



# Investigation Of The Cognitive Flexibility, Sleep Quality, Academic Performance Of Students Based On Physical Activity Level

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## ARTICLE INFO

## ABSTRACT

Physical activity levels are important in terms of cognitive activities and academic performance. In this context, the present study aims to comparatively examine the physical activity level, cognitive flexibility, sleep quality and academic performance of primary school students. The study included 600 students Data were collected using the International Physical Activity Questionnaire, the Cognitive Flexibility Scale, and the Pittsburgh Sleep Quality Index while academic performance was measured using the E-Okul system. According to the findings of the study, when the cognitive flexibility was compared with the physical activity, a significant difference was found between the group with moderate and high physical activity and the group with low physical activity. When the sleep quality and physical activity were compared, no significant difference was found between the groups. When the academic achievement and physical activity were compared, there was a significant difference between the group with moderate physical activity and the group with high physical activity. Based on the findings of this study, it can be concluded that moderate physical activity can positively affect cognitive flexibility and academic performance.

**Keywords:** academic achievement, cognitive flexibility, physical activity, sleep quality

## INTRODUCTION

Physical movements that increase energy consumption above the basal level through muscle contraction are considered as physical activity. The intensity of physical activity is divided into 3 classes according to its metabolic equivalent (MET): low, moderate and high (Bulut, 2013). The changes that occur in the organism may differ according to the intensity of physical activity. Therefore, it is necessary to determine the intensity of physical activity in accordance with the purpose and age group. When the literature is examined, it is clearly seen that regular physical activity plays a decisive role in maintaining physiological and psychological health (Hallal et al., 2012; Hills et al., 2015; Warburton & Bredin, 2016; Belcher et al., 2021; Karagöz et al., 2023; Mahindru et al., 2023; Sariakçali et al., 2022).

Physical activity also has an important role in the functioning and development of cognitive activities. Aerobic-based physical activity is recognized as an important stimulus for maintaining cognitive health and cerebral structural changes (Thomas et al., 2012; Canlı, 2022). It was also found that physical activity produces specific changes in the brain different from the changes that occur through learning or new experiences (Black et al., 1990; Buschert et al., 2019; Canlı, 2022). Previous studies have shown that regular physical activity increases hippocampus and cerebral blood volume (Thomas et al., 2012; Aghjayan et al., 2021). Moreover, physical activity has been found to have a positive effect on cognitive functions due to the increased stimulation of neurotransmitters such as serotonin and dopamine in the brain (Dishman et al., 2006; Marques et al., 2021). Therefore, it can be predicted that the cognitive performance of individuals who regularly engage in physical activity will be higher than those who do not. It is thought that physical activity will play a decisive role in the

development of factors related to cognitive performance such as information processing, cognitive flexibility, selective attention, decision making and academic success, especially in adolescence, which is regarded as one of the most important stages of development. It can also be said that sleep quality is effective on cognitive performance (Miyata et al., 2013; Zavec et al., 2020; Çağın & Yarım, 2023).

Cognitive flexibility, which is one of the sub-steps of cognitive performance, is defined as the individual's belief that there are options and alternatives suitable for all kinds of situations and feeling competent in these situations (Martin et al., 1998). Cognitive flexibility has a very important place in terms of being a determinant of learning and problem solving skills, particularly in adolescents. Another determinant of cognitive performance is academic achievement (Alvarez-Bueno et al., 2017; ). Academic achievement in adolescents is defined as the level of acquisition of behaviors aimed to be attained during academic life (Silah, 2003). In other words, it is defined as the state of achieving a higher status with degrees, grades and certificates obtained as a result of acquiring the necessary knowledge and competence. In this context, it can be said that both cognitive flexibility and academic achievement play an important role in determining cognitive performance in adolescents. Sleep refers to a process that allows the organism to store energy through cognitive renewal (Kline, 2013). In previous studies, it was observed that disruption in cognitive functions occurs in case of disruption in sleep patterns and a decrease in sleep quality due to this situation. If this situation persists for a long time, it can lead to various acute or chronic cognitive disorders (Nguyen et al., 2022; Özsoy & Karakuş, 2023). When the studies in the literature were evaluated, it was hypothesized that physical activity, cognitive flexibility and sleep quality may be related to academic achievement. Considering that physical activity in particular is related to all these parameters, the present study aims to examine the physical activity level, cognitive flexibility, sleep quality and academic performance of primary school students.

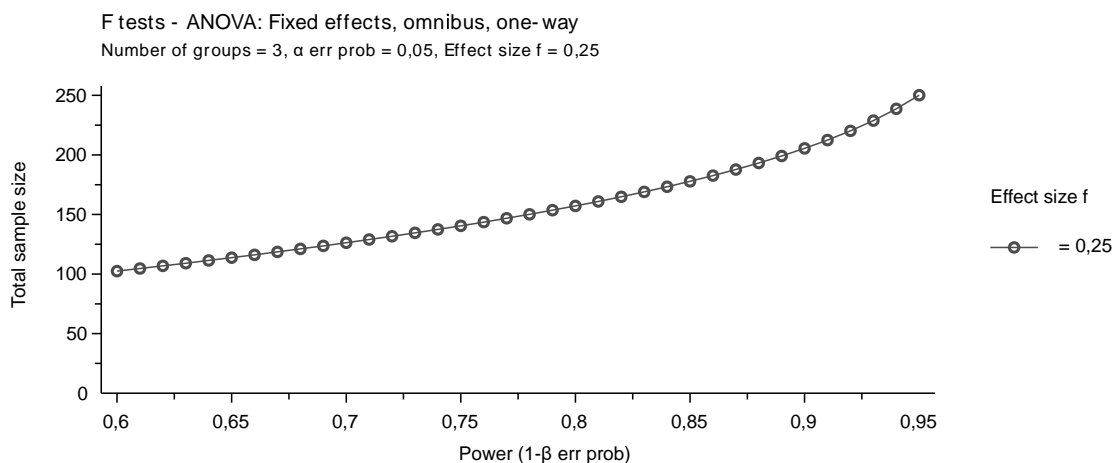
## METHODOLOGY

### Study Group

The power analysis method was used to determine the sample group of the study and the sample size was determined as a minimum of 252 individuals based on a one-way analysis of variance (ANOVA) with a confidence level of 95% ( $1-\alpha$ ), a test power of 95% ( $1-\beta$ ) and an effect size of  $f=0.25$  (Table 1). A total of 600 primary school students were included in the study. The inclusion criteria were as follows: studying in primary school, not being a mainstreamed student, not having an acute disability and not having any absenteeism. The number of male students participating in the study was determined as ( $n = 300$ ) and the number of female students was ( $n = 300$ ). The class distribution of the students was determined as follows: 5th grade ( $n= 146$ ); 6th grade ( $n= 151$ ); 7th grade ( $n= 150$ ); 8th grade ( $n= 153$ ). The mean age of the participants was  $12\pm 1$  years, mean body weight was  $47\pm 11$  kg, mean height was  $155\pm 10$  cm, and mean academic achievement score was  $72\pm 16$  points.

### Graphic 1

#### The Power Analysis Result



### Study Design

The necessary permission and approval was obtained from the Gazi University Ethics Commission (Code: 2023-631) and the study was conducted in accordance with the Declaration of Helsinki. The forms to be used for measurement purposes along with parental consent forms were hand-delivered to the teachers. After obtaining parental consent, data were collected face-to-face in an interactive manner.

### **Data Collection Tools**

The physical activity levels of the individuals who participated in the study were determined using the "International Physical Activity Questionnaire", their cognitive flexibility was determined using the "Cognitive Flexibility Scale", their sleep quality was determined using the "Pittsburgh Sleep Quality Index", and their academic achievement was determined using the E-Okul system.

### **Personal Information Form**

A personal information form structured by the researchers was used to collect data on the age, height, weight and gender of the participants.

### **International Physical Activity Questionnaire (IPAQ)**

The short version of the International Physical Activity Questionnaire (IPAQ) consisting of 7 questions was used to determine the physical activity levels of the participants. In the form, it was questioned whether physical activity was performed for a minimum of 10 minutes at a time in the last 7 days. A validity and reliability study of the questionnaire was conducted in Turkey (Öztürk, 2005). The MET (Metabolic Equivalent) method was used to determine the level of physical activity. Below 600 MET-min/week was defined as low level, between 600-3000 MET-min/week as medium level and above 3000 MET-min/week as high level physical activity.

### **Pittsburgh Sleep Quality Index (PSQI)**

The Pittsburgh Sleep Quality Index (PSQI) was used to determine the sleep quality of the students participating in the study. The PSQI is used to assess the sleep quality of individuals within a period of one month. The first 19 of the 24 questions in the PSQI are self-report questions and the remaining 5 questions are answered by a roommate or spouse. The final 5 questions, which are only used to obtain information in clinical studies, are not included in the scoring. The last question in the self-report section (question 19) is about whether there is a roommate or spouse. Therefore, it is not taken into account in determining the total and component scores of the PSQI. The 18 questions used for scoring are categorized into 7 separate component scores. While some of the components are determined with only one question, others are obtained by grouping several questions. Each question is evaluated on a 0-3 scale. The sum of the 7 component scores represents the total PSQI score. The total score has a range between 0-21. PSQI total scores greater than 5 indicate poor sleep quality and scores less than 5 indicate good sleep quality. The PSQI is a quantitative measure of sleep quality used to determine "good sleep" and "poor sleep". The reliability and validity studies of the scale for Turkey were conducted by Ağargün et al. in 1996.

### **Cognitive Flexibility Scale**

In order to measure the cognitive flexibility level of the students participating in the study, the Cognitive Flexibility Scale (CFS) developed by Martin and Rubin (1995) and its Turkish validity and reliability study by Çelikkaleli (2014) were used. The CFA is a Likert-type scale consisting of 12 items graded from (1) "Strongly disagree" to (6) "Strongly agree". Items 2, 3, 6 and 10 are reverse scored. High scores on the scale indicate high levels of cognitive flexibility. Cronbach's Alpha coefficients of this scale were found to be .74. (Çelikkaleli, 2014). Within the scope of this research, Cronbach's Alpha coefficient was found to be .72 for the entire scale.

### **Determination of Academic Success**

In order to measure the academic achievement of the students participating in the study, the e-Okul system, which was launched in January 2007 by the Ministry of National Education of the Republic of Turkey within the scope of the Ministry of National Education Information Systems project, was used.

## **Data Analysis**

The data obtained from the study were analyzed with SPSS (version 26.0; IBM Corp., Armonk, NY). Skewness and kurtosis values were taken into consideration to determine the normality of the data. Skewness and kurtosis values within the range of  $\pm 2$  indicate normal distribution (George & Mallery, 2019). According to the physical activity levels of the students; cognitive flexibility ( $Z_{skew}=-.281$ ,  $Z_{kurt}=-.090$ ), sleep quality ( $Z_{skew}=.575$ ,  $Z_{kurt}=.297$ ) and academic achievement ( $Z_{skew}=-.455$ ,  $Z_{kurt}=-.297$ ) scores were found to be normally distributed. Therefore, a One-Way ANOVA Test was applied to compare three independent groups (low, medium, high) and the Pearson Correlation Test was applied to determine the correlation between the parameters. The significance level was determined as  $p<0.05$ .

## FINDINGS

**Table 1** Comparison of cognitive flexibility, sleep quality total score and academic achievement score according to physical activity levels

Parameters	FA Level	N	Mean	ss.	f	p	Significant Difference
Cognitive Flexibility Total Score	Low	174	47.98	10.416	6.466	<b>.002</b>	<b>Moderate-Low/High-Low</b>
	Moderate	156	51.17	10.783			
	High	270	51.33	9.646			
Sleep Quality Total Score	Low	174	5.31	2.335	1.266	.283	-
	Moderate	156	5.63	2.402			
	High	270	5.68	2.633			
Academic Achievement Score	Low	174	73.52	16.933	3.091	<b>.046</b>	<b>Moderate-High</b>
	Moderate	156	74.93	15.686			
	High	270	71.04	16.115			

When the cognitive flexibility total score was compared with physical activity level, a significant difference was found between the group with moderate and high physical activity level and the group with low physical activity level ( $p < 0.05$ ). When the sleep quality total score was compared with physical activity level, no significant difference was found between the groups ( $p > 0.05$ ). When academic achievement score and physical activity level were compared, a significant difference was observed between the group with moderate physical activity level and the group with high physical activity level ( $p < 0.05$ ).

**Table 2** The relationship between academic achievement score, physical activity level, sleep quality total score and cognitive flexibility total score

		Academic Achievement Score	Physical Activity Level	Sleep Quality Total Score	Cognitive Flexibility Total Score
Academic Achievement Score	<b>r</b>	1			
	<b>p</b>				
Physical Activity Level	<b>r</b>	-.105**	1		
	<b>p</b>	<b>.010</b>			
Sleep Quality Total Score	<b>r</b>	-.118**	-.018	1	
	<b>p</b>	<b>.004</b>	.653		
Cognitive Flexibility Total Score	<b>r</b>	.222**	.035	-.267**	1
	<b>p</b>	<b>.000</b>	.389	<b>.000</b>	

When the correlation between the parameters was analyzed, a significant negative correlation was found between academic achievement and physical activity level ( $p < 0.05$ ). A significant negative correlation was found between academic achievement and sleep quality total score ( $p < 0.05$ ). There was a significant positive correlation between academic achievement and cognitive flexibility total score ( $p < 0.05$ ). There was a significant negative correlation between sleep quality total score and cognitive flexibility total score ( $p < 0.05$ ). There was no significant relationship between physical activity level and sleep quality total score, and no significant relationship between cognitive flexibility total score and physical activity level ( $p > 0.05$ ).

## DISCUSSION

In the present study, it was aimed to comparatively examine the cognitive flexibility, sleep quality and academic performance of primary school students according to their physical activity level. When the results of the study were analyzed; it was determined that cognitive flexibility increased as the physical activity level increased ( $p < 0.05$ ). In parallel with the findings of the present study, in a study conducted in 2018, it was found that increasing physical activity level also improved cognitive flexibility in children (Bidzan-Bluma & Lipowska, 2018). In another study conducted in 2021, the effects of 10 weeks of physical activity on students' cognitive

flexibility were examined. In the study conducted on a total of 114 children (aged 8-12 years) as control and experimental groups, it was observed that the cognitive flexibility of the more active group improved more (Ángel Latorre-Román et al., 2021). In another study, it was found that physical activity changes the brain structurally in a positive way and makes it more functional (Günay & Yılmaz, 2023). In a 2008 study investigating the effects of 23 minutes of walking on cognitive flexibility in children aged 7-11 years, it was found that low-intensity exercise had no significant effect on cognitive flexibility (Tomprowski et al., 2008). When the relationship between physical activity level and sleep quality was examined, it was found that as the physical activity level increased, sleep quality decreased, but there was no significant relationship ( $p > 0.05$ ). In parallel with the findings of the study, in a study conducted on university students in 2015, a negative, low-grade, significant relationship was found between physical activity level and total sleep quality (Işık et al., 2015). In a 2013 study conducted on children aged 8-10 years, it was concluded that moderate physical activity increased sleep quality (Ekstedt et al., 2013). In a study conducted in 2022 on university students, no significant difference was found between physical activity level and sleep quality (Arslan & Aydın, 2022). In a study conducted on adults, no significant relationship was found between physical activity level and sleep quality (Aktaş et al., 2015). In a 2020 study, physical activity was characterized as an effective method to improve sleep quality (Antczak et al., 2020).

When the relationship between physical activity level and academic achievement was examined; the academic achievement of individuals with moderate physical activity level was found to be the highest, and the academic achievement of individuals with high physical activity level was found to be the lowest ( $p < 0.05$ ). In parallel with the findings of this study, a study conducted in 2023 revealed that moderate physical activity positively affected academic achievement, while high physical activity negatively affected academic achievement. Based on the findings of the study, it was deemed appropriate to implement a physical activity program that is not insufficient or excessive, taking into account individual characteristics and needs in order to increase academic achievement (Fu et al., 2023). In contrast to the findings of the present study, in a study examining the effect of 24 minutes of high intensity aerobic physical activity applied to 8th grade students in physical education class on mathematics performance; it was concluded that high intensity aerobic physical activity increased the mathematical processing performance of the participants (Travlos, 2010). As a result of the literature review, it was concluded that physical activity does not have a negative effect on academic achievement or causes any obstacle. Improving the facilities for physical activity, particularly in schools, and encouraging students to engage in physical activity during breaks may have a positive effect on academic performance (Marsigliante et al., 2023).

When the relationship between the parameters was analyzed, a significant relationship was found between cognitive flexibility and academic achievement ( $p < 0.05$ ). According to this finding, it can be said that cognitive flexibility can positively affect academic achievement. It is known that academic achievement is influenced by numerous factors. One of these factors is cognitive abilities (Altun & Çakan, 2008; Dane et al., 2009). This issue has been addressed in several studies in the literature. In support of the findings of this study, it has been reported in multiple studies that regular physical activity has cognitive contributions on children and as a result, their academic achievement is positively affected (Owen et al., 2018; Singh et al., 2012). One of the most influential factors on academic achievement is sleep (Ekenler & Altinel, 2021). When the study findings were analyzed, a significant relationship was found between sleep quality and cognitive flexibility ( $p < 0.05$ ). According to this result, it can be said that cognitive flexibility may increase as sleep quality increases. In a study supporting this situation, it was found that cognitive flexibility was severely impaired when sleep quality was low (Whitney et al., 2015). Depending on this situation, a significant relationship was found between sleep quality and academic achievement ( $p < 0.05$ ). In this context, it can be said that as sleep quality increases, academic achievement may also increase. It has been stated that if sleep quality is low, many processes such as perception and adaptation are negatively affected in students, thus academic performance decreases (Muslu, 2023). In a study conducted on nursing students, students' sleep quality was generally found to be low. It was determined that students with low sleep quality also had low academic performance (Ekenler & Altinel, 2021). The results obtained from the study findings were generally consistent with the literature. In this context, it can be said that physical activity has a positive effect on the cognitive performance of primary school students. Furthermore, in order for physical activity to have a positive effect on cognitive activities in adolescents, it is necessary to determine the appropriate level of intensity for the related group. It can be suggested that physical education teachers working in schools should focus on the importance of physical activity, emphasize that the activity can positively affect the cognitive activities of students and support the transformation of physical activity into a habit.

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