International Journal of Sport Culture and Science
September 2023 : 11(3)
ISSN : 2148-1148
Doi : 10.14486/IntJSCS.2023.686

Investigation of Physiological and Kinematic Parameters of Tennis Players During the Simulated Games

Bilal EMEKTAR[1], Ömer ŞENEL [2], Sümer ALVURDU[3], Tevfik Cem AKALIN[4]
[1] Zonguldak Bulent Ecevit University, Zonguldak, Turkey
https://orcid.org/0000-0003-4696-844X
[2]Gazi University, Ankara, Turkey
https://orcid.org/0000-0003-0364-9799
[3]Gazi University, Ankara, Turkey
https://orcid.org/0000-0002-3439-973X
[4] Zonguldak Bulent Ecevit University, Zonguldak, Turkey
https://orcid.org/0000-0002-0598-3849
Email: bilalemektar@hotmail.com , osenel@gazi.edu.tr , sumeralvurdu@gazi.edu.tr , tc.akalin@hotmail.com

Type: Research Article (Received: 02.08.2023 – Accepted: 22.08.2023)

Abstract

In this study, it was aimed to examine the physiological and kinematic parameters of elite male tennis players during the simulated games. Ten male elite tennis players (age: 16.2±3.2 years, height: 179.4±4.7 cm, body weight: 67.3±8.1 kg, sports age: 9.7 years) voluntarily participated in the study. Each player was given two simulated games in the singles category. Research data were collected with the Catapult Sports Vector S7 GPS athlete tracking system, placed in the middle of each player's shoulder blades. Data were transferred to Openfield Console, and passive recovery periods were excluded. The Mann-Whitney U test was used in the comparative analysis of winner-loser and morning-afternoon games and the significance level was accepted as 0.05. The physiological activity variables of the players during the games were mean and maximum heart rate 144.9±13.5 beats/min and 178.2±11.05 beats/min, respectively; kinematic variables were determined as total running distance 4052.7±1034.3 m, maximum speed 19.01±2.07 km/h, maximum acceleration and deceleration values 3.49±0.42 m/s^2 and -3.75±0.61 m/s^2. It was determined that these variables did not differ statistically according to winning-losing and morning-afternoon games ($p>0.05$). The physiological and kinematic responses of elite tennis players differ when two consecutive games are played on the same day. These data may help to elucidate the need for specific pre-competition training loads or recovery strategies when faced with overloaded games. Physiological and kinematic findings obtained during competition are considered to be important for technical teams in planning training programs to improve athletes' performance.

Keywords: Match demands, athlete tracking systems, GPS, racket sports.

Introduction

Tennis is one of the most popular sports in the world, played according to the rules set by the International Tennis Federation (ITF). Tennis players participate in tournaments in different categories according to their ranking points in many countries (Fernandez et al., 2006). Men's Grand Slam competitions are played over five sets, all other national or international tournaments are played over three sets. Measuring the training and competition loads on the players in the competitions is an important process to manage the game profile (Gabbett, 2016). For this reason, the knowledge of the activity profile during the competition is very important for the preparation of appropriate training programs (Mendez-Villanueva et al., 2007).

The game of tennis is a sport that characteristically includes quick starts and finishes of varying intensity, and anaerobic movements such as slides, kicks and turns (Reid et al., 2013; Baiget, et al., 2014). However, it is very important to determine the physiological and kinematic requirements required during the competition in order to increase the training and competition performance of tennis players, with sports-specific tests and applications, and in laboratory and sports-specific field conditions (Cooke, Davey, 2005). With the recent technological developments, the physiological (heart rate, oxygen consumption, respiratory frequency, etc.) responses that occur during the competition and the kinematic findings (running speed, acceleration-deceleration, distance covered, etc.) become easy to measure, it is important for the instant status of the player (Fernandez-Fernandez et al.,2009; Fargeas-Gluck, Léger, 2012). Thus, as a result of instant measurements during the match, information about the match can be obtained, determining the competition profiles of the players and helping to plan appropriate training (Vickery et al., 2014).

The development of the global positioning system (GPS) and micro-electrical-mechanical-system (MEMS) has begun to provide real-time data collection to determine the performance of athletes. GPS devices have evolved over time from assessing physiological responses to assessing human movement in sports (Dokuma et al., 2014). Today, different versions of the GPS analysis system are widely used to measure external loads (running speed and distance covered) performed by athletes (Gabbett, Mulvey, 2008).

The performance of tennis players can be affected by various factors during the competition. Competition analyzes are made to define and evaluate the detailed competition performances of the players. When we review the literature, the most commonly used methods for performing competition profile analysis include video recordings (Martinez-Gallego et al., 2013; Pereira et al., 2016), Hawk-Eye (Reid et al.,2016) or different technologies (Reid et al., 2013; Gallo-Salazar et al., 2015) such as global positioning systems (GPS).

In this research, data were collected using Vector S7 brand GPS units designed by Catapult Sports (Catapult Sports, Melbourne, Australia). All physiological and kinematic parameters can be measured simultaneously with this system. The research, the physiological and kinematic analyzes of the players during the competition; It was designed to report the analysis results by detecting and evaluating the parameters of heart rate (beat/min), maximum heart rate, maximum speed (km/h), maximum acceleration (km/h), maximum deceleration (km/h), total distance (m) and total competition time (min). It is thought that obtaining this information during simulated tennis games will help coaches to obtain objective information about tennis competitions and to prepare an individual training program (Whiteside, Reid, 2017).

The aim of this research is to examine the physiological and kinematic parameters of elite tennis players during simulated games. It is assumed that these variables will be different between morning and afternoon games, as well as between winners and losers.

Material and Method

The study group consisted of 10 elite male tennis players who were in the top 100 in the country rankings in their age categories and were licensed athletes for at least 8 years (age: 16.2±3.2 years, height: 179.4±4.7 cm, body weight: 67.3±8.1 kg, sports age: 9.7±3.1 years). Players who did not have lower or upper extremity injuries within 6 months and did not take any drug supplements were included in the study group. Before starting the study, ethical approval was obtained with the decision of Gazi University Ethics Committee dated 20.03.2022 and numbered E-77082166-302.08.01-322518. In addition, after the players were informed about the study design and possible risks, their parents' consent was obtained and voluntary consent forms were filled.

In order to determine the physiological and kinematic parameters of the players during the competition, two simulated games were made for each player in the singles category. The games were played on the open hard-floor tennis court, in the morning and afternoon, by creating the official tournament conditions. Games were made based on the country rankings of the players. It was played over 3 sets (by applying a tie-break in each set) within the rules determined by the International Tennis Federation and federation approved tennis balls were used in the games. Each match was played against a different opponent to better adapt to the official tournament conditions. During the measurements, the experimental conditions (temp. mean 12-14^0 and relative humidity mean % 50-52) in morning and afternoon games were similar.

Statistical analysis

The data obtained in the study were evaluated by transferring them to the SPSS 26.0 program for statistical analysis. Descriptive data shown as “arithmetic mean+/- standard deviation”, median and minimum-maximum. After testing whether the data showed normal distribution with the Shapiro-Wilk test, the Mann-Whitney U Test was used for comparisons between groups (winner-loser and morning-afternoon games). The analysis results were evaluated within the 95% confidence interval, and $p<0.05$ statistically significant difference was accepted.

Findings

The descriptive features of the study group were determined as age: 16.2±3.2 years, height: 179.4±4.7 cm, body weight: 67.3±8.1 kg, sports age: 9.7 years) (Table 1).

Table 1. Descriptive data for the study group

Variables	Mean ± SD
Age (year)	16.2±3.2

Height (cm)	179.4±4.7
Body weight (kg)	18.6±2.5
Sports age (year)	9.7±0.5

Table 2. Physiological and kinematic measurement values of the players during all games

Variables	Mean ± SD	Min-Max
Heart rate (beat/min)	144.9±13.5	117-167
Maximum heart rate	178.2±11.05	150-195
Maximum speed (km/h)	19.01±2.07	15.1-21.4
Maximum acceleration (km/h)	3.49±0.42	2.6-4.4
Maximum deceleration (km/h)	-3.75±0.61	-5.2 - -3
Total distance (m)	4052.7±1034.3	2207.2-6129.1
Total competition time (min.)	75.43±20.28	49.16-119.19

The average heart rate of the players during all the games was 144.9±13.5 beats/min, the maximum heart rate was 178.2±11.05 beats/min, their maximum speed was 19.01±2.07 km/h, the maximum acceleration values were 3.49±0.42 m/s, the maximum deceleration values were -3.75±0.61 m/s and the total running distances were determined as -3.75±0.61 m/s and the total running distances of 4052.7 m (Table 2).

Table 3. Physiological and kinematic measurement values and comparison of the players during morning and afternoon games

Variables	**Morning Games** Mean ± SD (Med;Min-Maks)	**Afternoon Games** Mean ± SD (Med;Min-Maks)	***p***
Heart rate (beat/min)	144.6±12.3 (149.5;128-165)	145.1±15.3 (144;117-167)	0.853
Maximum heart rate	178.7±9.98 (177.5;164-195)	177.7±12.5 (179.5;150-189)	0.853
Maximum speed (km/h)	18.6±2.5 (19.2;15.1-21.4)	19.4±1.6 (19.8;16-21.1)	0.912
Maximum acceleration (km/h)	3.4±0.5 (3.4;2.6-4.3)	3.6±0.4 (3.6;3-4.4)	0.529

Maximum deceleration (km/h)	-3.7±0.5 (-3.6;-4.5--3)	-3.8±0.7 (-3.5;-5.2--3.1)	0.853
Total distance (m)	3962.7±824 (3695.5;3132.8-5630.8)	4142.7±1249.5 (3824.4;2207.2-6129.1)	0.796
Total competition time (min.)	75.4±14 (73;58-99)	75.2±25.9 (66;49-119)	0.684

When the physiological and kinematic measurement values of the players during the morning and afternoon games were examined, it was determined that there was no statistically significant difference between the heart rate (p=0.853), maximum heart rate (p=0.853), maximum speed (p=0.912), maximum acceleration (p=0.529), maximum deceleration (p=0.853), total distance (p=0.796) and total competition time (p=0.684) (Table 3).

Table 4. Physiological and kinematic measurement values and comparison of the winner and loser players during the games

Variables	**Winners** Mean ± SD (Med;Min-Maks)	**Losers** Mean ± SD (Med;Min-Maks)	***p***
Heart rate (beat/min)	144.2 ± 14.7 (146.5;117-165)	145.5±12.9 (147;128-167)	0.853
Maximum heart rate	180.1±12.4 (183.5;150-195)	176.3±9.8 (176;164-189)	0.393
Maximum speed (km/h)	18.6±2 (18.7;15.1-21.1)	19.5±2.2 (20.1;15.3-21.4)	0.247
Maximum acceleration (km/h)	3.4±0.4 (3.4;2.6-3.9)	3.6±0.5 (3.6;3-4.4)	0.353
Maximum deceleration (km/h)	-3.7±0.6 (-3.5;-5.2--3)	-3.8±0.6 (-3.7;-5.2--3.1)	0.353
Total distance (m)	4069.7±1045.6 (3825.6;2207.2-5630.8)	4035.7±1079.2 3694.4;3059.4-6129.1)	0.631
Total competition time (min.)	75.3±20.8 (72;49-119)	75.3±20.8 (72;49-119)	0.999

When the physiological and kinematic measurement values of the winner and loser players during the games were examined, it was determined that there was no statistically significant difference between the heart rate (p=0.853), maximum heart rate (p=0.393), maximum speed (p=0.247), maximum acceleration (p=0.353), maximum deceleration (p=0.353), total distance (p=0.631) and total competition time (p=0.999) variables (Table 4).

Discussion and Conclusion

When the kinematic findings of our study were examined, it was found that although there was no statistically significant difference, the players covered more distance in the afternoon games than in the morning games (Table 1), the winner and loser players were compared, it was determined that the total distance covered was higher in the winners than the loser players (Table 2). When the variables of maximum speed, maximum acceleration and maximum deceleration were examined, it was observed that the maximum speed was higher

in the afternoon games and in the losers, although there was no statistically significant difference (Table 1, Table 2). In the literature, it has been observed that running activities vary significantly according to age, gender, playing ground and competition results (Martinez-Gallego et al., 2013; Hoppe et al., 2016; Hoppe et al., 2014; Pereira et al., 2016). However, these differences were not observed for young elite players (Hoppe et al., 2016; Hoppe et al., 2014). Hoppe et al. (2014), found the total distance covered in simulated tennis games played on hard ground, especially in the morning tennis games, between 2900-3600 m (Hoppe et al., 2014), Pereira et al. (2016), the total distance covered in tennis games played on hard courts were 2012.3 ± 295.8 m (Pereira et al., 2016). Gallo-Salazar et al.(2019), determined that the total distance coveredby the winner players were 3668 ± 1313 m, and the total distance covered by the loser players were 3631 ± 1203 m (Gallo-Salazar et al., 2019).

Gallo-Salazar et al. (2019), study of game activity and physiological responses in young tennis players, found that all other variables did not change except maximum speed for afternoon games and for loser players (Gallo-Salazar et al., 2019). Our study results are also similar to other studies in the literature (Table 1, Table 2). In the literature, it has been observed that the total distance covered in the afternoon decreased in consecutive tennis games (Gescheit et al., 2015; Ojala, Hakkinen, 2013). In our study, the players covered more distance in the afternoon than in the morning games. It is thought that the reason for this may be related to individual player differences or fatigue levels. When the physiological results of our study were examined, it was determined that there was no statistically significant difference in the comparison of the heart rate (beat/min) and maximum heart rate of the players in the morning and afternoon games (Table 1). When the winner and loser players are compared, it is seen that the maximum heart rate is higher in the winner players than the loser players, although there is no statistically significant difference.

Girard and Millet (2004), in their study, determined that the average heart rate of the athletes during the competition was 181.8±11.9 and 172.8±17.2 beats/min, and their maximum heart rate was 201.1±8.5 beats/min (Girard, Millet, 2004). Fernandez-Fernandez et al. (2009), determined that the maximum heart rate of male (n=10) tennis players was 180.3±6.5 beats/min (Fernandez-Fernandez et al., 2009), as a result of the training match. Gallo-Salazar et al. (2919), determined the heart rate to be 157 ± 7 beats/min in morning games, and 154 ± 10 beats/min in afternoon games. In winners and losers, they determined that the winner heart rate was 156 ± 8, the loser 155 ± 9 beat/min, the maximum heart rate was 193 ± 5, the winner was 191 ± 8 beats/min (Gallo-Salazar et al., 2019). The results of our study are similar to other studies in the literature on elite tennis players.

As a result, it is thought that it would be more appropriate to make an individual training program by evaluating the physiological and kinematic parameters measured during the simulated games in tennis.

REFERENCES

Baiget, E., Fernández-Fernández, J., Iglesias, X., Vallejo, L., Rodríguez, F.A. (2014). On-court endurance and performance testing in competitive male tennis players. The Journal of Strength & Conditioning Research, 28(1), 256-264.

Cooke, K., Davey, PR. (2005). Tennis ball diameter: the effect on performance and the concurrent physiological responses. Journal of Sports Sciences, 23(1), 31-39.

Dokuma, D., Marshall, P., Earle, K., Nevill, A., Abt, G. (2014). Combining internal and external training load measures in professional rugby league. Int J Sports Physiol Perform 9: 905–912.

Fargeas-Gluck, M.A., Léger, L.A. (2012). Comparison of two aerobic field tests in young tennis players. The Journal of Strength & Conditioning Research, 26(11), 3036-3042.

Fernandez, J., Mendez-Villanueva, A., Pluim, B. M. (2006). Intensity of tennis match play. British journal of sports medicine, 40(5), 387-391.

Fernandez-Fernandez, J., Sanz-Rivas, D., Mendez-Villanueva, A. (2009). A review of the activity profile and physiological demands of tennis match play. Strength & Conditioning Journal, 31(4), 15-26.

Fernandez-Fernandez, J., Sanz-Rivas, D., Sanchez-Munoz, C., Pluim, B.M., Tiemessen, I., Mendez-Villanueva, A. (2009). A comparison of the activity profile and physiological demands between advanced and recreational veteran tennis players. J Strength Cond Res, 23(2).

Gabbett, T. (2016). The training-prevention paradox: Should athletes train smarter and harder? Br J Sports Med 50: 273–280.

Gabbett, T.J., Mulvey, M.J. (2008). Small field training games and time-motion analysis of competition in elite female football players. J Strength Cond Res 22: 543–552.

Gallo-Salazar, C., Areces, F., Abián-Vicén, J. et al. (2015). Enhancing physical performance in elite junior tennis players with a caffeinated energy drink. Int J Sports Physiol Perform;10(3):305-310. doi:10.1123/ijspp.2014-0103.

Gallo-Salazar, C., Del Coso, J., Sanz-Rivas, D., Fernandez-Fernandez, J. (2019). Game Activity and Physiological Responses of Young Tennis Players in a Competition With 2 Consecutive Competitions in a Day, International Journal of Sports Physiology and Performance, 14(7), 887-893. Retrieved Jul 6, 2023, from https://doi.org/10.1123/ijspp.2018-0234.

Gescheit, D.T., Cormack, S.J., Reid, M., Duffield, R. (2015). Consecutive days of prolonged tennis match play: Performance, physical, and perceptual responses in trained players. Int J Sports Physiol Perform.;10(7):913-920. doi:10.1123/ijspp.2014-0329.

Girard, O., Millet, G.P. (2004). Effects of the ground surface on the physiological and technical responses ın young tennis players, II. Science and racket sports, London.

Hoppe, M.W., Baumgart, C., Freiwald, J. (2016). Do Running Activities of Adolescent and Adult Tennis Players Differ During Play? Int J Sport Physiol Perform;11(6):793-801. doi:10.1123/ijspp.2015-0141.

Hoppe, M.W., Baumgart, C., Bornefeld, J., Sperlich, B., Freiwald, J., Holmberg, H.C. (2014). Running activity profile of adolescent tennis players during match play. Pediatr Exerc Sci.;26(3):281-290. doi:10.1123/pes.2013-0195.

Martinez-Gallego, R., J, F.G., James, N., Pers, J., Ramon-Llin, J., Vuckovic, G. (2013). Movement characteristics of elite tennis players on hard courts with respect to the direction of ground strokes. J Sport Sci Med.;12(2):275-281.

Mendez-Villanueva, A., Fernandez-Fernandez, J., Bishop, D., Fernandez-Garcia, B., Terrados, N. (2007). Activity patterns, blood lactate concentrations and ratings of perceived exertion during a professional singles tennis tournament. Br J Sport Med.;41(5):296-300. doi:10.1136/bjsm.2006.030536.

Ojala, T., Hakkinen, K. (2013). Effects of the tennis tournament on players' physical performance, hormonal responses, muscle damage and recovery. J Sport Sci Med.;12(2):240-248. http://www.ncbi.nlm.nih.gov/pubmed/24149802.

Pereira, L., Freitas, V., Moura, F.A., Aoki, M., Loturco, I., Nakamura, F.Y. (2016). The Activity Profile of Young Tennis Athletes Playing on Clay and Hard Courts: Preliminary Data. J Hum Kinet.;50(1):211-218.

Pereira, T.J., Nakamura, F.Y., Jesus, M.T. et al. (2016). Analysis of the distances covered and technical actions performed by professional tennis players during official competitions. J Sport Sci.:1-8. doi:10.1080/02640414.2016.1165858.

Reid, M., Morgan, S., Whiteside, D. (2016). Matchplay characteristics of Grand Slam tennis: implications for training and conditioning. J Sport Sci.:1-8. doi:10.1080/02640414.2016.1139161

Reid, M.M., Duffield, R., Minett, G.M., Sibte, N., Murphy, A.P., Baker, J. (2013).

Physiological, perceptual, and technical responses to on-court tennis training on hard and clay courts. The Journal of Strength & Conditioning Research, 27(6), 1487-1495.

Vickery, W.M., Dascombe, B.J., Baker, J.D., Higham, D.G., Spratford, W.A., Duffield, R. (2014). Accuracy and reliability of GPS devices for measurement of sports-specific movement patterns related to cricket, tennis, and field-based team sports. The Journal of Strength & Conditioning Research,28(6), 1697-1705.

Whiteside, D., Reid, M. (2017). External match workloads during the first week of Australian open tennis competition. Int J Sports Physiol Perform;12(6):756-763. doi:10.1123/ijspp.2016-0259.