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Effect of Sport Age on Selected Motor and Tennis Specific Performances on Tennis Players: An Observational Study

Tenisçilerde Spor Yaşının Seçilmiş Motor ve Tenise Özgü Performans Parametreleri Üzerine Etkisi: Gözlemsel Bir Çalışma

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ABSTRACT Objective: The aim of this study was to examine the effect of experience on selected motor and tennis specific performances in elite tennis players. **Material and Methods:** The study included 54 (24 female and 30 male) elite tennis players in the age range of 18-30 years, who have been actively playing tennis for at least 5 years and participated in national and international competitions. The participants were assessed for serve speed, agility performance, jumping performance, and dynamic balance. The serve speed test, shark skill test (SST), triple hop test (THT), and Y balance test were used to evaluate the serving performance, agility, jump performance, and dynamic balance, respectively. **Results:** Experience had a statistically significant and positive relationship with serving speed ($r=0.662$; $p<0.01$) and THT ($r=0.497$; $p<0.01$), and a significant negative relationship with the non-dominant side SST ($r=-0.417$; $p<0.01$). However, there was no significant relationship between experience and dynamic balance ($p>0.05$). **Conclusion:** The athletic performance of individuals who are engaged in sports for longer period was better and thus, the experience should be taken into account when evaluating the sportive performance. The results obtained in our study are thought to be a reference for future studies by providing information to researchers in the development and evaluation of performance in tennis.

Keywords: Age of onset; balance; performance; tennis

ÖZET Amaç: Bu çalışmanın amacı, elit tenis sporcularında spor yaşının seçilmiş motor ve tenise özgü performans üzerine etkisini incelemektir. **Gereç ve Yöntemler:** Çalışmaya en az 5 yıldır aktif tenis oynayan, ulusal ve uluslararası müsabakalara katılım gösteren 18-30 yaş arasında 54 (24 kadın ve 30 erkek) elit tenis sporcusu dâhil edildi. Çalışmaya dâhil edilen sporcuların servis atış hızları, çeviklik performansı, sıçrama performansları ve dinamik dengeleri değerlendirildi. Çalışmaya dâhil edilen sporcuların servis performansı, servis hızı testi ile çeviklik performansı, shark skill testi (SST) ile sıçrama performansı, tek bacak üçlü hop testi ile denge, dinamik olarak Y denge testi ile değerlendirildi. **Bulgular:** Çalışmada spor yaşı ile servis atış hızı ($r=0,662$; $p<0,01$) ve tek bacak üçlü hop testi ($r=0,497$; $p<0,01$) arasında istatistiksel olarak anlamlı ve pozitif yönde ilişki bulunurken non-dominant taraf SST ile anlamlı ve negatif yönde ilişki olduğu tespit edilmiştir ($r=-0,417$; $p<0,01$). Ancak spor yaşı ile dinamik denge arasında anlamlı bir ilişki olmadığı bulunmuştur ($p>0,05$). **Sonuç:** Bu çalışmanın sonucunda, daha uzun süreler spor ile uğraşan bireylerin sportif performanslarının daha iyi olduğu ve sportif performans değerlendirilmesinde spor yaşının göz önünde bulundurulmasının, performans üzerine olumlu etki göstereceği belirtilmiştir. Çalışmamızda elde edilen sonuçlar tenis sporunda spor yaşının bilinmesinin de performansın geliştirilmesi ve değerlendirilmesinde araştırmacılara bilgiler vererek gelecekteki çalışmalara referans olacağı düşünülmektedir.

Anahtar Kelimeler: Başlama yaşı; denge; performans; tenis

Unlike some sports, tennis is commonly played at all age groups and has a high commitment rate.[1] While many sports require high precision, professionally playing tennis requires a high level of physical fitness over a long period of time.[2] During their training and matches, tennis players perform repetitive dynamic movements that include acceleration, deceleration, multidirectional agility, and explosive jumps.[2] As an important factor in overall functional performance, tennis serve performance requires complex muscle activations that rely on power generation from multiple body parts. Therefore, the most appropriate tests in tennis are the ones that evaluate sport-specific functional factors such as serve speed.

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Serve speed is one of the most important parameters that determine the power and performance of tennis players and depends on several factors including upper extremity strength and shoulder joint range of motion. It is the only stroke that is completely under the control of the player rather than being a response to a ball from the opponent.[3] According to Akşit, physical features such as balance, strength, endurance, flexibility, coordination, and anaerobic and aerobic capacity are necessary for an efficient and powerful stroke in tennis.[4] The serve in tennis requires the involvement of several body segments, complex and coordinated muscle activations in a timely manner, and high level of power generation.[5] A lower serve speed negatively affects the performance of tennis players.[6]

Alike serve speed, agility plays a key role in performance. Thus, agility training is required to improve performance and to prevent injuries. Agility together with explosive power is important in returns, forehand volleys, and cross-court shots.[7] Balance is one of the fundamentals of tennis training programs, given the fact that some matches can last up to 3 hours.[8] Allowing the body to maintain control while hitting the ball, dynamic balance is a difficult skill to master. As the game speed increases, maintaining balance for a powerful and accurate stroke gets challenging. Thus, improving dynamic balance skills remain a necessity in tennis.[9]

Jumping is another important parameter in reflecting the performance in a tennis game. The main mechanism behind jump performance is associated with strength and other strength-related features (e.g., peak strength, velocity, and power generating capacity).[10] Jump height is an indicator of leg muscle strength and provides important information about functional capacity and performance in many sports. Vertical jumps require high motor coordination between the upper and lower extremities. In addition, some sport-specific jumping types are considered as basic motor skills.[11]

Most of the research in the relevant literature are commonly descriptive studies on the physiological, biomechanical, and performance parameters of tennis in comparison to other sports. However, not only anthropometric, biometric, physical, and technical-tactical characteristics, but also experience can influence performance in tennis.[12] Despite few studies examining the relationship of age and physical fitness, service speed, range of motion, and strength in elite tennis players, there is no study examining the effect of experience.[13-16]

This study aimed to examine the effect of experience on selected motor and tennis specific performances in elite tennis players. Our hypothesis was a direct relationship between experience and performance parameters.

MATERIAL AND METHODS

PARTICIPANTS

This prospective, observational study was carried out between December 2020 and July 2021. A total of 54 (24 women and 30 men) active tennis players participating in national and international competitions were included in the study. All participants had a history of minimum 5 years of playing tennis, no previous injury or surgery in their upper and lower extremities in the last 6 months.

The study was approved by Üsküdar University Non-Invasive Research Ethics Committee (date: November 26, 2020, no: 61351342/ 2020-582) and was conducted in accordance with the Declaration of Helsinki. The participants were informed about the aim and evaluation methods of the study. Socio-demographic data (including age, gender, height, weight, experience, and dominant hand and leg) were recorded. The participants signed informed consent forms.

EVALUATIONS

The participants were assessed for serve speed, agility performance, jumping performance, and dynamic balance. Before each evaluation, the participants completed the required warm-ups with 2 minutes of rest intervals between the evaluations.

SERVE SPEED TEST

As an important determinant of serve performance, the serve speed was measured in kilometers per hour with a calibrated radar gun (Bushnell 1101911 Ve-

locity Speed Gun, Overland Park, Kansas) [Intraclass correlation coefficient (ICC)=0.91-0.94].[17,18] All serves were performed in a closed tennis court to control the effect of the weather in measuring serve speed. The participants used their own rackets and standard tennis balls (diameter=6.7 cm, weight=58.4 g) in accordance with the standards of the International Tennis Federation. Each participant served 2 sets of 8 repetitions 1 meter behind the baseline. The radar gun was held 4 m behind the mid-baseline, as high as approximately 2.2 m, as shown in Figure 1. Participants were asked to serve 8 maximal repetitions with 30s of rest between serves. Serves that failed to land within the center mark were disregarded. For each participant, the average of recorded serve speeds was calculated and used for further analyses.

AGILITY PERFORMANCE

The shark skill test (SST) was used to assess lower extremity agility and neuromuscular control.[19] Using a floor marking tape, a 3×3 square grid was arranged on the floor (Figure 2). The participants were asked to stand in the middle square on one leg with their hands on their hips. They were instructed to hop to each box following a simple clockwise pattern and return to the center box each time. Prior to performing the timed test, the participants had a practice run on each foot. They performed the test twice on each foot and test results were recorded in seconds. One tenth of a second was added to the test result when the participant 1) Touched the ground with the other foot, 2) Removed their hands from hips, 3) Hopped into the wrong square, or 4) Did not return to the center square. The reliability of the test has been reported.[19]

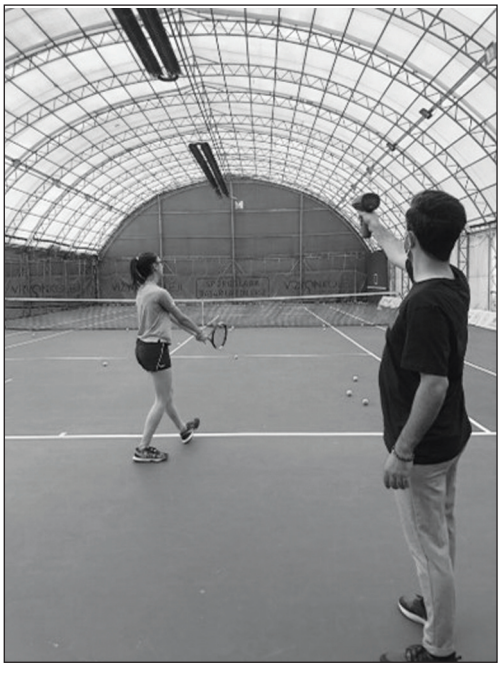

FIGURE 1: Radar gun.

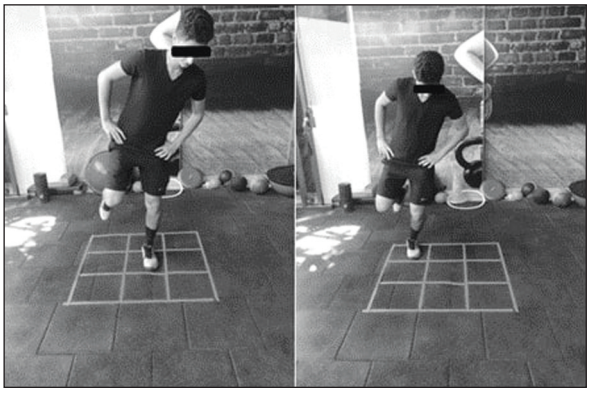

FIGURE 2: Shark skill test.

HOP PERFORMANCE

As a functional performance test, the single-leg triple hop test (THT) was used to assess hop performance. The test is reported as a reliable tool with ICC values of 0.92-0.97.[20] Before starting the test, the participants performed a standardized warm-up program (squats: 2 sets of 8 reps, and jumps: 2 sets of 5 reps). The participants were asked to stand behind the starting line on their dominant leg, hop forward as far as possible, and land firmly. Each participant repeated 3 consecutive hops and retained single-leg stance for 2 seconds after the last hop. During the test, the participants were allowed to use their arms to assist the explosive hop or for balance.

The total distance was measured from the starting point to the heel of the landing foot. Each hop was followed with a 30-second rest period. If the third hop had the largest distance, the participant performed a fourth hop. Yet, if the fourth had the largest distance, the average of all 4 hops was recorded. The test was considered invalid if the participant failed to retain balance, fell, or stepped forward, and if the hands or other foot touched the ground.[20]

DYNAMIC BALANCE

Dynamic balance was evaluated with the Y balance test (YBT), which is a modified form of star balance test. The test is reported as a reliable tool with ICC values of 0.85-0.91. The standard YBT kit was used in the present study. The participants were asked to stand on one leg at the midpoint of the test setup and reach out with the other foot in 3 different directions, namely anterior, posteromedial, and posterolateral. The test was repeated 3 times in all directions and the average was recorded in centimeter. The test was deemed invalid in case of losing balance at any time during the test.[21]

STATISTICAL ANALYSIS

All statistical analysis was performed using SPSS 25 Statistics Software (SPSS Inc. Chicago, IL). Data were tested for normality using the Kolmogorov-Smirnov test. Averages and standard deviations were calculated for each of the variables. Pearson correlation coefficients were calculated between sport age and the selected motor and tennis specific performances test scores. To describe the strength of the correlation, the following scale was used for the absolute value of the correlation coefficient (r): strong relationship ($0.50 \leq r \leq 1.0$), moderate relationship ($0.3 \leq r < 0.5$), and weak relationship ($r < 0.3$). The level of significance for all analysis was set at $p \leq 0.05$.[22]

RESULTS

The physical and demographic characteristics of the participants are shown in Table 1. Experience had a statistically significant positive correlation with serve speed ($r=0.662$; $p<0.01$) and single THT ($r=0.497$; $p<0.01$), and it had a significant negative correlation ($r=-0.417$; $p<0.01$) with the non-dominant leg SST. However, there was no significant relationship between experience and dynamic balance (Table 2).

DISCUSSION

The results of the present study investigating the effects of experience on performance in elite tennis players showed that experience was associated with serve speed, agility, and jumping performances. However, experience had no correlation with dynamic balance.

The serve speed is an important test used in the functional evaluation of tennis players. Hence, the fundamentals of an efficient serve (e.g., muscle strength, range of motion, stability, flexibility, and transfer of force in the kinetic chain) should be included in training strategies to increase serve performance.[23] Studies investigating the relationship between performance and success of athletes suggest that together with strength, range of motion, flexibility, and training history, long-term sports experience may also play a key role.[24,25] Serve speed is one of the important determinants of performance in tennis players. Girard and Millet reported that in elite athletes, besides lower extremity strength, age also has an impact on serve speed.[26] Consistent with the literature, our study supports that service speed is one of the important sport-specific performance determinants in tennis. While there is no previous study investigating the relationship between experience and serve speed performance, we found a direct relationship between these two. However, more studies are needed to identify the determinants of serve speed. The aforementioned relationship can help sports-related healthcare professionals and researchers in es-

TABLE 1: Physical and demographic characteristics of the participants.

	Minimum	Maximum	$\bar{X}$	SD
Age (years)	18	35	23.69	5.75
Height (cm)	144	198	172.19	10.73
Weight (kg)	37	88	62.33	13.15
BMI (kg/m^2)	14.53	29.75	20.85	3.21
Experience (years)	5	16	8.72	2.78

SD: Standard deviation; BMI: Body mass index.

TABLE 2: The relationship between experience and performance.

Experience	r value	p value
Performance		
Serve speed (km/s)	0.662**	0.001
Single leg triple hop test (cm)	0.497**	0.001
Shark skill test (Right) (sec)	0.095	0.493
Shark skill test (Left) (sec)	-0.417**	0.002
Y-balance		
Anterior	0.078	0.576
Posteromedial	0.186	0.178
Posterolateral	0.192	0.164

**p<0.01; r: Pearson's corelation coefficient.

timating the performance accumulation of the athletes, and in post-injury evaluations and treatment protocols.

Agility plays a key role in tennis performance. To evaluate agility, we used the SST, as it is a simple and user-friendly test that requires no specific equipment. Previous studies on agility in tennis have reported a gradual change in agility with age. It is known that performance can improve by including sports-specific agility-enhancing components in the training programs.[7,27]

In a study with 306 young tennis players, it was found that short-distance acceleration and neuromuscular control were associated with agility performance, and that male tennis players had higher agility performance levels compared to female players.[28] We found that experience had a positive effect on the agility performance of the left leg. This can be stemming from the fact that the number of athletes who used their left leg as the jumping leg was higher in our sample.

In tennis, agility is very important in situations where the player is close to the net and needs to hit within a close range.[29] Thus, we used the shark test as it includes sudden change of direction. However, the fact that the shark test is not a tennis-specific test (the racket is not used during the test) is one of the limitations of our study. Given the potential impact of various sports equipment (as used in tennis, squash, rugby, etc.) on agility, there is a need for further studies with a broader evaluation of performance using sport-specific tests and tools.[30]

Tennis is a dynamic sport and jumping performance, which is one of the main performance indicators, is an important feature of neuromuscular control, balance, and success in competitions.[31] The single leg THT evaluates functional performance, and neuromuscular control of athletes and can be used as a return-to-sports test.[31] In tennis, hopping is frequently used in reaching the balls thrown close to the net and in sudden forward moves. Considering that double-leg jump is rarely used in tennis, the single-leg jump test was chosen in our study.

Tennis players frequently perform lateral and forward single leg hops. In our study, experience was found to be associated with hop performance in elite tennis players. This indicates that elite athletes playing for longer periods will be more successful in hopping for quick return hits. Moreover, studies suggest that besides the effects of strength, gender, height, power, and flexibility on hop performance, the rate of muscle contraction types may have the primary impact on this performance.[32,33]

We evaluated the horizontal hop performance of the dominant leg using the THT. However, including the assessments of non-dominant leg and lateral hop could yield stronger results in the evaluation of performance. More studies are needed to evaluate the hoping performance of tennis players in a sport-specific manner.

Dynamic balance forms the basis of one's functional movements. In maintaining dynamic balance, the musculoskeletal and proprioceptive systems are constantly active to enhance postural control.[8] To investigate the effect of experience on dynamic balance, we used the YBT that enables us evaluate balance in 3 directions (i.e., anterior, posteromedial, and posterolateral). In tennis, and similarly in several other sports, high level of dynamic balance is crucial when high motor control such as sudden acceleration or deceleration is required.[34]

There was no significant relationship between experience and the three parameters of the YBT. A study conducted with young tennis players under the age of 19 stated that dynamic balance may be related to anthropometric characteristics.[35] This indicates the need for more studies with narrower age groups to in-

vestigate the relationship between anthropometric measurements and balance parameters and to compare within-group differences.

This study has some limitations that need to be addressed. The first limitation concerns the fact that gender differences were disregarded in our study, however, separately evaluating male and female participants could yield more detailed information. Other than functional parameters, muscular strength also has an impact on hop performance. This constitutes our second limitation and future studies are recommended to evaluate and include muscle strength to have a deeper insight into hop performance. When examining the relationship between experience and agility, we believe that there is a need for studies that also consider the dominant side and leg length. We recommend the use of performance tests in future studies using the racket, including movements specific to tennis.

CONCLUSION

It can be concluded that in elite tennis players, experience can lead to an increase in performance parameters (i.e., serve speed, agility, and hop performance); whereas it had no effect on dynamic balance. The results of this study can be a reference point for future studies by providing information on the development and evaluation of performance, knowing the effect of experience.

Source of Finance

During this study, no financial or spiritual support was received neither from any pharmaceutical company that has a direct connection with the research subject, nor from a company that provides or produces medical instruments and materials which may negatively affect the evaluation process of this study.

Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

Idea/Concept: *Bünyamin Haksever, Çağlar Soylu, Abdullah Samet Er;* ***Design:*** *Bünyamin Haksever, Abdullah Samet Er;* ***Control/Supervision:*** *Bünyamin Haksever, Çağlar Soylu;* ***Data Collection and/or Processing:*** *Bünyamin Haksever, Abdullah Samet Er;* ***Analysis and/or Interpretation:*** *Bünyamin Haksever, Çağlar Soylu;* ***Literature Review:*** *Bünyamin Haksever, Çağlar Soylu, Abdullah Samet Er;* ***Writing the Article:*** *Bünyamin Haksever, Çağlar Soylu, Abdullah Samet Er;* ***Critical Review:*** *Bünyamin Haksever, Çağlar Soylu;* ***References and Fundings:*** *Bünyamin Haksever, Çağlar Soylu;* ***Materials:*** *Abdullah Samet Er.*

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