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Matchplay characteristics and performance indicators of male junior and entry professional tennis players

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Abstract

Performance analysis during match play is vital for the long-term development of tennis players. The primary goal of this study was to establish the differences between junior and entry professional tennis player's selected performance indicators in five-game situations. Data were collected using the Sagit/Tennis tracking system during six junior and four professional tennis matches. Eight boys performed 3,112 strokes, while eight male professional players hit 1,631 strokes. The results showed slight differences in the distance covered by the two observed groups in the specific game situations. Professional players performed faster shots in all game situations, except when playing at the net. They played at a significantly faster tempo than the juniors. This difference was also affected by the higher shots speed and shorter distance between the two players during the rallies. When playing from the baseline, the entry professional players performed shots at a smaller angle than the juniors; and when serving, receiving and playing at the net, they hit shots at a greater angle than the juniors. Our findings may assist coaches and players in improving the effectiveness of their tactical and technical training to enhance their competitive performance.

Keywords

Performance analysis, racket sport, youth sport

Introduction

The number of junior tennis players competing in ITF tournaments is continually increasing, as reflected in the ever-higher number of male and female players competing in entry-level professional events – ITF World Tennis Tour. The United States Tennis Association[1] indicated that more tournaments, matches, sets, and games are required for players to climb professional tennis rankings lists successfully.

The transition to professional tennis is gradually becoming extremely demanding for junior tennis players. Reid et al.[2] found that 91% of boys in the top 20 of the ITF rankings, achieved a professional men's ranking, paving the way for their future professional success. Playing at entry professional tournaments is the first step towards top-level tennis, and in the event of a successful performance allows players to take up tennis professionally. McCraw[3] observed that junior players, previously ranked among the top 10 in the ITF junior rankings, needed more than 4 years, on average, to break into the top 100 of the ATP world rankings. In the same study, tennis players who scored their first ATP points at the age of 18, entered the top 100 at 21 years of age and reached their highest ATP ranking at 23.

Research has shown that the professional game of tennis is more physically demanding than the junior tennis game.[4] However, simply playing in tournaments more often does not in itself guarantee any improvement on the professional tennis ranking list. Players' development and progress should be built on tactical, technical, psychological, and conditioning competencies that can be captured by match performance

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indicators. Along with their ever-growing developmental path, young tennis players are required to meet or even exceed, performance indicator levels typically expected of professional tennis players.

In advanced tennis match play, effective strategies and tactics are essential for successful performance.[5] Tennis strategy is based on a combination of tennis strokes and game patterns in the five typical game situations: serving, receiving, playing at the baseline, approaching and/or playing at the net, and passing the player at the net.[6] A tennis player's effectiveness during a match depends on their sport-specific knowledge and cognitive (anticipation, perception, decision-making, or response selection), as well as motor skills (movement and stroke production) in response to various game situations. The developmental path of junior tennis players is long, and it is becoming even longer due to the growing level of competitiveness, the expansion of the pool of high-level tennis players, and the tennis game's constant development. To progress up the rankings (junior or professional), tennis players must commit to many hours of tennis, conditioning, and other training regimes in order to improve their game and reach the upper echelons of the rankings.

Different technology systems based on video footage are used to capture data: Sagit systems,[7] ASL SE5000 eye tracking system,[8] SIMI Scout software,[9] computer-based trace analysis,[10,11] Hawk-Eye[12] are just some of the systems. Recent technological advances provide opportunities to track various performance indicators including players' movements,[13–16] shot effectiveness,[17–21] and time characteristics.[22–24] Terroba et al.[25] presented a model based on video analysis of matches and Markov decision processes to identify the most successful strategies used by tennis players. The aforementioned studies analysed match efficiency in male and female professional tennis. In comparison, several researchers[7,20,26–30] have conducted notational analysis of the junior game.

Given that there are numerous developmental models and a wide array of changes that occur during a junior tennis player's long-term path of development, our aim was to provide tennis coaches and players with tactical insight in order to help them implement more effective tennis training. The aim of the study was to determine differences in shot efficiency, selected performance indicators, and tactics among male junior and entry professional tennis players. The main focus was to observe the differences between the two cohorts in terms of the distance covered by a player, the distance and time between shots, as well as the speed, and shot angles in various game situations. This study aimed to contribute to the understanding of the differences in some competitive performance characteristics between junior and entry professional tennis players. We hypothesize that there are group associations in the matchplay characteristics and indicators in specific game situations. By examining the matchplay indicators of male professional and male junior tennis players, the findings will provide coaches a better understanding of the interacting influence of age and level of play on match performance, to aid their tactical instruction of long-term game development.

Methods

Study design

During the tournaments, all matches were recorded with fixed SVHS video cameras (Ultrak CCD Colour KC 7501 CP) with a 25 Hz frequency of capturing input images. Each camera was fastened to the ceiling of indoor tennis facility, allowing its wide-angled lens (Ultrak KL 28141 s 2.8 mm, Japan) to cover an entire half of the court. The video recordings were digitized using the Video DC30* video digitizer hardware (Miro, Germany) with a resolution of 384×576 at a data rate of 2 MBs,[2] while processing was carried out at resolution of 384×288 pixels. The Sagit/Tennis tracking system calculates the player's position and velocity 25 times per second in numerical format. Software was written to produce a schematic location of the player, the player's velocity at that position and players activities (shots production, split-steps, etc.). The accuracy of the Sagit system had been already tested in other studies.[7,31] The digital images were processed with the Sagit/Tennis tracking system using a computer vision method. The study was conducted in accordance with the ethical standards outlined in the 1964 Declaration of Helsinki, following the 6th revision of 2008. Participation was based on written applications submitted by national coaches. Individual tennis players and their parents received information about the study before the assessments, and we obtained their signed consent before collecting data. All procedures were approved by the Faculty of Sport Ethics Committee.

Subjects

Eight boys (age 13.9 ± 0.8 years) performed 3,112 strokes, while another 1,631 strokes were carried out by eight male professional players (age 20.1 ± 1.1 years). In sum, 4,743 strokes were analysed. Data was collected during six matches at a junior's tournament (National Championship for the 14 & under boys), and four matches at an entry professional tennis tournament (ITF Men's World Tennis tournament). All tennis players were considered to be highly trained and ranked on the Slovenian national

14 & under ranking list (position 5.4 ± 4.2), as well as on the ATP professional ranking list (position 718.8 ± 503.4). All matches were played at the same indoor tennis facility on a Rebound Ace GS surface. The Human Ethics Committee of the Faculty of Sport approved the experimental design and protocol prior to data being collected.

Procedures

The matchplay characteristics for junior and entry professional tennis players were collected using the Sagit/Tennis tracking system: number of matches, match duration, rally and rest phases, rally range, rally number and length, number of shots, shot production, distance covered, and movement speed. In addition, data on the players' movement and position when performing shots were collected. Time and position of the shots were added manually by a specially trained technician and the use of slow-motion function. Based on this data, the following performance indicators for the two groups of players in the five-game situations (serving, receiving, playing at the baseline, playing at the net, and other shots) were calculated:

- distance covered by a player between shots (m);
- distance between the player's and the opponent's shots (m);
- time between the player's and the opponent's shots (s);
- average shot speed (km/h);
- rally tempo (number of shots per minute);
- angle between two successive shots (degrees).

Rally tempo refers to the anticipated number of shots if a rally lasts for one minute and determines the pace of the game. In serving, we considered the serve and the following shot of the server, while, in receiving a serve, the return of the serve and the next shot of the receiver was taken into account. Angle variation was measured based on the positions of player A and player B at the time the shot was taken (Figure 1).

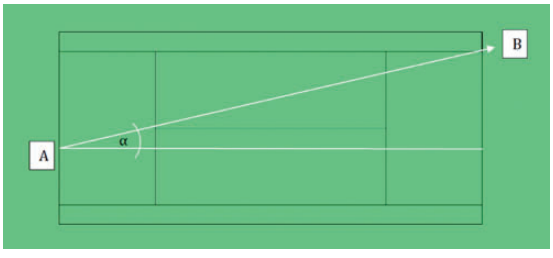

Figure 1. Calculation of the angle according to the positions of player A and player B at the time of the shot.

A player's position on the court was determined using the coordinate system, with the starting point 0.0 being placed in the centre of the baseline. When calculating the angle, the cathetus was placed perpendicular to the baseline (Figure 2).

Data analysis

All collected data was exported to a database, organised with a combination of SQL statements, exported into Microsoft Excel, and processed using the statistical programme SPSS 26 for Windows.

Descriptive statistics were reported for matchplay characteristics and performance indicators. The Normality of the variables was analysed by the Kolmogorov–Smirnov test. Welch's t-tests were used to evaluate differences between junior and entry professional matchplay characteristics and performance indicators. The extent of the differences between the two groups in characteristics and indicators was expressed using Cohen's d with an absolute value of d higher than 0.8 considered as a large, higher than 0.5 as medium, and higher than 0.1 as a small effect size difference.[32]

Results

The results concerning the differences between the junior and entry professional tennis players along with the matchplay characteristics are presented in Table 1. Matches played by entry professional tennis players lasted longer than those played by junior players. The duration of each rally at the entry professional level is significantly lower than that of the juniors.

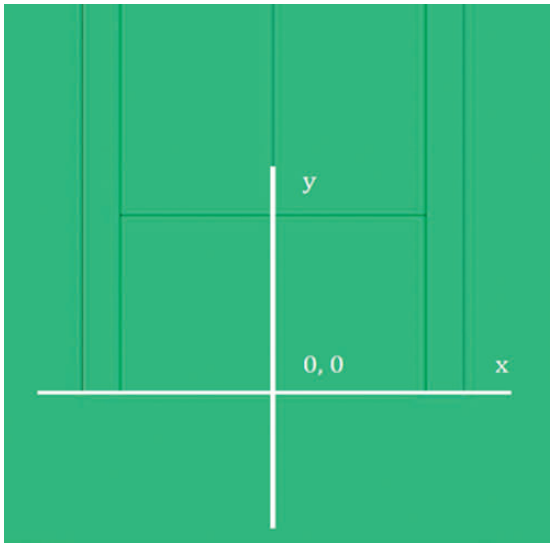

Figure 2. Positioning the coordinate system with starting point 0.0 in the middle of the baseline.

Table 1. Descriptive statistics and differences in matchplay characteristics of junior boys and male entry professional tennis players.

Matchplay characteristics	Junior boys	Professional men		
Match (no.)	6	4	*p*(*t*)	*d**
Time				
Match time (min)	65.4 (±18.3)	81 (±28)	1.79	−0.66
Rally time (s)	7.3 (±1.7)	4.4 (±0.5)	0.00	2.31#
Resting time per rally (s)	19.5 (±3)	20.5 (±2.4)	1.53	−0.37
Rally time (%)	27.5 ±(5.8)	17.9 (±3.4)	0.00	2.02#
Rallies range				
Rally 0-5 s (%)	51.5 (±8.7)	67 (±5.5)	2.00	−2.13
Rally 5-10 s (%)	22.7 (±4.9)	23.3 (±2.4)	1.24	−0.16
Rally 10-20 s (%)	18.9 (±4.9)	8.6 (±2.6)	0.00	2.63#
Rally 20+ s (%)	6.7 (±4)	0.8 (±0.7)	0.00	2.05#
Rallies and shots				
Rally (no.)	145.2 (±22.7)	193 (±52)	1.96	−1.19
Shots (no.)	1327.3 (±425.5)	1316.5 (±199.7)	0.95	0.03
Rally length (shots)	4.7 (±1.8)	3.4 (±0.3)	0.08	1.01
Shots production				
First serve	47.3 (±9.5)	66.5 (±11.1)	2.00	−1.86
Second serve	20.2 (±2.3)	32.5 (±9.6)	1.99	−1.76
Forehand return on first serve	20 (±12.2)	13.5 (±5.1)	0.20	0.70
Backhand return on first serve	14.8 (±4.9)	16 (±6.8)	1.31	−0.20
Forehand return on second serve	5.2 (±2.4)	1.8 (±.1.7)	0.01	1.63#
Backhand return on second serve	4.5 (±4.7)	22.5 (±8.9)	2.00	−2.53
Forehand	131.8 (±50.1)	68 (±8.7)	0.01	1.77#
Backhand	97.5 (±38.1)	83.3 (±11.6)	0.34	0.50
Net shots	5.3 (±5.4)	6.8 (±3.0)	1.49	−0.34
Other shots (slice and drop shots)	55.2 (±19.1)	40.8 (±19.3)	0.16	0.75
Distance travelled				
Distance per match (m)	2208 (±645.7)	1776.2 (±281.4)	0.12	0.87
Distance per rally (m)	15 (±2.8)	9.4 (±0.9)	0.00	2.69#
Distance per shot (m)	4.8 (±1.7)	4.3 (±1.4)	0.53	0.32
Movement speed				
Average movement speed (kph)	4.5 (±0.3)	4.9 (±0.5)	1.92	−0.97
Peak movement speed	1. (±1.5)	21.3 (±3.4)	1.18	−0.11

#Indicates a difference between junior boys and professional men at the 5% level or less.
*Cohen's d.

The same applies to the percentage of active match time (rally time) in terms of total match time, which is lower for entry professional tennis players. There were no differences in break duration between points among both groups of players. From the standpoint of the duration of individual rallies, juniors play a significantly larger number of longer rallies (more than 10 s). There were no differences in the rally number, shots number and shots number per rally.

Shot production analysis shows that the differences between the two groups are in the return of the serve, where entry professional tennis players perform fewer forehand returns on the second serve. Junior tennis players perform significantly more forehand shots at the baseline. In professional tennis, the ratio between forehand and backhand shots at the baseline was more balanced than in the junior matches. There were no differences in the number of serves, both returns on first serve and backhands return on second serve between the two cohorts. No differences were observed also for backhands at the base line, net shots and "other shots" (i.e., defensive, drop, and touch shots) between both study groups.

Movement analysis of the players shows that juniors cover a significantly longer distance during each rally compared to the entry professionals. There were no differences in the distance cover in a match and per shot between observed groups. No significant differences were found for the player groups in average and peak movement speed.

The results of matchplay performance indicators are shown in Table 2. In all game situations junior players covered a longer distance between two successive shots than their professional counterparts. There were significant differences in distance covered between the shots in serving ($p < 0.0$, $d = -0.37$), in baseline game

Table 2. Mean, SD, *N*, and Cohen's *d* of matchplay performance indicators of junior boys and male entry professional tennis players.

	Junior boys			Professional men				
	Mean	Std. deviation	*N*	Mean	Std. deviation	*N*	*p*(*t*)	*d**
Distance covered by player between shots (m)								
Serving	3.4	1.3	479	3.0	1.2	348	0.00	−0.37#
Receiving	5.1	1.6	400	5.4	1.6	247	1.99	0.22
Baseline game	4.7	1.9	1559	4.4	1.8	465	0.00	−0.14#
Net game	4.2	1.3	11	3.5	0.4	5	1.24	−0.64
Other shots	6.5	2.5	79	5.3	2.0	119	0.00	−0.57#
Distance between the player's and the opponent's shots (m)								
Serving	25.4	1.2	583	25.2	0.9	447	0.04	−0.12#
Receiving	26.4	1.8	479	25.2	1.8	348	0.00	−0.66#
Baseline game	27.2	2.5	1906	26.6	2.2	638	0.00	−0.23#
Net game	18.3	4.2	19	17.3	3.5	16	0.45	−0.26
Other shots	23.3	3.7	124	24.4	3.1	182	1.99	0.31
Time between player's and opponent's shots (s)								
Serving	1.2	0.2	583	0.9	0.2	447	0.00	−2.02#
Receiving	1.6	0.4	479	1.4	0.3	348	0.00	−0.65#
Baseline game	1.7	0.5	1906	1.3	0.3	638	0.00	−0.94#
Net game	1.4	0.4	19	1.6	0.4	16	1.75	0.38
Other shots	2.0	0.6	124	1.7	0.4	182	0.00	−0.85#
Average shot speed (km/h)								
Serving	75.9	13.4	583	104.0	17.4	447	2.00	1.85
Receiving	61.7	12.0	479	68.7	14.5	348	2.00	0.53
Baseline game	60.5	12.2	1906	75.4	12.4	638	2.00	1.21
Net game	50.5	17.3	19	45.2	20.8	16	0.43	−0.28
Other shots	43.3	10.1	124	54.9	11.2	182	2.00	1.08
Rally tempo (number of shots per minute)								
Serving	51.8	10.2	104	72.4	11.8	99	2.00	1.87
Receiving	32.2	4.6	79	40.7	6.0	101	2.00	1.54
Baseline game	23.3	4.0	347	29.8	4.0	173	2.00	1.61
Net game	22.0	3.6	8	27.7	3.5	11	1.99	1.61
Other shots	21.5	3.3	45	27.3	3.2	63	2.00	1.8
Angle between two successive shots (degrees)								
Serving	9.4	2.7	461	11.0	2.7	447	2.00	0.58
Receiving	10.2	4.2	509	10.4	5.1	348	1.39	0.04
Baseline game	7.3	4.4	1984	6.0	4.2	638	0.00	−0.3#
Net game	7.1	4.4	26	8.9	6.3	16	1.66	0.34
Other shots	8.9	4.9	132	8.4	4.7	182	0.36	−0.11

#Indicates a difference between junior boys and professional men at the 5% level or less.
*Cohen's d.

($p < 0.00$, $d = -0.14$) and in other shots ($p < 0.0$, $d = -0.57$), between the two groups observed. The longest distances between shots were measured for baseline play, and the shortest distances for net play. There were significant differences in distance in serving ($p < 0.04$, $d = -0.12$), receiving ($p < 0.00$, $d = -0.66$) and baseline game ($p < 0.00$, $d = -0.23$), between the two groups observed. The time between a player's and opponent's shots was much shorter for the group of professional players than that of the juniors in all game situations except for the net game. A large effect size was calculated for serving ($p < 0.00$, $d = -2.02$), baseline game ($p < 0.00$, $d = -0.94$) and other shots ($p < 0.00$, $d = -0.85$). A smaller difference in time between shots was shown for the receiving, where a medium effect size was calculated ($p < 0.00$, $d = -0.65$). Measured speed is the average speed of the ball on the path from one player to another. Therefore, the values are significantly lower than those that can be monitored in tennis matches, where the measured value represents the highest (peak) speed of the shot. There were no significant differences in average speed in all game situations. There were no significant differences in rally tempo in all game situations. Larger differences in the angle of shots between the professional ($M = 6.01$) and junior tennis players

($M = 7.3$) were only found for baseline shots, where the juniors performed forehand's and backhands at a significantly larger angle ($p < 0.00$, $d = -0.3$).

Discussion and conclusions

The total match time for junior and entry professional players was in accordance with the values reported in other studies, which are comparable in terms of court surface, the number of sets played, player's age, and competitive standards.[33,34] In our study, junior tennis player match duration was shorter than noted by Torres-Luque et al.,[27] both in terms of total match time as well as the number of rallies.

The percentage of rally time compared to match time established the work-rest ratio, which is an important indicator and allows coaches to define training workloads appropriately, both in tennis training, as well as strength and conditioning.[34,35] Effective rally time often represents one-third of total match time.[36,37] The ratio of effective rally time is influenced by court surface type, age, and the level of the tennis players, as well as by psychological, tactical, and fitness factors. In the present study, the values in both junior and professional tennis players were lower, which supports the findings of studies conducted on hard court surfaces,[35,38] where these percentages amounted to 21–23% of total match time.

In the present study, rally duration was higher, on average, than in a sample of 16-year-old players observed by Torres-Luque et al.[27] Fernandez-Fernandez et al.[35] measured even shorter lasting points in female junior tennis players. On average, junior tennis players perform 3–5 shots per rally, which means that more than 50–60% of rallies end within 5–6 seconds.[28] It was found that in entry professional tennis players matches, point duration is influenced by higher accuracy and increased velocity of the first serve.[39] On the other hand, a shorter rally duration means that only 10% of the points last more than 10 seconds.

The study shows that juniors differ from professional tennis players in serve and return of serve efficiency and two more shots that follow. In junior tennis, almost half of all rallies were completed within 1–3 strokes,[28] whereas in professional tennis, points won from 0–4 rallies were most strongly associated with success.[40] In future, juniors will need to develop technical competencies that will allow them to create pressure on the opponent, seize opportunities to take advantage and finish the rallies.

In tennis matchplay, the forehand is generally considered to be the dominant shot at the baseline, due to biomechanical, technical, and tactical factors. Players perform the forehand shot with greater adaptability, variability, and efficiency (speed and precision), with the tactical intention of creating pressure on the opponent.[41] More frequent use of the forehand from the baseline was also shown in our study, especially in junior tennis players, which is in agreement with the results from Klaus et al.,[28] who found that 14-year-old players hit forehands more often than backhand strokes. In our study, male entry professional players hit more forehand return shots on the second serve, which indicates on the players' competence to take the initiative and control of the rally with the return of serve.

We found that the distance covered during a match was 1700–2200 m, which falls within the range of results obtained by Fernandez-Fernandez et al.[34] and Pereira et al.[42] However, it is important to emphasize the relationships between the distance covered and the number of rallies and number of shots played. In our study, the results related to the distance covered between two successive shots mainly exceed what has generally been accepted for both professional, and especially, junior tennis players. Nonetheless, these values were lower than the values obtained by Reid et al.[21] Professional male tennis players at the Australian Open covered 10 meters per winning point and eight meters if they lost the point. Kovalchik and Reid[29] found that professional male tennis players covered greater distances per rally than junior players.

In our study, professional tennis players in serving and baseline game situations used game patterns that prevented the opponent to open the court and thus indirectly complete a shorter distance. Torres-Luque et al.[27] pointed out the importance of developing other tactical and technical competencies such as shot speed, opening angles, power, and ball heaviness. The distance between the player and opponent is continuously changing. From a tactical perspective, if a player is closer to the net, this means a more offensive position which increases the possibility of taking control over the point and dominating the opponent. Using the Sagit/Tennis technology, Martínez-Gallego et al.[14] confirmed that winning professional players spend more time in the offensive zones and cover longer distances per individual point than their less successful counterparts.

Distance between player and opponent in serving, receiving, and playing at the baseline was significantly shorter in professional than in junior tennis players. Reid et al.[21] found that male players hit serve returns close to or inside the baseline and thereby shorten the distance, and consequently the time, of ball flight, which on average lasts ≈ 0.7 s.

In terms of time, professional tennis players also have a shorter time between two consecutive strokes than the juniors in all game situations except for the

net game. Kovalchik and Reid[29] also found lower reaction time values on the serve and the return as a result of the shorter distance between the players. Professional tennis player's competence to position themselves further up the court, for shots in all game situations, showed the most significant difference between the groups observed. The junior tennis players will have to develop reaction, perception and anticipation skills, adapt the technique of the baseline shots and return of serve and develop effective game patterns. At the same time, they will need to be able to use developed abilities and skills under mental pressure with a high accuracy.

The differences in the time and the distance between successive shots among the two observed groups indicated the most important area of future development of junior tennis players. Shots speed is definitely a performance indicator, which is important in tennis, but in our study did not significantly differ professional and junior tennis players. Shot speed indirectly shows the technical competence of a player who, with different movement patterns and strokes, is capable of effectively solving various game situations. Entry professional tennis players performed their shots in all game situations, except net play, faster than the juniors. The difference in power was observed in the serve, where the professionals' serves were on average 29 km/h faster than the juniors' serves, which confirms the findings of Vaverka et al.[43] who also found that professional tennis players direct their serves closer to the line. In addition, they mentioned tactical and technical competences and body height as important performance factors. Hizan et al.[5] correlated the higher serve speed in professional tennis players to a higher number of aces, and a higher percentage of points won with the serve.

Rally tempo is a complex performance indicator, which determines the frequency of successive shots performed by a player if the rally lasts for 1 minute. In our study, rally tempo did not prove to be a performance indicator that distinguished the two groups of players significantly.

As expected, the highest rally tempo is found in the serve and return, while values for the baseline game and net game situations drop considerably. Weber and Born[44] explain the higher tempo in the serve and return due to the quality of both strokes and to time pressure since both players execute strokes within the first four shots of a rally. This concept emphasizes the importance of daily training for the serve and return, as well as that of the first two shots after the two initial strokes.

Professional tennis players perform shots by employing an optimal ratio between speed and precision. Shot precision is influenced, in the lateral direction, by the angle between the incoming and outgoing ball. Brody[45] found that if the shots were aimed straight down the middle of the court, they would give quite a sizeable margin for error, of almost 10 degrees to the right or left, before the ball lands in the alley. Our results confirmed this conclusion since it was only while serving and receiving that the angle sizes somewhat exceeded the value of 10 degrees. In our opinion, this is due to the position of the service box, which forces players to hit wide serves, along with the technical characteristics of the serve, which allows for a more lateral rotational effect. On the other hand, in this case, the player returning the serve also has a chance to hit the return of serve with a slightly larger angle. Otherwise, the importance of the optimal shot angle grows as incoming balls move at ever higher speeds. In our study, differences between the observed groups in the shot angles were significant in baseline game. It is worth mentioning that professional tennis players at the baseline play faster than juniors and at the same time perform shots at a smaller angle, meaning that they primarily avoid making lateral errors. Evidently, they are better at using the geometry of the court.

The present study has certain limitations, which are mainly linked to small sample size. The sample size limits the generalization and interpretation of the results with groups of tennis players that have different characteristics than those found in our study group. The technology available for tennis match data capture was mostly manual, making the data collection both challenging and time-consuming. Data collection regarding the performance indicators was therefore combined in the five-game situations, in order to increase the frequency of the occurrence of individual shots. These circumstances explain why in serving and receiving we did not separate the first and second serves, and the returns of the first and second serves. Similarly, in the "other group" of shots, we included those actions in which players performed shots in defensive situations, or solved situations following drop shots. A limitation of the present study was also that in the execution of the individual strokes, we did not analyse the various characteristics of ball flight, such as ball rotation (spin), height and depth, or impact height. These ball properties have an important influence on shot efficiency and match play success. The offensive or defensive types of play were evaluated indirectly with rally tempo, which can determine the tactical intention of a tennis player. We did not evaluate the types of movement, direction changes, or split step characteristics in movement analysis in this study.

In conclusion, the present study aimed to determine the differences in shot efficiency, selected performance indicators, and tactics among male junior and entry professional tennis players. The results will help

coaches of junior tennis players focus their long-term plans on developing appropriate tactical-technical competencies and fitness abilities in their players. Moreover, the findings demonstrate, above all, the need to include the monitoring of important performance indicators, such as speed, shot placement, movement location, and shot execution, in their daily work and match analysis. Coaches have to include relevant game patterns in their daily programs and monitor the repeatability and reproducibility of performance.

Entry professional players cover significantly shorter distance (serving, baseline game) than junior tennis players which was also affected by the shorter distance between the two players when exchanging shots (serving, receiving, baseline game), and thus resulted in a shorter time between shots (serving, receiving, baseline game, other shots game situation). The result is a higher value of rally tempo. The study contributes to the understanding of the differences in performance indicators that emerge during a player's long-term development from the age of 14 and up to the senior category. These findings provide information for coaches and players, to help them increase the effectiveness of tactical and technical training and, ultimately, to enhance matchplay performance.

Apparent differences between professional and junior tennis players show, that the long-term development of junior players not only changes specific elements of their fitness (movement speed, agility, power) and technical competence (shot speed, adaptability, variety, disguise) but also the area of perceptual-cognitive skills that results in the dynamic interaction between the anticipation and ability to recognize specific game patterns of the opponent while receiving the serve and defending when opponent is at the net.

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References

1. Tennis Association United States. *Coaching tennis successfully*. Champaign, IL: Human Kinetics, 2004.
2. Reid M, Crespo M, Santilli L, et al. The importance of the International Tennis Federation's junior boys' circuit in the development of professional tennis players. *J Sports Sci* 2007; 25: 667–672.
3. McCraw PD. Making the Top 100: ITF Top 10 junior transition to Top 100 ATP tour (1996-2005) ITF Coach. *Sport Sci Rev* 2011; 19: 11–13.
4. Fernandez-Fernandez J, Mendez-Villanueva A and Pluim BM. Intensity of tennis match play. *Br J Sports Med* 2006; 40: 387–391.
5. Hizan H, Whipp P and Reid M. Gender differences in the spatial distributions of the tennis serve. *Int J Sports Sci Coach* 2015; 10: 87–96.
6. Crespo M and Miley D. *Advanced coaches manual*. London: International Tennis Federation, 2002.
7. Filipcic A, Pers J and Klevisar A. 4th World Congress of Science and Racket Sports. In: *Comparison between young male and female tennis players in terms of time and movement characteristics*. Madrid, Spain, 2006, pp.87–90.
8. Moreno-Hernández FJ, Avila-Romero F, Reina-Vaíllo R, et al. Visual behaviour of tennis coaches in a court and video-based conditions. *Int J Sport Sci* 2006; 5: 28–41.
9. Hurnik E, Unierzyski P and O'Donohue P. Reliability of a computerised system for recording location on a tennis court. *Int J Perform Anal Sport* 2008; 8: 138–144.
10. Suda K, Michikami S, Sato Y, et al. Applied sport science for high performance tennis. In: M Crespo, M Reid and D Miley (eds) *Automatic measurement of running distance during tennis matches using computer-based trace analysis*. London: International Tennis Federation, 2003, p.151.
11. Takahashi H, Wada T, Maeda A, et al. The relationship between court surfaces and tactics in tennis using a computerized scorebook. *Int J Perform Anal Sport* 2006; 6: 15–25.
12. Loffing F, Hagemann N and Strauss B. The serve in professional men's tennis: effects of players' handedness. *Int J Perform Anal Sport* 2009; 9: 255–274.
13. Hughes M and Meyers R. Movement patterns in elite men's singles tennis. *Int J Perform Anal Sport* 2005; 5: 110–134.
14. Martínez-Gallego R, Guzmán Luján JF, James N, et al. Movement characteristics of elite tennis players on hard courts with respect to the direction of ground strokes. *J Sport Sci Med* 2013; 12: 275–281.
15. Filipcic A, Leskosek B, Munivrana G, et al. Split-Step timing of professional and junior tennis players. *J Hum Kinet* 2017; 55: 97–105.
16. Filipcic A, Leskosek B, Munivrana G, et al. Differences in movement speed before and after a split-step between professional and junior tennis players. *J Hum Kinet* 2017; 55: 117–125.
17. O'Donoghue P and Ingram B. A notational analysis of elite tennis strategy. *J Sports Sci* 2001; 19: 107–115.
18. Johnson CD and McHugh MP. Performance demands of professional male tennis players. *Br J Sports Med* 2006; 40: 696–699.
19. Gillet E, Leroy D, Thouvarecq R, et al. A notational analysis of elite tennis serve and serve-return strategies on slow surface. *J Strength Cond Res* 2009; 23: 532–539.

20. Hizan H, Whipp P and Reid M. Comparison of serve and serve return statistics of high performance male and female tennis players from different age-groups. *Int J Perform Anal Sport* 2011; 11: 365–375.
21. Reid M, Morgan S and Whiteside D. Matchplay characteristics of grand slam tennis: implications for training and conditioning. *J Sports Sci* 2016; 34: 1791–1798.
22. Fernandez-Fernandez J, Sanz-Rivas D, Fernandez-Garcia B, et al. Match activity and physiological load during a clay-court tennis tournament in elite female players. *J Sports Sci* 2008; 26: 1589–1595.
23. Over S and O'Donoghue PG. Whats the point – tennis analysis and why. *ITF Coach Sport Sci Rev* 2008; 15: 19–21.
24. Fernandez-Fernandez J, Kinner V and Ferrauti A. The physiological demands of hitting and running in tennis on different surfaces. *J Strength Cond Res* 2010; 24: 3255–3264.
25. Terroba A, Kosters W, Varona J, et al. Finding optimal strategies in tennis from video sequences. *Int J Patt Recogn Artif Intell* 2013; 27: 1355010–1355031.
26. Torres-Luque G, Sanchez-Pay A and Moya M. Competitive analysis of requirement of young tennis players. *J Sport Heal Res* 2011; 3: 71–78.
27. Torres-Luque G, Cabello-Manrique D, Hernández-García R, et al. An analysis of competition in young tennis players. *Eur J Sport Sci* 2011; 11: 39–43.
28. Klaus A, Bradshaw R, Young W, et al. Success in national level junior tennis: Tactical perspectives. *Int J Sport Sci Coach* 2017; 12: 618–622.
29. Kovalchik SA and Reid M. Comparing matchplay characteristics and physical demands of junior and professional tennis athletes in the era of big data. *J Sport Sci Med* 2017; 16: 489–497.
30. Torres-Luque G, Fernández-García AI, Sánchez-Pay A, et al. Differences in the statistics of competition in individual tennis. *Rev Iberoam Ciencias Del Deport* 2017; 6: 75–80.
31. Vuckovic G, Pers J, James N, et al. Measurement error associated with the SAGIT/squash computer tracking software. *Eur J Sport Sci* 2010; 10: 129–140.
32. Cohen J. *Statistical power analysis for behavioral sciences*. 2nd ed. Mahwah, NJ: Lawrence Erlbaum Associates, 1988.
33. Kovacs MS. A comparison of work-rest intervals in mens professional tennis. *Med Sci Tennis* 2004; 9: 10–11.
34. Fernandez-Fernandez J, Sanz-Rivas D and Mendez-Villanueva A. A review of the activity profile and physiological demands of tennis match play. *Strength Cond J* 2009; 31: 15–26.
35. Fernandez-Fernandez J, Mendez-Villanueva A, Fernandez-Garcia B, et al. Match activity and physiological responses during a junior female singles tennis tournament. *Br J Sports Med* 2007; 41: 711–716.
36. Smekal G, von Duvillard SP, Rihacek C, et al. A physiological profile of tennis match play. *Med Sci Sports Exerc* 2001; 33: 999–1005.
37. Kovacs MS. Tennis physiology: training the competitive athlete. *Sport Med* 2007; 37: 189–198.
38. Christmass M. a, Richmond SE, Cable NT, et al. Exercise intensity and metabolic response in singles tennis. *J Sports Sci* 1998; 16: 739–747.
39. Reid M, McMurtrie D and Crespo M. The relationship between match statistics and top 100 ranking in professional men's tennis. *Int J Perform Anal Sport* 2010; 10: 131–138.
40. Fitzpatrick A, Stone JA, Choppin S, et al. A simple new method for identifying performance characteristics associated with success in elite tennis. *Int J Sport Sci Coach* 2019; 14: 43–50.
41. Reid M, Elliott B and Crespo M. Mechanics and learning practices associated with the tennis forehand: a review. *J Sport Sci Med* 2013; 12: 225–231.
42. Pereira TJC, Nakamura FY, de Jesus MT, et al. Analysis of the distances covered and technical actions performed by professional tennis players during official matches. *J Sports Sci* 2017; 35: 361–368.
43. Vaverka F, Nykodym J, Hendl J, et al. Association between serve speed and court surface in tennis. *Int J Perform Anal Sport* 2018; 18: 1–11.
44. Weber K and Born HP. The special significance of the expanded game opening in competitive tennis. Justification, guidelines, and implication in practical training. *Leistungssport* 2012; 42: 26–32.
45. Brody H. Unforced errors and error reduction in tennis. *Br J Sports Med* 2006; 40: 397–400.