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Is Cognitive Performance Deficiency a Potential Outcome in Rugby Players? A Study Based on the Symbol Digit Modalities Test

Ragbi Sporcularında Bilişsel Performans Eksikliği Olası Bir Sonuç mudur? Sembol Sayı Modaliteleri Testi Temelli Bir Araştırma

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Abstract

The aim of this study is to analyze and evaluate the cognitive performance of Turkish rugby players by comparing the data obtained through the Symbol Digit Modalities Test (SDMT) with that of a healthy control group. The study included 44 male athletes actively engaged in rugby at three different rugby clubs in Istanbul and a control group consisting of 40 healthy male volunteers residing in Istanbul who had no prior involvement in any contact sports. Participants were administered three separate SDMTs with 10-minute rest intervals between each test. Data analysis was conducted using JASP version 0.19, and the significance level was set at $p < 0.05$. When the SDMT results were compared between the groups, it was observed that the control group had significantly higher scores in SDMT-1, SDMT-2, and SDMT-3 compared to the rugby players. In the within-group analysis of SDMT results, both the rugby players and the control group demonstrated significant improvements in scores across SDMT-1, SDMT-2, and SDMT-3, respectively. In conclusion, rugby players scored lower than the control group on this test, which assesses cognitive functions such as visual scanning, information processing speed, attention, and motor speed. These findings suggest that collisions and impacts experienced by rugby players may have adverse effects on cognitive functions. Additionally, the observed within-group performance improvements in repeated tests for both groups may be associated with the participants' cognitive adaptation to the task. The findings of this study highlight the risk of cognitive performance deficits in rugby players and underscore the importance of implementing measures to protect their neurocognitive health. Thus, it is recommended that regular evaluation programs and screenings for cognitive functions be established for these athletes. Furthermore, educational programs aimed at reducing the frequency and severity of collisions, as well as enhancing the effectiveness of protective equipment such as helmets, are suggested to support the cognitive health of rugby players.

Keywords: Cognitive performance, Neuropsychology, Rugby

Özet

Bu araştırmanın amacı Türk ragbi sporcularından, Sembol Sayı Modaliteleri Testi (SDMT) dahilinde elde edilecek olan verileri sağlıklı kontrol grubu ile karşılaştırarak analiz etmek ve bilişsel performans açısından değerlendirmeye çalışmaktır. Bu kapsamda çalışmaya İstanbul ilinde bulunan üç farklı ragbi kulübünde aktif spor hayatına devam eden 44 erkek sporcu ile kontrol grubu olarak İstanbul'da ikamet eden herhangi bir temas sporu ile ilgilenmemiş sağlıklı 40 erkek gönüllü dahil edilmiştir. Katılımcılar 10 dakika dinlenme aralıkları ile 3 farklı Sembol Sayı Modaliteleri Testi (SDMT) uygulamıştır. Elde edilen sonuçların veri analizi işlemleri JASP 0.19 programı kullanılarak tamamlanmıştır. Analizler için anlamlılık düzeyi $p<0.05$ olarak kabul edilmiştir. Katılımcıların, Sembol Sayı Modaliteleri Testi (SDMT) sonuçları gruplar arası değerlendirildiğinde kontrol grubunun; SDMT-1, SDMT-2 ve SDMT-3 başarı puanlarının ragbi sporcularından anlamlı düzeyde daha yüksek olduğu belirlenmiştir. Sembol Sayı Modaliteleri Testi (SDMT) sonuçları grup içi incelendiğinde ise hem ragbi sporcuları hem de kontrol grubu açısından sırası ile SDMT-1, SDMT-2 ve SDMT-3 başarı puanlarında anlamlı düzeyde artış olduğu gözlenmiştir. Sonuç olarak ragbi sporcuları, görsel tarama, bilgi işleme hızı, dikkat ve motor hız gibi bilişsel işlevleri değerlendiren bu testte kontrol grubuna göre daha düşük puanlar almıştır. Bu bulgular, rugby sporcularının yaşayabileceği çarpışma ve temasların bilişsel işlevlerde olumsuz etkilere yol açabileceği fikrini ortaya koymaktadır. Bu duruma ek olarak her iki grupta da gözlemlenen test tekrarlarında ortaya koyulan grup içi performans artışları, katılımcıların göreve dair bilişsel adaptasyon kazanmalarıyla ilişkili olabileceğini düşündürmüştür. Çalışmamızın bulguları, rugby sporcularında bilişsel performans eksikliği riskini ve bu sporcuların nörobilişsel sağlıklarının korunması için tedbirlerin alınması gerektiğini vurgulamaktadır. Böylece sporcuların bilişsel işlevlerini düzenli olarak değerlendirecek programların ve taramaların uygulanması önerilmektedir. Ayrıca sporcuların çarpışma sıklığını ve şiddetini azaltmaya yönelik eğitim programlarının yanı sıra kask gibi koruyucu ekipmanların etkinliğinin artırılmasının bilişsel sağlığı destekleyeceği düşünülmektedir.

Anahtar Kelimeler: Bilişsel performans, Nöropsikoloji, Ragbi

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INTRODUCTION

Rugby originated in the town of Rugby, England, when one of the players, while playing football, picked up the ball and ran towards the opponent’s goal. Subsequently, the sport gained significant support, particularly from schools in England. With its inclusion in school programs and the establishment of various rules, rugby’s popularity began to grow. Since 1823, rugby has been played across England and numerous European countries and it has become a widely practiced sport in nations like South Africa and Australia. Over time, with the development of numerous regulations, rugby has secured its place among respected sports disciplines (Dunning, 2013).

Rugby, a dynamic and contact-intensive team sport, is played by approximately 8.5 million participants worldwide. Due to its aggressive nature, competitive intensity, high physical demands, and frequent exposure to contact and collisions, rugby has recently been associated with a high incidence of injuries. The physical intensity of rugby poses a substantial risk for concussions (Fraas & Burchiel, 2016; Martin et al., 2017; Yeomans et al., 2018). The estimated incidence of injuries and the speed of gameplay in rugby have nearly doubled over the past 40 years. Despite the diversity in levels of play, concussions (25%) and sprains (48%) are among the most common types of injuries encountered (Kaplan et al., 2008; Willigenburg et al., 2016).

Rugby players are likely to experience multiple concussions throughout their careers. In contact sports like rugby, American football, kickboxing, and boxing, concussion is notably higher than in other sports (McCrory et al., 2013; Mehmedov, 2014; Sindelar & Bailes, 2018). In these sports, impacts on the head, neck, or other parts of the body that convey force to the head are the primary causes of concussions (Brody, 2015; Yaman & Yaman, 2002). However, studies have shown that rugby players often do not report concussions (Sye et al., 2006; Baker et al., 2013; Fraas et al., 2014). Some research suggests that the lack of reporting may stem from a lack of awareness (Broglio et al., 2010; Fraas et al., 2014). This lack of awareness reportedly extends beyond athletes to coaches, parents, and healthcare professionals, affecting the detection of concussions (Fraas & Burchiel, 2016). Martin et al. (2017) More than one-third of rugby players showed concussion indications before the matches started. Other studies have estimated the proportion of players with at least one concussion in a season to be between 3% and 45% in exposure-to-concussion ratios of rugby players. Concussion is a common athletic injury, and it occurs in different sports. Most concussions result from collisions (20%) and head-to-head impacts (28%) (Schussler, 2016).

Sport-associated neuropsychological disabilities catching contact and collision sports have been reported to detect cognitive impairments using neuropsychological tests (Jordan et al., 1996; Matser et al., 1992; Matser et al., 1998). Psychometrically, the Symbol Digit Modalities Test (SDMT) is a trustable method of brain injury sensitivity (Smith, 1968; Spreen & Strauss, 1998). The SDMT is an extensively implemented scanning test for neurological disorders both clinically and as a part of research assessment (Smith, 2007). The SDMT test performance depends on visual scanning, motor speed, perceptual speed, and attention. Deficits on this test have been linked to traumatic brain injury, sports-related head trauma, and Parkinson's disease (Strauss et al., 2006).

METHOD

Rugby presents a potential risk that may negatively impact players' cognitive functions due to its inherent nature involving contact and collisions. This research sets out to analyze and evaluate the cognitive achievement of Turkish rugby players by comparing data obtained through the SDMT with that of healthy individuals. By supplying essential observations regarding the neurological health of rugby players, the study seeks to assess their cognitive performance and raise awareness about preventative measures that may be taken to protect their cognitive health. All stages of this study were conducted in accordance with the latest version of the Declaration of Helsinki, and the necessary Ethical Approval procedures were obtained.

Research Model

This is a cross-sectional study within the scope of the quantitative research method (Creswell & Creswell, 2018).

Study Group

The athlete group in this study consists of 44 right-handed male rugby players from three rugby clubs in Istanbul, Türkiye. The control group comprises 40 right-handed healthy male volunteers residing in Istanbul who have not engaged in any contact sports. The rugby players in the study have a mean age of 21.47 ± 5.66 years and participate in rugby training sessions twice a week, each lasting 90 minutes. Additionally, the rugby players have an average of 8.06 ± 6.14 years of sports experience. In comparison, participants in the control group have a mean age of 24.35 ± 4.21 years.

Data Collection

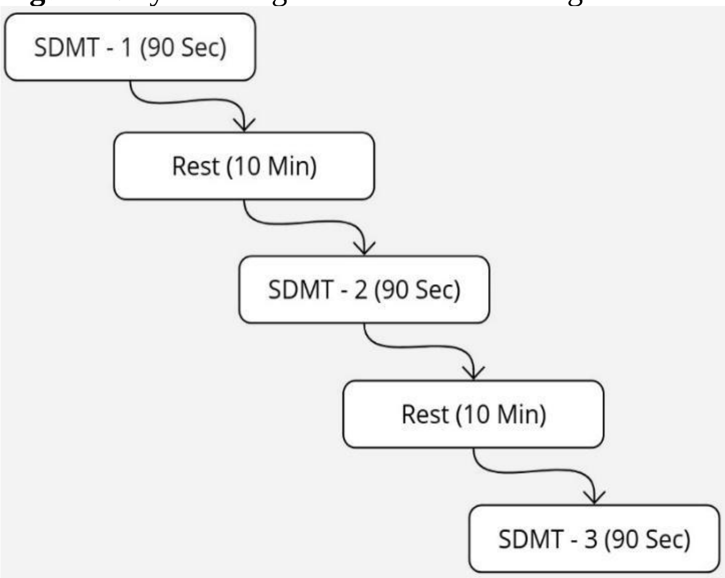
Participants received information about the tests and signed an informed consent form first. To be included, participants had to be healthy, not have chronic or acute medical conditions, nor consume any medication or stimulant likely to affect the central nervous system or cognitive achievement. Participants were also advised not to drink alcohol, smoke, or drink coffee for 48 hours before the tests. All tests in this study were conducted under ventilated, quiet, comfortable, temperature-controlled indoor conditions. Environmental conditions were controlled, participants were dressed comfortably, and hunger and fatigue were avoided before testing.

Data Collection Instruments

Edinburgh Handedness Inventory: To determine participants' hand preferences, they were asked to respond to questions within the inventory based on their hand preference (Oldfield, 1971). The scores from their responses were then totaled. This method allowed for categorizing participants as left-handed, ambidextrous, or right-handed.

Symbol Digit Modalities Test (SDMT): Participants completed three separate SDMTs with 10-minute rest *intervals* between each. Prior to the test, they were provided with an exercise part made up of boxes with shapes on the top and corresponding numbers from 1 to 9 on the bottom to familiarize them with the task of matching shapes to numbers. Participants were instructed to match the shapes on the surface with the correct numbers in the shortest possible time without missing any of them. After this practice session, participants performed the test within a timed period of 90 seconds, during which they were asked to make as many correct matches as possible. Correct responses within the 90-second period were noted, and the average of the three SDMT results was calculated for each participant. Timing for each session was recorded with a 0.01-second precision electronic hand stopwatch (Casio Hs-70w-1DF, JP).

Figure 1. Symbol Digit Modalities Test Diagram



Data Analysis

A power analysis was initially conducted using the G*Power 3.1.9.7 program. With an effect size of 0.7, a Type I error rate (α level) of 0.05, and a power of 0.80, the required sample size for the study was calculated as 68 participants (Faul et al., 2009). However, data collection exceeded this required sample size, completing the study with 84 participants. Data analysis was conducted using JASP 0.19 (University of Amsterdam, Nieuwe Achtergracht 129B, AMS, NL).

Table 1. Normality Distribution Analysis of Data Obtained from Participants Using the Shapiro-Wilk Test

Test	Group	w	p
SDMT 1	Rugby Athletes	0.992	0.991**
	Controls	0.983	0.812**
SDMT 2	Rugby Athletes	0.986	0.874**
	Controls	0.991	0.989**
SDMT 3	Rugby Athletes	0.959	0.115**
	Controls	0.983	0.793**

$p<0.05$* $p>0.05$**

The Shapiro-Wilk Test was conducted to assess the normality of the data distribution. According to this test, a result of $p<0.05$ indicates that the data do not follow a normal distribution, while $p>0.05$ suggests that the data are normally distributed (Shapiro & Wilk, 1965). Examination of the results revealed that the data followed a normal distribution.

Table 2. Levene's Test for Equality of Variance Between Groups

Test	f	df_1	df_2	p
SDMT 1	0.155	1	82	0.695**
SDMT 2	0.007	1	82	0.931**
SDMT 3	0.318	1	82	0.575**

$p<0.05$* $p>0.05$**

Levene's Test was applied to identify if the assumption of equal variances was met. According to this test, a result of $p<0.05$ indicates a significant dissimilarity in variances between groups, meaning variances are not equal and homogeneous. Conversely, $p>0.05$ suggests that variances are equal and homogeneous (Levene, 1960; Brown & Forsythe, 1974). Examination of the results indicated no significant difference in variances, confirming that variances are equivalent.

Findings for the Shapiro-Wilk and Levene's Tests showed that parametric tests would be suitable for analyzing the data obtained in this study. Accordingly, an Independent Samples T-Test was implemented to analyze Symbol Digit Modalities Test results between groups. For within-group assessments of test results, Repeated Measures ANOVA was applied. To control the significance level within each group, the Bonferroni correction, a post hoc test, was used (Howell, 2012). Additionally, effect sizes for all data were calculated using Cohen's d method (Cohen, 1988). The significance level was set at $p<0.05$.

RESULTS

Table 3. Comparison of Intergroup Symbol Digit Modalities Test Score Differences Using Independent Samples T-Test

Test	Group	n	Mean ± SD	t	p	Cohen's d
SDMT 1	Rugby Players	44	44.568 ± 8.219	-2.490	0.015*	-0.544
	Controls	40	48.900 ± 7.672			
SDMT 2	Rugby Players	44	51.682 ± 10.677	-3.979	< .001*	-0.869
	Controls	40	61.125 ± 11.067			
SDMT 3	Rugby Players	44	57.250 ± 9.782	-3.304	0.001*	-0.722
	Controls	40	64.650 ± 10.748			

p<0.05*

The table presents the score differences between groups across three separate Symbol Digit Modalities Tests (SDMT) conducted with participants. Statistical analysis showed that during the SDMT 1 test, rugby players achieved an average score of 44.568 ± 8.219, while the control group achieved an average score of 48.900 ± 7.672. This difference was statistically significant ($t = -2.490$; $p = 0.015$; Cohen's $d = -0.544$). During the SDMT 2 test, rugby players reached an average score of 51.682 ± 10.677, whereas the control group scored an average of 61.125 ± 11.067, also revealing a statistically significant difference ($t = -3.979$; $p < .001$; Cohen's $d = -0.869$). In the SDMT 3 test, rugby players achieved an average score of 57.250 ± 9.782, while the control group scored an average of 64.650 ± 10.748, with this difference being statistically significant as well ($t = -3.304$; $p = 0.001$; Cohen's $d = -0.722$).

Table 4. Comparison of Intragroup Symbol Digit Modalities Test Score Differences Using Repeated Measures ANOVA

Group	n	Test	Mean ± SD	f	p	Cohen's d	Bonferroni
Rugby Players	44	[a] SDMT 1	44.568 ± 8.219	56.989	< .001*	-0.740	a<b
		[b] SDMT 2	51.682 ± 10.677			-1.319	a<c
		[c] SDMT 3	57.250 ± 9.782			-0.579	b<c
Group	**n**	**Test**	**Mean ± SD**	**f**	**p**	**Cohen's d**	**Bonferroni**
Controls	40	[a] SDMT 1	48.900 ± 7.672	69.087	< .001*	-1.229	a<b
		[b] SDMT 2	61.125 ± 11.067			-1.583	a<c
		[c] SDMT 3	64.650 ± 10.748			-0.354	b<c

p<0.05*

The table presents the intragroup score differences across three separate Symbol Digit Modalities Tests (SDMT) for participants. Statistical analysis indicated that rugby players achieved an average score of 44.568 ± 8.219 in SDMT 1, 51.682 ± 10.677 in SDMT 2, and 57.250 ± 9.782 in SDMT 3. This progression showed a statistically significant difference across the SDMT tests for rugby players ($f = 56.989$; $p < .001$; Cohen's $d = -0.740, -1.319, -0.579$; Bonferroni = a<b, a<c, b<c). Similarly, the control group achieved an average score of 48.900 ± 7.672 in SDMT 1, 61.125 ± 11.067 in SDMT 2, and 64.650 ± 10.748 in SDMT 3. This progression also demonstrated a statistically significant difference across the SDMT tests for the

control group ($f = 69.087$; $p < .001$; Cohen's $d = -1.229, -1.583, -0.354$; Bonferroni = a<b, a<c, b<c).

DISCUSSION

When evaluating the Symbol Digit Modalities Test results between groups, it was observed that the control group had significantly higher scores in SDMT-1, SDMT-2, and SDMT-3 compared to the rugby players. In the intragroup analysis of the Symbol Digit Modalities Test results, a significant increase was observed in the success scores from SDMT-1 to SDMT-2 and from SDMT-2 to SDMT-3 for both the rugby players and the control group.

Ponsford and Kinsella (1992) observed that participants with head trauma performed significantly worse on the SDMT compared to the control group. Similarly, Macciocchi et al. (1996) reported that athletes with head injuries scored lower on the Digit Symbol Test compared to the control group. Collins et al. (1999), who found an association between a history of concussions and learning disabilities, reported lower SDMT performance. Hinton-Bayre et al. (1999) SDMT performance was significantly lower for football players who had sustained concussions. Mrazik et al. (2000) found that more concussions predicted poor SDMT performance. Bate et al. (2001) SDMT reported dramatic impairment of the SDMT in those with traumatic brain injury compared to healthy individuals. Additionally, Echemendia et al. (2001), at one-week post-concussion, injured athletes also had significantly poorer SDMT performance than controls.

Draper and Ponsford (2008), investigating cognitive deficits 10 years after TBI, showed significantly worse SDMT performance and overall cognitive functioning in individuals with TBI than controls. Similarly, Willmott et al. (2009) found that TBI individuals scored significantly less than the controls on SDMT. Dymowski et al. (2015) reported similar findings and indicated that patients with a history of sustaining TBI performed significantly worse on the SDMT when compared to healthy controls. Brett et al. (2022) examined American football players approximately 15 years after retiring and found that increased duration of active sports participation was associated with a decline in SDMT performance.

Based on prior literature, it has been suggested that the number of concussions is related to SDMT performance, that a history of head trauma is associated with impairments on the Digit Symbol Test, and that in professional American football players, years of playing career is associated with SDMT performance decrements. Football players who have sustained concussions also show significantly reduced SDMT performance. Moreover, even after a decade of post-traumatic brain injury, significant reductions in SDMT performance have been noted. Researchers believe that these findings are related to the concussive head traumas experienced by athletes.

This study examined the effects of high-contact rugby on cognitive performance by comparing the cognitive functions of rugby players with those of a healthy control group. The Symbol Digit Modalities Test (SDMT) used in this study revealed significant deficits in cognitive performance among rugby players. Rugby players scored lower than the control group on this test, which assesses cognitive functions such as visual scanning, information processing speed, attention, and motor speed. These findings suggest that the repeated head impacts and contact experienced by rugby players may adversely affect cognitive functions. High-contact sports like rugby pose risks not only to the physical endurance of players but also to their long-term cognitive health. In this context, our findings confirm the risk of cognitive impairment in rugby players and underscore the need for measures to protect their neurocognitive health.

When examining the SDMT-1, SDMT-2, and SDMT-3 scores, a sequential and significant within-group performance increase is observed across tests for both the rugby and control groups. This trend may be attributed to cognitive adaptation to the task, where repeated activities within the cognitive task positively influence performance.

CONCLUSION

The findings of this study emphasize the importance of developing strategies to prevent concussions and other traumatic injuries in high-contact sports such as rugby. It is recommended to implement regular programs and screenings to systematically assess athletes' cognitive functions. Additionally, the development of awareness programs for rugby players and the healthcare professionals who support them could contribute to a better understanding of the neuropsychological risks associated with these sports. Both the performance and long-term health of athletes in high-contact sports like rugby should be prioritized. In this regard, it is suggested that educational programs aimed at reducing the frequency and severity of collisions, as well as enhancing the effectiveness of protective equipment such as helmets, could play a crucial role in supporting cognitive health.

Ethics Statement

Approval for this study was collected from the Ethics Committee of the Faculty of Sport Sciences at Atatürk University, as documented in the letter dated 23.02.2024, numbered E-

70400699-000-2400069728, titled "Ethics Committee Approval." Furthermore, all stages of the research were operated in parallel with the latest version of the Declaration of Helsinki.

Author Contributions

Research design: MSÇ; Supervision: MSÇ; Data collection: MSÇ, EM, HOS; Data analysis: MSÇ; Literature review: MSÇ; Writing: MSÇ; Critical review: MSÇ, EM, HOS.

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