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A Study On Adolescent Tennis Players: Investigation Of The Relationship Between Change Of Direction And Selective Attention, Simple, Selective And Discrimination Visual Reactions

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ABSTRACT

The tennis branch inherently includes skills that require rapid motor control. In order for athletes to exhibit the desired performance in tennis, it is very important for them to react quickly to stimuli from the opponent, carefully adapt their game setups to the opponent, and respond to changes in direction that may develop during the game. In this context, the relationship between reaction, selective attention, and change of direction skills, which are thought to affect the outcome of the match, is a matter of curiosity. Therefore, the aim of the study is to determine the relationship between change of direction, selective attention, and various reaction parameters in adolescent tennis players. A total of 30 adolescent tennis players, 20 male and 10 female, operating in the province of Ankara were included in the study. The inclusion criteria for the study were determined as having a tennis resume of at least 5 years, actively participating in competitions, not having color blindness, and not having any history of acute illness. The average age of the tennis players was determined as 13±1.32 years, and the average age of tennis was determined as 7±1.86 years. Participants' reaction performances were determined with ÇAĞIN Hand and Foot Reaction Tests, selective attention performances with Flanker Test, and direction change performances with Spider Drill Test. Data obtained from participants were transferred to SPSS 29.0 package program and Pearson Correlation Test and descriptive statistics were applied. When the relationship between direction change and hand/foot reaction performances of tennis players was examined, a significant relationship was found only between direction change and hand discrimination reaction time ($p<0.05$), and no relationship was found between other parameters ($p>0.05$). When the relationship between selective attention and hand/foot reaction performances of tennis players was examined, no significant relationship was found between parameters ($p>0.05$). In the light of the findings obtained, it can be said that there is no significant relationship between reaction, selective attention and direction change skills, which are thought to be the determinants of sports performance in tennis, but that determining the mentioned skills in different methods and sample groups in future studies can contribute to the literature in order to understand the relationships between the relevant parameters in more depth.

keywords: tennis, reaction, change of direction, selective attention, adolescent

INTRODUCTION

Tennis is a technically and tactically demanding racket sport that necessitates a multifaceted integration of physical components, including strength, power, speed, agility, aerobic and anaerobic capacity, and neuromuscular coordination (Fernandez-Fernandez, Mendez-Villanueva and Pluim, 2006). It has been reported that 80% of all strokes in tennis are made within a 2.5-meter area, while 5% are made within an area greater than 4.5 meters (Ferrauti, Weber and Wright, 2003). These results suggest that accelerations, decelerations, and changes of direction are of primary importance in tennis compared to maximum sprint speed (Madruga-Parera et al., 2020). This is because in tennis, with the increase in technical and tactical performance comes an increase in the pace of the game, so from an early age tennis players tend to position themselves close to the sidelines of the court (Kovalchik and Reid, 2017). Therefore, change of direction (COD) performance has been recognized as one of the most important physical attributes in tennis. In a recent study, a sample of 1434 junior tennis players (11-17 years old), a strong correlation was found between COD speed and tennis performance (i.e., ranking in tennis) (Ulbricht, Fernandez-Fernandez, Mendez-Villanueva and Ferrauti, 2016).

In-game adaptations (visual search strategies), prediction and decision-making skills were found to be superior in advanced tennis players (Masters, Poolton, Maxwell ve Raab, 2008). Tennis requires visual processing (visuospatial orientation) and cognitive control to make informed decisions with specific tennis motor skills. Grigore et al. (2015) showed that there is a positive correlation between decision-making time and sport performance (i.e., ranking in tennis) in elite tennis players aged 15-17 years. Furthermore, tennis players with improved decision-making skills are able to use movement pattern information to strategically determine stroke selection, reduce their reaction latency and hence improve their stroke performance (Shim, Carlton, Chow and Chae, 2005).

Reaction time has a long history as a popular measure of human motor skill performance and has been associated with motor performance (Singh, Raza and Mohammad, 2011). Cognitive functions are important for sport performance, as sport requires cognitive tasks such as decision making, planning and perception. Athletes develop cognitive functions depending on their discipline (open and closed skill sports) (Chiu, Chen and Muggleton, 2017). For example, tennis, being an open skill sport, requires planning, perception, visual skills, and cognitive control in training or during a match (Ishihara, Sugasawa, Matsuda and Mizuno, 2017). Magill and Anderson (2010) divided reaction time into three main groups: a) simple reaction time (in this reaction time there is only one stimulus and only one response to this stimulus), b) selective reaction time (in this type of reaction time there is more than one stimulus and a different behavior for each stimulus) and discrimination reaction time, c) (in this type of reaction time there is more than one stimulus but only one behavior).

Reaction time is prominently involved in the open skills required in several sports (e.g., boxing, ice hockey). In baseball, for example, the entire trajectory of a pitch may measure only 400 ms and the swing of the bat may take 120 ms (R. Schmidt, 2008). Thus, if a batter takes an extra 100 ms to perceive the velocity and trajectory of the pitch, this can severely reduce the chances of successful contact. Previous studies on reaction have found that decision-making time is shorter in highly skilled players than in less skilled players (Gabbett, Kelly and Sheppard, 2008; Serpell, Ford and Young, 2010). These results emphasize the importance of the cognitive component in the training and testing of this complex skill.

Tennis is among the sports branches that require high levels of reaction (Shangguan and Che, 2018). Especially during the game, players may have very little time to both take the appropriate position against the ball coming at high speeds and to choose the stroke against the incoming ball. Therefore, the present study aimed to investigate the relationship between COD test and selective attention and various reaction parameters (simple, selective, discrimination) in adolescent tennis players.

MATERIAL AND METHOD

Study Model

The present study investigated the relationship between various physical tests of tennis players using a single-group experimental study method. The Scientific Research and Publication Ethics Directive of Higher Education Institutions was followed during the study. The participants' age and sports background (licensed) were recorded by checking their license through their coaches. All tests were performed on the same day between 14:00 and 17:00. The selective attention tests were administered in a 22-degree quiet room, while the reaction and change of direction tests were conducted on a 24-degree indoor tennis court. Prior to the measurements, participants were instructed to abstain from strenuous training or alcohol consumption on the day before the measurements. They were also informed that they should not consume stimulant foods (caffeine, energy drinks, etc.) on the day of the measurement. The measurements commenced with a selective attention test that did not require physical effort. Following this, a 15-minute dynamic warm-up protocol was administered to the participants. Reaction tests were then conducted three minutes after the conclusion of the warm-up process. Five minutes following the completion of the reaction tests, the change-of-direction test was administered, and the

measurements were finalized. All tests were administered to the participants twice, and their best scores were taken into consideration.

Study Sample and Population

A total of 30 adolescent tennis players (20 boys and 10 girls) from Ankara were included in the study. The inclusion criteria were as follows: a tennis history of at least 4 years, active participation in competitions, no color blindness, and no history of acute illness. The mean age of the tennis players was found as 13 ± 1.32 years, and their mean tennis age was 7 ± 1.86 years.

Data Collection Tools

The participants' reaction performances were determined using the ÇAĞIN Hand and Foot Reaction Tests, the selective attention performances were determined using the Flanker Test, and the change of direction performances were determined using the Spider Drill Test.

ÇAĞIN Hand and Foot Reaction Tests

The ÇAĞIN Hand and Foot Reaction Test is a test battery applied with FitLight Trainer or BlazePod devices to determine the simple, selective and discrimination reaction performance of the subjects. It is a reaction test battery with very high validity and reliability (r= 0.70-0.90) (Çağın et al., 2024).

ÇAĞIN Color Blindness Test

Prior to the administration of the hand and foot reaction tests, the ÇAĞIN Color Blindness Test was administered to determine the subject's fitness for participation in the study. The subject was presented with a random selection of yellow, red, blue, and green colors and was prompted to identify each color. Participants who correctly identified two colors were included in the test, while those who incorrectly identified any of the colors were excluded from further analysis.

ÇAĞIN Hand Simple Reaction Test

In accordance with the protocol, sensors and a blue cup were positioned on the table. The experiment involved turning off the blue lights, which were programmed to turn on randomly for a duration of 20 seconds. After each light was turned off, the subject was instructed to change their hand and to position the glass so that it touched the half of the cup that was closest to them. Lights that were turned off without a change in hand position or contact with the aforementioned half-area were designated as error points, with a value of 1 point for each error. Following the completion of 20 seconds, the reaction time, the number of lights turned off, and the number of errors were documented. The participants were administered the test twice, and their best performance was evaluated.

ÇAĞIN Hand Selective Reaction Test

According to the protocol, sensors and cups of various colors (blue, red, yellow, and green) were placed on the table. The participants were instructed to pick up the cup and turn off the color of the lights that would be randomly lit for 20 seconds. After each light was turned off, they were asked to change their hand and to touch the glass to the half of the field closest to the subject. Any failure to adhere to these instructions, whether it be a failure to change the hand, to touch the cup to the half-area close to oneself, or to turn off the lights with the cup of the wrong color, was scored as an error (1 point for each error). At the conclusion of 20 seconds, the reaction time, the number of lights turned off, and the number of errors were recorded. The participants were administered the test twice, and their best performance was evaluated.

ÇAĞIN Hand Discrimination Reaction Test

In accordance with the protocol, sensors and a red cup were positioned on the table. The participants were randomly selected to turn off the light of a specific color (blue, red, green, or yellow) that were illuminated simultaneously for a duration of 20 seconds. After the extinction of each color, participants were instructed to transition their hand and make contact with the glass at the half-area closest to themselves. Any failure to adhere to these instructions, whether it be the failure to change hands, to touch the cup to the half-area closest to oneself, or to turn off the incorrect light, was scored as an error, with a point being allotted for each error. Upon completion of 20 seconds, the reaction time, the number of lights turned off, and the number of errors were recorded. The participants performed the test twice, and their best performance was evaluated.

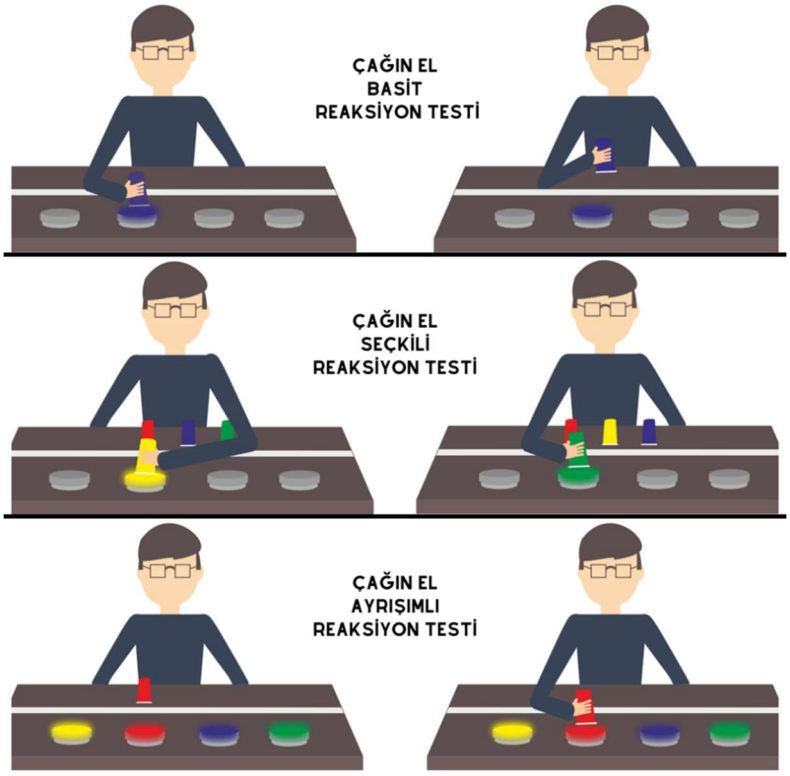

Figure 1. ÇAĞIN Hand Reaction Tests

ÇAĞIN Foot Simple Reaction Test

In accordance with the protocol, sensors and a blue rectangular paper were placed on the floor. The participants were instructed to turn off the blue lights, which were randomly activated for a duration of 20 seconds. After each light was turned off, the foot on the paper that turned off the light was required to change. Lights that were turned off without a change in foot position were designated as error points, with a value of one point for each error. At the conclusion of 20 seconds, the reaction time, the number of lights turned off, and the number of errors made were recorded. The participants were administered the test twice, and their best performance was evaluated.

ÇAĞIN Foot Selective Reaction Test

According to the protocol, sensors and blue, red, yellow, and green rectangular papers were placed on the floor. The participants were asked to turn off the lights randomly for 20 seconds with one foot on the rectangular paper according to its color. After each light was turned off, the foot on the paper and the foot that turned off the light were instructed to change. Any failure to change the foot or turn off the lights by stepping on the incorrect colored paper was designated as an error score (1 point for each error). At the conclusion of 20 seconds, the reaction time, the number of lights turned off, and the number of errors were documented. The participants were administered the test twice, and their best performance was evaluated.

ÇAĞIN Foot Discrimination Reaction Test

The sensors and the red color were placed on the rectangular floor according to the protocol. The participants were randomly asked to turn off only the red color among the blue, red, green, and yellow colors that would light up at the same time for 20 seconds. After each light was turned off, they were asked to change the foot on the paper and the foot that turned off the light. Any failure to change the foot or turn off the incorrect light was recorded as an error, with a point being assigned for each error. At the conclusion of the 20-second period, the reaction time, the number of lights turned off, and the number of errors made were documented. The participants were administered the test twice, and their best performance was evaluated.

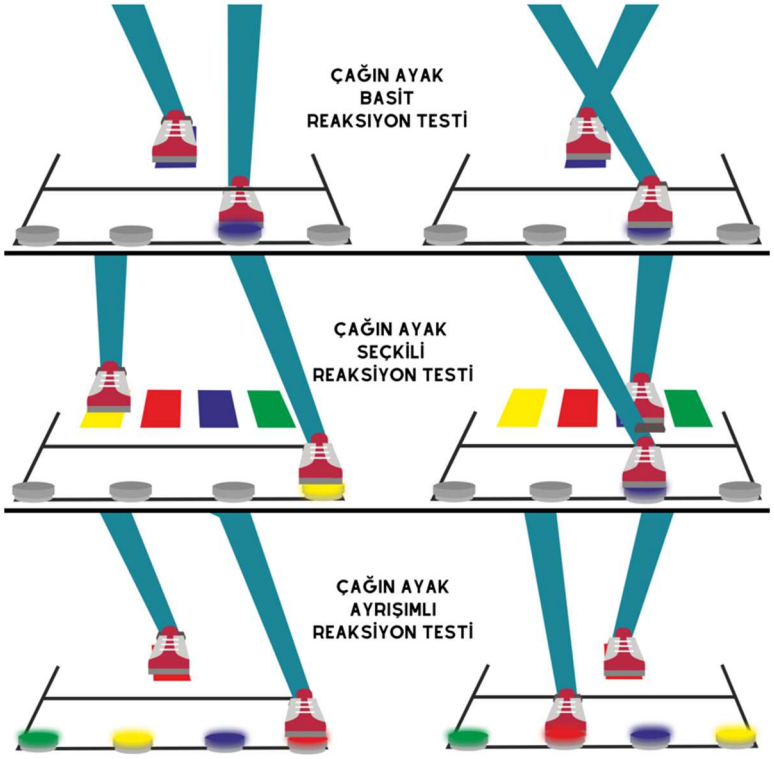

Figure 2. ÇAĞIN Foot Reaction Tests

Statistical Analysis of ÇAĞIN Hand and Foot Reaction Tests

ÇAĞIN Hand and Foot Reaction Tests can determine the participants' average reaction time, total number of touches and number of errors. With this data, the average reaction time as well as the correct and incorrect reaction rate of the participants can be determined.

Average Reaction Time: Automatically determined by the FitLight Trainer after 20 seconds of testing (e.g., 0.444 seconds).

Correct and Incorrect Reaction Rate: The ratio between the total number of touches and the number of errors is taken into account. For example, if the participant touched 20 times and made 5 errors, the correct reaction rate of the participant is 75% and the incorrect reaction rate is 25%.

Flanker Test

The Flanker Test is defined as a psychophysical test that measures selective attention performance. The test was administered in a computer environment using version 2.1 of the PEBL cognitive test battery (Mueller and Piper, 2014). During the experimental session, the participants were instructed to observe arrows arranged horizontally in groups of five or as individual arrows in the center of the computer screen. The subjects were asked to press the "Right Shift" or "Left Shift" keys of the keyboard according to the direction of the arrow if the stimulus appeared individually. In instances where the stimulus was presented in groups of five, the subjects were instructed to press the "Right Shift" or "Left Shift" key of the keyboard according to the direction indicated by the arrow in the center of the group. The test comprised a total of 120 stimuli, with each stimulus appearing on the screen for 500 milliseconds. The subsequent stimulus would then appear 500 milliseconds after the subject's response. Prior to the commencement of the actual test, a preliminary test comprising 12 stimuli was administered to all subjects. The total duration of the test was approximately five minutes.

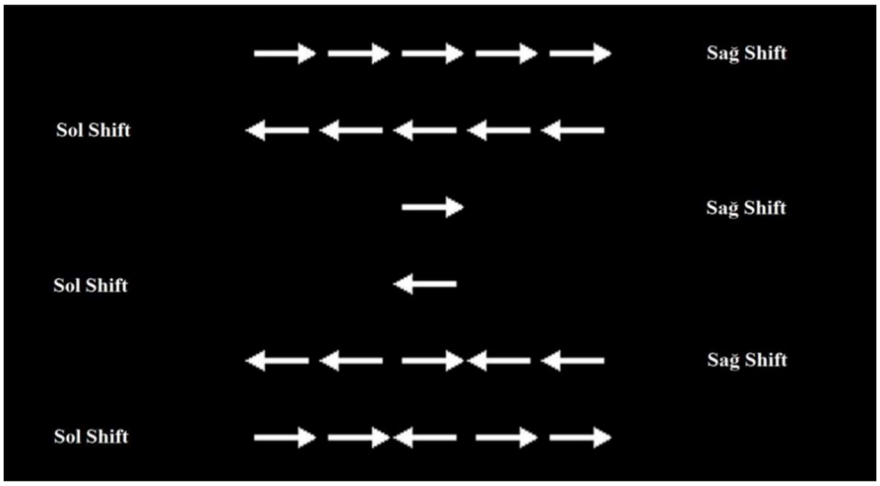

Figure 3. Descriptive visual representing the stimuli applied during the Flanker Test and the keyboard keys to be pressed by the subjects

Spider Drill Test

The Spider Drill test starts with the participants exiting the starting gate. Sprints are performed in a specific pattern, starting with a sprint to the right and moving counterclockwise. The distances for each sprint were variable. After the participants completed the last sprint, they turned 90° to the right and sprinted through the timing gates to finish the test. Sprint times were recorded using Fitlight Trainer (FitLight Corp, Ontario, Canada) sensors placed 0.4 meters above the ground at the start line.

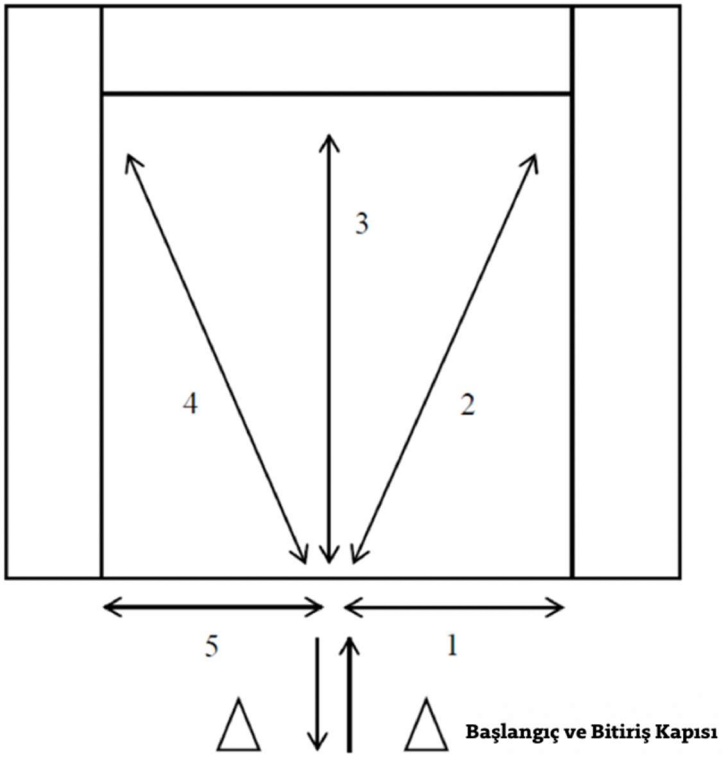

Figure 4. Spider Drill Test

Data Analysis

The data obtained from the participants were transferred to the SPSS 29.0 package program and the Pearson Correlation Test and descriptive statistics were applied. Correlation coefficients between 0.70-1.00 in absolute value was defined as a high level correlation, between 0.69-0.30 as a moderate level correlation, and between 0.29-0.00 as a low level correlation (Büyüköztürk, 2018). The significance level for this study was determined as $p<0.05$.

Study Ethics

The necessary permission was obtained from the Ethics Commission of Gazi University (E-77082166-604.01.02-547090) and the study was conducted in accordance with the Declaration of Helsinki. Participation in the study was voluntary. The parents of the students signed a voluntary consent form and were informed about all details of the study.

FINDINGS

Table 1. Demographic features of the participants

	Mean	Standard Deviation	Lowest	Highest
Age (years)	13.65	1.3	11	16
Height (cm)	166	12.33	139	191
Weight (kg)	57.91	12.11	40	78
Sports Background (years)	7.6	1.83	4	11

A total of 30 male and female tennis players participated in the study. Table 1 shows the demographic characteristics of the participants.

Table 2. The relationship between change of direction and hand/foot reaction parameters

Parameter		Hand Simple reaction (sec)	Hand Selective reaction (sec)	Hand Discrimination reaction (sec)	Foot Simple reaction (sec)	Foot Selective reaction (sec)	Foot Discrimination reaction (sec)
Spider Test (sec)	r	.238	.339	.378*	-.117	.042	.056
	p	.205	.067	**.040**	.537	.825	.770

When the relationship between the change of direction and hand/foot reaction performances of the tennis players was analyzed, a significant relationship was found only between the change of direction and hand discrimination reaction time ($p<0.05$), and no relationship was found between the other parameters ($p>0.05$).

Table 3. The relationship between selective attention and hand/foot reaction parameters

Parameter	Hand Simple reaction (sec)	Hand Selective reaction (sec)	Hand Discrimination reaction (sec)	Foot Simple reaction (sec)	Foot Selective reaction (sec)	Foot Discrimination reaction (sec)

Flanker Test (Number or Errors)	r	.297	.265	.227	-.029	.118	.082
	p	.112	.157	.228	.878	.533	.666

When the relationship between the selective attention and hand/foot reaction performances of the tennis players was analyzed, no significant relationship was found between the parameters ($p>0.05$).

Table 4. The relationship between selective attention and change of direction

	Parameter	Spider Test (sec)
Flanker Test (Number of Errors)	r	.260
	p	.165

When the selective attention and change of direction performances of the tennis players were analyzed, no significant relationship was found between the parameters ($p>0.05$).

DISCUSSION AND CONCLUSION, SUGGESTIONS

The present study aimed to examine the correlation between change of direction and selective attention, as well as simple, selective, and discrimination visual reaction. The findings revealed an absence of a statistically significant relationship between the change of direction test results and hand simple, hand selective, foot simple, foot selective, and foot discrimination reaction parameters. However, a significant relationship was observed between the hand discrimination reaction parameter. Additionally, the flanker test results demonstrated an absence of a statistically significant relationship between the change of direction results and both selective attention and hand/foot reaction test results.

The reaction parameter, a critical performance measure reflecting the speed and efficiency of decision-making, is estimated to influence the performance of tennis players in the match, including agility and change of direction. Given the nature of tennis as an open skill sport, the ability to anticipate and react to opponents' strokes during a match can provide a competitive edge. This underscores the critical role of attention and reaction time in successful performance. The efficacy of these elements hinges on effective decision-making processes (Pesce, Tessitore, Casella, Pirritano and Capranica, 2007). In a previous study the significance of swift decision-making, reaction time, and visual scanning in addition to basic motoric characteristics (speed, power, agility) was underscored for optimal performance (Gabbett, Johns and Riemann, 2008).

In the study conducted by Grigore et al. (2015), a significant relationship between the decision-making time of Romanian tennis players, their attention (alertness to stimuli), and the results they obtained for sports performance was reported, as expressed by tennis ranking. In a study encompassing players with varying degrees of experience in tennis training, players with more extensive training exhibited superior performance in reaction time (switching task) and working memory (Xu et al., 2022). These findings underscore the significance of tennis training experience on reaction time.

Contrary to these observations, the present study did not identify a significant relationship between the total time spent in the Spider change of direction test and the outcomes of the ÇAĞIN hand and foot reaction tests. The Spider test, which requires participants to move in five different directions, might have influenced the overall time. Salonikidis and Zafeiridis (2008) observed that tennis players' reaction times varied between right, left, and forward runs, which could provide a potential explanation for the observed outcomes. In future studies, it would be advisable to utilize tests that assess reactive agility, whether in one or two directions, as opposed to tests that necessitate more than one directional change.

Tennis players are required to possess the capacity to alternate their focus between multiple targets, as well as respond expeditiously and with precision in a constantly shifting, uncertain, and externally dictated environment (Shangguan and

Che, 2018). For instance, when playing tennis, players must commit to complex sequences of movements, maintain focus on the ball and their opponent's position, and swiftly transition their attention when under time constraints. These activities are theorized to engage analogous brain regions implicated in higher-level cognitive processes, such as cognitive flexibility (M. Schmidt, Jager, Egger, Roebers and Conzelmann, 2015).

It is likely that tennis players demonstrate superior performance on the court when they exhibit a higher proportion of accurate responses in tasks that demand reacting to a particular event. The incorporation of competitive modeling in training regimens, coupled with adequate mental preparation, has been shown to enhance athletes' ability to prepare for perceptual and physical activities over extended periods. In the present study, no significant correlation was observed between Flanker test results and the change of direction test results, as well as selective attention and hand/foot reaction test results. In a study conducted with volleyball players (n = 43), it was reported that there was no significant correlation between Flanker test results and change of direction and jump test results (Trecroci et al., 2021), which supports the findings of the present study. The majority of studies in the literature on this subject reported significant differences in Flanker test results following chronic training practice (Akın, Odabaş and Yarsuvat, 2024; Silvestri et al., 2023). Therefore, it is hypothesized that the examination of the relationship between the Flanker test, various reaction tests, and measures such as reactive agility in future studies will contribute to the existing literature on this subject.

The limitations of the present study are attributed to the physical and mental state of the subjects during the test (e.g., fatigue, emotional-motivational factors), which may result in alterations in motor responses. Another limitation was the sample of athletes. The participants in the study consisted of both male and female athletes. In future studies, it would be advantageous to examine male and female participants as distinct groups, which would contribute to a more comprehensive understanding of the subject.

In conclusion, in the present study conducted with tennis players, no significant correlation was found between the results of the Spider change of direction test, the ÇAĞIN foot discrimination reaction test and the Flanker test. However, the findings encourage the expansion of knowledge on the relationships between cognitive and motor skills in the context of sport performance.

Ethics Committee Permission Information

Ethics review board: Gazi University Ethics Commission

Date of the ethics review document: 13.12.2022

Number of the ethics review document: 2022-1459 (E-77082166-604.01.02-547090)

Declaration of Researcher Contribution Rates

The authors contributed equally to all stages of the study.

Conflict Statement

There is no personal or financial conflict of interest within the scope of the study.

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