

Does football improve cognitive performance?

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Abstract. Cognitive performance can be defined as the performance of mental processes associated with perception, memory, intelligence and action. Perceptual-cognitive skill is the ability of the person to receive, define and process environmental information to select and carry out appropriate actions for the moment. In recent years, there is strong evidence that about a close relationship between motor development and cognitive functions. Football is a sport that stimulates not only simple technical elements, but also motor and cognitive development, especially attention abilities. *Objective.* The study aimed to investigate the relationship between football and cognitive skills by evaluating the cognitive performance of young professional football players and sedentary individuals. *Material and Method.* Participants were 94 male volunteers aged 16 and over: 47 football players (age 20.02 ± 3.86 years) and 47 sedentary individuals (age 21.66 ± 2.87 years). Both groups were undergone to Stroop TBAG test for cognitive performance. An evaluation form was filled in to the participants. Height and weight values were measured and body mass indexes (BMI) were calculated. The physical activity levels of the participants were evaluated with the International Physical Activity Questionnaire (IPAQ). *Results.* Stroop1 and Stroop5 times of the football players were significantly lower ($p=.001$; $p=.003$). There was a significant and positive correlation between BMI and age in football players ($p=0.000$; $r=0.603$). A significant and positive correlation was observed between Stroop1 and age in footballers and sedentary individuals ($p=.035$; $r=0.309$). There was a significant and positive correlation between Stroop5 and age in sedentary group ($p=.040$; $r=0.301$). *Conclusion.* As a result of this study, it was concluded that footballers have higher cognitive performance than sedentary individuals. It was observed that attention and adaptation periods were shorter in young individuals for both groups. In sedentary individuals, a decrease in cognitive performance was observed with increasing age.

Key words: cognition, cognitive function, Stroop test, football, soccer, exercise.

Introduction

Football is the most popular sport in the world and attracts over 265 million participants worldwide. It is considered as an important part of offense and defense games (1). Football is a sport that stimulates not only simple technical elements, but also motor and cognitive development, especially attention abilities. Players must respond quickly and appropriately to the movements during the game and constantly evaluate the situation of the match. In the light of these evaluations, they should decide on the course of the match within the framework of their abilities and duties in the game and apply appropriate tactics (2). Football is not just about running and hitting the ball; it includes both motor coordination and perceptual skills (2). Kicking a moving ball is a high-level movement that requires forward control, perceptual skills and motor coordination. In this context, it requires proprioceptive knowledge and motor planning processes (3). It is reported in the literature that training for running skills is a way to develop cognitive abilities indirectly. Because football skills include using complex cognitive abilities to anticipate teammates and opponents' behaviors and using appropriate strategies to adapt to changing task demands (2). Different sports activities require different mental skills. After a new and difficult task, conjunct activation of the prefrontal cortex, cerebellum and basal ganglia occurs first. Then, motor and cognitive development shows a similar developmental timeline. Finally, motor and cognitive skills underlie the basis of common processes such as inhibition, planning, and observation. The interaction between cognitive and motor skills in children has been shown in many studies in the literature (3). One of the cognitive tests that commonly used in the dual task paradigms is the Stroop test (4). In a recent study, cognitive performances of athletes who doing different types of exercise training were evaluated with the Stroop test. Stroop test is a neuropsychological assessment commonly used in perceptual speed and executive functions (5).

Although previous studies have shown cognitive performance values with Stroop test in children under the age of 16, who have played professional football, cognitive performance differences in children aged 16 and

over have not been shown with the Stroop test (2-3). In addition, cognitive performances of tennis players were evaluated and it was stated that they were more developed in the last stages of the Stroop test than the sedentary individuals, and there was no significant difference in the 1st and 2nd stages of the Stroop test (6). In a team game like football, cognitive performances are likely to be much more advanced than in an individual game.

The aim of this study is to investigate the relationship of football and cognitive skills by evaluating the cognitive performances of young individuals who playing professional football and sedentary with Stroop test, which is a neuropsychological evaluation method that commonly used in perceptual speed and executive functions.

Material and Method

The participants over the age of 18 and the parents or legal guardians of the participants under the age of 18 were contacted to sign an informed consent, and they were informed about the goals of the study and that their participation was voluntary. Istanbul Okan University Science, Social and Non-Interventional Health Sciences Research Ethics Committee approval was received (13.02.2019/103). Participants were randomly recruited from Demiroglu Bilim University students for sedentary group and were recruited from Bagcilar Sports Club A team and Kucukcekmece Idmanyurdu Youth and Sports Club for footballers group over age of 16.

Participants. Professional male football players aged 16 and over, licensed, training 2 days a week and sedentary male individuals were included in the study. Then, we excluded the individuals with vision disorders and color blind.

Procedure. Demographic information, medical history, height and weight of the participants were recorded. The physical activity levels of the participants were evaluated with the International Physical Activity Questionnaire (IPAQ). Cognitive performances were evaluated with the Stroop TBAG test.

Physical Activity Level. We assessed the participants' physical activity level using the IPAQ (short version) that self-administered format and we handled data according to the IPAQ scoring protocol. IPAQ validity and reliability study was carried out in Turkey (7).

Within the last 7 days with the survey; severe physical activity (football, basketball, aerobics, fast cycling, weight lifting, load carrying etc.) duration (min), moderate physical activity (light load carrying, normal speed cycling, folk dances, dance, bowling, table tennis, etc.) duration (min), walking and one-day sitting times (min) were questioned. Severe, moderate activity and walking times were converted to MET, which corresponds to basal metabolic rate, by calculating the total physical activity score (MET-min/week) (8).

Walking score (MET-min/week) = 3.3 * walking time * walking day

Moderate activity score (MET-min/week) = 4.0 * moderate activity time * moderate activity day

Severe activity score (MET-min/week) = 8.0 * severe activity time * severe activity day

Total Physical Activity score (MET-min/week) = Walking + Moderate activity + Severe activity scores.

According to the total physical activity score, the physical activity levels of the participants were classified as "low, medium and high". Physical Activity Levels (8): low level - below 600 MET-min/week; intermediate level - 600-3000 MET-min/week; high level: over 3000 MET-min/week.

Cognitive Test. Stroop Test was used for cognitive evaluation. The Stroop test is a neuropsychological test that measures the frontal region activity of the brain. It was first used by Stroop in 1935 (9). Saying the names of objects or colors takes longer than reading these words. It was shown for the first time by Stroop that "color-word interference effect" was the basis of this situation (10, 11). There are many forms of the Stroop test. The Stroop Test TBAG Form created within the scope of BİLNOT battery is composed of the combination of the original Stroop Test and the Victoria Form. The validity and reliability of this test in Turkish was done by Karakaş et al. (10). In our study, the Stroop Test TBAG Form was used (10, 11).

The Stroop Test TBAG Form consists of four white cards measuring 14.0 cm x 21.5 cm. Each card has 6 lines of 4 items. The first card has color words (blue, green, red and yellow) printed in black, and the second card has color words (blue, green, red and yellow) printed in blue, green, red and yellow. In this card, the color used in the printing of each word is different from the color meaning the word. The third card contains circles with a diameter of 0.4 cm, printed in blue, green, red and yellow. On the fourth card, there are neutral words (much, weak, if and medium) without color words printed in blue, green, red and yellow (10).

The Stroop TBAG test consists of 5 stages. These stages and related cards are as follows in their order of application: Step 1 - reading color words printed in black (1st Card); Step 2 - reading color words printed in

color (2nd Card); Step 3 - tell the color of shapes (3rd Card); Step 4 - saying the color of various neutral words (4th Card); Step 5 - saying the color of the color words using the 2nd card (2nd Card).

In each steps, the stopwatch was run after the command "Get Started" was issued. When the participant completed the line of the last card, the stopwatch was stopped. The elapsed time to completion of each card was recorded in the place that reserved for this section on the registration form and these processes were repeated for each card. When all the steps in the Stroop Test TBAG Form are completed, the number of errors and the number of corrections in each card were determined and written again in their place on the registration form. The scoring of the Stroop Test TBAG Form takes place in three ways: 1- the elapsed time from issued the "Get Started" command to reading/saying the last line of the card; 2- the number of errors; 3- the number of corrected reactions is written on the registration form. The total practice time of the test takes about 10 minutes (10). The number of errors and corrections in the Stroop Test TBAG Form is not evaluated because it has been shown to have a low reliability coefficient in healthy individuals (10). Therefore, in this study, only the completion times of the stages were taken into consideration and the number of errors and corrections was not evaluated.

Statistical Analysis. The data were analyzed using Statistical Package for Social Sciences (SPSS, Version 22.0). Average standard deviation was used as descriptive statistical methods in the evaluation of the data. Student *t* test was used to compare quantitative continuous data between two independent groups. Pearson correlation analysis was applied among the continuous variables of the study. According to the power analysis, the sample calculation was done using the G*Power (Version 3.1,Heinrich-Heine-Universität Düsseldorf) program with 0.80 power, 0.05 margin of error and 0.52 effect size and 94 participants were included in the study, with 47 people in both groups (6).

Results

Our study was carried out on 47 professional male football players and 47 male sedentary individuals. The average age of the football players was 20.02 ± 3.86 years, and the sedentary members were 21.66 ± 2.87 years. The physical characteristics of the participants are shown in table 1.

IPAQ scores of the participants differed significantly ($p=0.00$). IPAQ scores of the football players (mean = 6008.43) were higher than sedentary group IPAQ scores (mean = 2411.64) (Table 1). Stroop1 and Stroop5 times of football players were significantly lower ($p=.001$; $p=.003$) (Table 2).

Table 1. Physical Characteristics of the Participants

Variables	Football Players (n=47)		Sedentary (n=47)		p
	Mean	SD	Mean	SD	
Age, yrs.	20.02	3.86	21.66	2.87	0.02
BMI, kg/m ²	21.88	1.97	25.01	3.46	0.00
Total Physical Activity (MET-min/week)	6008.43	2960.71	2411.64	1736.53	0.00

BMI: Body Mass Index

Table 2. Differences of Stroop Times by Groups

Test, sec.	Football Players (n=47)		Sedentary (n=47)		p
	Mean	SD	Mean	SD	
Stroop1	7.10	1.05	7.87	1.70	0.01
Stroop2	8.28	1.83	9.29	3.18	0.06
Stroop3	10.48	1.99	10.92	2.70	0.36
Stroop4	13.28	2.23	12.90	2.31	0.42
Stroop5	17.29	3.10	19.80	7.14	0.03

A significant and positive correlation was found between BMI and age in football players ($r=0.60$). A significant and positive correlation was found between Stroop1 and age in footballers and sedentary ($r=0.30$) (Table 3).

Table 3. Correlation Analysis among Age, BMI, IPAQ and Stroop Scores in Football Players

Variables	Age, yrs.	BMI, kg/m ²	IPAQ	Stroop1, sec.	Stroop2, sec.	Stroop3, sec.	Stroop4, sec.	Stroop5, sec.	
Age, yrs.	r	1.00							
	p	0.00							
BMI, kg/m ²	r	0.60**	1.00						
	p	0.00	0.00						
IPAQ	r	-0.22	0.20	1.00					
	p	0.13	0.15	0.00					
Stroop1, sec.	r	0.30*	0.21	0.19	1.00				
	p	0.03	0.14	0.19	0.00				
Stroop2, sec.	r	0.22	-0.00	-0.04	0.64**	1.00			
	p	0.12	0.95	0.75	0.00	0.00			
Stroop3, sec.	r	0.25	0.06	0.22	0.55**	0.40**	1.00		
	p	0.08	0.68	0.13	0.00	0.00	0.00		
Stroop4, sec.	r	0.11	0.04	0.21	0.48**	0.42**	0.71**	1.00	
	p	0.44	0.74	0.15	0.00	0.00	0.00	0.00	
Stroop5, sec.	r	0.00	-0.08	0.20	0.54**	0.40**	0.53**	0.68**	1.00
	p	0.99	0.55	0.17	0.00	0.00	0.00	0.00	0.00

*<0.05; **<0.01, BMI: Body Mass Index; IPAQ: International Physical Activity Questionnaire

Table 4. Correlation Analysis among Age, BMI, IPAQ and Stroop Scores in Sedentary Life

Variables	Age, yrs.	BMI, kg/m ²	IPAQ	Stroop1, sec.	Stroop2, sec.	Stroop3, sec.	Stroop4, sec.	Stroop5, sec.	
Age, yrs.	r	1.00							
	p	0.00							
BMI, kg/m ²	r	0.09	1.00						
	p	0.52	0.00						
IPAQ	r	-0.03	0.16	1.00					
	p	0.82	0.27	0.00					
Stroop1, sec.	r	0.40**	-0.04	0.05	1.00				
	p	0.00	0.77	0.70	0.00				
Stroop2, sec.	r	0.19	-0.06	0.00	0.71**	1.00			
	p	0.19	0.67	0.96	0.00	0.00			
Stroop3, sec.	r	0.12	0.00	-0.14	0.56**	0.42**	1.00		
	p	0.39	0.95	0.32	0.00	0.00	0.00		
Stroop4, sec.	r	0.13	-0.12	-0.08	0.44**	0.43**	0.70**	1.00	
	p	0.35	0.39	0.57	0.00	0.00	0.00	0.00	
Stroop5, sec.	r	0.30*	-0.08	-0.10	0.45**	0.42**	0.76**	0.83**	1.00
	p	0.04	0.58	0.47	0.00	0.00	0.00	0.00	0.00

*<0.05; **<0.01 BMI: Body Mass Index; IPAQ: International Physical Activity Questionnaire

Discussion

Our aim in the study was to determine the effect of football on cognitive performance. In the main results of our study, a significant difference was observed in the cognitive performances of the individuals playing football compared to the sedentary individuals. It was observed that younger ages had shorter Stroop1 duration in footballers and sedentary individuals. In sedentary individuals, the duration of the Stroop5 stage was prolonged while the age increased.

It has been shown in many studies that sports increase cognitive performance (3, 12-17). In this context, the cognitive achievements of professional athletes must have been positively affected. In our study, cognitive performances of football players and sedentary individuals were measured. Stroop test is a five-step test in which the cognitive load increases from 1 to 5. A statistically significant difference was found between sedentary individuals and footballers in favor of footballers at stage 1 with the lowest cognitive load and at

stage 5 with the highest cognitive load. No statistically significant difference was found between the other stages.

In a recent study, the cognitive performances of tennis players were evaluated with the Stroop test and it was shown that tennis players' cognitive performances were better in the final stages of the Stroop test compared to sedentary individuals. (6). In another study conducted by football players by et al. (2), it was shown that football players' reaction times are shorter and decision making skills are better than sedentary individuals. The results of our study are consonance with literature in this view. However, in our study, a statistically significant difference was found in the 1st stage of the Stroop test. It can be thought that this difference was due to the fact that sedentary individuals adapted to the test a little later than football players.

Traditionally, coordinative skills are known to stimulate the activation of the cerebellum, which affects the working memory as well as the speed and accuracy of attention tasks. In this view, football has revealed that as a physical activity, it can improve both motor and cognitive development (2). Stage 1 of the Stroop test aims to read the words that written in black background as soon as possible. This is mostly related to attention and adaptation. Stroop test is a test that aims to measure attention as well as cognitive performance (10). Therefore, the result of our study is consonance with the interpretation that the Stroop test also measures attention. In addition, Booth et al. (18) reported that regular physical activity increased attention especially in adolescence men.

In our study, a positive correlation was found between the 1st stage of the Stroop test times the football players and the age. Kun & Toth (19) compared the kinetic memory and thinking level of the football players aged 10 and 13; both values were found to be significantly better in 10 year old footballers. In this view, the difference between age and cognitive performance in our study is consonance with the literature.

This performance also shows a positive correlation between the ages of sedentary individuals and their cognitive performances. Unlike footballers, it was stated that there was a positive correlation in the sedentary group in the 5th stage as well as in the 1st stage of the Stroop test. The reason for this is that cognitive performance decreases in sedentary individuals with increasing age. In football players, it can be said that the 5th stage of Stroop test did not correlate with age, because they prevented their cognitive performances from decreasing with age by playing football.

Varekova and Dadova (20) reported that regular physical activity supports cognitive functions in healthy children and adults. In the literature, there is no study of cognitive performance in female football players. For this reason, we think that further researches should be conducted in which the cognitive performance of male and female football players is evaluated. Cognitive performances of football players can be compared with individuals who do different types of sports.

Limitations. Physical and mental activities differ depending on the position of football players on the field. In this study, it was not possible to consider in which position the footballers are playing. Our current number of players did not give a chance to evaluate according to their positions.

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