Game Characteristics in Professional Tennis at Different Levels of International Tournaments

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ABSTRACT

Fast tennis shots and quick movements are required in professional tennis; however, the game performance can be different in various international tournament levels. The aim is to analyse and compare game characteristics and the frequency of rally shots in male matches at the Australian Open and at the ITF Men's World Tennis Tour tournament, the Milovice Open. We analysed 1,738 points in seven matches at the Australian Open and 1629 points in fifteen matches at the Milovice Open. Based on previous research, selected game characteristics such as point duration, rally length, time between the points, rally pace or work to rest ratio were compared between the tournaments. In both tournament levels, 60 % of rallies were finished within the first four shots of the rally. Other observed variables were also very similar in both tournaments, but the rally pace was significantly different. The players played in a significantly faster rally pace at the Australian Open (1.22±0.03) compared to the Milovice Open (1.27±0.05), p=0.02. These findings show a difference in game performance between the top and lower international level of tennis tournaments. Coaches can use information about the match game performance to optimize the practice sessions.

1. Introduction

The game characteristics of a tennis match can be different in various levels of international tennis tournaments or between the genders [1,2]. The structure of professional men's international tournaments starts at ITF tournaments (International Tennis Federation). The ITF Men's World Tennis Tour (previously known as Futures tournaments) are the lowest professional tournaments with the lowest prize money and ranking points. Next, the players can progress to a higher level of tournaments that are the ATP (Association of Tennis Professionals) Challengers and ATP Tour tournaments. Each category of these tournaments can have different prize money and ranking points. The top tournaments are the Grand Slams (Australian Open, French Open, Wimbledon and U.S. Open).

Even though the on-court performance in tennis can be different; the task for the players at different levels remains

the same. The players need to react very quickly on an incoming ball, coordinate their movement and hit the ball. Players usually try to hit the ball as fast as possible to hit a winner or to provide the opponent with as little time as possible. The ball flight duration from the server to receiver is between 0.5–1.2 s depending on the serve quality and type, its initial velocity and spin and the court surface [3,4].

Previous studies showed that men reach much higher serve speeds compared to women [5,6]. Differences in game performance including strength levels, running speed or court coverage by genders were previously published [2,7,8]. Some studies compared the specific parts of the game performance between the beginner and experienced tennis players such as the quality of forehand stroke [9] or anticipation skills [10]. Only a limited number of studies compared game performance in various level of tennis tournaments. International level players, compared to national level players, reached higher speeds of serve, return and groundstrokes or hit the balls more precisely [11]. Professional tennis matches have a longer duration, and players play more aggressively from the baseline than junior players [12]. On the other hand, Janak & Zhanel [13] did not reveal any difference in the level of the game characteristics between junior and adult players. Researchers and experts [13-15] suggest that analyses of various match records of game performance and performance indicators may provide valuable information and significant feedback for scientists, coaches and players.

Weber et al. [16] stated that more than 50 % of points in male and female matches are decided within the first 4 shots of the rally. Various match characteristics were previously reported and examined in international tennis matches. The time between the points differ from 19.4 s to 33.1 s [16-18], however the ITF and Grand Slam rules allow 25 s between the points [19]. Intermittent load is typical for tennis including repeatable high intensity movements and rest. A work to rest ratio in tennis is 1:2-1:5 depending on the court surface [20-25]. Morante & Brotherhood [26] found a time difference in point duration between the male and female tennis players at Wimbledon 2005 and the 2005 Australian Open. They showed the mean point duration was at the Australian Open 6.4 s in male and 7.0 s in female matches. During this time, the player performs high intensity acyclic and cyclic movements [1,21], however Reid et al. [2] argue, that men play at a higher pace. Carboch & Placha [27] examined the rally pace during the rally (i.e. how quickly the ball travels between the opposing players, in other words, how much time the player has to hit the ball since the opponent hits the ball in the whole rally). They revealed that the rally pace was faster in the late stage (1.16 s) compared to the early stage (1.23 s) in the Australian Open female matches. Moreover, it was found that the ball change does not affect the rally pace [28]. The ball change varies at this level of the tournaments, as the ball change at the ITF Men's World Tennis Tour is after 11 and 13 games thereafter using 4 balls in play and at the Grand Slams the ball change happens after 7 and every 9 games thereafter using 6 balls in play.

Tennis balls can slowly lose pressure through the balls core and the ball wear becomes used. Each ball is subject to have 105 racket or ground impacts [29]. Damage is not only in the racket-ball interaction that damages the ball wear, but by the surface as well. The mass reduction is increased by impact speed and the number of impacts causing the felt cover degradation [30,31]. This affects the ball flight characteristics; used balls have larger drag, smaller lift force, reduced stiffness and different aerodynamic properties [32,33]. The players need to adapt to this during the match and for the new balls after the ball change as well. In practical terms, used balls become slower and may reach less spin rate, which can affect match tactics or serving strategy [34]. The ball degradation is expected to be bigger at the ITF Men's World Tennis Tour, as the ball change is not as often as in the Grand Slams and there are fewer balls in play as mentioned above.

The purpose of this study is to analyse and compare how specific game characteristics differ at the lowest and highest international tournament level including the play with new and used balls. To the authors' knowledge, selected game characteristics used in this study (based on [27]) were not examined between the tournament levels, i.e. what is the difference in game performance at the top and at the bottom international tennis levels. The aim is to analyse and compare game characteristics and the frequency of rally shots in male matches at the Australian Open and at the ITF Men's World

Tennis Tour tournament, the Milovice Open.

2. Methods

2.1. Participants

We analysed 15 matches at the ITF Men's World Tennis Tour, the Milovice Open in 2019 (MO), 15,000 USD in prize money and 7 male matches at the Australian Open (AO). In 15 randomly selected matches of MO, we analysed 1629 points. Nine of the matches were 1st round matches, three 2nd round matches, two quarter-finals and final match. Professional tennis players n = 21 (22.9± 4.7 years) in these matches had a mean ATP ranking of 1019.9±343.4. In 7 male AO matches we observed a total of 1738 points. Four of the matches were first round matches, two semi-finals and final match. In these matches professional tennis players n = 12 (mean 28.0±4.9 years) and had a mean ATP ranking of 45.0±35.7. Both tournaments have been played on the same hard court Plexicushion acrylic surface. This study was approved by the Ethics Committee at the Faculty of Physical Education and Sport, Charles University.

2.2. Procedures

The match recordings were obtained from television or internet broadcasts. The quality of the video was found appropriate for the subsequent analyses. A spreadsheet with all the observed variables was prepared in advance for each match. The evaluator marked down if the server put the ball in play with the first or second serve and the variables were [27]: (1) Number of rally shots (rally length) – every stroke (racket-ball contact) was considered as a shot excluding the occasions when the ball just touched the racket frame and continued behind the striking player (this was not considered as a shot). (2) Point duration – the measurement of this variable was started by the striking of the ball by the server (in the case of a 1st serve fault, the measurement was started by the striking of the ball at the 2nd serve) until the point was finished. The point was finished in the following cases – when the ball was out (touched the court outside the lines or hit the permanent fixture); the ball ended up in the net; when the ball bounced for the second time. (3) Time between the points – the time was measured when the previous point was finished to the racket-ball contact by the following first serve. The time was measured only during the games themselves (from the end of the first point of each game until the last point of the game). This variable was not measured during changeovers and after the end of the game or during tie-breaks. The time between the points was not measured in the following unusual situations, which would delay the expected continuation of the play: racket change, medical time out, discussion or argument with the umpire, a player's challenge (use of electronic line calling system), unusual crowd behaviour delaying the game. (4) Rally pace – was flowingly calculated: point duration divided by rally shots. (5) Work to rest ratio (point duration/time between the points). Data were excluded from the sample when a player made a double fault (time between the points was not excluded); when the ball became invisible (e.g. landed in the stands).

Each match was observed twice. Point duration and rally shots were observed during the first observation. The time between the points was observed during the second observation. The time was measured using a stopwatch. After every point, the video-recording was stopped and the evaluator marked the measured variables into the spreadsheet. In unclear situations, the video-recording was paused or reviewed.

Data for new balls were collected from every two games after the ball change. The first ball change was after 7 games and every 9 games thereafter in case of the AO and after 11 games and every 13 games at the MO. We did not use data from the first 2 games of the match as the same balls were used for the warm-up. Data for the used balls were collected from the last two games prior to the ball change.

2.3. Data analyses

All of the matches were analysed by one evaluator. The evaluator had a one-hour practice session for data observation and measurement before he started the match analyses. The intra-rater reliability using Intra-Class Correlation reached in all the observed variables ≥ 0.98. Firstly, we calculated the means of each variable from every single match. Data were analysed using descriptive statistics and paired samples T-tests (within the tournament) or independent samples T-tests including Levene's test for equality of variances (between the AO and MO). Effect sizes (Cohen's *d*) were calculated and can be interpreted as small (0.20 to 0.49), moderate (0.50 to 0.79), and large ($d \geq 0.80$) [35].

3. Results

The overall comparison of tournaments is detailed in table 1. The values between the tournaments are very similar except to the rally pace. The rally pace was significantly faster at the AO compared to the MO, which is accompanied by a large effect size. The same variables were compared after all the points were played, when the players hit the first serve in (table 2). T-tests did not show any significant differences between the tournaments when the play continued after the first serve. Only large effect size was revealed in the rally pace, being faster at the AO.

Table 1. *Comparison of all observed variables between the Australian Open and the Milovice Open.*

	Australian Open	Milovice Open	Mean Difference	95 % CI		T-test	*p*	Cohen *d*
				Upper	Lower			
Rally shots	4.85±0.48	4.84±0.69	0.01	-0.53	0.55	0.04	0.97	0.02
Point duration (s)	5.93±0.67	6.18±1.05	-0.25	-1.03	0.53	-0.68	0.50	-0.28
Time between points (s)	21.46±2.88	22.34±1.51	-0.88	-2.81	1.06	-0.95	0.35	-0.38
Rally pace (s)	*1.22±0.03	1.27±0.05	-0.05	-0.09	-0.01	-2.49	0.02	-1.21
Work to rest ratio	1:3.63±0.38	1:3.72±0.19	-0.09	-0.60	0.41	-0.39	0.70	-0.30

*Significantly different than Milovice Open (*p*<0.05).

Table 2 also shows detailed scores of observed variables in all the points, when the players missed the first serve and used the second serve. Rally pace was significantly faster at the AO after the ball got into the play after the second serve and the time between the points was significantly longer at the MO, both variables are supported by large effect sizes. If we compare the same variables within the tournament, we can see some differences between the game characteristics after the first and the second serve. At the AO, paired samples T-tests showed that there were significantly more: rally shots after the second serve t(6)= -4,34, *p*=0,005; longer point duration after the second serve t(6)= -3,05, *p*=0,013; and longer time between the points after the second serve t(6)= -10,83, *p*<0,001 (means and standard deviations can be seen in table 2). Large effect size was observed in rally shots (*d*=-1.95), point duration (*d*=-1.48) and work to rest ratio (*d*=-0.92), and medium effect size in the time between the points (*d*=-0.64). At the MO, T-tests revealed significant difference in all observed variables between the first and second serve, including large effect size except medium effect in the rally pace. The players hit more rally shots after the second serve t(14)= -9,41, *p*<0,001 (*d*=-1.94); had longer point duration after the second serve t(14)= -12,46, *p*<0,001 (*d*=-1.80); longer time between the points after the second serve t(14)= -12,46, *p*<0,001 (*d*=-2.27); slower rally pace after the second serve t(14)= -3,19, *p*=0,007 (*d*=-0.60); and different work to rest ratio t(14)= 5,47, *p*<0,001 (*d*=0.85).

Large effect size was revealed in the rally pace between the tournaments both with the play with the new and used balls; or medium effect size was shown in the time between the points with the new balls or in the work to rest ratio with

the used balls (table 3). However T-tests did not show any significant difference between the tournaments in the play with the new or used balls. The effect of ball change was also tested within the tournament. At the AO, paired samples T-tests showed that there were significantly different work to rest ratios with the new balls (M=1:3.92, SD=0.59) compared to used balls (M=1:3.25, SD= 0.58) t(6)=24,63, $p<0,001$. Large effect size between the new and used balls was found in the rally shots (d=-0.82) and work to rest ratio (d=1.16); and medium effect was revealed at the point duration (d=-0.78). At the MO, T-tests did not show any significant difference in all observed variables between the play with the new or used balls and only medium effect was found in the work to rest ratio (d=-0.51).

Table 2. Game characteristics of the tournaments after the 1st and 2nd serve.

	Australian Open	Milovice Open	Mean Difference	95 % CI		T-test	p	Cohen d
				Upper	Lower			
1st serve in								
Rally shots	4.43±0.53	4.22±0.71	0.21	-0.42	0.85	0.70	0.49	0.34
Point duration (s)	5.43±0.72	5.33±1.05	0.09	-0.83	1.02	0.21	0.83	0.11
Time between points (s)	20.72±2.81	20.88±1.68	-0.16	-2.15	1.83	-0.17	0.87	-0.07
Rally pace (s)	1.22±0.04	1.26±0.05	-0.04	-0.08	0.01	-1.58	0.13	-0.88
Work to rest ratio	1:3.85±0.53	1:4.07±0.90	-0.22	-0.86	0.42	-0.71	0.49	-0.15
2nd serve in								
Rally shots	5.63±0.69	5.80±0.91	-0.17	-0.98	0.64	-0.44	0.66	-0.21
Point duration (s)	6.71±0.99	7.49±1.33	-0.79	-1.97	0.40	-1.39	0.18	-0.67
Time between points (s)	*22.45±2.56	24.48±1.49	-2.03	-3.82	-0.23	-2.36	0.004	-0.97
Rally pace (s)	*1.19±0.09	1.29±0.05	-0.10	-0.16	-0.04	-3.28	0.02	-1.37
Work to rest ratio	1:3.39±0.47	1:3.38±0.71	0.01	-0.60	0.63	0.05	0.96	0.02

*Significantly different than Milovice Open ($p<0.05$).

Table 3. *Game characteristics during the play with the new and used balls.*

	Australian Open	Milovice Open	Mean Difference	95 % CI Upper	Lower	T-test	p	Cohen d
New balls								
Rally shots	4.44±0.57	4.58±1.35	-0.15	-1.00	0.71	-0.36	0.72	-0.14
Point duration (s)	5.38±0.77	5.83±2.00	-0.45	-1.68	0.79	-0.76	0.46	-0.30
Time between points (s)	20.84±2.52	22.80±2.64	-1.97	-2.15	-4.46	-1.65	0.11	-0.76
Rally pace (s)	1.21±0.04	1.26±0.07	-0.05	-0.11	0.02	-1.56	0.13	-0.88
Work to rest ratio	1:3.91±0.56	1:4.29±1.07	-0.38	-1.28	0.53	-0.87	0.40	-0.44
Used balls								
Rally shots	4.95±0.67	4.87±1.00	0.08	-0.79	0.95	0.20	0.84	0.09
Point duration (s)	6.04±0.92	6.21±1.41	-0.17	-1.39	1.05	-0.29	0.77	-0.14
Time between points (s)	21.15±2.65	22.12±2.25	-0.97	-3.24	1.30	-0.89	0.38	-0.21
Rally pace (s)	1.22±0.04	1.27±0.06	-0.05	-0.11	0.00	-2.01	0.06	-0.98
Work to rest ratio	1:3.25±0.58	1:3.75±1.04	-0.51	-1.39	0.38	-1.20	0.25	-0.59

Frequency analysis of rally shots is detailed in table 4. The table shows not only overall tournament frequencies, but frequencies after the 1st and 2nd serve or with the new and used balls play as well. Notably, specific comparisons between the AO and MO are quite equal. To better illustrate and visualize the frequencies, figure 1 shows the distribution of the rally shots, which is remarkably similar.

Table 4. *Frequency analysis of rally shots between the tournaments.*

Rally shots	Australian Open					Milovice Open				
	Overall	1st serve in	2nd serve in	New Balls	Used Balls	Overall	1st serve in	2nd serve in	New Balls	Used Balls
1	8,6	12,7	0,7	9,8	10,1	8,1	12,9	0,8	7,5	9,7
2	21,9	23,4	18,9	26,4	17,4	21,5	24,3	17,3	22,1	20,9
3	16,2	16,2	16,1	19,4	16,6	17,5	17,9	16,8	18,1	14,8
4	12,2	10,7	15,1	9,3	11,0	12,7	12,5	13,0	14,6	13,3
5	9,0	9,0	9,2	9,6	8,4	10,3	10,3	10,4	6,5	11,2
6	7,8	6,5	10,1	4,8	9,6	6,5	4,3	9,9	5,5	6,6
7	5,7	4,8	7,6	6,5	7,0	6,1	4,9	7,9	9,0	6,1
8	4,7	4,7	4,3	3,7	4,5	4,2	2,6	6,5	2,0	5,1
9	2,9	2,8	3,3	2,5	3,9	3,1	2,4	4,0	4,5	3,1
10	2,2	1,7	3,3	0,8	2,2	1,8	1,2	2,8	1,0	2,0
11	2,4	2,1	3,0	2,2	2,2	2,3	1,9	2,9	2,0	1,5
12	1,4	1,4	1,4	0,8	1,4	1,5	1,3	1,7	1,0	1,5
13+	4,9	4,0	6,9	4,2	5,6	4,4	3,5	6,0	6,0	4,1
Points played	1738	1156	582	343	347	1629	983	646	199	196

All the values in rows 1 – 13+ are reported as a valid percent.
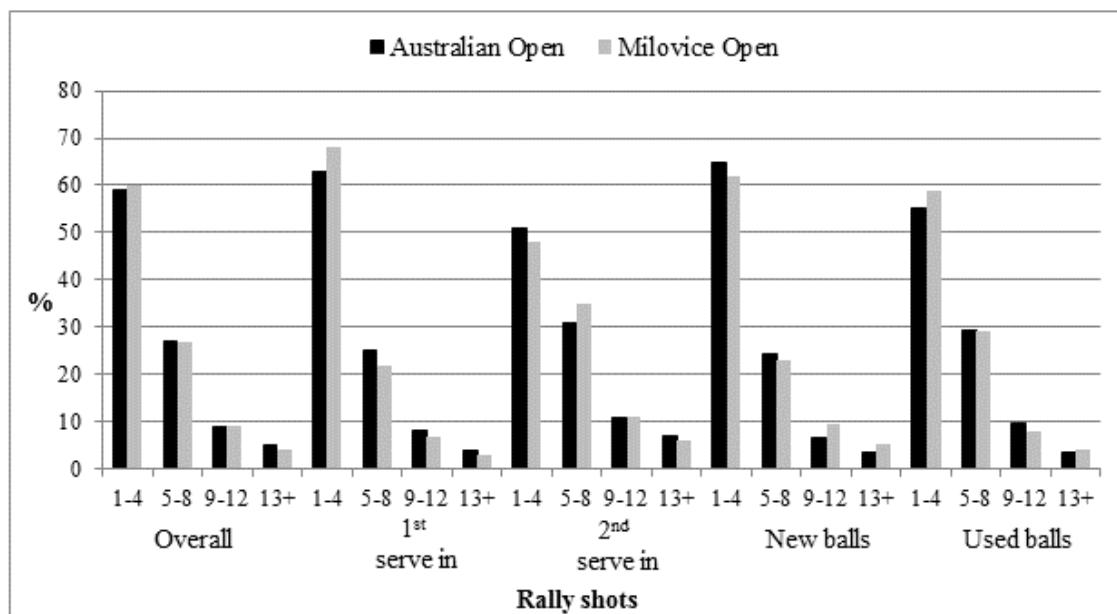

Figure 1. *Distribution of rally shots.*

4. Discussion and Conclusion

The aim was to analyse and compare game characteristics and the frequency of rally shots in male matches at the AO and at the ITF Men's World Tennis Tour tournament the MO. The game characteristics were shown to be quite equal between the tournaments except for the rally pace. The rally pace (mean duration of the shot ball flight time between the opposing players) was different between the tournament levels. A different rally pace may be explained by the quality of the players and their game performance, as better ranked players may be able to hit the groundstrokes faster and move around the court quicker.

Remarkably, there was a bigger difference in the rally pace after the second serve between the observed tournaments, hence the rally pace became faster after the second serve in the AO compared to the rally pace after the first serve. However, in the MO, the rally pace became slower after the second serve compared to the first serve. This may be attributed to the better quality of the return shots of players at the AO, as the players may return the ball with higher speed (or hit fewer defensive shots). Another explanation may be that the game performance of lower ranked male players at the MO may partly be closer to the female game performance. Some authors [2] reported that male play is at a higher pace, compared to women, as men reach significantly higher movement speed and cover more meters on the court. Also Morante & Brotherhood [26] stated that men reach higher stroke frequency. But still, we can only assume and cannot really compare these gender game performances, even at this level at the MO, the male players serve faster compared to top female players. A theory could be mentioned here that the top players at the AO were able to cover more meters (which can also include better anticipation skills) or move faster on the court than the lower ranked players at the MO. If the player is moving slowly on the court, he can be late to position for his stroke. Consequently, the player needs to expand

sideways during the hitting phase, leading to a lower stroke speed (loss of power), which can also change the stroke intention (instead of hitting a winner to avoid the error) [36]. However, Reid & Duffield [24] stated that the fatiguing effect on the players' movement and their shot result is still unclear. Of course, the rally pace can be affected by fatigue, especially in long matches or after long rallies.

Muscle fatigue is present in long matches [37] and negatively influences a player's overall performance, e.g. biomechanical forces, ball speed, motion flexibility, or decreases metabolism and physiological processes [38-41]. On the other hand, Gescheit et al. [42] argue that fatigue does not affect the stroke speed in consecutive long matches, but decreases the total movement in explosive tasks of lower limbs such as sprinting and jumping. Some game characteristics are very similar after the first serve between the tournament levels (table 2). More disparencies between the tournament levels can be observed after the second serve. Longer point duration at the MO can suggest that players at this level can have less efficient shots and try to keep the ball more in play or players at the AO could have more aggressive playing styles. Notably, the point duration increased by 2 s after the second serve in the MO, that resulted in a longer time between points. This suggests that the players try to rest more after a longer point duration.

In both tournament levels, the point was obtained within the first four shots in 60 %. This is 10 % more than on a clay court [16, 43]. These values can be explained because of the court surface or that the players developed a more aggressive playing style. Our study also splits the data after the first and second serve, showing that after the second serve it is around 50 % of points and that was similar in both tournaments. The work to rest ratio in our study is similar to previous studies [22,24]. Together with the mentioned rally pace, these pieces of information can help the coaches utilize the practice sessions better.

As the used balls become slower, it can allow the player to have more time to reach the incoming ball and can make it harder to hit a winner. The results also indicate that the different ball change did not affect the rally pace [28]. Interestingly, equally in both tournaments (even with different ball change), the rally pace with the used balls was 0.01 s slower than with the new balls. The effect of ball degradation did not show any differences between the tournaments, other than the rally pace as already mentioned above. The ball stiffness slowly decreases after the impacts; therefore used balls have a reduced stiffness as compared to the new balls. Practically, it should be easier to hit a winner with the new balls. Balls with greater stiffness contact the racket for less time during a hit than softer balls, resulting in a significant difference in control and reaction forces felt by the player's arm [34]. The point was finished within the first four shots of the rally at the AO in 10% more cases with new balls than with the used balls, even though the balls are changed more often at the AO. However, at the MO the difference reached only less than 4 %. We would expect a bigger difference in the MO due to larger ball degradation (more ball impacts due to the ball changes and fewer balls in play). However, one explanation may be that players at the MO hit the ball with more control and play more carefully with the new balls as not to make an unforced error. Or as they could feel a bigger difference between the balls after more games played, they try to adapt to the new balls more carefully.

We tried to provide insight to specific variables from the practical view with the focus on the rally pace, which was (to the authors' knowledge) not used before by other researchers in this way. The authors are aware that the study was limited by the sample size of matches, especially for the new and used balls results. Many researchers are now able to use data from sophisticated software (e.g. Hawk-Eye system), which easily allows collecting huge amounts of data and can observe a lot of variables. However, we used "old school" notational analyses by hand to measure specific components of the game performance, which consisted of indirect match observation and manually marking down every value for each variable. In regard to this, it takes much more time to obtain the data (especially when we observed each match twice) than using automated software. Therefore we believe that we observed a sufficient number of points and the results are in this way very valuable. This study indicates some significant differences between the tournament levels and we

believe these results can provide useful information for the coaches. Next, the rally pace and other game characteristics can be affected by various factors, such as the individual playing style of opposing players, their tactics and strategy, by weather conditions and fatigue, etc. Further studies should examine the players' game performance from a similar view on other court surfaces, or between the junior and professional players. It is very likely that similar results could be obtained from another tournament played on the same surface.

We analysed specific parts of the game performance between the Grand Slam and lower international tournament. Overall, players at the AO tournament played at a faster rally pace than at the MO. This difference was even larger after the second serve. This has been the most important finding between the tournament levels. Comparison of other game characteristics such as point duration, rally length, time between points, work to rest ratio or shot frequencies was very similar. This study provides insight into the practical aspects of specific game performance characteristics in professional tennis matches that could be used by coaches to optimize the training session, tactics and enhance the performance.

Acknowledgment

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