COMPARISON OF MATCH-PLAY CHARACTERISTICS OF JUNIOR AND PROFESSIONAL TENNIS PLAYERS

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ABSTRACT

COMPARISON OF MATCH-PLAY CHARACTERISTICS OF JUNIOR AND PROFESSIONAL TENNIS PLAYERS

M.S., The Department of Physical Education and Sports

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The main purpose of this study was to compare the match-play characteristics of junior and professional tennis players on clay, grass, and hard courts. Surface-related variations according to competitive level and gender differences were also investigated. The match-play characteristics of players who competed and won the matches in the first-round singles main draws of the 2022 French Open, Wimbledon, and US Open Tournaments were obtained from the official web pages. A total of 576 matches (junior = 192, professional = 384) consisting of 288 males and 288 females were analyzed. The results of the study indicated that professional players demonstrated significantly higher average set duration and ace per set than juniors on each of the court surfaces. Junior boys had significantly higher return points won on grass and hard courts than professionals. Professional female players performed significantly higher first serve points won and total points won on grass court than junior girls. When the effect of surface was analyzed for each category, it was observed that in professional males, the variables of first serve points won, ace per set, and double faults per set were significantly higher on grass and hard courts, compared to clay court. Moreover, females performed significantly higher unforced errors per set than males on each of the courts. These findings may be a guideline for

coaches and athletes to create better training programs and adapted match strategies in order to increase athletes' performance.

Keywords: Grand Slams, racket sports, match-play outcomes, court surface, match analysis

ÖZ

GENÇ VE PROFESYONEL TENİS OYUNCULARININ MAÇ AKTİVİTELERİNİN KARŞILAŞTIRILMASI

Yüksek Lisans, Beden Eğitimi ve Spor Bölümü
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Ekim 2023, 53 sayfa

Bu çalışmanın temel amacı, genç ve profesyonel tenis oyuncularının toprak, çim ve beton kortlardaki maç aktivitelerini karşılaştırmaktı. Müsabaka kategorisi ve cinsiyet farklılıklarına göre yüzeyle ilgili farklar da araştırıldı. 2022 Fransa Açık, Wimbledon ve Amerika Açık Turnuvalarında ilk tur tekler ana tablolarında mücadele eden ve maçları kazanan oyuncuların maç aktiviteleri resmi internet sayfalarından elde edildi. 288 erkek ve 288 kadın tenis oyuncusunun mücadele ettiği toplam 576 maç (genç = 192, profesyonel = 384) analiz edildi. Araştırmanın sonuçları, profesyonel oyuncuların kort yüzeylerinin her birinde genç oyunculara göre anlamlı olarak daha yüksek ortalama set süresi ve set başına ace sergilediklerini gösterdi. Genç erkek oyuncuların çim ve beton kortlarda kazandıkları servis karşılama puanları, profesyonellere göre anlamlı olarak fazla bulundu. Kadın oyuncuların, çim sahada kazanılan ilk servis puanları ve kazanılan toplam puanlarının genç kızlara göre anlamlı olarak daha yüksek olduğu gözlemlendi. Her kategori için yüzey etkisi analiz edildiğinde, profesyonel erkeklerde kazanılan ilk servis puanı, set başına ace ve set başına çift hata değişkenlerinin çim ve beton kortlarda toprak korta kıyasla anlamlı olarak daha yüksek olduğu gözlendi. Bununla birlikte, kadınlar tüm kortlarda erkeklere göre set başına anlamlı olarak daha yüksek basit hata sergiledi. Bu

bulgular, sporcuların performansını artırmak amacıyla daha iyi antrenman programları ve uyarlanmış maç stratejileri oluşturmak için antrenörlere ve sporculara bir kılavuz olabilir.

Anahtar Kelimeler: Grand Slam, raket sporları, maç aktiviteleri, kort yüzeyi, maç analizi

To my family

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I am so lucky that I always have my family behind me. In each part of my life, they always found ways to support me in every difficulty I had. I want to thank them for raising me and teaching me and bringing me to these days. Since we are too many kilometers away from each other, I always feel like they are here with me. They always call me to ask how I am doing and if they have something to do for me. Feeling this kind of support helped me through these beautiful days. I am so proud of making them happy by being in this part of my life. In each success I have reached, I knew that I was not alone and that they were silently helping me.

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LIST OF ABBREVIATIONS

ITF	International Tennis Federation
WTA	Women's Tennis Association
ATP	Association of Tennis Professionals
LA	Lactate Concentration

CHAPTER 1

INTRODUCTION

Sport performance is influenced by a multitude of interconnected factors that encompass physiological, psychological, and environmental dimensions (Bali, 2015). Physiologically, an athlete's fitness level, including their fatigue, muscular strength, and flexibility, significantly impacts their performance (Paul et al., 2016; Verschueren et al., 2020). Additionally, nutrition plays a crucial role, as optimal fueling and hydration contribute to sustained energy levels and enhanced endurance (Malsagova et al., 2021). From a psychological perspective, an athlete's mindset, self-confidence, motivation, and ability to manage stress directly influence their performance outcomes (Murphy, 2012). Moreover, environmental factors such as weather conditions, altitude, and facilities' accessibility can either bolster or impede performance (Davids & Baker, 2007; Brocherie et al., 2015; Bishop & Girard, 2013). The complex interaction among these factors underscores the need for a holistic approach when considering strategies for enhancing sports performance (Bali, 2015; Gomez-Ruano et al., 2020).

The utilization of performance analysis in sports has arisen as a crucial method for improving athletes' and teams' results, as it offers a data-centered structure to enhance training, tactics, and decision-making processes (Hughes & Franks, 2004). Therefore, computerized systems for sports analysis were developed to document athletes' movements and technical maneuvers, leading to subsequent explorations through descriptive investigations across diverse sports (McGarry et al., 2002). The analysis of match and training performances seeks to uncover both the strengths and areas that require improvement of the players, with the goal of detecting the important training priorities (Lames & McGarry, 2007).

Notational analysts focus on enhancing and assessing sports performance, relying heavily on video analysis and related technology (Hughes & Bartlett, 2002). With

increasing technological accessibility to athletes in various sports, the field of performance analysis has advanced over recent years, demonstrating its crucial role in athlete growth, coaching methods, and a substantial edge in competition (Krizkova et al., 2021). During the past few years, a growing body of literature on sports sciences is focused on performance analysis of racket sports such as tennis, table tennis, and squash (Lees, 2003). Technological progress, encompassing visual tracking systems and wearable sensors, has simplified the analysis of the specific requirements in tennis (Pluim et al., 2023).

Tennis is the most popular racket sport played by girls, boys, women, and men in the world, including wheelchair players (Bylak & Hutchinson, 1998; Kovacs, 2006; Rietveld et al., 2020). Presently, it attracts millions of players and fans globally (Fernandez, 2006). The invention of tennis took place in the United Kingdom (Baodong, 2014). The primary racket sports, including badminton, squash, table tennis, and tennis, involve utilizing handheld rackets to shoot a ball among two or four players, aiming to tactically position the ball to hinder effective returns by the opposing player (Lees, 2003). The proficiency in racket skills has consistently captured the attention of physical educators, coaches, and experts (Lees, 2019). Over the past years, participation in racket sports has experienced a remarkable surge, accompanied by a corresponding increase in scientific curiosity aimed at investigating various disciplines within this domain, including badminton, padel, table tennis, tennis, and squash (Gallardo et al., 2023). Recently, racket sports are considered as one of the most popular recreational activities (Wang, 2018).

Tennis has transformed from an era when wooden rackets led to strategic, extended rallies characterized by elegance and skill, to today's high-speed, dynamic sport focused on strength, power, and speed, with serves reaching speeds as high as 210 km/h (Kovacs, 2007). However, tennis relies on diverse aspects of physical fitness; while points are swiftly scored in under 3-10 seconds with short sprints and directional changes, the potential for matches lasting up to 5 hours underscores the significance of tennis-specific endurance (Lambrich & Muehlbauer, 2022). These aspects are followed by quick recovery periods of 10–20 seconds, all interspersed with occasional longer rest breaks lasting 60–90 seconds (Genevois, 2019). In addition to tennis, Leite

et al. (2017) mentioned that the mean duration of table tennis rallies was 3.3 seconds, and the duration of rest between rallies was 18.6 seconds in World Table Tennis Championships and the Olympic Games that was held between years 2009 and 2012. Additionally, in a study conducted on 12 (female = 8, male = 4) internationally ranked badminton players, Faude et al. (2007) found that the mean rally duration was 5.5 ± 4.0 seconds and the mean rest duration was 11.4 ± 6.0 seconds.

Dağdelen & Söğüt (2020) investigated the effects of age, gender, and height on the distance covered on different court surfaces. The sample was 84 male (grass = 42, hard = 41) and 94 female (grass = 42, hard = 52) professional tennis players who played in the first draws of Wimbledon and US Open tournaments. It was reported in the research that on grass court, the total distance covered by males was 1934.4 ± 602.3 meters, while it was 1679.1 ± 610.8 meters in females. On hard court, males performed a total distance covered of 2289.0 ± 681.4 meters, while females covered a total distance of 1592.9 ± 555.2 meters. It was also observed in the study that shorter female players performed significantly higher mean set distance and mean point distance on both grass and hard courts, compared to their taller counterparts. This may prove the fact that stature has a significant effect on match performance.

Purpose of the Study

The main purpose of this cross-sectional study was to compare the match-play characteristics of junior and professional tennis players on various court surfaces. Besides, surface-related variations in match-play outcomes according to competitive level were investigated. Lastly, differences between male and female players were analyzed.

Research Questions

Are there any differences between junior and professional tennis players in terms of match-play variables on different court surfaces?

Are there any court surface related differences in match-play characteristics for both junior and professional players?

Are there any differences between male and female tennis players in terms of match-play characteristics on different court surfaces?

Significance of the Study

Although there were many studies related to match-play characteristics of tennis competitions, to the best of the author's knowledge, studies related to the comparison of characteristics based on the competitive level were limited. In addition, there was also limited evidence regarding gender differences of match-play characteristics between junior and professional tennis players. This study examines the match-play differences of tennis players in terms of court surface and compares the variables to obtain a new perspective related to these differences. Results of the study may provide better insight on the competitive level, surface, and gender-related variations in match-play outcomes. These information may be useful for athletes and coaches to develop more accurate training programs and individualized strategies and tactics to improve athletes' match performance.

Definition of Terms

First serve percentage: The percentage of successful first serves that a player makes out of the total number of first serves attempted during a match.

First serve points won: The percentage of points won by a player when they successfully land their first serve in play.

Second serve points won: The percentage of points won by a player when they make their second serve.

Average set duration: The average amount of time it takes to complete a set in a tennis match.

Ace per set: The average number of aces that a player serves in a single set. An ace occurs when a player serves the ball in such a way that the opponent cannot return it, resulting in a point for the server.

Double fault per set: The average number of double faults that a player commits in a single set. A double fault takes place when a player fails to put both of their serves into play, resulting in a point for the opponent.

Winner per set: The average number of winners a player hits in a single set. A winner is a shot that is hit with power, precision, and placement, making it difficult or impossible for the opponent to return. It is an offensive shot that results with a point for the player who hit it.

Unforced error per set: The average number of unforced errors committed by a player in a single set. An unforced error occurs when a player makes an error in a shot that is not forced or pressured by the opponent. It is generally an error that is avoidable, such as hitting a shot into the net, missing an easy volley, or hitting a shot long or wide.

Net points won: The average number of net points won by a player in a single set. It measures the player's success in winning points when they approach and play shots near the net.

Break points won: The number of times that a player successfully wins a game when they have had the opportunity to break their opponent's serve. In tennis, a break point takes place when the returning player has a chance to win the game on their opponent's serve.

Return points won: The number of points a player wins when returning their opponent's serve.

Total points won: The total number of points won by a player throughout a match.

CHAPTER 2

LITERATURE REVIEW

2.1. The Physiological Demands of Tennis Match-Play

Tennis is a sport characterized by its inherent unpredictability (Kovacs, 2006). In contrast to numerous other sports that prioritize high levels of physical fitness in only a few areas, in addition to physical fitness to successfully perform advanced maneuvers and effectively compete against skilled opponents, tennis demands exceptional performances across a wide range of components from its players (Fernandez-Fernandez et al., 2009; Kovacs, 2007, O'Donoghue & Ingram, 2001). Supporting that, Fernandez-Fernandez et al. (2011) emphasized that tennis is a complex game that requires a combination of physical attributes such as strength, power, speed, agility, explosiveness, and endurance elements.

In a study conducted with 6 (female = 2, male = 4) tennis players with a mean age of 22 ± 2.9, Martin et al. (2011) measured the physiological variables of athletes during and after the matches on clay and hard courts. A total of 16 randomized singles matches were played with 2 matches per player. At the end of the process, 3 matches were played on both courts. Results of the study demonstrated that the mean match duration on clay court was 56.9 ±5 minutes and 56.0 ±10.1 minutes on hard court. The percentage of effective playing time on the clay court was 26.2 ±1.9 and 19.5 ±2.0 on the hard court. The percentage of effective resting time was 73.8 ±1.9 on the clay court and 80.5 ±2.0 on hard the court. The mean rally duration was 8.5 ±0.2 seconds on the clay court and 5.9 ±0.5 seconds on the hard court. The mean heart rate was 154 ±12 beats per minute (BPM) on the clay court and 141 ±9 BPM on the hard court.

Murias et al. (2007) conducted a study to compare the physiological differences of tennis players on clay and hard courts. Several match-play characteristics were also

measured. 4 healthy male ranked tennis players with a mean age of 16.9 ± 0.7 years and a mean height of 181.2 ± 8.5 cm were requested to complete 3 tennis matches. Each match was limited to 90 minutes. A total of 12 tennis matches (clay = 6, hard = 6) were played at the end of the experiment. It was observed in the results that mean playing time was 8.8 ± 5.3 seconds on clay court while it was 7.2 ± 4.4 seconds on hard court. The mean resting time on the clay court was 24.9 ± 23.4 seconds and it was 26.1 ± 24.8 seconds on the hard court. Players' mean distance ran was 1,447 ±143 meters on the clay court and 1,199 ± 168 meters on the hard court. The mean heart rate (b·min-1) was 143 ± 22 BPM on the clay court, while it was 135 ± 21 BPM on the hard court. The mean lactate concentration (LA) (mmol·L-1) was 1.65 ± 0.60 on the clay court and 1.16 ± 0.34 on the hard court. The mean VO2max (ml·kg-1·min-1) was 47.6 ± 6.5 on the clay court and 49.5 ± 4.8 on the hard court.

2.2. Match Analysis in Tennis

The term "Match Analysis" is used to describe the performance analysis in a sports competition (O'Donoghue, 2004). The expansion of sports science in recent times has directed considerable focus towards enhancing performance, resulting in an intensified investigation and comprehension of various facets pertaining to racket sports. (Fernández-García, 2021; Lees, 2003). The inclusion of match analysis demonstrated its significance in the development of athletes, coaching processes, and notable competitive edge (Krizkova et al., 2021). The importance of match analysis rendered it possible for researchers to conduct further studies, obtain various approaches, and develop new theories related to match performance (Memmert, 2021). Furthermore, there are three main methods to analyze racket sports matches and players' performance as notational analysis, hawkeye system, and global positioning system (GPS) (James, 2017; Lupo et al., 2010; Bartlett, 2017; Gillet, 2009; Singh Bal & Dureja, 2012; Mecheri et al., 2016; Baodong, 2014; Owens et al., 2003; Collins & Evans, 2011; Galé-Ansodi et al., 2017).

2.2.1. Notational Analysis

Notational analysis is a method which is used to examine various facets of performance by creating a documentation of various situations during the match

(James, 2017). It is a method which athletes' match data is observed and noted by hand or by computer (Hughes, 2003). Notational analysis serves as a useful instrument in enhancing coaching techniques and understanding team sports, in addition to empowering coaches and scientists to gain deeper insights into performances, facilitating a greater level of knowledge acquisition (Lupo et al., 2010). The primary focuses of notational analysis are strategy and tactics, utilizing performance indicators related to matches, and technical aspects (Bartlett, 2017). Moreover, it is frequently implemented in racket sports (Gillet, 2009).

2.2.2. Hawkeye System

Hawkeye System refers to the technology of monitoring the ball during the entire match and it makes it possible for viewers to re-watch the position of the ball by capturing multiple images (Singh Bal & Dureja, 2012; Mecheri et al., 2016). Also commonly known as "Instant Replay System", Hawkeye System includes the placement of 8 or 10 high-speed cameras which are capable of capturing 2000 pictures per/second around the court and generating 3D replay visuals out of them (Baodong, 2014). The first idea of the development of the Hawkeye System was to make it easier and cheaper to track the ball more accurately during the match (Owens et al., 2003). Presently, it is a widely used technology in different sports such as tennis, cricket, and soccer (Collins & Evans, 2011; Singh Bal & Dureja, 2012).

2.2.3. Global Positioning System

Global Positioning System (GPS) was first invented for armies to use but recently it is applied to analyse mach performance outcomes for several sports such as football, rugby, field hockey and tennis (Edgecomb & Norton, 2006; Randers et al., 2010; Jennings et al., 2012; Hausler et al., 2016; Gale-Ansodi et al., 2017; Vickery et al., 2014). Utilizing 27 operational satellites around Earth, the GPS system employs atomic clocks to synchronize and continually transmit precise time information to GPS receivers, which is worn on the subject, allowing for the calculation of signal travel time and subsequent determination of satellite distance by multiplying this time by the speed of light (Larsson, 2003). By using the measured time delay and the established

signal velocity, a computer can easily determine the distance to individual satellites; however, for triangulating a singular point, this technique necessitates collecting measurements simultaneously from three satellites in a 2D plane and four satellites in a 3D space. Recent advancements of GPS devices has enabled their broader use across various sports, offering an extra avenue to characterize and comprehend the physical exertions experienced by players (Baiget Vidal, 2011).

2.3. Match-Play Variables in Tennis

The literature on analyzation of performance parameters of tennis players has started to grow recently (Cui et al., 2019; McGary et al., 2013). Several studies (Cui et al., 2018; Kachel et al., 2015; Kovalchik & Reid, 2017; Limpens et al., 2018; Ma et al., 2013; Sánchez-Pay et al., 2021; Smith, 2017; Söğüt, 2018; Tudor, 2014) investigated match-play outcomes of tennis competitions from different perspectives. These outcomes help coaches to obtain a better understanding of developing more accurate and individualized training programs (Cui et al., 2017).

2.4. Factors Affecting the Match-Play Variables in Tennis

There are three main factors that affect match-play variables in tennis. These factors are as follows: (1) competitive level, (2) court surface, and (3) gender.

2.4.1. Competitive Level

Kovalchik and Reid (2017) have conducted a study to compare the match-play characteristics of junior and professional tennis players, with a sample of 1433 official Grand Slam tennis players (female = 742, male = 724,) who played one professional or one junior match in singles category. It was observed in the results that in 2017 Australian Open Tournament, professionals including both females and males had demonstrated a significantly higher percentage of aces, net points won, and unforced errors than juniors. In addition to these results, both female and male junior players had significantly higher total points won. Furthermore, among each of the surfaces,

professional males performed significantly higher first and second serve points won than junior boys.

A study (Fernández-García et al., 2020) was conducted with a total sample of 1092 (female = 556, male = 536) junior and professional tennis players who played in Grand Slam Tournaments on clay, grass, and hard courts. The results indicated that professional males performed significantly higher aces, aces per set, higher percentage of first serve, first and second serve points won, winners, and higher unforced errors per set. Junior players, when compared to professionals, had significantly higher percentage of return points won and break points won per set. In females' category, professionals had significantly higher percentage of first serve in, while juniors made significantly more double faults per match.

2.4.2. Court Surface

Martin & Prioux (2016) defined three different tennis court surfaces as clay, grass, and hard. They classified these surfaces according to their vertical bouncing effect on the ball. It is also mentioned in the same study that grass court is the fastest court type among three surfaces because of the fact that the first and second bouncing time of the ball was the shortest, clay court is insubstantially slower, while clay court is slower than hard court. Performance changes due to shifts in movement patterns and playing styles correlated with the mechanical aspects of these different tennis surfaces (Starbuck et al., 2016).

In a study that four high-performing junior male tennis players were requested to apply identical training programs on both clay and hard courts, Reid et al. (2013) reported that after the various intermittent and tennis-related workout programs, players demonstrated significantly higher forced and unforced errors on the hard court, compared to the clay court. However, although both training periods caused an increase in HR, capillary blood lactate; and a decrease in pH, bicarbonate, and partial pressure of oxygen, no significant differences were observed between the clay and the hard courts, in terms of these parameters. Furthermore, no significant differences found in the total distance covered and the stroke volume between the two courts.

Another study (Martin et al., 2011) investigated the physiological differences between matches played on clay and hard courts. The sample was 6 high-performance tennis players. To compare the physical aspects, a total of 6 tennis matches were played as three on clay, and three on hard courts. Results showed that LA in the clay court was significantly higher that in the hard court. In addition, average rally duration and effective playing time were significantly higher on the clay court. Yet, the performance of running time was similar in both courts.

Takahashi et al. (2009) analyzed the effect of court surface on the temporal span of 82 professional male tennis players who played a total of 41 matches in the singles' category of Grand Slam Tournaments. They compared the results of matches played in French Open (clay court), Wimbledon (grass court) and US Open (hard court). It was observed in the results that in the matches played in French Open, players demonstrated significantly longer first and second serve times. In contrast, no statistical significance in ground strokes were found among the three surfaces.

Néri-Fuchs et al. (2023) evaluated the effect of court surface in terms of medical withdrawals from official tennis competitions of male and female professional tennis players. The study included a total of 975,766 Women's Tennis Association (WTA) and Association of Tennis Professionals (ATP) singles matches dated from 1969 to 2018. The term "withdrawal" was divided into two groups as walkover and retirement. Walkover was mentioned as the player being unable to begin the match due to injuries, illnesses, or different reasons. Withal, retirement was defined as the player quitting the match during the game because of the same reasons. Both terms were accepted and included as withdrawals, reported by the official doctors of the tournaments. Results indicated that women had a significantly higher percentage of withdrawals on slow surface. On the contrary, no significant differences were found in men's category, depending on the surface. Moreover, it was observed that players who played on the slow surface were more likely to withdraw, compared to the ones who played on the fast surface.

In contrast to the previous study, Pluim et al. (2017) found no significant injury rate differences between clay and hard courts. The sample was 20,000 random male and

female Royal Netherlands Lawn Tennis Association (KNLTB) members, with the age of at least 16. The members received a 6-month online questionnaire, which included 5 questions related to their injuries: (1) Their type of injuries, (2) The locations of injuries, (3) How many days they were unable to play, (4) If they need medical intervention, (5) The type of court that medical intervention was needed. At the end of the questionnaire period after 6 months, 600 (8.0 hours per month) members who played on clay court and 718 (7.6 hours per month) members who played on hard court completed at least one of the questionnaires. According to the results, there were no significant statistical differences in injury rates between clay and hard courts. Nevertheless, the overuse injury rate of the players who played on multiple courts was significantly higher.

Murias et al. (2007) conducted a study to compare the metabolic and functional response differences in running, playing, and resting times on clay and hard court surfaces. The sample was 4 healthy, top-ranked male tennis players who were competing in the Argentinean Professional National circuit, with at least six years experience of playing and training. Each of the players was requested to play three matches on both surfaces and the matches were limited to 90 minutes. Players' amount of oxygen uptake (VO2) was measured for 30 minutes (between 50th and 80th minutes) with a portable mask. Their heart rate was measured online with wearable technology and was transferred to a computer every 5 seconds, during the entire match. In addition, players' LA was measured before and every 10 minutes of the match. Results revealed that playing time on clay courts was significantly higher than that of the hard court's. In contrast, no significant differences were found in resting time on both courts. Players demonstrated significantly higher mean distance per point on clay courts than the hard courts. Furthermore, mean heart rate and mean LA were significantly higher on clay courts.

Vaverka et al. (2018) investigated the relationship between serve speed and court surface in tennis players who played all four Grand Slam Tournaments in the years 2008, 2012, and 2016, in singles categories. The data of tournaments were received from the official websites of four Grand Slam Tournaments. All of the subjects whose data on serve speed were available were included in the study. Additionally, all of the

included subjects were in the top 100 list of players based on their official ATP and WTA rankings. Results showed that in the men's category, among all of the four Grand Slam Tournaments, fastest serve speed was significantly lower in 2016 French Open Tournament. Similarly, in the women's category, the fastest serve speed was significantly lower in only 2016 French Open and 2012 Australian Open. Moreover, the average serve speed of both first and second serves was significantly higher in only Wimbledon Tournaments.

2.4.3. Gender

Gale-Ansodi et al. (2017) analyzed gender differences of 37 (female = 17, male = 20) young tennis players. They compared the physical match-play parameters of average speed, maximum speed, total distance covered, and distance covered during acceleration in Tennis matches played. Results revealed that female players demonstrated a significantly lower number of rallies. Although the accelerations between males and females were similar, males performed significantly higher maximum and average speed. Besides, the distance in a minute during matches was significantly higher than females.

Another study was conducted by Sánchez-Pay et al. (2017) to compare the match-play statistics of male and female tennis players who played traditional and wheelchair tennis on different court surfaces. Ninety-six official tennis players (female = 48, male = 48) who played a total of 220 sets in Australian Open, French Open, and US Open were included. According to the results, in wheelchair tennis matches, females performed significantly higher double faults, return points, and break points won than males. In contrast, the serving performance of traditional tennis players was significantly higher than wheelchair players. Furthermore, in traditional matches, male players demonstrated significantly higher serving speed, compared to females.

Hizan et al. (2015) analyzed the serve location patterns of 23 (female = 12, male = 11) under-16 and under-12 singles tennis matches from 2008 Australian Open, which was played on the hard court. After the analysis of a total of 5221 (female = 1949, male = 3272) serves, male players performed a preference for targeting the corners of the

service box, whereas female players leaned towards directing more serves towards their opponent's body. Analyzing the points won from service aces and service winners revealed that male professionals achieved higher success on the deuce side of the court by serving to their opponents' backhand, while female professionals demonstrated more success on first serves by aiming towards their opponent's body.

Breznik (2013) investigated the advantages and disadvantages of being right or left-handed and their effect on match-play characteristics of male and female tennis players in official tennis competitions. The data of a total of 33,164 (female = 16,432; male = 16,732) tennis players were received from ATP and WTA Tennis Tournaments' websites. Then, the handedness data of each player were recorded except for 6248 players, whose data was not available. The matches played between the years 1968 and 2011 were included in the study. Results indicated that being left-handed in professional tennis matches is a significantly higher advantage in the males' category, compared to females. Hence, no relationship was found between match duration and the handedness. Furthermore, the study emphasized that the surface of the court does not have any impact on the advantages of being right or left-handed.

CHAPTER 3

METHOD

3.1. Matches

The match-play characteristics of players who competed and won the matches in the first-round singles main draws of the 2022 French Open, Wimbledon, and US Open Tournaments were obtained from the official web pages. The distributions of matches according to gender, competitive level, and court surface are presented in Table 1. No missing matches or injured players who could not complete their matches were found in tournaments. In total, the match-play characteristics of 576 match-winning players were analysed.

Table 1. The distributions of matches included in the study

Competitive Level	French Open		Wimbledon		US Open		Total
	Male	Female	Male	Female	Male	Female	
Junior	32	32	32	32	32	32	192
Professional	64	64	64	64	64	64	384

3.2. Statistical Analysis

The data were collected from the official websites of the three included tournaments. Then, collected data were manually transferred to Microsoft Excel (Microsoft Corp., Version 2016) software. After that process, the entire data were double-checked by the author three times and by the advisor one time by randomly selecting variables several times and mathcing them with the data on the official websites. Subsequently, the data were transferred to SPSS 27 (IBM Corp., 2020) software to

conduct the statistical analysis. Prior to statistical analyses, the normality of the data was checked for each of the analyses. The only non-normal distributed data were males' ace and unforced error variables. However, according to Ghasemi and Zahediasl (2012), violation of normality of data could not cause biased estimations with a sample size larger than 30 or 40. As a result, non-normality of these variables was ignored. One way analysis of variance (ANOVA) was used to measure the effects of court surface. An independent samples t-test was used to analyze the gender and competitive level differences. To measure the effect size in t-tests, Cohen's d (Cohen, 1988) was used and classified as: <0.20 (trivial), 0.20–0.59 (small), 0.60–1.19 (moderate), 1.20–1.99 (large), 2.0–3.9 (very large), and >4.0 (extremely large) effect sizes (Hopkins et al., 2009). Besides, eta squared ($\eta 2$) was calculated in ANOVA as : $\eta 2 = 0.01$ (small), $\eta 2 = 0.06$ (medium), $\eta 2 = 0.14$ or higher (large) (Cohen, 1988).

CHAPTER 4

RESULTS

Table 2 represents the descriptive statistics of female players on grass court and t-test results. Three statistically significant differences in match-play characteristics were found in matches played on grass court. Results indicated that professional female players showed a significantly ($p < 0.05$, $d = -0.50$) higher percentage of winning first serve points, compared to juniors. Moreover, junior female players performed significantly ($p < 0.01$, $d = 1.27$) more unforced errors per set than professional female players. Moreover, professional female players performed significantly ($p < 0.05$, $d = 0.43$) higher total points when compared to junior players. No statistically significant differences observed among the other match-play characteristics on grass court.

Table 2. Descriptive statistics of female players on grass court and t-test results

Match-play characteristics	Junior	Professional	*t*	*P*	*d*
1st serve (%)	59.78±7.06	62.47±7.30	-1.720	0.089	0.37
1st serve points won (%)	68.94±7.31	72.68±7.70	-2.286	0.024	-0.50
2nd serve points won (%)	48.97±12.25	53.02±11.25	-1.613	0.110	-0.35
Average set duration (min)	40.95±6.57	40.05±8.84	-0.507	0.613	0.11
Aces per set (#)	1.04±1.03	1.28±1.22	-0.974	0.332	-0.21
Double faults per set (#)	1.83±1.19	1.52±1.13	1.269	0.207	0.28
Winner per set (#)	9.90±4.26	9.38±2.95	0.692	0.491	0.15
Unforced error per set (#)	14.76±4.29	9.92±3.57	5.853	0.001	1.27
Net points won (%)	61.75±17.68	65.10±17.44	-0.886	0.378	-0.19
Break points won (%)	50.47±19.44	55.17±18.47	-1.156	0.251	-0.25
Return points won (%)	48.69±6.22	47.47±6.43	0.884	0.379	0.19
Total points won	83.44±19.33	75.50±17.80	2.001	0.048	0.43

- number

Table 3 indicates the descriptive statistics of female players on clay court and t-test results. The results demonstrated no statistically significant ($p > 0.05$) differences between junior and professional players in any of the match-play characteristics. Since there were no data of winner per set, unforced error per set, net points won and total points won for junior players on the official website of Rolland Garros Tournament, comparison could not be made.

Table 3. Descriptive statistics of female players on clay court and t-test results

Match-play characteristics	Junior	Professional	*t*	*P*	*d*
1st serve (%)	61.31±7.23	63.05±8.73	-0.969	0.335	-0.21
1st serve points won (%)	64.50±8.11	67.84±9.25	-1.737	0.086	-0.38
2nd serve points won (%)	50.5±11.95	51.72±11.95	-0.495	0.621	-0,11
Average set duration (min)	42.19±7.07	42.44±8.00	-0.155	0.877	-0.03
Aces per set (#)	0.83±0.91	1.14±1.04	-1.456	0.149	0.31
Double faults per set (#)	1.64±1.36	1.35±0.99	1.153	0.252	0,25
Winner per set (#)	-	10.70±3.59	-	-	-
Unforced error per set (#)	-	10.67±3.62	-	-	-
Net points won (%)	-	69.56±17.63	-	-	-
Break points won (%)	51.63±13.79	50.92±13.79	0.237	0.813	0,05
Return points won (%)	49.75±5.69	50.42±5.69	-0.504	0.615	-0,11
Total points won	-	-	-	-	-

- number

Table 4 presents the descriptive statistics of female players on hard court and t-test results. Results revealed that professional female players had significantly ($p < 0.05$, $d = -0.62$) higher average set duration than juniors. Furthermore, junior female players performed significantly ($p < 0.05$, $d = 0.53$) higher return points won than professionals. The other characteristics were observed to be similar ($p > 0.05$).

The descriptive statistics of male players on grass court and t-test results are given in Table 5. Professional players obtained a significantly ($p < 0.05$, $d = -0.50$) higher average set duration than juniors. In addition, aces per set of professional players was significantly ($p < 0.05$, $d = -0.46$) higher than junior players. Junior players performed

significantly ($p < 0.01$, $d = 0.86$) higher percentage of return points won. Professional players won significantly ($p < 0.01$, $d = -1.87$) higher total points than juniors. The reason for this difference may be that professional matches are played over 5 sets. The other match-play characteristics on grass court were similar ($p > 0.05$).

Table 4. Descriptive statistics of female players on hard court and t-test results

Match-play characteristics	Junior	Professional	*t*	*P*	*d*
1st serve (%)	60.66±6.53	62.47±7.74	-1.137	0.258	-0.25
1st serve points won (%)	68.16±10.76	71.58±8.57	-1.690	0.094	-0.37
2nd serve points won (%)	54.44±13.25	51.81±10.95	1.031	0.305	0.22
Average set duration (min)	39.22±9.42	44.46±7.96	-2.859	0.005	-0.62
Aces per set (#)	1.17±0.95	1.65±1.47	-1.666	0.099	-0.36
Double faults per set (#)	1.60±0.95	1.68±1.10	-0.353	0.725	-0.08
Winner per set (#)	9.64±3.52	10.19±3.56	-0.712	0.478	-0,15
Unforced error per set (#)	13.15±7.40	11.05±4.22	1.766	0.081	0.38
Net points won (%)	65.25±19.81	69.48±15.93	-1.130	0.261	-0.25
Break points won (%)	49.19±18.11	54.89±17.08	-1.511	0.134	-0.33
Return points won (%)	51.25±7.65	47.47±6.89	2.444	0.016	0.53
Total points won	76.53±16.75	76.72±14.77	-0.056	0.955	-0.01

- number

Table 5. Descriptive statistics of male players on grass court and t-test results

Match-play characteristics	Junior	Professional	*t*	*P*	*d*
1st serve (%)	62.59±8.82	62.64±6.27	-0.030	0.976	-0.01
1st serve points won (%)	78.59±7.87	77.13±6.66	0.958	0.340	0.21
2nd serve points won (%)	55.28±11.71	56.80±7.57	-0.765	0.446	-0.17
Average set duration (min)	36.80±6.91	40.51±7.68	-2.304	0.023	-0.50
Aces per set (#)	2.09±1.40	2.89±1.89	-2.113	0.037	-0.46
Double faults per set (#)	1.14±0.66	1.18±0.73	-0.273	0.785	-0.06
Winner per set (#)	10.25±2.83	10.96±3.15	-1.079	0.283	-0.23
Unforced error per set (#)	9.78±3.91	8.74±2.90	1.465	0.146	0.32
Net points won (%)	71.66±10.11	69.33±8.08	1.222	0.225	0.26
Break points won (%)	54.97±21.17	47.88±18.78	1.672	0.098	0.36
Return points won (%)	45.56±6.58	40.27±5.93	3.975	0.001	0.86
Total points won	72.59±15.31	122.89±31.00	-8.651	0,001	-1.87

- number

The descriptive statistics of male players on clay court and t-test results are represented in Table 6. Professional players performed significantly ($p < 0.05$, $d = -0.50$) higher average set duration, compared to juniors. Additionally, they performed significantly ($p < 0.05$, $d = -0.53$) higher aces per set. Junior players were observed to have significantly ($p < 0.01$, $d = 0.61$) higher double fault per set, compared to professionals. No other significant differences were found. Additionally, no data were found on winner per set, unforced error per set, net points won and total point won were found on the official website of Roland Garros Tournament. Thus, comparison was not possible for these characteristics.

Table 6. Descriptive statistics of male players on clay court and t-test results

Match-play characteristics	Junior	Professional	*t*	*P*	*d*
1st serve (%)	62.97±7.60	63.95±6.04	-0.690	0.492	-0.15
1st serve points won (%)	71.63±7.38	72.59±7.65	-0.592	0.556	-0.13
2nd serve points won (%)	55.78±10.39	56.20±9.89	-0.194	0.847	-0.04
Average set duration (min)	39.67±7.98	43.66±8.00	-2.302	0.024	-0.50
Aces per set (#)	0.99±1.01	1.72±1.51	-2.452	0.016	-0.53
Double faults per set (#)	1.17±0.85	0.77±0.55	2.829	0.006	0.61
Winner per set (#)	-	10.48±3.26	-	-	-
Unforced error per set (#)	-	8.61±2.69	-	-	-
Net points won (%)	-	71.88±9.25	-	-	-
Break points won (%)	52.38±16.67	47.19±15.58	1.502	0.136	0.33
Return points won (%)	46.41±8.23	44.16±6.91	1.410	0.162	0.31
Total points won	-	-	-	-	-

- number

The descriptive statistics of male players on hard court and t-test results are indicated in Table 7. Professionals performed significantly ($p < 0.05$, $d = -5.52$) higher average set duration than juniors. They also performed significantly ($p < 0.05$, $d = -0.61$) higher aces per set. Junior players were observed to have a significantly higher percentage of break points ($p < 0.05$, $d = 0.56$) and return points won ($p < 0.01$, $d = 0.70$). Professional players acquired significantly ($p < 0.01$, $d = -1.94$) higher total points won, compared to juniors. This difference may have been caused by the fact that the matches of professionals are played over 5 sets. The other match-play characteristics on hard court were similar ($p > 0.05$).

Table 7. Descriptive statistics of male players on hard court and t-test results

Match-play characteristics	Junior	Professional	*t*	*P*	*d*
1st serve (%)	60.16±6.67	60.28±6.17	-0.091	0.928	-0.02
1st serve points won (%)	77.03±7.40	76.98±6.89	0.031	0.976	0,01
2nd serve points won (%)	55.69±11.52	55.59±8.98	0.044	0.965	0.01
Average set duration (min)	39.35±10.79	43.70±7.01	-2.378	0.019	-0.52
Aces per set (#)	2.06±1.60	3.01±1.56	-2.778	0.007	-0.61
Double faults per set (#)	1.32±0.95	1.33±0.94	-0.019	0.985	-0.01
Winner per set (#)	9.28±2.49	10.50±3.25	-1.862	0.066	-0.40
Unforced error per set (#)	9.41±3.27	9.22±3.10	0.232	0.817	0.05
Net points won (%)	67.94±14.07	70.61±15.46	-0.822	0.413	-0.18
Break points won (%)	57.88±20.41	48.20±15.44	2.591	0.011	0.56
Return points won (%)	46.31±8.29	41.55±5.87	3.253	0.002	0.70
Total points won	72.13±17.62	120.23±27.64	-8.964	0,001	-1.94

- number

Table 8 shows the ANOVA results for the effects of playing surface in junior girls. No statistically significant ($p > 0.05$) effect of court surface on any match-play characteristics was observed in junior girls. In addition, there was a lack of data on characteristics of winner per set, unforced error per set, net points won and total points won in the official website of Roland Garros Tournament. Therefore, comparison was not made.

Table 8. ANOVA results for the effects of playing surface in junior girls

Match-play characteristics	*F*	*P*	η^2	*Post hoc*
1st serve (%)	0.391	0.677	0.01	-
1st serve points won (%)	2.292	0.107	0.05	-
2nd serve points won (%)	1.631	0.201	0.03	-
Average set duration (min)	1.172	0.314	0.03	-
Aces per set (#)	1.042	0.357	0.02	-
Double faults per set (#)	0.365	0.695	0.01	-
Winner per set (#)	-	-	-	-
Unforced error per set (#)	-	-	-	-
Net points won (%)	-	-	-	-
Break points won (%)	0.159	0.853	0.01	-
Return points won (%)	1.227	0.298	0.03	-
Total points won	-	-	-	-

- number, G= Grass, H= Hard, C= Clay

Table 9 shows the ANOVA results for the effects of playing surface in professional female players. It was observed in the results that court surface was significantly effective in terms of percentage of first serve points won ($p < 0.05$, $\eta 2 = 0.06$), average set duration ($p < 0.05$, $\eta 2 = 0.05$) and return points won ($p < 0.05$, $\eta 2 = 0.04$). Post hoc results revealed that professional female players performed significantly higher percentage of first serve points won on grass and hard courts, than on clay court. Average set duration of females was significantly higher on hard court than grass court. Additionally, percentage of return points won on clay sourt surface was significantly higher than on grass and hard courts. There were no data on total points won on official website of Roland Garros Tournament. Therefore, it was not possible to compare these characteristics. The other match-play characteristics were not significantly ($p > 0.05$) different.

Table 9. ANOVA results for the effects of playing surface in professional female players

Match-play characteristics	*F*	*P*	η^2	*Post hoc*
1st serve (%)	0.113	0.893	0.01	-
1st serve points won (%)	5.662	0.004	0.06	C<G,H; G=H
2nd serve points won (%)	0.272	0.762	0.01	-
Average set duration (min)	4.558	0.012	0.05	H>G; C=G
Aces per set (#)	2.763	0.066	0.03	-
Double faults per set (#)	1.467	0.233	0.02	-
Winner per set (#)	2.469	0.087	0.03	-
Unforced error per set (#)	1.454	0.236	0.02	-
Net points won (%)	1.436	0.241	0.02	-
Break points won (%)	1.323	0.269	0.01	-
Return points won (%)	4.313	0.015	0.04	C>G,H; G=H
Total points won	-	-	-	-

- number, G= Grass, H= Hard, C= Clay

The ANOVA results for the effects of playing surface in junior boys are represented in Table 10. It was found that the percentage of first serve points ($p < 0.01$, $\eta 2 = 0.14$) and aces per set ($p < 0.05$, $\eta 2 = 0.13$) were significantly affected by court surface in

junior boys. It was observed in the post hoc results that junior boys performed significantly higher percentage of first serve points won on grass court, compared to clay court. They also had significantly higher aces per set on grass and hard courts than on clay court. There were no data on winner per set, unforced error per set, net points won, and total points won on the official website of Roland Garros Tournament. Thus, comparison was not possible. The other characteristics were insignificant ($p > 0.05$).

Table 10. ANOVA results for the effects of playing surface in junior boys

Match-play characteristics	*F*	*P*	η^2	*Post hoc*
1st serve (%)	1.244	0.293	0.03	-
1st serve points won (%)	7.5	0.001	0.14	G>C; G=H
2nd serve points won (%)	0.018	0.982	0.01	-
Average set duration (min)	1.045	0.356	0.02	-
Aces per set (#)	6.832	0.002	0.13	C<G,H; G=H
Double faults per set (#)	0.460	0.633	0.01	-
Winner per set (#)	-	-	-	-
Unforced error per set (#)	-	-	-	-
Net points won (%)	-	-	-	-
Break points won (%)	0.636	0.532	0.01	-
Return points won (%)	0.114	0.892	0.01	-
Total points won	-	-	-	-

- number, G= Grass, H= Hard, C= Clay

Table 11 demonstrates the ANOVA results for the effects of playing surface in professional male players. The results revealed that percentage of first serve ($p < 0.05$, $\eta2 = 0.06$), percentage of first serve points won ($p < 0.01$, $\eta2 = 0.08$), average set duration ($p < 0.05$, $\eta2 = 0.04$), aces per set ($p < 0.01$, $\eta2 = 0.11$), double faults per set ($p < 0.01$, $\eta2 = 0.09$) and percentage of return points won ($p < 0.01$, $\eta2 = 0.06$) were significantly affected by court surface in professional male players. Post hoc results showed that males had significantly higher percentage of first serve points won, aces per set, and double faults per set on grass and hard courts than on clay court surface. In contrast, They had significantly higher percentage of first serve on clay court than on hard court. Although there was a significant effect of court surface on average set

duration, no significant differences were observed in the post hoc results. There were no data on total points won on the official website of Roland Garros Tournament. The other characteristics were found to be similar ($p > 0.05$).

Table 11. ANOVA results for the effects of playing surface in professional male players

Match-play characteristics	*F*	*P*	η^2	*Post hoc*
1st serve (%)	5.842	0.003	0.06	C>H; G=C,H
1st serve points won (%)	8.474	0.001	0.08	C<H,G; C=H
2nd serve points won (%)	0.295	0.745	0.01	-
Average set duration (min)	3.738	0.026	0.04	-
Aces per set (#)	11.818	0.001	0.11	C<G,H; G=H
Double faults per set (#)	9.47	0.001	0.09	C<G,H; G=H
Winner per set (#)	0.461	0.631	0.01	-
Unforced error per set (#)	0.648	0.524	0.01	-
Net points won (%)	0.798	0.452	0.01	-
Break points won (%)	0.062	0.94	0.01	-
Return points won (%)	6.431	0.002	0.06	C>G; H=C,G
Total points won	-	-	-	-

- number, G= Grass, H= Hard, C= Clay

Table 12 shows gender differences by court surface in junior players. The results showed that junior boys performed significantly higher percentage of first serve points won on grass ($p < 0.01$, $d = -1.27$), clay ($p < 0.01$, $d = -0.92$) and hard ($p < 0.01$, $d = -0.96$) courts. Gender difference in average set duration was present only on grass court. Junior girls performed significantly higher average set duration ($p < 0.05$, $d = 0.62$) on grass court. Junior boys performed significantly higher aces per set on grass ($p < 0.01$, $d = -0.86$) and hard ($p < 0.01$, $d = -0.68$) courts. Double faults per set were significantly higher in junior girls ($p < 0.01$, $d = 0.73$) on grass court. Gender difference in double faults per set was not significantly ($p > 0.05$) present on clay and hard courts. Junior girls were observed to have significantly higher unforced errors per set on grass ($p < 0.01$, $d = 1.22$) and hard ($p < 0.05$, $d = 0.65$) courts. Junior boys performed significantly higher percentage of net points won on grass court ($p < 0.01$, $d = -069$). Gender difference in percentage of return points won was observed on clay ($p < 0.05$, $d = 0.47$) and hard ($p < 0.05$, $d = 0.62$) courts. Junior females performed significantly higher percentage of return points won. Only gender difference in total points won was

observed to be on grass court ($p < 0.05$, $d = 0.62$). Junior females performed significantly higher total points won on grass court. There was no significant ($p > 0.05$) gender difference observed in match-play characteristics of second serve points won, winner per set and break points won in any of the courts. Additionally, there was no data on winner per set, unforced error per set, net points won and total points won in the official website of Roland Garros Tournament. This caused the comparison was not made.

Table 12. Gender differences by court surface in junior players

Match-play characteristics	Grass			Clay			Hard		
	t	*P*	*d*	*t*	*P*	*d*	*t*	*P*	*d*
1st serve (%)	-1.409	0.164	-0.35	-0.893	0.375	-0.22	0.303	0.763	0.08
1st serve points won (%)	-5.082	0.001	-1.27	-3.677	0.001	-0.92	-3.845	0.001	-0.96
2nd serve points won (%)	-2.106	0.039	-0.53	-1.887	0.064	0.47	-0.403	0.689	-0.1
Average set duration (min)	2.463	0.017	0.62	1.334	0.187	0.33	-0.051	0.959	-0.01
Aces per set (#)	-3.455	0.001	-0.86	-0.696	0.489	-0.17	-2.713	0.009	-0.68
Double faults per set (#)	2.91	0.005	0.73	1.633	0.108	0.41	1.163	0.249	0.29
Winner per set (#)	-0.392	0.697	-0.1	-	-	-	0.471	0.639	0.12
Unforced error per set (#)	4.863	0.001	1.22	-	-	-	2.616	0.011	0.65
Net points won (%)	-2.752	0.008	-0.69	-	-	-	-0.626	0.534	-0.16
Break points won (%)	-0.886	0.379	-0.22	-0.196	0.845	-0.05	-1.801	0.077	-0.45
Return points won (%)	1.95	0.056	0.49	1.89	0.063	0.47	2.475	0.016	0.62
Total points won	2.487	0.016	0.62	-	-	-	1.025	0.309	0.26

Table 13 represents gender differences by court surface in professional players. Gender difference in match-play characteristics of percentage of first serve points won, percentage of second serve points won, unforced error per set and return points won was significantly present on grass, clay and hard courts. Professional male players performed significantly higher percentage of first serve points won on grass ($p < 0.01$, $d = -0.62$), clay ($p < 0.01$, $d = -0.56$) and hard ($p < 0.01$, $d = -0.70$) courts, compared to females. Males performed significantly higher percentage of second serve points won on grass ($p < 0.05$, $d = -0.39$), clay ($p < 0.05$, $d = -0.43$) and hard ($p < 0.05$, $d = -0.38$) courts. Gender was significantly effective in aces per set in three courts. Males performed significantly higher aces per set on grass ($p < 0.01$, $d = -1.01$), clay ($p <$

0.05, d = -0.44) and hard (p < 0.01, d = -0.90) courts. Females performed significantly higher double faults per set on grass (p < 0.05, d = 0.36) and clay (p < 0.05, d = 0.74) courts. Grass court was the only court that gender difference in winner per set was present. On grass court, males performed significantly higher winner per set than females (p < 0.01, d = -0.52). Gender was significantly effective in unforced error per set in each three courts. Females performed significantly higher unforced error per set on grass (p < 0.05, d = 0.36) clay (p < 0.01, d = 0.74) and hard (p < 0.05, d = 0.35) courts. Females performed significantly higher percentage of break points won on hard court (p < 0.05, d = 0.41). Gender difference in percentage of return points won was observed to be in three courts. Females performed significantly higher percentage of return points won on grass (p < 0.01, d = 1.16), clay (p < 0.01, d = 0.96) and hard (p < 0.01, d = 0.93) courts. At the same time, Gender was significantly effective in terms of total points won on grass (p < 0.01, d = -1.88) and hard (p < 0.01, d = -1.96) courts. No data on total points won on clay court was found in the official website of Roland Garros Tournament. Accordingly, no comparison was made. No significant (p > 0.05) gender difference was found in percentage of first serve, average set duration and net points won in any of court surfaces.

Table 13. Gender differences by court surface in professional players

Match-play characteristics	Grass			Clay			Hard		
	t	*P*	*d*	*T*	*P*	*D*	*t*	*P*	*d*
1st serve (%)	-0.143	0.887	-0.03	-0.683	0.496	-0.12	1.769	0.079	0.31
1st serve points won (%)	-3.488	0.001	-0.62	-3.165	0.002	-0.56	-3.932	0.001	-0.7
2nd serve points won (%)	-2.231	0.027	-0.39	-2.418	0.017	-0.43	-2.137	0.035	-0.38
Average set duration (min)	-0.311	0.756	-0.06	-0.857	-0.393	-0.15	0.579	0.564	0.1
Aces per set (#)	-5.717	0.001	-1.01	-2.508	0.013	-0.44	-5.074	0.001	-0.90
Double faults per set (#)	2.029	0.045	0.36	4.169	0.001	0.74	1.953	0.053	0.35
Winner per set (#)	-2.93	0.004	-0.52	0.36	0.719	0.06	-0.517	0.606	-0.09
Unforced error per set (#)	2.057	0.042	0.36	3.661	0.001	0.65	2.55	0.012	0.45
Net points won (%)	-1.756	0.082	-0.31	-0.929	0.355	-0.16	-0.405	0.686	-0.07
Break points won (%)	2.216	0.028	0.39	1.441	0.152	0.26	2.323	0.022	0.41
Return points won (%)	6.586	0.001	1.16	5.333	0.001	0.94	5.235	0.001	0.93
Total points won	10.606	0.001	-1.88	-	-	-	11.108	0.001	-1.96

CHAPTER 5

DISCUSSION

The main purpose of this study was to examine the match-play characteristics of match-winning tennis players and compare these characteristics of junior and elite players. It was also aimed in this study to observe the influence of court surface and gender on match-play characteristics. The findings of the study revealed that on each of the court surfaces, professional players exhibited notably longer average set durations and a higher number of aces per set compared to junior players. When compared to junior girls, boys demonstrated significantly higher return points won on grass and hard court surfaces. Professional females performed significantly higher unforced errors per set than males, regardless of the court surface. Court surface had a significant effect on professional males. The variables of first serve points won, ace per set, and double faults per set were significantly lower on clay court, compared to grass and hard surfaces in males.

Regardless of court surface, aces per set were significantly higher in professional males when compared to junior boys. Consistently with the findings of Fernández-García et al. (2021), professional females were significantly better at winning first serve points than junior girls. Additionally, Kovalchik & Reid (2017) indicated that professional males had significantly higher first serve points won than junior boys but there were no significant differences for females. On the contrary, it was observed in the results of this study that females had significantly higher first serve points than juniors on clay, grass, and hard court surfaces. This inconsistency may be caused by the by the reason that Kovalchik & Reid (2017) included the match data of different year intervals (from 2000 to 2015), while this study included only Grand Slam Tournaments that took place in the year 2022. Furthermore, no data on Australian Open Tournament were included in the present study.

This study reported that there were significantly higher aces and double faults on grass and hard courts than on clay court in the professional males' category. Similarly, Söğüt (2019) investigated a total of 5138 (clay = 1631, grass = 527, hard = 2980) ATP matches in males' singles category and observed that significantly more aces and double faults were performed on grass court surface than on both other courts. In relation to this difference, Martin & Prioux (2016) stated that court surface have influence on players' playing style, while these differences of match-play characteristics were caused by two main factors as coefficient of friction and coefficient of restitution of different court surfaces. Thus, it may be concluded from these studies that professional male players tend to perform more aces and double faults as type of court surface gets faster.

Gale-Ansodi et al. (2017) investigated gender-related match-play characteristics with a total of 98 (female = 49, male = 49) high-ranked tennis players with a mean age of 14.0 ± 2.9. According to the results of the study, males performed significantly higher distance covered, maximum speed, and average speed than females. Another study (Breznik, 2013) was conducted to examine the advantages and disadvantages of being right-handed or left-handed in males and females. It was observed in the results that only in males' category, it was significantly more advantageous to be left-handed in players. It can be deducted from these results that when comparing genders and handedness, being a left-handed male is the greatest advantage in terms of demonstrating a better match performance in tennis.

In the present study, match-play characteristics of professional males were observed to be influenced by the variable of court surface more than any other age and gender categories. Moreover, junior girls were the least affected group from the court surface with no significant differences on any of the surfaces. The reason for this may be the fact that males have higher amount of muscles to hit the ball with higher speed, which make it harder to reach and receive the ball for the opponent, while junior girls do not differ among each other significantly in terms of strenght and speed. These findings may direct the readers to consider that significant differences caused by court surfaces are more likely to occur as physiological differences among populations increase.

There were several limitations of this study. The first limitation was that there were no data available on match-play characteristics of 2022 Australian Open Tournament on the official website of the tournament. Thus, the inclusion of matches played on 2022 Australian Open was not possible. However, same as Australian Open, US Open Tournament is played on hard court surface as well. Eventually, data of matches played on hard court were able to be reached. The second limitation was that no data of junior players on variables of winner per set, unforced error per set, and net points won were found in the official website of Rolland Garros Tournament. Additionally, total points won were not accessible for both juniors' and professionals' categories. This study investigated match-play characteristics of Wimbledon, US Open and Rolland Garros Tournaments that took place in the year 2022. Future research may focus on long-term comparison of these characteristics to provide non-exceptional results and prevent coincidental findings.

These findings highlight the importance of proper training programs for each age and court surface. There are several suggested practical implications of this study for coaches and athletes. Firstly, when training a tennis athlete, more importance should be given on court-based long-term and short-term training methods to improve the athletes' surface-related performance. Secondly, coaches should take into account the statistical match-play differences between junior and professional players to obtain more accurate information on what causes these differences. Furthermore, gender-based training on different court surfaces should be applied on both junior and professional athletes. Longitudinal studies are required to have a deeper understanding on athletes' match-play performance and various facets of training methods.

5.1. Conclusion

This study examined the differences of match-play characteristics of junior and professional tennis players on clay, grass and hard court surfaces. Professional players exhibited notably greater average set duration and aces per set compared to junior players across all court surfaces. There were notably higher return points won on grass and hard courts in junior boys than on professionals. Professional females displayed notably higher rates of first serve points won and total points won on grass courts. It

was evident that among professional male players, metrics such as first serve points won, aces per set, and double faults per set were significantly elevated on grass and hard courts when contrasted with clay courts. Junior boys showcased a significantly higher percentage of first serve points won in comparison to junior girls on grass, clay, and hard courts. In professional male players, there were notably higher levels of first serve points won and aces per set when compared to their female counterparts across all three court types. This study may be a guideline for coaches and players, in terms of training methods. Further longitudinal studies are required to obtain new perspectives related to well-shaped training programs.

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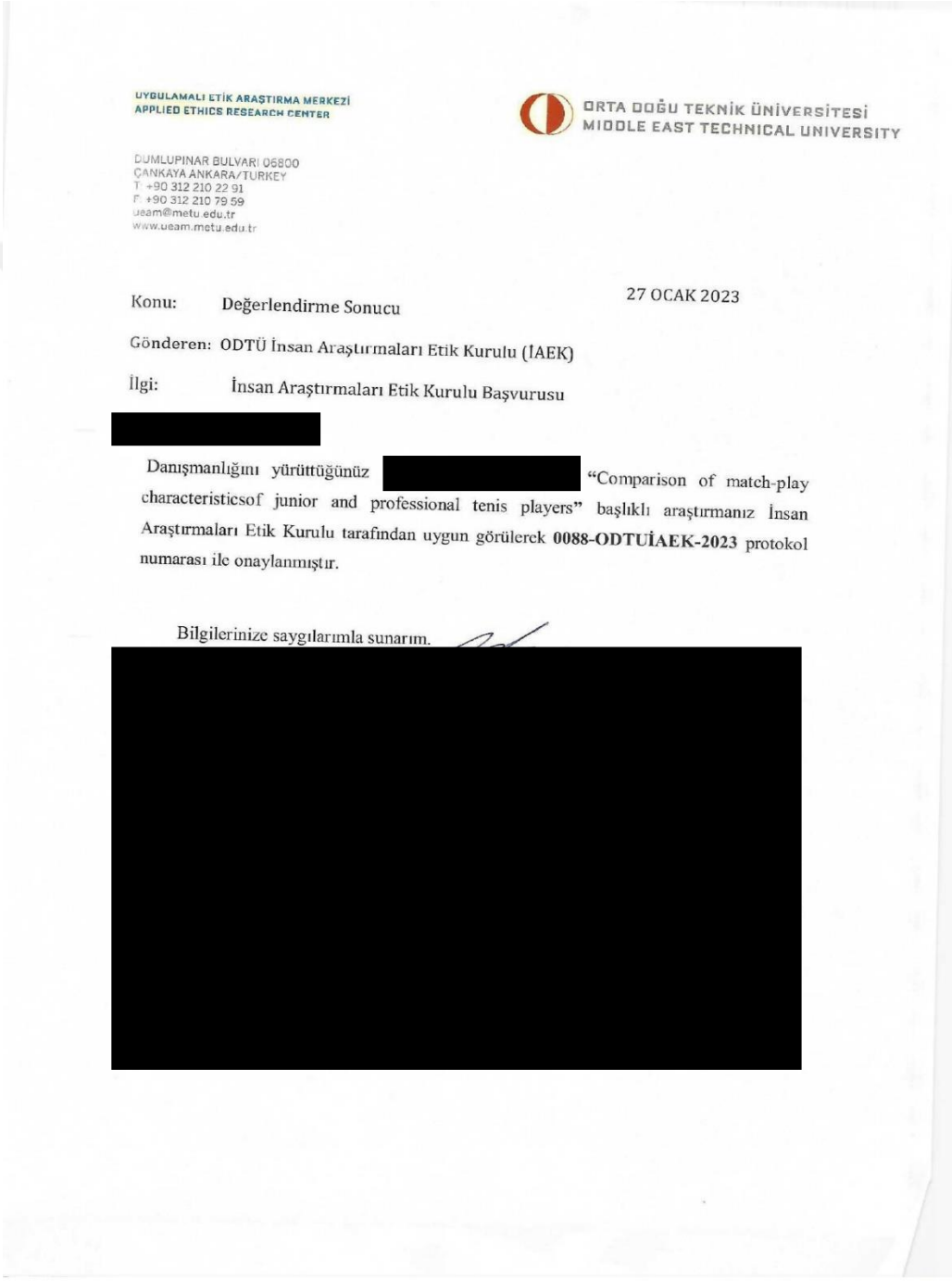
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APPENDICES

A. APPROVAL OF THE METU HUMAN SUBJECTS ETHICS COMMITTEE



UYGULAMALI ETİK ARAŞTIRMA MERKEZİ
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27 OCAK 2023

Konu: Değerlendirme Sonucu

Gönderen: ODTÜ İnsan Araştırmaları Etik Kurulu (İAEK)

İlgi: İnsan Araştırmaları Etik Kurulu Başvurusu

[redacted]

Danışmanlığını yürüttüğünüz [redacted] "Comparison of match-play characteristicsof junior and professional tenis players" başlıklı araştırmanız İnsan Araştırmaları Etik Kurulu tarafından uygun görülerek **0088-ODTÜİAEK-2023** protokol numarası ile onaylanmıştır.

Bilgilerinize saygılarımla sunarım.

[redacted]

B. TURKISH SUMMARY / TÜRKÇE ÖZET

BÖLÜM 1

GİRİŞ

Sporda performans analizinin kullanımı, antrenman, taktik ve karar verme süreçlerini geliştirmek için veri merkezli bir yapı sunduğundan, sporcuların ve takımların sonuçlarını iyileştirmek için önemli bir yöntem olarak ortaya çıkmıştır (Hughes ve Franks, 2004). Bu nedenle, sporcuların hareketlerini ve teknik manevralarını belgelemek için spor analizine yönelik bilgisayarlı sistemler geliştirilmiş, bu da çeşitli spor dallarında tanımlayıcı araştırmalar yoluyla sonraki keşiflere yol açmıştır (McGarry ve ark., 2002). Maç ve antrenman performanslarının analizi, önemli antrenman önceliklerini tespit etmek amacıyla oyuncuların hem güçlü yönlerini hem de geliştirilmesi gereken alanlarını ortaya çıkarmayı amaçlamaktadır (Lames ve McGarry, 2007).

1.1. Çalışmanın Amacı

Bu kesitsel çalışmanın temel amacı, genç ve prefesyonel tenis oyuncularının çeşitli kort yüzeylerinde maç aktivitelerini karşılaştırmaktır. Ayrıca, müsabaka kategorisine göre maç sonuçlarındaki yüzeyle ilgili farklılıklar araştırılmıştır. Son olarak, erkek ve kadın oyuncular arasındaki farklılıklar analiz edilmiştir.

1.2. Araştırma Soruları

1. Genç ve profesyonel tenisçiler arasında farklı kort yüzeylerinde maç oynama değişkenleri açısından herhangi bir fark var mı?
2. Hem genç hem de profesyonel oyuncular için maç aktivitelerinde kort yüzeyi ile ilgili farklılıklar var mı?

3. Erkek ve kadın tenisçiler arasında farklı kort yüzeylerinde maç aktiviteleri açısından herhangi bir fark var mı?

1.3. Çalışmanın Önemi

Tenis müsabakalarının maç aktiviteleriyle ilgili birçok çalışma olmasına rağmen, yazarın bildiği kadarıyla, müsabaka düzeyine dayalı özelliklerin karşılaştırılmasıyla ilgili çalışmalar sınırlıdır. Buna ek olarak, genç ve profesyonel tenis oyuncuları arasındaki maç aktivitelerinin cinsiyet farklılıklarına ilişkin de sınırlı kanıt bulunmaktadır. Bu çalışma, tenis oyuncularının maç oynama farklılıklarını kort yüzeyi açısından incelemekte ve bu farklılıklarla ilgili yeni bir bakış açısı elde etmek için değişkenleri karşılaştırmaktadır. Çalışmanın sonuçları, maç sonuçlarındaki müsabaka düzeyi, yüzey ve cinsiyete bağlı farklılıklar hakkında daha iyi bilgiler sağlayabilir. Bu bilgiler, sporcuların ve antrenörlerin daha doğru antrenman programları geliştirmeleri ve sporcuların maç performansını artırmak için bireyselleştirilmiş stratejiler ve taktikler geliştirmeleri için faydalı olabilir.

BÖLÜM 2

LİTERATÜR TARAMASI

2.1. Tenis Maç Oyununun Fizyolojik Gereksinimleri

Tenis, doğasında var olan öngörülemezlik ile karakterize edilen bir spordur (Kovacs, 2006). Sadece birkaç alanda yüksek düzeyde fiziksel uygunluğa öncelik veren diğer birçok sporun aksine, ileri manevraları başarıyla gerçekleştirmek ve yetenekli rakiplere karşı etkili bir şekilde rekabet etmek için fiziksel uygunluğa ek olarak tenis, oyuncularından çok çeşitli bileşenlerde olağanüstü performanslara gereksinim duyar (Fernandez-Fernandez ve ark., 2009; Kovacs, 2007, O'Donoghue ve Ingram, 2001). Fernandez-Fernandez ve ark. (2011) ve O'Donoghue (2000) bunu destekleyerek tenisin kuvvet, güç, hız, çeviklik, patlayıcılık ve dayanıklılık gibi fiziksel özelliklerin bir arada olmasını gerektiren karmaşık bir oyun olduğunu vurgulamıştır.

2.2. Teniste Maç Analizi

"Maç Analizi" terimi, bir spor müsabakasındaki performans analizini tanımlamak için kullanılır (O'Donoghue, 2004). Son zamanlarda spor bilimlerinin genişlemesi, performansı artırmaya anlamlı olarak odaklanmış ve raket sporlarıyla ilgili çeşitli yönlerin yoğun bir şekilde araştırılması ve anlaşılmasıyla sonuçlanmıştır. (Fernández-García, 2021; Lees, 2003). Maç analizinin dahil edilmesi, sporcuların gelişiminde, antrenörlük süreçlerinde ve kayda değer rekabet avantajında önemini göstermiştir (Krizkova ve ark., 2021).

2.3. Notasyonel Analiz

Notasyonel analiz, maç sırasında çeşitli durumların dokümantasyonunu oluşturarak performansın çeşitli yönlerini incelemek için kullanılan bir yöntemdir (James, 2017). Sporcuların maç verilerinin elle veya bilgisayarla gözlemlendiği ve not edildiği bir yöntemdir (Hughes, 2003). Notasyonel analiz, antrenörlerin ve bilim insanlarının performanslar hakkında daha derin görüşler elde etmelerini sağlamanın yanı sıra, antrenörlük tekniklerini geliştirmede ve takım sporlarını anlamada yararlı bir araç olarak hizmet eder ve daha yüksek düzeyde bilgi edinmeyi kolaylaştırır (Lupo ve ark., 2010).

2.4. Şahin Gözü Sistemi

Şahin gözü sistemi, tüm maç boyunca topu izleme teknolojisini ifade eder ve izleyicilerin birden fazla görüntü yakalayarak topun pozisyonunu yeniden izlemelerini mümkün kılar (Singh Bal ve Dureja, 2012; Mecheri ve ark., 2016). Yaygın olarak "Anında Tekrar Sistemi" olarak da bilinen Hawkeye Sistemi, sahanın etrafına saniyede 2000 görüntü yakalayabilen ve bunlardan 3 boyutlu bir tekrar görüntüsü oluşturabilen 8 veya 10 yüksek hızlı kameranın yerleştirilmesini içerir. (Baodong, 2014). Hawkeye Sisteminin geliştirilmesindeki ilk fikir, maç sırasında topu daha doğru bir şekilde takip etmeyi daha kolay ve daha ucuz hale getirmekti (Owens ve ark., 2003). Şu anda tenis, kriket ve futbol gibi farklı spor dallarında yaygın olarak kullanılan bir teknolojidir (Collins ve Evans, 2011; Singh Bal ve Dureja, 2012).

2.5. Küresel Konumlandırma Sistemi

Dünya etrafındaki 27 operasyonel uyduyu kullanan küresel konumlandırma sistemi (GPS), hassas doğrudan sayı zaman bilgisini senkronize etmek ve sürekli olarak GPS alıcılarına iletmek için atomik saatler kullanır; bu da kişiye takılır ve sinyal seyahat süresinin hesaplanmasına ve ardından bu sürenin ışık hızıyla çarpılmasıyla uydu mesafesinin belirlenmesine olanak tanır (Larsson, 2003). Ölçülen zaman gecikmesini ve belirlenen sinyal hızını kullanarak, bir bilgisayar tek tek uydulara olan mesafeyi kolayca belirleyebilir.

2.6. Teniste Maç Aktiviteleri

Tenis oyuncularının performans parametrelerinin analizine ilişkin literatür son zamanlarda büyümeye başlamıştır (Cui ve ark., 2019; McGary ve ark., 2013). Birçok çalışma (Cui ve ark., 2018; Kachel ve ark., 2015; Kovalchik ve Reid, 2017; Limpens ve ark., 2018; Ma ve ark., 2013; Sánchez-Pay ve ark., 2021; Smith, 2017; Söğüt, 2018; Tudor, 2014) tenis müsabakalarının maç sonuçlarını farklı açılardan incelemiştir. Bu sonuçlar, antrenörlerin daha doğru ve bireyselleştirilmiş antrenman programları geliştirme konusunda daha iyi bir anlayış elde etmelerine yardımcı olmaktadır (Cui ve ark., 2017).

2.7. Teniste Aktivitelerini Etkileyen Faktörler

Tenis müsabakaları genellikle maçlar sırasında hem fiziksel hem de psikolojik zorluklardan oluşur. Bu zorlukların üstesinden gelmek ve daha iyi bir maç performansı sergilemek için oyuncuların iyi antrenmanlı bir vücuda ve motive olmuş bir zihniyete sahip olmaları çok önemlidir. Maç performansı çoğunlukla genetik ve çevresel faktörlerden etkilenir. Her oyuncunun farklı antrenman yöntemlerine verdiği tepki farklıdır. Bu nedenle, sporcuların daha iyi maç istatistikleri elde etmeleri ve daha ileri başarılara ulaşmaları için hem fiziksel hem de zihinsel antrenman yöntemleri uygulanmalıdır.

2.8. Müsabaka Kategorisi

Kovalchik & Reid (2017), tekler kategorisinde bir profesyonel veya bir genç maçı oynayan 1433 resmi Grand Slam tenisçisinden (Kadın = 742, Erkek = 724,) oluşan bir örneklem ile genç ve profesyonel tenisçilerin maç aktivitelerini karşılaştırmak için bir

çalışma yürütmüştür. Araştırma bulgularında, 2017 Avustralya Açık Turnuvası'nda hem kadın hem de erkeklerden oluşan profesyonellerin gençlere kıyasla anlamlı olarak daha yüksek set başına kazanılan doğrudan sayı, net puanı kazanma ve basit hata yüzdesi sergilediği görülmüştür. Bu bulgulara ek olarak, hem kadın hem de erkek genç oyuncular anlamlı olarak daha yüksek toplam puan kazanmıştır. Ayrıca, her bir yüzeyde, profesyonel erkekler genç erkeklere kıyasla anlamlı olarak daha yüksek birinci ve ikinci servis puanı kazanmıştır.

2.9. Kort Yüzeyi

Vaverka ve ark. (2018), 2008, 2012 ve 2016 yıllarında dört Grand Slam Turnuvasının tamamında tekler kategorisinde oynayan lisanslı tenisçilerde servis hızı ve kort yüzeyi arasındaki ilişkiyi incelemiştir. Turnuvalara ait veriler dört Grand Slam Turnuvasının resmi internet sitelerinden alınmıştır. Servis hızı verilerine ulaşılabilen tüm denekler çalışmaya dahil edilmiştir. Ayrıca, çalışmaya dahil edilen tüm denekler resmi ATP ve WTA sıralamalarına göre ilk 100 oyuncu listesinde yer almıştır. Sonuçlar, erkekler kategorisinde, dört Grand Slam Turnuvası arasında en hızlı servis hızının 2016 Fransa Açık Turnuvası'nda anlamlı olarak daha düşük olduğunu göstermiştir. Benzer şekilde, kadınlar kategorisinde, en hızlı servis hızı sadece 2016 Fransa Açık ve 2012 Avustralya Açık Turnuvalarında anlamlı olarak düşüktü. Dahası, hem birinci hem de ikinci servislerin ortalama servis hızı sadece Wimbledon Turnuvalarında anlamlı olarak daha yüksektir.

2.10. Cinsiyet

Gale-Ansodi ve ark. (2017), 37 (Kadın = 17, Erkek = 20) genç tenis oyuncusunun cinsiyet farklılıklarını analiz etmiştir. Oynanan tenis maçlarında ortalama hız, maksimum hız, kat edilen toplam mesafe ve hızlanma sırasında kat edilen mesafe gibi maç aktivitelerini karşılaştırmışlardır. Sonuçlar, kadın oyuncuların anlamlı olarak daha düşük ralli sayısı sergilediğini ortaya koymuştur. Erkekler ve kadınlar arasındaki ivmelenmeler benzer olmasına rağmen, erkekler anlamlı olarak daha yüksek maksimum ve ortalama hız gerçekleştirmiştir. Ayrıca, maçlar sırasında bir dakikada kat edilen mesafe kadınlardan anlamlı derecede daha yüksekti.

BÖLÜM 3

YÖNTEM

3.1. Maçlar

Fransa Açık, Wimbledon ve Amerika Açık Turnuvalarının 2022 ilk tur tekler ana tablo maçlarında yarışan ve maçları kazanan oyuncuların maç aktiviteleri resmi internet sayfalarından elde edilmiştir. Maçların cinsiyet, müsabaka düzeyi ve kort yüzeyine göre dağılımları Tablo 1'de sunulmuştur. Turnuvalarda eksik maç veya maçlarını tamamlayamayan oyuncu bulunmamıştır. Toplamda sadece kazanan oyunculardan oluşan 576 maçın aktiviteleri analiz edilmiştir.

Tablo 1. Çalışmaya dahil edilen maçların dağılımları

Müsabaka düzeyi	Fransa Açık		Wimbledon		Amerika Açık		Toplam
	Erkek	Kadın	Erkek	Kadın	Erkek	Kadın	
Genç	32	32	32	32	32	32	192
Profesyonel	64	64	64	64	64	64	384

3.2. İstatistiksel Analiz

Veriler, dahil edilen üç turnuvanın resmi internet sitelerinden toplanmıştır. Daha sonra, toplanan veriler Microsoft Excel (Microsoft Corp., Sürüm 2016) yazılımına manuel olarak aktarılmıştır. Daha sonra, veriler istatistiksel analizi gerçekleştirmek için SPSS 27 (IBM Corp., 2020) yazılımına aktarılmıştır. İstatistiksel analizlerden önce, her bir analiz için verilerin normalliği kontrol edilmiştir. Kort yüzeyinin etkilerini ölçmek için tek yönlü varyans analizi (ANOVA) kullanılmıştır.

BÖLÜM 4

BULGULAR

Tablo 8, genç kızlarda oyun yüzeyinin etkileri için ANOVA sonuçlarını göstermektedir. Genç kızlarda kort yüzeyinin herhangi bir maç aktivitesi üzerinde istatistiksel olarak anlamlı ($p > 0.05$) bir etkisi gözlenmemiştir.

Tablo 8. Genç kızlarda oyun yüzeyinin etkileri için ANOVA sonuçları

Maç oyunu özellikleri	*F*	*P*	η^2	*Post hoc*
İlk servis (%)	0.391	0.677	0.01	-
İlk servisten kazanılan puan (%)	2.292	0.107	0.05	-
İkinci servisten kazanılan puan (%)	1.631	0.201	0.03	-
Ortalama set süresi (dakika)	1.172	0.314	0.03	-
Set başına ace (#)	1.042	0.357	0.02	-
Set başına çift hata (#)	0.365	0.695	0.01	-
Set başına kazanan vuruş (#)	-	-	-	-
Set başına basit hata (#)	-	-	-	-
File önünde kazanılan puanlar (%)	-	-	-	-
Kazanılan servis kırma puanları (%)	0.159	0.853	0.01	-
Kazanılan servis karşılama puanları (%)	1.227	0.298	0.03	-
Kazanılan toplam puan	-	-	-	-

- sayı, Ç= Çim, B= Beton, T= Toprak

Tablo 9, profesyonel kadın oyuncularda oyun yüzeyinin etkileri için ANOVA sonuçlarını göstermektedir. Araştırma bulglarında, kort yüzeyinin kazanılan ilk servis puanı yüzdesi ($p < 0.05$, $\eta^2 = 0.06$), ortalama set süresi ($p < 0.05$, $\eta^2 = 0.05$) ve kazanılan servis karşılama sayısı ($p < 0.05$, $\eta^2 = 0.04$) açısından anlamlı olarak etkili olduğu görülmüştür. Post hoc sonuçları, profesyonel kadın oyuncuların çim ve beton kortlarda, toprak kortlara kıyasla anlamlı olarak daha yüksek oranda ilk servis sayısı kazandığını ortaya koymuştur. Kadın oyuncuların ortalama set süreleri beton kortta çim korta göre anlamlı derecede daha yüksektir. Ayrıca, toprak kortta kazanılan geri dönüş puanlarının yüzdesi çim ve beton kortlara kıyasla anlamlı olarak daha yüksekti.

Genç erkeklerde oyun yüzeyinin etkileri için ANOVA sonuçları Tablo 10'da gösterilmiştir. Genç erkeklerde ilk servis puanı yüzdesinin ($p < 0.01$, $\eta^2 = 0.14$) ve set başına set başına kazanılan doğrudan sayısının ($p < 0.05$, $\eta^2 = 0.13$) kort yüzeyinden anlamlı olarak etkilendiği bulunmuştur. Post hoc sonuçlarında, genç erkeklerin çim kortta, toprak korta kıyasla anlamlı olarak daha yüksek oranda ilk servis sayısı kazandıkları görülmüştür. Ayrıca çim ve beton kortlarda, toprak korta kıyasla set başına anlamlı olarak daha yüksek set başına kazanılan ace elde etmişlerdir.

Tablo 9. Profesyonel kadın oyuncularda oyun yüzeyinin etkileri için ANOVA sonuçları

Maç oyunu özellikleri	*F*	*P*	η^2	*Post hoc*

İlk servis (%)	0.113	0.893	0.01	-
İlk servisten kazanılan puan (%)	5.662	0.004	0.06	T<Ç,B; Ç=B
İkinci servisten kazanılan puan (%)	0.272	0.762	0.01	-
Ortalama set süresi (dakika)	4.558	0.012	0.05	B>Ç; T=Ç
Set başına ace (#)	2.763	0.066	0.03	-
Set başına çift hata (#)	1.467	0.233	0.02	-
Set başına kazanan vuruş (#)	2.469	0.087	0.03	-
Set başına basit hata (#)	1.454	0.236	0.02	-
File önünde kazanılan puanlar (%)	1.436	0.241	0.02	-
Kazanılan servis kırma puanları (%)	1.323	0.269	0.01	-
Kazanılan servis karşılama puanları (%)	4.313	0.015	0.04	T>Ç,B; Ç=B
Kazanılan toplam puan	-	-	-	-

- sayı, Ç= Çim, B= Beton, T= Toprak

Tablo 10. Genç erkeklerde oyun yüzeyinin etkileri için ANOVA sonuçları

Maç oyunu özellikleri	*F*	*P*	η^2	*Post hoc*
İlk servis (%)	1.244	0.293	0.03	-
İlk servisten kazanılan puan (%)	7.500	0.001	0.14	Ç>T; G=H
İkinci servisten kazanılan puan (%)	0.018	0.982	0.01	-
Ortalama set süresi (dakika)	1.045	0.356	0.02	-
Set başına ace (#)	6.832	0.002	0.13	C<G,H; G=H
Set başına çift hata (#)	0.460	0.633	0.01	-
Set başına kazanan vuruş (#)	-	-	-	-
Set başına basit hata (#)	-	-	-	-
File önünde kazanılan puanlar (%)	-	-	-	-
Kazanılan servis kırma puanları (%)	0.636	0.532	0.01	-
Kazanılan servis karşılama puanları (%)	0.114	0.892	0.01	-
Kazanılan toplam puan	-	-	-	-

- sayı, Ç= Çim, B= Beton, T= Toprak

Tablo 11, profesyonel erkek oyuncularda oyun yüzeyinin etkileri için ANOVA sonuçlarını göstermektedir. Sonuçlar, ilk servis yüzdesi ($p < 0.05$, $\eta^2 = 0.06$),

kazanılan ilk servis puanı yüzdesi ($p < 0.01$, $\eta^2 = 0.08$), ortalama set süresi ($p < 0.05$, $\eta^2 = 0.04$), set başına set başına kazanılan ace ($p < 0.01$, $\eta^2 = 0.11$), set başına çift hata ($p < 0.01$, $\eta^2 = 0.09$) ve kazanılan karşılama puanı yüzdesi ($p < 0.01$, $\eta^2 = 0.06$) profesyonel erkek oyuncularda kort yüzeyinden anlamlı olarak etkilenmiştir.

Tablo 11. Profesyonel erkek oyuncularda oyun yüzeyinin etkileri için ANOVA sonuçları

Maç oyunu özellikleri	*F*	*P*	η^2	*Post hoc*
İlk servis (%)	5.842	0.003	0.06	T>B; Ç=T,B
İlk servisten kazanılan puan (%)	8.474	0.001	0.08	T<B,Ç; K=B
İkinci servisten kazanılan puan (%)	0.295	0.745	0.01	-
Ortalama set süresi (dakika)	3.738	0.026	0.04	-
Set başına ace (#)	11.818	0.001	0.11	T<Ç,B; Ç=B
Set başına çift hata (#)	9.470	0.001	0.09	T<Ç,B; Ç=B
Set başına kazanan vuruş (#)	0.461	0.631	0.01	-
Set başına basit hata (#)	0.648	0.524	0.01	-
File önünde kazanılan puanlar (%)	0.798	0.452	0.01	-
Kazanılan servis kırma puanları (%)	0.062	0.940	0.01	-
Kazanılan servis karşılama puanları (%)	6.431	0.002	0.06	T>Ç; B=T,Ç
Kazanılan toplam puan	-	-	-	-

- sayı, Ç= Çim, B= Beton, T= Toprak

Tablo 12, genç oyuncularda kort yüzeyine göre cinsiyet farklılıklarını göstermektedir. Sonuçlar, genç erkeklerin çim ($p < 0.01$, $d = -1.27$), toprak ($p < 0.01$, $d = -0.92$) ve beton ($p < 0.01$, $d = -0.96$) kortlarda kazanılan ilk servis puanlarının yüzdesini anlamlı olarak daha yüksek gerçekleştirdiğini göstermiştir. Ortalama set süresinde cinsiyet farkı sadece çim kortta mevcuttur. Genç kızlar çim kortta anlamlı derecede daha yüksek ortalama set süresi ($p < 0.05$, $d = 0.62$) sergilemiştir. Genç erkekler çim kortta ($p < 0.01$, $d = -0.86$) ve beton kortta ($p < 0.01$, $d = -0.68$) set başına anlamlı olarak daha yüksek set başına ace yapmıştır. Genç kızlarda set başına çift hata sayısı çim kortta anlamlı derecede daha yüksektir ($p < 0.01$, $d = 0.73$). Set başına çift hatalarda cinsiyet farkı toprak ve beton kortlarda anlamlı olarak ($p > 0.05$) mevcut değildir. Genç kızların çim ($p < 0.01$, $d = 1.22$) ve beton kortlarda ($p < 0.05$, $d = 0.65$) set başına anlamlı olarak daha fazla basit hataya sahip olduğu görülmüştür. Genç erkekler çim kortta anlamlı olarak daha fazla file önünde kazanılan puan yüzdesi elde etmiştir ($p < 0.01$, $d = -069$). Toprak ($p < 0.05$, $d = 0.47$) ve beton ($p < 0.05$, $d = 0.62$) kortlarda

kazanılan karşılama puanı yüzdesinde cinsiyet farkı gözlenmiştir. Genç kadınlar kazanılan karşılama puanı yüzdesinde anlamlı olarak daha yüksek performans göstermiştir. Kazanılan toplam puanlardaki tek cinsiyet farkının çim kortta olduğu görülmüştür ($p < 0.05$, $d = 0.62$). Genç kadınlar çim kortta anlamlı derecede daha yüksek toplam puan kazanmıştır.

Tablo 12. Genç oyuncularda kort yüzeyine göre cinsiyet farklılıkları

Maç oyunu özellikleri	Çim			Toprak			Beton		
	t	*P*	*d*	*T*	*P*	*d*	*t*	*P*	*d*
İlk servis (%)	-1.409	0.164	-0.35	-0.893	0.375	-0.22	0.303	0.763	0.08
İlk servisten kazanılan puan (%)	-5.082	0.001	-1.27	-3.677	0.001	-0.92	-3.845	0.001	-0.96
İkinci servisten kazanılan puan (%)	-2.106	0.039	-0.53	-1.887	0.064	0.47	-0.403	0.689	-0.10
Ortalama set süresi (dakika)	2.463	0.017	0.62	1.334	0.187	0.33	-0.051	0.959	-0.010
Set başına ace (#)	-3.455	0.001	-0.86	-0.696	0.489	-0.17	-2.713	0.009	-0.68
Set başına çift hata (#)	2.910	0.005	0.73	1.633	0.108	0.41	1.163	0.249	0.29
Set başına kazanan vuruş (#)	-0.392	0.697	-0.10	-	-	-	0.471	0.639	0.12
Set başına basit hata (#)	4.863	0.001	1.22	-	-	-	2.616	0.011	0.65
File önünde kazanılan puanlar (%)	-2.752	0.008	-0.69	-	-	-	-0.626	0.534	-0.16
Kazanılan servis kırma puanları (%)	-0.886	0.379	-0.22	-0.196	0.845	-0.05	-1.801	0.077	-0.45
Kazanılan servis karşılama puanları (%)	1.950	0.056	0.49	1.890	0.063	0.47	2.475	0.016	0.62
Kazanılan toplam puan	2.487	0.016	0.62	-	-	-	1.025	0.309	0.26

Tablo 13 profesyonel oyuncularda kort yüzeyine göre cinsiyet farklılıklarını göstermektedir. Kazanılan ilk servis puanı yüzdesi, kazanılan ikinci servis puanı yüzdesi, set başına basit hata ve kazanılan karşılama puanı gibi maç aktivitelerinde cinsiyet farkı çim, toprak ve beton kortlarda anlamlı olarak mevcuttur. Profesyonel erkek oyuncular çim ($p < 0.01$, d = -0.62), toprak ($p < 0.01$, $d = -0.56$) ve beton ($p < 0.01$, $d = -0.70$) kortlarda kadınlara kıyasla anlamlı olarak daha yüksek ilk servis puanı yüzdesi sergilemiştir. Erkekler çim ($p < 0.05$, d = -0.39), toprak ($p < 0.05$, $d = -0.43$) ve beton ($p < 0.05$, $d = -0.38$) kortlarda kazanılan ikinci servis puanlarının yüzdesinde anlamlı derecede daha yüksek performans göstermiştir. Cinsiyet, üç kortta da set başına set başına kazanılan doğrudan sayısında anlamlı olarak etkili olmuştur. Erkekler çim ($p < 0.01$, d = -1.01), toprak ($p < 0.05$, $d = -0.44$) ve beton ($p < 0.01$, $d = -0.90$) kortlarda set başına anlamlı olarak daha yüksek set başına ace sergilemiştir.

Kadınlar çim ($p < 0.05$, $d = 0.36$) ve toprak ($p < 0.05$, $d = 0.74$) kortlarda set başına anlamlı olarak daha yüksek çift hata yapmıştır. Çim kort, set başına kazanan vuruşte cinsiyet farkının mevcut olduğu tek korttu. Çim kortta erkekler kadınlara kıyasla set başına anlamlı derecede daha yüksek kazanan vuruş performansı sergilemiştir ($p < 0.01$, $d = -0.52$). Cinsiyet, her üç kortta da set başına basit hatalarda anlamlı olarak etkili olmuştur. Kadınlar çim ($p < 0.05$, $d = 0.36$) toprak ($p < 0.01$, $d = 0.74$) ve beton ($p < 0.05$, $d = 0.35$) kortlarda set başına daha fazla basit hata yapmıştır. Kadınlar beton kortta kazanılan servis kırma puanı yüzdesinde anlamlı derecede daha yüksek performans göstermiştir ($p < 0.05$, $d = 0.41$). Kazanılan karşılama puanı yüzdesinde cinsiyet farkının üç kortta olduğu görülmüştür. Kadınlar çim ($p < 0.01$, $d = 1.16$), toprak ($p < 0.01$, $d = 0.96$) ve beton ($p < 0.01$, $d = 0.93$) kortlarda anlamlı olarak daha yüksek karşılama puanı yüzdesi elde etmiştir. Aynı zamanda, Cinsiyet çim ($p < 0.01$, $d = -1.88$) ve beton ($p < 0.01$, $d = -1.96$) kortlarda kazanılan toplam puanlar açısından anlamlı olarak etkili olmuştur.

Tablo 13. Profesyonel oyuncularda kort yüzeyine göre cinsiyet farklılıkları

Maç oyunu özellikleri	Çim			Toprak			Beton		
	t	*P*	*d*	*t*	*P*	*d*	*t*	*P*	*d*
İlk servis (%)	-0.143	0.887	-0.03	-0.683	0.496	-0.12	1.769	0.079	0.31
İlk servisten kazanılan puan (%)	-3.488	0.001	-0.62	-3.165	0.002	-0.56	-3.932	0.001	-0.70
İkinci servisten kazanılan puan (%)	-2.231	0.027	-0.39	-2.418	0.017	-0.43	-2.137	0.035	-0.38
Ortalama set süresi (dakika)	-0.311	0.756	-0.06	-0.857	-0.393	-0.15	0.579	0.564	0.10
Set başına ace (#)	-5.717	0.001	-1.01	-2.508	0.013	-0.44	-5.074	0.001	-0.90
Set başına çift hata (#)	2.029	0.045	0.36	4.169	0.001	0.74	1.953	0.053	0.35
Set başına kazanan vuruş (#)	-2.930	0.004	-0.52	0.360	0.719	0.06	-0.517	0.606	-0.09
Set başına basit hata (#)	2.057	0.042	0.36	3.661	0.001	0.65	2.550	0.012	0.45
File önünde kazanılan puanlar (%)	-1.756	0.082	-0.31	-0.929	0.355	-0.16	-0.405	0.686	-0.07
Kazanılan servis kırma puanları (%)	2.216	0.028	0.39	1.441	0.152	0.26	2.323	0.022	0.41
Kazanılan servis karşılama puanları (%)	6.586	0.001	1.16	5.333	0.001	0.94	5.235	0.001	0.93
Kazanılan toplam puan	10.606	0.001	-1.88	-	-	-	11.108	0.001	-1.96

BÖLÜM 5

TARTIŞMA

Bu bulgular, her yaş ve saha yüzeyi için uygun antrenman programlarının önemini vurgulamaktadır. Bu çalışmanın antrenörler ve sporcular için önerilen birkaç pratik sonucu vardır. İlk olarak, bir tenis oyuncusunu eğitirken, sporcuların yüzeyle ilgili performansını geliştirmek için kort tabanlı uzun ve kısa vadeli antrenman yöntemlerine daha fazla önem verilmelidir. İkinci olarak, antrenörler, genç ve profesyonel oyuncular arasındaki istatistiksel maç aktivite farklılıklarını dikkate almalı ve bu farklılıklara neyin sebep olduğu konusunda daha doğru bilgiler edinmelidir. Ayrıca, farklı kort yüzeylerinde cinsiyete dayalı antrenman hem genç hem de profesyonel sporculara uygulanmalıdır. Sporcuların maç performansı ve antrenman yöntemlerinin çeşitli yönleri hakkında daha derin bir anlayışa sahip olmak için boylamsal çalışmalar gereklidir.

5.1. Sonuç

Bu çalışmada, genç ve profesyonel tenis oyuncularının toprak, çim ve beton kort yüzeylerindeki maç aktiviteleri arasındaki farklar incelenmiştir. Profesyonel oyuncular, tüm kort yüzeylerinde genç oyunculara kıyasla daha fazla ortalama set süresi ve set başına set başına kazanılan doğrudan sayısı sergilemiştir. Genç erkeklerde çim ve beton kortlarda kazanılan dönüş sayıları profesyonellere kıyasla belirgin şekilde daha yüksektir. Profesyonel kadınlarda çim kortta kazanılan ilk servis sayıları ve kazanılan toplam sayı oranları belirgin şekilde daha yüksektir. Profesyonel erkek oyuncular arasında, kazanılan ilk servis sayısı, set başına set başına kazanılan doğrudan sayısı ve set başına çift hata sayısı gibi ölçütlerin toprak kortlara kıyasla çim ve beton kortlarda anlamlı olarak yükseldiği görülmüştür. Genç erkekler, genç kızlara kıyasla çim, toprak ve beton kortlarda anlamlı olarak daha yüksek bir ilk servis sayısı kazanma yüzdesi sergilemiştir. Profesyonel erkek oyunculardа, her üç kort türünde de kadın meslektaşlarına kıyasla kazanılan ilk servis sayıları ve set başına set başına kazanılan doğrudan sayıları anlamlı olarak daha yüksekti. Bu çalışma, antrenman yöntemi açısından antrenörler ve oyuncular için yol gösterici olabilir. İyi

şekillendirilmiş antrenman programlarına ilişkin yeni perspektifler elde etmek için daha fazla uzun vadeli çalışma yapılması gerekmektedir.

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