their competitive effectiveness. In professional tennis, the most important indicator of a player's competitive effectiveness is their position on the ATP ranking list. Their ranking depends on the number of tournaments played and the results achieved. Logically, in addition to their ATP ranking, the performance statistics of individual tennis matches would appear to represent another meaningful indicator of player performances. The relationship between the ranking and match statistics of the top 100 male professional players was examined by Reid et al. (2010). A stepwise regression analysis showed that second-serve points won and second-serve return points were the most relevant match statistics, explaining 52% of the ranking variance in the men's game. Other studies compare the performance characteristics of winners and losers (Filipcic, Filipcic & Berendijas, 2008; Choi, O'Donoghue & Hughes, 2009; Cross & Pollard, 2009; Cross, 2010; Cross & Pollard, 2011), although these are generally limited by the smaller number of matches, the shorter period and the level of observed players (Grand Slam Tournaments).

The goal of this study was to find potential differences between two groups of top quality male players according to 15 tennis match statistics. The groups consisted of top 300 ATP players who had won more matches (G_1), which was labelled the high quality group, and players who had lost more matches (G_2), which was labelled the quality group, in given competitive seasons at professional tennis tournaments. A player's success was defined by the number of points and position on the ATP ranking list at the end of 1991, 2000 and 2010, respectively. Therefore, the aims of this study were: (a) to examine differences between the two quality groups in performance indicators across the three observed periods; and (b) to investigate the impact of interactions (period, performance indicators) on differences within and between the two quality groups.

Materials and methods

Sample of subjects

For the purpose of this study, the sample of players consisted of all male tennis players ranked in the top 300 on the ATP official ranking list within three one-year time periods (1991, 2000, 2010). Since the ranking changes every week, the sample included all players ranked within the top 300 at the end of the year and who had played at least 10 matches in a given year. The criteria were met by 126 players in 1991 (G_1 = 51; G_2 = 75), 137 players in 2000 (G_1 = 58; G_2 = 79) and 129 players in 2010 (G_1 = 46; G_2 = 83). The average ATP rankings of the G_1 players were 45.2 in 1991, 44.4 in 2000 and 33.4 in 2010. Players with a negative win-loss number of matches held higher average ATP rankings: namely 96.6 in 1991, 103.4 in 2000 and 98.4 in 2010.

Protocol

The data were accessed through the ATP website, a public domain. The subject matter was match statistics from all ATP tournaments, including the Grand Slam, ATP World Tour Masters 1000, ATP World Tour 500, and ATP World Tour 250 tournaments played in the 20 years up to 2010. The sample consisted of (Table 1): (i) for 1991, match statistics from 41 tournaments for 1,961 matches played; (ii) for 2000, match statistics from 53 tournaments for 2,363 matches played; and (iii) for 2010, match statistics from 64 tournaments for 2,660 matches played.

Table 1. Percentage of tournaments on different types of surface

Surface	1991	2000	2010
Carpet	17.1	7.6	3.1
Clay	34.2	35.9	32.8
Grass	12.2	11.3	9.4
Hard court	36.6	45.3	54.7
Total	100 (41)	100 (53)	100 (64)

The statistics were compiled for each match in men's singles over the investigated period. To obtain the final performance indicators and to form the groups, the average number of matches played in each period and the average number of matches won and lost in both groups (G_1, G_2) were calculated.

To collect data from the official ATP site, an application in the C# programming language was created to allow the collected data to be stored in a specially designed database on a MySQL Database Server 5.1. Data were prepared for the analysis using the application made in C# and using the MySQL database, where each player's match was interpreted independently.

Variables

The sample of dependent variables consisted of 15 match statistics (performance indicators), divided into three groups:

1. Efficiency of the serve
   - Aces per match [n]
   - Double faults per match [n]

- First-serve points won [%]
- Second-serve points won [%]
- Total serve points won [%]

2. Efficiency of return of serve
   - First-serve return points won [%]
   - Second-serve return points won [%]
   - Break points saved [%]
   - Break points won [%]
   - Total return points won [%]
3. General match characteristics
   - Total points won [n]
   - Duration of the match [min]

Statistical Analysis

Descriptive statistics were generated and a Kolmogorov-Smirnov test was run on the dependent variables before the main analyses. There was a significant deviation from a normal distribution in three of the 15 cases which was corrected with a log transformation. A t-test for independent samples was used to check the differences between the two groups of tennis players in the three different periods. Differences between the three periods for each group were tested separately with a multivariate ANOVA (MANOVA – Wilks' lambda) test, followed by univariate ANOVA for each variable. All analyses were run with Statistica for Windows 9.1 and alpha was set at 0.05 throughout.

Results

Tables 2, 3 and 4 describe the two groups of players who had a positive (G_1) and a negative win-loss number of matches (G_2) in the observed time periods (1991, 2000 and 2010). There was an increase in the maximum number of matches played by tennis players of G_1 (1991 = 60; 2000 = 71; 2010 = 78) and the average number of completed matches in both groups (G_1: 1991 = 34.5; 2000 = 41.9; 2010 = 52.3 and G_2: 1991 = 18.5; 2000 = 22.4; 2010 = 27.9) for all three time periods.

Table 2. Number of matches and the ratio of wins and losses (G_1, G_2) for all three time periods

					1991					
			G_1					**G_2**		
	N	**Mean**	**Min**	**Max**	**S.D.**	**N**	**Mean**	**Min**	**Max**	**S.D.**
N_MATCH	51	34.5	13	60	11.6	75	18.5	10	36	6.1
WIN	51	22.1	8	47	9.7	75	7.3	1	17	3.4
LOSS	51	12.4	5	20	3.6	75	11.2	5	19	3.4
					2000					
			G_1					**G_2**		
	N	**Mean**	**Min**	**Max**	**S.D.**	**N**	**Mean**	**Min**	**Max**	**S.D.**
N_MATCH	58	41.9	11	71	15.5	79	22.4	10	44	9.4
WIN	58	26	6	54	11.3	79	8.8	1	22	5.3
LOSS	58	15.9	4	24	5.9	79	13.7	6	24	4.7
					2010					
			G_1					**G_1**		
	N	**Mean**	**Min**	**Max**	**S.D.**	**N**	**Mean**	**Min**	**Max**	**S.D.**
N_MATCH	46	52.3	19	78	14.1	83	27.9	10	58	13.4
WIN	46	33.9	11	67	12.4	83	11.1	0	29	7.2
LOSS	46	18.5	8	27	5.0	83	16.8	5	29	6.7

The results (Table 3) show that in 1991 and 2000 the G_1 players performed significantly better with regard to: first-serve points won, second-serve points won, break points saved (only in 1991), first-serve return points won, second-serve return points won, break points won (only in 1991), total serve points won, total return points won and total points won. In 2010, significant differences between the G_1 and G_2 players existed in all performance indicators except for first-serve percentage, serve games played and return games played.

Table 3. Means for the two quality groups of players (G_1, G_2), t-value (t), and significance level of t-test (p) for the three observed periods

	1991				2000				2010			
	G_1	G_2	T	p	G_1	G_2	t	p	G_1	G_2	T	p
Aces per match	4.5	4.0	1.3	0.2	6.4	5.9	1.0	0.3	6.7	5.3	2.6	0.0*
Double faults per match	2.9	3.3	-1.7	0.1	3.5	3.8	-1.6	0.1	2.5	3.0	-2.5	0.0*
First-serve percentage	60.4	59.8	0.6	0.5	57.5	57.1	0.4	0.7	61.4	60.3	1.4	0.2
First-serve points won	69.9	67.0	3.4	0.0*	72.0	69.8	2.5	0.0*	72.7	68.6	5.2	0.0*
Second-serve points won	51.0	48.6	4.4	0.0*	51.1	48.8	4.2	0.0*	52.4	48.7	6.1	0.0*
Break points saved	55.5	53.5	2.1	0.0*	56.6	55.0	1.7	0.1	56.1	53.2	3.1	0.0*
Serve games played	12.7	12.8	-0.5	0.6	12.6	12.7	-0.4	0.7	12.4	12.2	1.1	0.3
First-serve return points won	31.9	30.0	3.4	0.0*	28.7	27.1	3.2	0.0*	29.5	26.7	4.9	0.0*
Second-serve return points won	50.0	48.7	2.1	0.0*	49.5	47.9	2.9	0.0*	49.9	47.1	4.6	0.0*
Break points won	44.2	40.0	3.4	0.0*	40.6	38.9	1.6	0.1	40.2	37.9	2.2	0.0*
Return games played	12.6	12.8	-0.8	0.4	12.6	12.7	-0.8	0.5	12.3	12.2	0.5	0.6
Total serve points won	62.3	59.3	5.1	0.0*	63.0	60.7	3.9	0.0*	64.8	60.7	6.7	0.0*
Total return points won	39.3	37.5	3.6	0.0*	37.7	36.0	3.7	0.0*	37.5	34.7	5.1	0.0*
Total points won	50.7	48.5	7.0	0.0*	50.2	48.3	5.4	0.0*	51.0	47.8	8.1	0.0*
Duration of the match	107.8	109.2	-0.8	0.4	101.0	100.9	0.1	0.9	109.2	105.4	2.2	0.0*

*p < 0.05

A multivariate ANOVA test revealed statistically significant differences in the match statistics for the three observed periods (1991, 2000 and 2010) for the G_1 and G_2 players. The results (Wilks' lambda G_1 = 0.3, P< 0.05, G_2 = 0.4, P< 0.05; Rao's R G_1 = 8.2, P< 0.05, G_2 = 8.7, P< 0.05) indicate that the performance indicators' influence on a player's success changed from 1991 to 2000 and 2010.

The results of a univariate ANOVA (Table 4) test showed statistically significant differences between the three observed periods for G_1 in 10 and for G_2 in 11 of the variables. In G_1, there were statistically significant differences between the periods in aces per match, first-serve points won, second-serve points won and total serve points won (whose values are higher in 2000 and even higher in 2010), first-serve percentage and first-serve return points won (whose values are lower in 2000 and then higher in 2010), break points won, total return points won and duration of the match (whose values are lower in 2000 and even lower in 2010) and double faults per match (whose values are higher in 2000 and then lower in 2010). In G_2, there were statistically significant differences between the periods in aces per match, double faults per match, first-serve points won and total serve points won (whose values are higher in 2000 and then lower in 2010), first-serve percentage and duration of the match (whose values are lower in 2000 and then higher in 2010), serve games played, first-serve return points won, second-serve return points won, return games played and total return points won (whose values are lower in 2000 and even lower in 2010).

Table 4. Univariate ANOVA for the G_1 and G_2 players

	G_1		G_2	
1991/2000/2010	F	p-level	F	p-level
Aces per match	8.2	0.0*	9.5	0.0*
Double faults per match	9.5	0.0*	9.4	0.0*
First-serve percentage	9.4	0.0*	8.0	0.0*
First-serve points won	4.6	0.0*	6.9	0.0*
Second-serve points won	3.0	0.0*	0.1	0.9
Break points saved	0.7	0.5	2.3	0.1
Serve games played	1.5	0.2	6.4	0.0*
First-serve return points won	20.8	0.0*	23.3	0.0*
Second-serve return points won	0.4	0.7	4.2	0.0*
Break points won	10.7	0.0*	1.7	0.2
Return games played	1.8	0.2	5.7	0.0*

Total serve points won	7.2	0.0*	4.3	0.0*
Total return points won	7.8	0.0*	16.2	0.0*
Total points won	2.7	0.1	2.0	0.1
Duration of the match	13.1	0.0*	14.4	0.0*

*$p < 0.05$

Discussion

The results of this study show statistically significant differences between the two quality groups of tennis players in the efficiency of serve, return-of-serve, and general match characteristics, such as total points won, duration of the match etc. A comparison of the differences in the specific time periods reveals that the high quality players are becoming competent and more efficient in performing first- and second-serve (number of aces and double faults).

Data from 2010 revealed the greatest statistical disparity between the two groups, with significant differences recorded in 12 match statistics. The results may describe a positive trend in professional tennis player performance and be related to the number of participants on the ATP Tour which increased the level of competency. That is, in 1991, 1,131 tennis players were included on the ATP ranking list. In 2000, the number had risen to 1,332 players and then to 1,753 players by 2010.

The data revealed that the G_1 tennis players were more successful in the serve and return-of-serve performance indicators. For example, in 2010 the G_1 players won 72.7% of first-serve points and 52.4% of second-serve points, while in the G_2 group the players recorded lower serve percentages of 68.6% and 48.7%, respectively. The first-serve percentage, the number of aces and double faults, and the percentage of first- and second-serve points won are consistent with the results of Reid, et al. (2010). The high quality tennis players won more points on their first serves, while they were also more successful when receiving their opponents' second serves. A comparison between these two groups of players in 2010 showed that the G_1 players won more second-serve return points (G_1=49.9%, G_2=47.1%), first-serve return points (G-1=29.5%, G_2=26.7%), and break points (G_1=40.2%, G_2=37.9%).

On average, the G_1 players had more effective first (more aces) and second serves (fewer double faults), made more effective first- and second-serve returns, and won more service games than the G_2 players. These differences are more evident in 2010 than in 2000 or 1991. In professional tennis, research has shown that it is not only the effectiveness of the first serve that is important: the quality of the second serve and the return of the second serve are even more important (Barnett & Pollard, 2007; Barnett, Meyer & Pollard, 2008; Choi, et al. 2009; Gillet & Leroy, 2009; Reid, et al., 2010). In addition, it should be noted systematic and logical coherence between serve and return of serve and significant impact of the initial strokes' effectiveness on the continuation of the playing point.

The opposite applies with reference to first-serve return points won and break points won. Specifically, those values were lower for both quality groups than the values for 1991. As expected, the values of total serve points won for G_1 and G_2 were higher, while total return points were lower than in 1991. The same was observed for the G_2 group in which numerous changes were noted. Players served more aces per match, and had higher first-serve percentages and first-serve points won over time. They made fewer double faults and had lower values of first- and second-serve return points won compared to 1991. In 2010, these players also had lower values in serve and return games played.

Interestingly, the analysis of the annual tournament calendar reveals a difference in the proportion of matches played on fast and slow surfaces between 1991 and 2010 in favour of fast surfaces. As mentioned, the number of tournaments played on a hard court rose from 15 in 1991 to 35 in 2010. O'Donoghue and Ingram (2001), O'Donoghue and Ballantyne (2004) and Verlinden, et al. (2004) found an increasing proportion of shorter points where the serve and return of serve were more important from fast (grass), medium (hard court) to slow surfaces (clay).

During play on a slow surface, a more aggressive baseline player and a player who serves wide (to outer zones of the service box) will have an advantage. The slower and higher bounce on clay courts provides the receiver with more of an opportunity to return the serve than on faster surfaces. A common strategy used by players on clay is to direct their shot in open court, often to use a combination of short cross-court and down-the-line shots. Conversely, on fast surfaces players with an excellent first and second serve and a high return-of-serve percentage are more likely to win a match (Unierzyski & Wieczorek, 2004). Moreover, the effects of other factors which have changed over the last 20 years (characteristics of tennis balls, rackets, altitude etc.) on performance indicators should not be underestimated. The current research shows that the duration of a tennis match is related to the surface speed and the type of ball (Hughes & Clarke, 1995; Haake & Coe, 2000; Unierzyski & Wieczorek, 2004; Miller, 2006; Gillet & Leroy, 2009; Takahashi, et al., 2009) , a player's ranking, tactics, game style (Verlinden, et al. 2004; Gillet & Leroy, 2009; Reid, et al., 2010) , and the opponent's characteristics. The association between the player and the opponent is important but, to the knowledge of the authors, no study has analysed interdependence between observed subjects. Further, an opponent is defined with the same characteristics, skills and competencies that are reflected in a match's performance indicators. For

example, changes were observed in the duration of matches between 1991 and 2010. The long-term changes regarding match duration show that matches had become shorter by 2000, which is consistent with conclusions reported by O'Donoghue and Liddle (1998), and then in 2010 the duration of matches again increased. In the final rounds of tournaments, high quality players engage in a bigger number of closer matches; consequently, they play longer matches.

Serve and return-of-serve performance indicators have been observed in many studies (Barnett & Pollard, 2007; Filipcic, et al., 2008; Barnett, et al., 2008; Choi, et al. 2009). Other game situations (baseline game, approach or net, and defensive) were not analysed in this study although they have strong influence on the final result of a match. Top male players are able to play from the baseline with a very high pace and small number of unforced errors. Technically, they are equally strong on both sides (forehand and backhand). They are able to put an opponent under pressure and or manage defensive situations.

The long-term development of player's tennis performance is noticeable in both quality groups. The present findings suggest that the observed performance indicators are sensitive enough to establish differences between high quality and quality tennis players. Research has shown that tennis players are nowadays more tactically and technically complete, better trained, and able to perform at the highest level throughout the competitive season (Coe, 2000). However, we understand that performance indicators are not the only important factors for a tennis player's success. Other crucial factors should be taken into account in tennis matches, including the tactical quality, creativity, the ability to disguise, the quality of strokes in all game situations, and a player's self-confidence and emotional control.

Conclusions

To the authors' knowledge, to date no cross-sectional studies have determined differences between high quality and quality tennis players based on an analysis of performance indicators. The efficiency of serve and return of the serve have improved in the last two decades and assume an important role in professional tennis (Barnett & Pollard, 2007; Barnett, et al. 2008; Reid, et al., 2010;). Based on the performance indicators used in this study, it is possible to conclude that tennis is evolving into more of an all-round game, characterised by increasingly effective serves and returns of serve that allow players to win more points in total.

The present findings suggest that tennis coaches should consider guiding young tennis players in the direction of developing a high level of serve, return of serve and baseline tactical and technical competencies. Therefore, promising young tennis players should be able to adapt to different players, surfaces and other factors that affect matchplay.

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