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Comparison of the Cognitive Skills of Adolescent Basketball Players and Sedentary Adolescents

Egemen MANCI[1A], Fırat ÖZDALYAN[2B], Sercin KOSOVA[2C], Hikmet GÜMÜŞ[1D], Celal GENÇOĞLU[2E]

[1]Dokuz Eylül Üniversitesi, Spor Bilimleri Fakültesi, Antrenörlük Eğitimi Bölümü, İzmir/Türkiye
[2]Dokuz Eylül Üniversitesi, Spor Bilimleri Fakültesi, Beden Eğitimi Ve Spor Öğretmenliği Bölümü, İzmir/Türkiye
Address Correspondence to E. Mancı: e-mail: egemenmanci@gmail.com

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A:Orcid ID: 0000-0001-8965-4884 B:Orcid ID: 0000-0003-3577-0235 C: Orcid ID: 0000-0003-1005-3387
D:Orcid ID: 0000-0001-7671-4868 E: Orcid ID: 0000-0001-5568-1331

Abstract

Starting basketball/sports at young ages, participating in practices and games for years improves children in various subjects. Chronic exercise provides a physical and physiological improvement, while also supporting cognitive development significantly. The aim of this study is to apply some cognitive tests that we think reflects some cognitive skills to both athlete and sedentary adolescents compare and evaluate these test results. Twenty-two licensed male adolescent basketball players (x̄:15.59 ±.66 age) and 13 sedentary adolescents (x̄: 15.08 ±.76 age, 5 female) who did not exercise in their daily routine participated in the study. All participants were aged between 12 and 18. Three different cognitive skill tests (Mackworth Clock Test, Timewall Test and Change Detection Test) were applied among the participants via the "Psychology Experiment Building Language Test Battery" on a laptop computer, and the results were recorded. When the findings were analyzed, the results of the Change Detection Test comparisons showed that the athletes' times of completing the whole test and their times of response to each question were shorter than those of the sedentary adolescents (both p<0.01). When the timing scores were analyzed according to the comparisons of the Timewall Test, it was seen that the athletes were significantly more successful (p<0.01). According to the results of the Mackworth Clock Test comparisons, the athletes' correct reaction rates and reaction times were significantly better (both p<0.001). In this study, some cognitive performances of the basketball player and sedentary adolescents were tested and compared to each other. Athletes are continuously exposed to a cognitive process during a practice or a game, and furthermore, they need to make a decision quickly under stress and pressure. As a result of this situation. it might be thought that adolescent athletes may have better cognitive performance than their sedentary peers since they always use these cognitive skills during practices and games for years.

Keywords: Basketball, Cognitive Performance, Reaction Time, Cognitive Tests

Adölesan Basketbolcuların Bilişsel Becerilerinin Spor Yapmayan Yaşıtları ile Karşılaştırılması

Özet

Çocukların küçük yaşlardan itibaren spora/basketbola başlamaları, yıllarca antrenman yapmaları ve müsabakalara çıkmaları onları birçok konuda geliştirmektedir. Kronik egzersiz fiziksel ve fizyolojik gelişim sağlamanın yanı sıra önemli bir şekilde bilişsel gelişimi de desteklemektedir. Bu çalışmanın amacı da bazı bilişsel yetenekleri yansıtacağını düşündüğümüz bilişsel testleri hem sporcularda hem de spor yapmayanlarda uygulayarak sonuçlarının karşılaştırılması ve değerlendirilmesidir. Araştırmaya yaşları 12-18 arasında lisanslı olarak basketbol oynayan 22 (x̄15,59 ±,66 yaş) erkek adölesan sporcu ve günlük yaşantısında spor yapmayan 13 (x̄15,08 ±,76 yaş, 5'i kız) sedanter adölesan katılmıştır. Katılımcılara bir diz üstü bilgisayarda "Psychology Experiment Building Language Test Bataryası" ile üç farklı bilişsel beceri testi (Mackworth Clock Test, Timewall Testi ve Change Detection Testi) uygulanmış ve sonuçları kaydedilmiştir. Sonuçlar değerlendirildiğinde Change Detection Testi için yapılan karşılaştırmalar sonucunda sporcuların, sedanterlere göre tüm testi tamamlama süreleri ve tek bir soruyu cevaplama süreleri anlamlı olarak daha kısa bulunmuştur (İkisi de p<0,01). Timewall Test için yapılan karşılaştırmalar sonucunda zamanlama skorları değerlendirildiğinde ise sporcuların anlamlı olarak daha başarılı olduğu görülmüştür (p<0,01). Mackworth Clock Test için yapılan karşılaştırmaların sonucuna göre ise sporcuların doğru tepki verme oranları ve reaksiyon zamanları anlamlı olarak daha başarılıdır (İkisi de p<0,001). Bu araştırmada basketbolcu ve sedanter adölesanların bazı bilişsel performansları ölçülmüş ve birbiri ile karşılaştırılmıştır. Sporcular bir antrenman ya da müsabaka sırasında sürekli olarak bir bilişsel sürece maruz kalmaktadırlar, ayrıca sporcuların baskı altında ve stres durumunda da hızlı bir şekilde karar almaları gerekmektedir. Bu durumun sonucu olarak, sporcuların bilişsel yetilerini yıllar boyunca antrenmanlarda ve müsabakalarda sürekli kullanmalarından dolayı, spor yapmayan yaşıtlarına göre daha iyi bir bilişsel performansa sahip olabilecekleri düşünülebilir.

Anahtar Kelimeler: Basketbol, Bilişsel Performans, Reaksiyon Zamanı, Bilişsel Testler

INTRODUCTION

Basketball is a team sport that is played by two teams of five players each (30). In a basketball game each player plays in their own specific position. There are some determined roles and responsibilities for these positions. Players are expected to play suitably for these roles, and they take part in physical training on these positions throughout years starting with childhood. Every position has characteristics that are sometimes similar and sometimes different to others. These positions are indicated with numbers and names as: Number 1 = PG, Point Guard, Number 2 = SG, shooting guard, Number 3 = SF, small forward, Number 4 = PF, power forward and Number 5 = C, center (1). Although there are five different positions in basketball, the duties of these positions may be examined under three groups based on their similarities. Some researchers have examined these positions as guards, forwards, and centers (1,11,20). Starting with their initiation to playing basketball at early ages, athletes are directed towards playing in these positions in a short time, and as years pass, they start to increase both their physical and cognitive development by gaining expertise in these positions. The effects of exercise on physical and cognitive functions have been demonstrated in previous studies (6).

Basketball is a complex sports branch where motoric and mental characteristics are on a high level (1). It is a sensory branch that requires a fast communication. Most importantly, the branch of basketball necessitates an excellent skill of perceiving and applying the game in players. That's why, in a game like basketball that constantly flows, the capacity to make the correct decisions in moments is as important as physical performance.

Previous studies showed that chronic exercise increased cognitive performance and academic success (2). In parallel with these studies, it is thought that basketball players may reach sports-related and academic success with the effects of chronic training and competitions.

There is a complicated relationship between exercise and cognitive performance. Changes are observed in cognitive load depending on the selected cognitive task and type of exercise (19). It has been reported in previous studies that, while there are increases or decreases in some cognitive performances in relation to exercise, there are no changes in others (9,18,34). Additionally, research results also show that a good physical condition or exercising increases academic performance (29).

Kamijo et al. (18) examined the effects of exercise intensity on information processing in the central nervous system. They applied the "go/no-go reaction time" test, which is a cognitive test, on 20 male participants at the ages of 22-23 in resting and after low-, moderate- and high-intensity exercise with a cycle ergometer. At the end of the study, while it was determined that attention decreased because of high-intensity exercise, it increased followed moderate-intensity exercise, and it did not change significantly after low-intensity exercise, it is a matter of curiosity what these results would at lower ages.

Although a program specific for cognitive performance is not included in the training contents of athletes in the branch of basketball, it is considered that they are more inclined towards some cognitive loads due to the nature of basketball-specific positions, and their cognitive skills may be more developed than their sedentary peers. It was reported that this situation was also reflected on the academic lives of adolescents (2).

It was hypothesized that adolescent basketball players' cognitive skills might be better than their sedentary peers. If this hypothesis of ours turns out to be accurate, because of assessing cognitive performances in terms of both athlete selection and academic success at early ages, it may be possible to train athletes and adolescents appropriately by guiding them correctly. This way, their probabilities of becoming more successful in their sports or academic lives may be increased.

The purpose of this study is to apply cognitive tests that we think will reflect some cognitive skills (sustained attention, perception, timing, reaction time) on both athletes and sedentary individuals, compare the results and make recommendations regarding both academic and sports-related life.

MATERIAL METHOD

Participants and Experimental Protocol

While determining the number of participants required for the study, the minimum required number of participants for an independent-samples t-test with a significance level of 0.05, power of 0.80 and confidence interval of 0.95 was calculated via PASS (NCSS, Kaysville, Utah, USA) (8,26). As a result of this calculation, the minimum number of participants per group was determined as 17, but problems were experiencing in reaching sedentary participants due to the conditions of the COVID-19 pandemic. In consequence, the study included 22 male adolescents who had been playing basketball as licensed athletes for at least 3 years ($\bar{x}$: 15.59±.66 age) and 13 sedentary individuals who did not take part in exercise in their daily lives ($\bar{x}$: 15.08±.76 age, 5 female) at the ages of 12-18. As in the case of previous studies, the analyses conducted between the male and female participants did not show any effect of sex on cognitive performance (31).

The heights and weights of the participants were recorded, and their body mass index (BMI) values were calculated. The participants were then explained the tests in detail before implementations, and 3 different cognitive skill tests (Mackworth Clock Test, Timewall Test and Change Detection Test) were applied in the same order for each participant on a laptop computer using the "Psychology Experiment Building Language (PEBL) Test Battery" (24,27). No particular interval was given between the tests. Measurements were taken within the same hour of the day from all participants (2.00-4.00 PM). After each test, the participants were asked to score their experiences of how difficult they found the test on a scale of 1 (simplest) to 10 (most difficult). At the end of this process, the Ratings of Perceived Mental Exertion (RPE-M) of the participants for each test were determined (17). As the participants were under the age of 18, signed documents showing that they volunteered to participate were collected from their legal parents. This study was approved by the Non-interventional Studies Ethics Committee of Dokuz Eylül University with the decision numbered 2019/21-31 and dated 04.09.2019. The research procedures of this study were followed in compliance with the ethical standards of the Declaration of Helsinki.

Cognitive Tests

Change Detection Test (CDT): The participant is expected to notice a circle that disappears or whose color, dimension or position changes within a flashing pattern consisting of circles with different dimensions and colors displayed on the screen (Figure 1). The participant needs to freeze the screen when they notice the change and mark the change by clicking on the position where they observed the change. The reaction times of the participants, their numbers of correctly identified changes and their times of completing the test were analyzed (28).

Figure 1: Change Detection Test

Mackworth Clock Test for Sustained Attention (CT): Along a circular path consisting of small circles, a red light moves in one direction by flashing (Figure 2). Whenever the light skips a position, the participant needs to notice this and press the button in the shortest time possible. The test measures sustained attention, vigilance and reaction time and takes an average of one minute to complete (21).

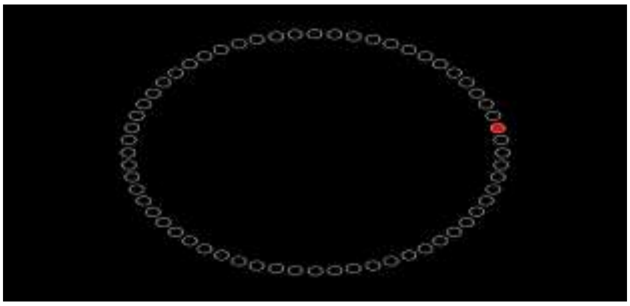

Figure 2: Mackworth Clock Test

Timewall Test (TT): The participant is expected to predict the time when a green rectangle with a width of 0.5 cm moving downwards with a constant velocity hits the ground behind a wall covering the lower third of the screen and press the button when they think it hits the ground (Figure 3). This test assesses visual-spatial perception. The differences between the reaction times of the participants and the target time and the ratios of these differences to the target time were calculated, and the reaction times were assessed as "Early Press", "Late Press" and "Great Accuracy" (13).

Figure 3: Timewall Test

Data Analysis

The normality tests that were conducted on the data did not show a normal distribution. Therefore, non-parametric tests (Mann Whitney U test, and Wilcoxon Signed-Rank test) were used in the analyses. The level of significance was taken as $p<0.05$ for all analyses.

RESULTS

This study included 22 male adolescents who had been playing basketball as licensed athletes for at least 3 years (x̄: 15.59±.66 age) and 13 sedentary individuals who did not take part in exercise in their daily lives (x̄: 15.08±.76 age, 5 female) at the ages of 12-18. The descriptive and demographic information of the participants is given in Table 1.

Table 1. Descriptive and demographic information of the participants

	Sedentary Adolescents (n=13)				**Adolescent Basketball Players** (n=22)			
	Min.	**Max.**	**X̄**	**SD±**	**Min.**	**Max.**	**X̄**	**SD±**
Age (years)	14	16	15.08	.76	14	16	15.59	.66
Height (cm)	155.00	178.00	166.92	7.27	174.00	196.00	188.36	5.80
Weight (kg)	41.00	71.00	55.76	8.69	56.00	107.00	77.36	11.63
BMI (kg/m^2)	17.07	23.03	19.91	1.98	17.28	29.64	21.77	2.79
Years of License	0				3	8	5.68	1.64
CDT RPE-M	6	9	7.54	.967	6	10	7.82	.95
CT RPE-M	2	5	3.69	.855	1	8	3.27	1.57
TT RPE-M	4	7	5.62	.870	2	7	4.73	1.63

X̄= Mean, SD±= Standard Deviation, BMI= Body Mass Index, CDT= Change Detection Test, CT= Clock Test, TT= Timewall Test, RPE-M= Ratings of Perceived Mental Exertion

As a result of the comparisons made for the Change Detection Test results, the times of the basketball players to complete the entire test and their times of answering each question were significantly shorter than those of the sedentary adolescents (respectively, p=0.007 and p=0.001, Table 2). No significant difference was found between the groups in terms of the numbers of correct answers. Accordingly, the adolescent athletes reached the same number of correct answers in a shorter time than the sedentary adolescents.

Table 2. Change Detection Test Result

	Whole Test Completion Time (min.)		**Single Trial Response Time (sec.)**		**Number of Correct Answers**	
	Sedentary	**Athlete**	**Sedentary**	**Athlete**	**Sedentary**	**Athlete**
X̄	6.66±1.35	5.44±1.29	15.59±2.94	11.98±2.60	13.07±1.38	14.09±2.65
Z	-2.646		-3.090		-1.399	
Sig. (p)	0.007*		0.001*		0.16	

X̄=Mean, ±= Standard Deviation, *p<0.01

As a result of the comparisons made for the Timewall Test results, it was observed that the numbers of the sedentary adolescents to press the button early were significantly higher (p=0.004, Table 3). In the assessment of the numbers of excellent timings, the adolescent athletes were found to be significantly more successful (p=0.005, Table 3). These results showed that the adolescent athletes had better timing skills than the sedentary adolescents, and they did not hurry to respond to the tests.

Table 3. Timewall Test Results

	Number of Early Presses		Number of Late Presses		Great Accuracy Numbers	
	Sedentary	**Athlete**	**Sedentary**	**Athlete**	**Sedentary**	**Athlete**
X̄	9.77±3.24	6.05±3.72	1.46±.77	1.36±1.29	8.77±3.56	12.59±3.31
Z	-2.794		-.604		-2.748	
Sig. (p)	0.004*		0.546		0.005*	

X̄=Mean, ±= Standard Deviation, *p<0.01

As a result of the comparisons made for the results of the Mackworth Clock Test, the correct reaction rates of the athletes were found to be significantly higher (p<0.001, Table 4). In terms of the reaction times, the adolescent athletes had significantly shorter values (p<0.001, Table 4). These results showed that the reaction times and sustained attention levels of the adolescent athletes were better than those of the sedentary adolescents.

Table 4. Mackworth Clock Test Results

	Correct Reaction Rate (%)		Reaction Time (sec.)	
	Sedentary	**Athlete**	**Sedentary**	**Athlete**
X̄	87.96±6.44	94.87±3.31	.60±.22	.37±.80
Z	-3.692		-3.209	
Sig. (p)	<0.001*		<0.001*	

X̄=Mean, ±= Standard Deviation, *p<0.001

Ratings of Perceived Mental Exertion (RPE-M)

The participants were asked to assess the difficulty of the tests on a scale of 1 to 10. When the scores they reported were compared, no significant difference was found between the sedentary and adolescent athletes (Figure 4). These results demonstrated that both groups had the same level of difficulty in the tests, but the adolescent athletes coped with this difficulty better and received better results.

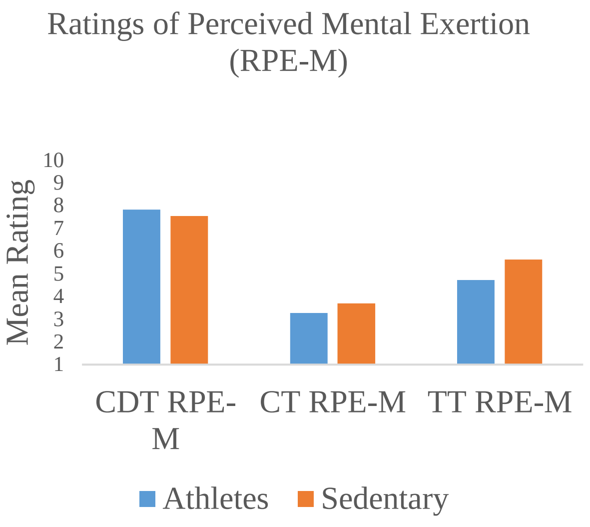

Figure 4. Ratings of Perceived Mental Exertion (CDT=Change Detection Test, CT= Clock Test, TT= Timewall Test, RPE-M = Ratings of Perceived Mental Exertion)

DISCUSSION

This study aimed to evaluate the cognitive performances of adolescents who took part in basketball with a license and sedentary peers those who were not involved in sports in their daily lives. The findings of the study showed that there were differences between the cognitive performances of the athletes and the sedentary adolescents. It is thought that, because of training for years, the cognitive capacities of athletes who start sports/basketball at early ages required by the branch of sports also increase. As in many sports branches, capacities such as being able to sustain attention, reaction time, being able to perceive what one sees fast, selective attention and timing skills are also prominent in basketball. These cognitive capacities are those that are used and made a priority not only during a training session or a competition but also in all areas of life.

As shown by Ursula et al., it was reported that chronic exercise influences cognitive performance and academic success (32). Similarly, it was seen in this study that the cognitive performance levels of the basketball players among the adolescents increased because of chronic training. Additionally, as shown in previous studies, it is believed that the academic success levels of basketball players would also increase because of chronic training (32,33). For example, when students are taking examinations throughout their academic lives, they need to be able to focus on examination questions for long periods of time. Their chances of becoming more successful in these examinations may be increased by improving these attention skills of theirs. Thus, these cognitive capacities that are developed with sports may also allow both athletes and sedentary individuals to become more successful in their sports-related and academic lives. Among previous studies, there are those that have compared several different characteristics of adolescent athletes and sedentary adolescents including their physical fitness, body compositions, anthropometric properties, and social skills (4,10). In addition to these, there are also studies that have examined the cognitive test performances of athletes in different branches (16). However, the number of studies directly examining cognitive performances between sedentary adolescents and adolescent athletes is highly limited. In this context, it is believed that this study will make a significant contribution to the literature.

In the recent literature, the number of studies examining the effects of acute exercise on cognitive performance is constantly increasing (3,12,15). The current literature shows that there is a complicated relationship between exercise and cognitive performance. Changes are observed in cognitive performance based on the selected cognitive capacities, cognitive tasks, and exercise types (19). It has been reported in previous studies that, while there are decreases or increases in some cognitive performances based on exercise, there are no changes in some others (9,18,19). Studies investigating the physiological effects of different types of exercise on the brain have found that blood circulation in the brain increases during an acute exercise (5,22). A relationship has been found between increased brain blood circulation and cognitive performance, and the positive effects of exercise on brain functions have been demonstrated in many studies (14,23,25). However, the effect of chronic adaptation on cognitive performance has not been clarified in the literature yet. Previously Kamijo et al. (18) investigated the effects of exercise intensity on information processing in the central nervous system. They applied the "go/no-go reaction time" test, which is a cognitive test, on 20 male participants at the ages of 22-23 in resting and after low-, moderate- and high-intensity exercise with a cycle ergometer. At the end of the study, while it was determined that attention decreased as a result of high-intensity exercise, it increased followed moderate-intensity exercise, and it did not change significantly after low-intensity exercise, it is a matter of curiosity what these results would at lower ages. In this study, the chronic effect of exercise in adolescent age groups was evaluated, and when the results were interpreted, it was observed that long-term exercise had a positive effect on many cognitive performance categories. Furthermore, in light of this information, it is thought that chronic basketball training may be effective in the development of several different cognitive capacities (sustained attention, perception, timing, reaction time).

Although athletes in the branch of basketball do not specifically take part in cognitive training, as a requirement of the sport and nature of basketball-specific positions, it is seen that they are more inclined towards some cognitive loads and have more developed cognitive skills in comparison to their sedentary peers because of their long-term training. It was stated that regular long-term training has a positive effect on the neural structural development of the brain (7). Based on this, it is considered that athletes may show a more successful cognitive performance compared to their sedentary peers.

The literature review did not reveal any study, which examined the RPE-M data of cognitive tests applied on adolescents involved in basketball (CDT, CT, and TT). Therefore, it is believed that our study will provide a valuable contribution to the literature. In this study, when the RPE-M data were examined, it was observed that both groups had the same levels of difficulty in the same cognitive tests, and there was no significant difference between them in terms of RPE-M. These findings revealed that, because of chronic training, the adolescent athletes could overcome tasks with high RPE-M more successfully than their sedentary peers, and they became more successful in cognitive tasks with the same difficulty levels. Additionally, in this study, the cognitive tests were applied in the same order in each participant, and the durations of the cognitive tests differed. It is recommended for future studies to compare the RPE-M values of cognitive tests in settings where the cognitive tests are applied on participants in a randomized order, and the durations of the tests are standardized.

According to the sample size calculation, the minimum number of participants per group was determined as 17. And 22 male adolescent basketball players were included in the study. However, due to the COVID-19 pandemic situation, 13 sedentary adolescents were included in the study instead of a minimum number of 17. And this may be considered as a limitation of the study. For this reason, future studies carried out with an adequate number of participants are recommended by the authors.

CONCLUSION

Consequently, in this study, some cognitive performances of adolescent basketball players and sedentary adolescents were measured and compared to each other. Athletes are constantly exposed to a cognitive process during a training session of a competition, and they must make decisions fast under pressure and stress. It is believed that, as they had used these cognitive capacities of theirs for years throughout training sessions and competitions, the adolescent athletes had better cognitive performance than their sedentary peers. Cognitive processes become prominent not only in sport-related life but also in social, daily, and academic life. Therefore, it is thought that introducing individuals to sports from early ages will be important in terms of the development of their cognitive performance and academic success. For the above-mentioned reasons, it is recommended that children start playing basketball to improve their cognitive abilities as well as physical abilities. Moreover, in terms of player development, it might be beneficial for basketball coaches to add cognitive development training to their long-term training plans.

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