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8-15 YAŞ GRUBU ÇOCUK FUTBOLCULARDA BİLİŞSEL PERFORMANSIN DEĞERLENDİRİLMESİ: STROOP TESTİ TBAG FORMU VE ÇOCUKLAR İÇİN RENKLİ İZ SÜRME TESTİ TEMELLİ BİR ARAŞTIRMA

EVALUATION OF COGNITIVE PERFORMANCE IN CHILD FOOTBALL PLAYERS AGED 8-15: A STUDY BASED ON THE STROOP TEST TBAG FORM AND THE CHILDREN'S COLOUR TRAILS TEST

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8-15 Yaş Grubu Çocuk Futbolcularda Bilişsel Performansın Değerlendirilmesi: Stroop Testi TBAG Formu ve Çocuklar İçin Renkli İz Sürme Testi Temelli Bir Araştırma

ÖZ

Bu araştırma 8-15 yaş arası çocuk futbolcuların bilişsel fonksiyonlarını; dikkat, işlem hızı ve bilişsel esneklik açısından değerlendirmeyi amaçlamaktadır. Bu kapsamda çalışmaya Yalova ilinde yer alan spor kulüplerinde futbol oynayan 46 erkek sporcu ile kontrol grubu olarak ilköğretim ve ortaöğretim seviyesinde eğitim alan 60 erkek gönüllü öğrenci dahil edilmiştir. Katılımcılara Stroop Testi TBAG Formu ve Çocuklar İçin Renkli İz Sürme Testi (CCTT) uygulatılmıştır. Elde edilen sonuçların veri analizi işlemleri JASP 0.19 programı kullanılarak tamamlanmıştır. Analizler için anlamlılık düzeyi p<0.05 olarak kabul edilmiştir. Bulgular incelendiğinde çocuk futbolcuların Stroop Testi TBAG Formu üzerinde kontrol grubuna göre daha hızlı tamamlama sürelerine sahip olduğu görülmektedir. Fakat hata ve düzeltme sayısı bakımından gruplar arasında genel olarak anlamlı bir fark bulunmamıştır. Bunun yanında çocuk futbolcuların kontrol grubuna göre Stroop Testi TBAG Formu üzerinde daha fazla hata ve düzeltme uyguladığı gözlemlenmiştir. Çocuklar İçin Renkli İz Sürme Testi (CCTT) sonuçlarına bakıldığında ise, futbolcuların her iki formda da kontrol grubuna göre daha kısa tamamlama sürelerine sahip olduğu görülmektedir. Fakat bu farklar istatistiksel olarak anlamlılık taşımamaktadır. Sonuç olarak Stroop Testi TBAG Formu üzerinde çocuk futbolcuların hız üstünlüğüne rağmen artan hata ve düzeltme sayıları hız ve doğruluk arasında bir denge problemi olabileceğini ortaya koymaktadır. Ayrıca Çocuklar İçin Renkli İz Sürme Testi (CCTT) sonuçlarına göre, futbolcuların işlem hızı yüksek görünse de bu farkın istatistiksel olarak anlamlı olmaması farklı bilişsel görevlerde hız avantajının her zaman belirgin olmadığını göstermektedir. Sonuç olarak, futbol gibi yoğun fiziksel aktivitelerin bilişsel hız üzerinde olumlu etkileri olabileceği düşünülmektedir.

Anahtar Kelimeler: Bilişsel performans, futbol, nöropsikoloji

Evaluation of Cognitive Performance in Child Football Players Aged 8-15: A Study Based on the Stroop Test TBAG Form and the Children's Colour Trails Test

ABSTRACT

This study aims to evaluate the cognitive functions of child football players aged 8-15 in terms of attention, processing speed, and cognitive flexibility. Accordingly, the study included 46 male athletes who played football at sports clubs in Yalova. Additionally, a control group was formed, comprising 60 male volunteer students from elementary and secondary school levels. Participants were administered the Stroop Test TBAG Form and the Children's Colour Trails Test (CCTT). The data obtained were analyzed using the JASP 0.19 software, and the significance level was set at p<0.05. The findings revealed that child football players had faster completion times on the Stroop Test TBAG Form compared to the control group. However, there was no significant difference between the groups in terms of the number of errors and corrections. Nonetheless, child football players made more errors and corrections on the Stroop Test TBAG Form than the control group. Regarding the results of the Children's Colour Trails Test (CCTT), football players demonstrated shorter completion times on both forms compared to the control group; however, these differences were not statistically significant. In conclusion, despite the speed advantage observed in child football players on the Stroop Test TBAG Form, the increased number of errors and corrections suggests a potential imbalance between speed and accuracy. Furthermore, the results of the Children's Colour Trails Test (CCTT) indicate that although football players exhibited higher processing speed, the lack of statistical significance suggests that the speed advantage may not always be evident across different cognitive tasks. Ultimately, it is proposed that intensive physical activities, such as football, may have positive effects on cognitive processing speed.

Keywords: Cognitive performance, football, neuropsychology

INTRODUCTION

Football is played by approximately 270 million people worldwide, either professionally or recreationally, and has reached a level of popularity that no other sport has achieved[1,2]. Football, which involves high-intensity activities, carries a high risk of injury for young, amateur, and professional players[3]. During these intense activities, altered neuromuscular control and ineffective movement patterns are seen as key factors contributing to the elevated possibility of damage among young sportsmen[4,5]. Football is among the sports with the highest injury rates and risks of injury[6]. Like almost every sport, football is susceptible to various organ injuries. The American Academy of Pediatrics Policy[7] published a report classifying football alongside American football and hockey, defining it as a contact and collision sport.

Traumatic brain injury remains one primary reason for death and long-term disability among youth around the world, affecting approximately 3 million children annually[8]. In a study published by Tysvaer, (1992)[9] it was reported that 4-22% of football-related injuries were head injuries. The origin of heading the ball in football can be traced back to Northern England. Heading became an integral part of football after hand contact with the ball was banned by the Football Association in 1872[10]. Therefore, it is not surprising that there has been speculation regarding the possibility of causing head trauma by heading the ball, in addition to the risks of collisions involving different body parts or head-to-head impacts during matches[11,12]. More assessments and comprehensive studies are being conducted to determine the extent of this issue[11-13]. In recent years[14,15], football has been recognized as a common contact sport associated with a comparably elevated risk for brain injuries[16].

Some football players start their athletic journey as early as six years old, a critical stage in neurological growth[17]. Studies indicate that football is responsible for roughly 37% of all sports-related concussions[18]. Moreover, concussions represent 5.8% of all injuries in male's football over a 15-year span[19] and 8.6% of all injuries in female's football[20]. Notably, goalkeepers appear to be the most susceptible to concussions, with 80% having suffered at least one head injury during their careers[21]. Research shows that around 62% of footballers experienced a concussion during their sports life, yet only 20% of them recognize and report the injury[22]. This highlights the possibility that some players continue participating even after sustaining a concussion, exposing themselves to additional neurological risks[23].

Given football's global popularity and status as the most widely practiced sport, the lasting effects of concussions and head injuries linked to the game are considered a major public health concern[24]. Repeated head impacts have been shown to contribute to the development of chronic traumatic encephalopathy (CTE), a condition marked by ongoing neurological decline[25]. Typical concussion symptoms include headaches, nausea, fatigue, and sometimes visual disturbances like diplopia (double vision). It is well established that head injuries can impair cognitive functions, including memory and planning skills. A strong correlation exists between frequent participation in football and increasing deficits in memory and planning, as evidenced by psycho-neurological evaluations[26].

Neuropsychological assessments have proven effective in identifying cognitive deficits caused by participation in contact and high-impact sports[27-29].

The Stroop Test was created by J. R. Stroop to evaluate selective attention in individuals with traumatic brain injury[30]. There is a widespread consensus regarding the use of the Stroop Test for assessing frontal lobe functions[31,32].

First introduced in 1944 as part of the "Army Individual Test Battery" by the U.S. Army[33], the Trail Making Test has been used to assess a range of neurocognitive abilities, including psychomotor speed, complex attention, visual scanning, and mental flexibility. It has repeatedly been proven to be sensitive to brain damage in adults[34-37]. Reynolds suggests that the Trail Making Test is especially valuable for identifying deficits in the frontal lobe, as well as difficulties with psychomotor speed, visual scanning, sequencing, and attention[38]. The Children's Colour Trails Test, developed for children, is a tool used to assess visual conceptualization and visual-motor tracking, psychomotor speed, complex visual scanning, simple motor skills, basic sequencing abilities, visual tracking, mental flexibility, visual attention, focused attention, visual perceptual skills, and executive functions[39].

The present study is among the first to evaluate the cognitive performance of Turkish child football players using the Stroop Test TBAG Form and the Children's Colour Trails Test. This approach provides a unique perspective on the potential cognitive benefits and challenges associated with youth football activities, filling a gap in the literature regarding cognitive processing speed and attention in this demographic.

MATERIALS AND METHODS

Research Design

This is a cross-sectional study conducted within the scope of quantitative research methods[40].

Research Group

Power analysis was initially conducted using G*Power 3.1.9.7. With a Type I error rate (α level) of 0.05 and a power of 0.80, it was determined that 94 participants were required for the study[41]. However, the data collection process was completed with 106 participants, exceeding the required sample size.

The athlete group of the study consists of 46 male football players aged 8-15 from sports clubs in Yalova. The control group includes 60 male volunteer students aged 8-14 who are studying at elementary and secondary public schools located in Istanbul. The child football players examined in the study had an average age of 10.196 ± 1.833 years and participated in football training twice a week for 90 minutes. Additionally, the child football players had a sports age of 249.457 ± 244.173 days. The control group participants had an average age of 10.500 ± 1.722 years.

Ethical Approval

All participants were thoroughly informed about the purpose of the study. All stages of the research were conducted in accordance with the latest version of the Declaration of Helsinki. Ethical approval for this study was obtained from the Ethics Committee of the Faculty of Sports Sciences at Atatürk University, with a letter dated January 30, 2024, reference number E-70400699-000-2400036232, and titled "Ethics Committee Approval." Additionally, permission to collect data from students attending schools under the Ministry of National Education of the Republic of Turkey was granted by the Istanbul Provincial Directorate of National Education, under the "Research Application Permits Circular (2024/41)" (Application No: MEB.TT.2024.001208).

Data Collection

The tests conducted within the scope of the study were performed in a well-ventilated, noise-free indoor environment at room temperature with optimal humidity. The environmental conditions were controlled, and participants were tested while wearing comfortable clothing, free from hunger or fatigue. A 10-minute break was given between tests.

Stroop Test TBAG Form: The Stroop Test, created by J.R. Stroop, is a test primarily designed to measure the Stroop effect, focusing on the interference effect caused by the colour in which a word is written versus the colour named during reading. This test measures an individual's ability to name colours despite a tendency to read the words, as well as their ability to maintain attention and shift behavior[42]. The Stroop test has different forms that include colour names printed in various colours[43,44].

Within the scope of the study, the Stroop Test TBAG Form was used to measure the working memory and attention processes of the participants. The test, standardized by Karakaş et al. (1999)[45], consists of five cards. During the test, participants were asked to read the words on the stimulus cards. Reading times, errors made during reading, and corrections were recorded. The cards used were as follows: 1. Black-and-White Word Reading, 2. Coloured Word Reading, 3. Coloured Dot Reading, 4. Coloured Nonsense Word Reading, and 5. Naming the Colours of Coloured Words.

Participants were given the following instructions for cards 1, 2, 3, and 4: "Now, I will show you cards containing colour names. I want you to read these words as quickly as possible. If you realize you made a mistake, correct it." The cards were shown in sequence. In the fifth section, the second card was presented again, with the instruction: "Now, I do not want you to read the colour names here, but to say the colour in which the words are printed." For each section, the time taken by participants during the application was measured using a 0.01-second precision electronic hand stopwatch (Casio Hs-70w-1DF, JP). The completion time, the number of errors, and the number of corrections (if any) for each section were recorded on an evaluation form for each participant.

Children's Colour Trails Test: The original version of the test is found in the Partington Pathways, a language-independent measure within the Leither-Partington Adult Performance Scale[46]. The children's version (CCTT) was developed by Llorente et al.[47]. The validity and reliability of the test for Turkey were also studied by Bayer[39].

The Children's Colour Trails Test (CCTT) consists of two pages, CCTT 1 and CCTT 2. The application is explained to the participant using the practice exercise on the front side of the CCTT 1 form. In the practice section, the participant is asked to connect the numbers from 1 to 8, which are coloured pink and yellow, in sequential order without lifting the pen from the paper (e.g., pink 1 - yellow 2 - pink 3 - yellow 4, etc.). Each number appears once. After the practice exercise is completed, the participant moves on to the test on the back page, where they are asked to connect the numbers from 1 to 15 as quickly and accurately as possible. Similarly, in the CCTT 2 form, the practice exercise on the front page is shown to the participant, where they are asked to connect the numbers from 1 to 8 in pink and yellow; however, this time each number appears twice, one in pink and one in yellow. Participants are instructed to connect the numbers in a sequence alternating between pink and yellow without lifting the pen (e.g., pink 1 - yellow 2 - pink 3 - yellow 4, etc.). After completing the practice exercise, the participant proceeds to the test on the back page, where they are asked to connect the numbers from 1 to 15 as quickly and accurately as possible. In both sections, the number of errors, whether the error was in the colour (colour sequence) or number (number sequence) dimension, the number of prompts provided, any near misses while connecting the numbers, and the time taken for the test are all scored[39].

Within the scope of this study, completion times were measured to evaluate performance on the Children's Colour Trails Test (CCTT). The analyses focused solely on the completion times. This approach, similar to the study by Messinis et al. (2024)[48] aims to identify neurocognitive differences among children by evaluating cognitive processing speed and attention performance.

Data Analysis

Data analysis was performed using JASP 0.19 (University of Amsterdam, Nieuwe Achtergracht 129B, AMS, NL). The Shapiro-Wilk Test was applied to determine whether the data followed a normal distribution. According to the Shapiro-Wilk Test results, if $p<0.05$, the data were considered non-normally distributed; if $p>0.05$, the data were considered normally distributed[49]. Upon examination, it was found that the data generally did not follow a normal distribution. Therefore, the decision was made to apply non-parametric tests. Within this scope, the Mann-Whitney U Test was used to compare the Stroop Test TBAG Form and Children's Colour Trails Test data between groups. Additionally, effect sizes were determined by analyzing the obtained data using the Rank-Biserial Correlation (r_{rb}) method[50]. The significance level for the analyses was set at $p<0.05$.

RESULTS

Table 1. Comparison of Score Differences in Stroop Test TBAG Form Section 1 (Reading Colour Names Printed in Black) Between Groups Using Mann-Whitney U Test

Test	Group	n	Mean ± SD	U	p	r_{rb}
Completion Time (sec)	Child Football Player	46	9.635 ± 2.019	874.500	0.001*	-0.366
	Control	60	11.412 ± 3.375			
Number of Errors	Child Football Player	46	0.087 ± 0.285	1477.000	0.094	0.070
	Control	60	0.017 ± 0.129			
Number of Corrections	Child Football Player	46	0.065 ± 0.327	1417.500	0.412	0.027
	Control	60	0.017 ± 0.129			

p<0.05*

Table 1 shows that child football players completed the test significantly faster compared to the control group (U = 874.500, p = 0.001). However, there were no significant differences between the groups in the number of errors (U = 1477.000, p = 0.094) or corrections (U = 1417.500, p = 0.412). Despite this, child football players tended to make more errors and corrections.

Table 2. Comparison of Score Differences in Stroop Test TBAG Form Section 2 (Reading Colour Names Printed in Colours) Between Groups Using Mann-Whitney U Test

Test	Group	n	Mean ± SD	U	p	r_{rb}
Completion Time (sec)	Child Football Player	46	10.615 ± 2.277	833.000	< .001*	-0.396
	Control	60	13.050 ± 4.327			
Number of Errors	Child Football Player	46	0.043 ± 0.206	1416.000	0.431	0.026
	Control	60	0.033 ± 0.258			
Number of Corrections	Child Football Player	46	0.022 ± 0.147	1386.500	0.871	0.005
	Control	60	0.033 ± 0.258			

p<0.05*

Table 2 shows that child football players completed the test significantly faster compared to the control group (U = 833.000, p < 0.001). No significant differences were found in the number of errors (U = 1416.000, p = 0.431) or corrections (U = 1386.500, p = 0.871) between the groups, though child football players tended to perform worse in both aspects.

Table 3. Comparison of Score Differences in Stroop Test TBAG Form Section 3 (Naming Shape Colours) Between Groups Using Mann-Whitney U Test

Test	Group	n	Mean ± SD	U	p	r_{rb}
Completion Time (sec)	Child Football Player	46	15.383 ± 3.668	981.500	0.011*	-0.289
	Control	60	17.395 ± 4.769			
Number of Errors	Child Football Player	46	0.370 ± 0.771	1660.000	< .001*	0.203
	Control	60	0.017 ± 0.129			
Number of Corrections	Child Football Player	46	0.326 ± 0.598	1718.500	< .001*	0.245
	Control	60	0.017 ± 0.129			

p<0.05*

Table 3 shows that child football players completed the test significantly faster than the control group (U = 981.500, p = 0.011). However, they made significantly more errors (U = 1660.000, p < 0.001) and corrections (U = 1718.500, p < 0.001) compared to the control group.

Table 4. Comparison of Score Differences in Stroop Test TBAG Form Section 4 (Naming the Colours of Non-Colour Words) Between Groups Using Mann-Whitney U Test

Test	Group	n	Mean ± SD	U	p	r_{rb}
Completion Time (sec)	Child Football Player	46	21.251 ± 5.735	1086.500	0.062	-0.213
	Control	60	23.638 ± 6.182			
Number of Errors	Child Football Player	46	0.413 ± 0.748	1801.000	< .001*	0.305
	Control	60	0.033 ± 0.258			
Number of Corrections	Child Football Player	46	0.261 ± 0.575	1624.000	0.002*	0.177
	Control	60	0.033 ± 0.258			

p<0.05*

Table 4 shows that while child football players completed the test faster than the control group but this difference was not statistically significant (U = 1086.500, p = 0.062). However, they made significantly more errors (U = 1801.000, p < 0.001) and corrections (U = 1624.000, p = 0.002) compared to the control group.

Table 5. Comparison of Score Differences in Stroop Test TBAG Form Section 5 (Naming the Colours of Words with Colour Names) Between Groups Using Mann-Whitney U Test

Test	Group	n	Mean ± SD	U	p	r_{rb}
Completion Time (sec)	Child Football Player	46	28.158 ± 6.521	980.000	0.011*	-0.290
	Control	60	34.221 ± 10.962			
Number of Errors	Child Football Player	46	1.152 ± 1.897	1576.000	0.155	0.142
	Control	60	0.567 ± 0.945			
Number of Corrections	Child Football Player	46	0.957 ± 1.460	1566.500	0.162	0.135
	Control	60	0.450 ± 0.769			

p<0.05*

Table 5 shows that child football players completed the test significantly faster than the control group (U = 980.000, p = 0.011). There were no significant differences in the number of errors (U = 1576.000, p = 0.155) or corrections (U = 1566.500, p = 0.162), though child football players tended to perform worse in both aspects.

Table 6. Comparison of Completion Time Differences in Children's Colour Trails Test Between Groups Using Mann-Whitney U Test

Test	Group	n	Mean ± SD	U	p	r_{rb}
CCTT A Completion Time (sec)	Child Football Player	46	23.783 ± 15.249	1110.500	0.086	-0.195
	Control	60	25.844 ± 10.560			
CCTT B Completion Time (sec)	Child Football Player	46	50.217 ± 15.688	1282.000	0.534	-0.071
	Control	60	53.052 ± 18.155			

p<0.05*

Table 6 shows that while child football players had shorter completion times for both the CCTT A and CCTT B forms compared to the control group, these differences were not statistically significant (CCTT A: U = 1110.500, p = 0.086; CCTT B: U = 1282.000, p = 0.534).

DISCUSSION

When examining the data obtained in the study, it is observed that child football players had faster completion times on the Stroop Test TBAG form. This result indicates that regular football activities may enhance functions such as cognitive processing speed. However, despite the higher processing speed favoring the child football players, there wasn't any significant mismatch between the two groups regarding errors and corrections counts. Additionally, it was observed that the child football players made more errors and corrections on the Stroop Test TBAG form. This indicates that there may be a balance problem between cognitive processing speed and accuracy for child football players. Regarding the results of the Children's Colour Trails Test (CCTT), it was found that football players had shorter completion times on both forms, though not statistically significant.

It has been suggested that concussion injuries and heading in both amateur and professional footballers may be a cause of neuropsychological impairment[29,51]. Additionally, it has been found that football players perform statistically significantly worse on neuropsychological tests compared to rugby athletes and athletes taking part in non-contact sports on a non-professional level[52,53]. Head blows in football independently contribute to cognitive impairment[51]. In particular, impacts to the frontal and temporal regions of the head, rather than the occiput, elevates the possibility of injury[54,55].

Literature has demonstrated that a football striking a player's head can lead to serious neurological injuries, including large chronic or subacute subdural hematomas[56]. Repeated head impacts have been associated with declines in brain functions such as memory consolidation, planning, and cognitive abilities[57,58]. Prospective research on middle school women's footballers reported that 30.5% of concussions resulted from heading the ball[59]. Likewise, a recent retrospective research of high school footballers revealed that 30.6% of concussions, and 25.3% among female athletes, were due to heading the ball. Nevertheless, the most frequent cause of concussions was found to be player collisions during tackles[60].

In a neuropsychological assessment that involved assessments of attention, focus, recollection, and logic, 81% of footballers were found to have impairments, while only 40% of the control group showed mild impairments[61]. Furthermore, football players exhibited lower performance in tasks involving verbal and visual memory, planning, and visual perceptual processing, showing greater cognitive impairments compared to the control group. Performance on neuropsychological tests was also affected by field position, with forwards and defenders scoring significantly lower than midfielders and goalkeepers[29].

Male and female footballers were contrasted to swimmers through neuropsychological tests assessing motor speed, attention, concentration, reaction time, and conceptual thinking. The findings revealed that footballers scored less than swimmers on tasks involving conceptual thinking, suggesting a possible link between playing football and cognitive impairment[62]. In another study, the cognitive achievement of professional and non-professional men footballers aged 16-34 was examined with a focus on the impact of heading exposure. Participants completed a series of six neuropsychological tests. Those who had headed the ball in the previous 7 days and had the highest rates of heading exposure performed significantly worse on tests measuring verbal learning, verbally based conceptual skills, planning, attention, and information processing speed compared to other groups[63]. Additionally, male college football players were compared to rugby and non-contact sport athletes who were the same age and sex in the Attention Performance Test, with football players showing significantly poorer performance than both rugby athletes and non-contact sport participants[64].

Zhang et al. (2013)[65] sought to explore whether playing football contributes to cognitive dysfunction and brain injury. They evaluated the executive functions of two different groups of high school woman students (footballers and sedentary) aged 15-18. Each football player performed an average of 6 headers per session during the training session before the test. Additionally, participants in the non-player group did not perform any headers prior to the test, enabling researchers to specifically assess the effects of heading exposure. The slower performance of football players compared to controls suggested a distinct impairment in voluntary responses. Moreover, the findings indicated a link between slower reaction times and both increased weekly playing time and years of football experience. Witol and Webbe (2003)[66] examined the connection between heading the ball during football matches and neuropsychological deficits. A neurocognitive test battery was implemented on 60 men's footballers across high school, amateur, and professional levels, along with a control group of 12 nonfootball players. The findings revealed that those with the highest lifetime heading rates scored lower on assessments of attention, concentration, cognitive flexibility, and overall mental functioning. Thus, players who reported more frequent heading had a higher likelihood of clinical-level impairment.

Ellemberg et al. (2007)[67] aimed to examine the long-term cognitive outcomes following concussions by evaluating cognitive functions in female football players after their first concussion and again 6 to 8 months post-injury. 22 university-level women's footballers took part in the research. Athletes with a history of concussions were compared to age-matched individuals who had never experienced a concussion. Athletes with a concussion history performed significantly slower on the Stroop Test. These results suggest that cognitive functions are susceptible to sport-related concussions, with impairments lasting for at least six months after the injury in university-level female football players. Cayuela et al. (2020)[68] conducted research on non-professional adult footballers to examine the effects of heading on frontal lobe executive functions. Participants completed the Stroop Test, followed by six consecutive headers, and then repeated the Stroop Test. Significant and specific negative cognitive changes were noted in women's footballers after performing headers. It was determined that this led to adverse changes in executive functions.

Cente et al. (2023)[69] implemented research to evaluate the potential association between repeated low-intensity head impacts and focused attention and cognitive flexibility in young adult elite football players. The results indicated that the football players scored significantly worse on both parts of the Trail Making Test (TMT). Abdul Rahman et al. (2019)[70] conducted research to examine motor and cognitive performance in children with traumatic brain injury. Sixteen children with TBI and a control group of 22 individuals participated in the study. The Children's Colour Trails Test (CCTT) was administered to the participants. The results showed that children with traumatic brain injury performed worse in terms of completion time on the Children's Colour Trails Test compared to the control group.

Literature contains research that contradicts the findings mentioned earlier and offers alternative conclusions. For instance, Janda et al. (2001)[71] investigated the effects of repeated head impacts from heading in men's and women's non-professional footballers, with an average age of 11.5 years, by employing a neuropsychological test protocol and recording concussion signs. The footballers were monitored for three seasons, during which the number of headers each footballer did was tracked. Comparisons of pre-season and post-season test scores revealed no significant differences. However, it is noteworthy that in the initial phase of the study, 49% of athletes reported headaches after heading the ball. The researchers indicated that it was not certain if these pains in the head were due to mild head trauma or localized pain at the site of impact. Similarly, Stephens et al. (2005)[72] compared the neuropsychological test results of male school footballers aged 13-16 with those of rugby players and non-contact sport athletes, finding no significant differences in the test scores among the groups.

Rodrigues et al. (2019)[73] investigated the effects of football on cognitive functions in professional football players. In this context, 44 male football players from two teams in the Brazilian Serie A and 47 age- and education-matched non-athletes were examined. The findings showed that football players outperformed the control group in response times on the Stroop Test, as well as in general motor coordination, executive function, and memory tests. They also scored higher in accuracy on executive function tests. Furthermore, there were no significant differences tracked in test performance between the two subgroups of football players, which were categorized based on their self-reported number of headers. Guskiewicz et al. (2002)[74] conducted a study to determine whether football leads to chronic neuropsychological dysfunction. They examined 91 football players, 96 athletes from sports other than football, and 53 non-athletes. The Trail Making Test B form was administered to the participants, and no significant differences were found between the groups. Putukian et al. (2000)[75] investigated the acute effects of heading the ball on cognitive functions in football. In this context, 44 male and 56 female elite footballers from Penn State University and a control group were included in the study. The participants were administered the Trail Making Test A and Trail Making Test B forms, and no significant performance differences were observed between the footballers and controls in the neurocognitive tests.

Straume-Naesheim et al. (2005)[76] evaluated the relationship between long-term heading exposure and concussions in male professional football players with a mean age of 25.6, using their performance on neuropsychological tests. All participants completed a computerized neuropsychological test battery measuring motor function, decision-making, simple, divided, and complex attention, working memory, and learning memory. The results showed that there was no relationship between heading exposure and cognitive performance. Kaminski et al. (2007)[77] investigated whether there was a relationship between the number of headers performed during a season and cognitive function and balance scores in high school and college female football players. The study also included a control group of non-athletes whose sex and ages were equal to the experimental group. All participants underwent a series of neuropsychological and postural stability tests before and immediately after the football season. Additionally, the number of headers performed during matches was tracked. No significant differences were observed between pre-season and post-season outcomes in both the college and high school groups. Therefore, the study didn't find any proof of cognitive or balance decline among female footballers. Kaminski et al. (2008)[78] similarly assessed the computerized neuropsychological performance of football players prior to and post a season, along with the number of headers per match. Their findings didn't show any signs of cognitive impairment. Despite including a large sample size and assessments throughout an entire season, this study did not provide conclusive evidence regarding the potential long-term effects of heading the ball.

CONCLUSION

This study shows that child football players perform faster than non-athletes on tasks requiring processing speed and cognitive control. However, despite their speed advantage, the increased number of errors and corrections among the child football players suggests a potential balance issue between speed and accuracy. Moreover, according to the Children's Colour Trails Test (CCTT) results, although football players demonstrated higher processing speed, the missing statistically significant dissimilarities indicate that the speed advantage might not always be evident across different cognitive tasks.

Based on these findings, several recommendations can be made for this age group. To maximize the cognitive benefits of football while minimizing potential drawbacks, routine training sessions could incorporate cognitive-motor exercises that emphasize accuracy alongside speed. For example, drills combining rapid decision-making with precision-focused tasks may help young athletes strike a better balance between cognitive speed and accuracy. Similarly, integrating activities such as attention-training games and error-correction practices into regular football practices could enhance overall cognitive performance. Educating coaches and parents about the importance of balancing physical and cognitive training in football is also essential. Providing young athletes with supportive feedback that prioritizes accuracy and decision-making over mere speed could foster a more comprehensive development. Routine assessments to monitor players' cognitive and motor performance may help identify areas requiring targeted interventions.

In conclusion, while football has the potential to positively influence cognitive speed and control, structured and balanced training programs can help address its limitations, ensuring a safer and more effective developmental pathway for young athletes. Additionally, future research could further explore how the dynamic between cognitive speed and accuracy evolves across different sports and age groups.

LIMITATIONS

The research employs a cross-sectional design, meaning the outcomes are limited to data from a single point in time. Although the sample size is sufficient, the study is restricted to male football players aged 8-15. Therefore, the findings may not be generalizable to other age groups or to female football players.

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