Negative correlation between the sleep qualities and cardiorespiratory fitness in adolescents

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Abstract

Background & Study Aim: To gain health and fitness benefits from moderate-to-vigorous physical activity, it is advisable to accumulate moderate-to-vigorous physical activity in 30 minutes' periods in most cases on the recommended days of the week. The role exercise plays affect brain plasticity, physical activity is important for cognitive development, mood state, memory, learning, and concentration in students. The purpose of this study was knowledge about the physical fitness and sleep quality of male high school students participating in regular physical activities.

Material & Methods: Thirty healthy young male participants who were male high school students: 17 good sleep group and 13 poor sleep group. All participants measured body composition, sleep quality, and physical fitness. The Pittsburgh Sleep Quality Index (PSQI) is a self-report questionnaire that assesses sleep quality and quantity.

Results: PSQI global score ($p<0.001$), sleep quality ($p<0.01$), sleep onset latency ($p<0.01$), sleep duration ($p<0.001$), and daytime dysfunction ($p<0.05$) were significant difference in two groups. The physical fitness was no significant difference between the two groups. A negative correlation was found between the PSQI global score and VO2max ($r = -0.488$, $p<0.01$).

Conclusions: This study indicates an association between poor sleep quality and cardiopulmonary endurance. In addition, shortened sleep duration, longer sleep onset latency, and daytime dysfunction led to poor sleep quality even if participating in regular physical activity. These findings provide preliminary evidence that adolescents who have poor sleep quality are required that necessary to continue exercise or physical activity to improve cardiopulmonary endurance.

Keywords: cardiopulmonary endurance • physical fitness • students

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Cardiopulmonary endurance – definitions of phenomena related to this term: **cardiorespiratory endurance** – *noun* the body's ability to carry out prolonged exercise, taking into account both muscle strength and aerobic capacity; **cardiovascular endurance** – *noun* the ability of the cardiovascular system to deliver sufficient blood to the muscles to sustain intense activity for any period of time [32].

Cardiovascular disease – *noun* reduced function of the heart and arteries caused by excessive intake of saturated fats. Abbreviation **CVD** [32]**.**

Endurance – *noun* the ability or power to bear prolonged exertion, pain or hardship [32].

Physical activity – *noun* exercise and general movement that a person carries out as part of their day [32].

Fitness – noun the fact of being strong and healthy [32].

INTRODUCTION

To gain health and fitness benefits from moderate-to-vigorous physical activity, it is advisable to accumulate moderate-to-vigorous physical activity in 30 minutes' periods in most cases on the recommended days of the week [1]. The role exercise plays affect brain plasticity, physical activity is important for cognitive development, mood state, memory, learning, and concentration in students [2]. However, decreased physical activity in childhood and adolescence is an important risk factor for chronic diseases such as obesity, hypertension, and cardiovascular disease in adulthood [3].

Especially reported that as strong and specific association between an indicator of childhood social circumstances and cardiovascular disease mortality among males [4]. Also, cardiopulmonary endurance was also associated with cognitive processing speed [5]. Therefore, prevention of cardiovascular disease through the promotion of physical activity in childhood is more important than anything else [6].

Another point that irregular sleep schedules, characterized by daily fluctuations in sleep duration or timing, indicate a mild but much more common and chronic disorder of the circadian rhythm in the general population than shift work [7]. Given that significant linear associations exist between sleep-disordered and the mental state, vitality health, physical functioning, role of physical, and general health quality [8]. Researchers generally assume that sleep has three main functions. These include metabolic function (critical metabolic, immunologic, and restorative physiologic processes) and learning and neural plasticity (cognitive performance) [9]. Also, sleep quality and quantity are closely related to student learning capacity and academic performance [10].

Thus, high school students are important cardiopulmonary endurance and sleep quality in adolescence. However, there are some studies to investigate the each of cardiopulmonary endurance and sleep quality through intervention studies. But, the association between the cardiopulmonary endurance and sleep quality in high school students with regular physical activity has not been previously examined.

The purpose of this study was knowledge about the physical fitness and sleep quality of male high school students participating in regular physical activities.

MATERIAL AND METHODS

Study participants

Among the 30 healthy males who volunteered to participate in the study, who participated in regular physical activities (60 minutes, 3 days of physical activities such as handball, volleyball, soccer, and basketball per week) over the 1 year. The participants were divided into the good sleep (GS; n = 17) and the poor sleep (PS; n = 13). The physical characteristics of the participants are shown in Table 1.

All subjects who agreed to participate in the study had the study explained to them to ensure a complete understanding of its purpose and the methods used with the ethical standard of the Declaration of Helsinki. The subjects also signed an informed consent form before participation.

Study design

All participants were screened for sleep quality using the PSQI (Pittsburgh sleep quality index) from Buysse et al. [11] 1) sleep quality, 2) latency, 3) duration, 4) habitual sleep efficiency, 5) use of

Table 1. The characteristic of the subjects.

Variable	Groups		
	good sleep (n = 17)	poor sleep (n = 13)	*p*-value
Age (years)	16.53 ±0.87	16.38 ±1.12	0.694
Height (cm)	175.8 ±7.04	174.9 ±7.38	0.751
Weight (kg)	63.81 ±8.61	66.67 ±10.2	0.414
BMI (kg/m^2)	20.60 ±2.09	21.66 ±1.97	0.170
Fat free mass (kg)	55.65 ±6.79	56.12 ±7.49	0.868

medications, 6) disturbance, and 7) daytime dysfunction. The global PSQI score of ≤5 correctly identified of 'good', >5 correctly identified of 'poor'.

Measurement of body composition

Physical and anthropometric variables were measured in both groups. Body mass and height were measured to the nearest 0.1 kg and 0.1 cm, respectively, using a body composition analyzer (Inbody 770, Body Composition Analyzer; Inbody, Seoul, Korea). BMI was calculated as weight in kilograms divided by the square of the height in meters.

Measurement of sleep quality

The Pittsburgh Sleep Quality Index (PSQI) is a self-report questionnaire that assesses sleep quality and quantity. All participants completed the PSQI. The PSQI comprises 19-item self-report questionnaire that yields 7 component scores: subjective sleep quality, sleep latency, duration, habitual sleep efficiency, sleep disturbances, use of sleeping medication, and daytime dysfunction. Each component is rated on a 0–3 Severity Scale referring to the frequency of each disturbance, and yields a global score with a range of 0–21 [11]. A PSQI global score of 5 or greater indicates clinically significant sleep disturbances

Measurement of physical fitness

In the evaluation of physical fitness, we utilized muscle strength, muscle endurance, flexibility, and a 20-m shuttle run. Grip strength and back strength were used to assess muscle strength. Sit-ups, push-ups, and repetition jumps were used to assess muscle endurance. Sit and reach were used to assess flexibility. The Progressive Aerobic Cardiovascular Endurance Run (PACER) to assess aerobic capacity. The PACER is a 20-m shuttle run that progressively increases in difficulty. All the tests were performed twice, and the best score was retained, except the 20-m shuttle run test, which was performed only once.

Maximal oxygen uptake (VO_2max) from the 20-m shuttle run, following formulas [12]: VO_2max (mL/kg/min) = (−0.875 × body mass index) + (2.031 × duration time except warm-up time) + 51.856

Statistical analysis

All results were reported as the mean, standard deviation (±), significance level, probability (*p*). All data were analyzed using SPSS version 25.0 (SPSS Inc., USA). The unpaired participation independent two-sample t-test was used to assess the difference two groups. The relationships between sleep quality and cardiopulmonary endurance were analyzed using Pearson's correlation coefficients. Statistical significance was accepted at the 0.05 level.

RESULTS

According to sleep quality in both groups

Paired *t*-test showed that PSQI global score ($p<0.001$), PSQI sleep quality ($p=0.003$), PSQI sleep onset latency ($p = 0.003$), PSQI sleep duration ($p<0.001$), and PSQI daytime dysfunction ($p = 0.045$) were significant difference in two groups. However, no significant difference in PSQI sleep efficiency, PSQI sleep disturbance, and PSQI use of medications (Table 2).

Table 2. The sleep quality of the each groups.

Variable (PIQI)	Groups		
	good sleep (n = 17)	poor sleep (n = 13)	*p*-value
global score	2.24 ±1.20	6.69 ±1.60	**<0.001**
sleep quality	0.64 ±0.61	1.31 ±0.48	**0.003**
sleep onset latency	0.29 ±0.47	1.00 ±0.71	**0.003**
sleep duration	0.18 ±0.53	1.85 ±1.07	**<0.001**
sleep efficiency	0.12 ±0.33	0.77 ±1.30	0.056
sleep disturbance	0.71 ±0.47	0.92 ±0.49	0.230
use of medications	0.06 ±0.24	0.08 ±0.28	0.850
daytime dysfunction	0.24 ±0.44	0.77 ±0.93	**0.045**

Table 3. The physical fitness of the each groups.

Variable	Groups		
	good sleep (n=17)	poor sleep (n=13)	*p*-value
Grip strength (kg)	40.54 ±5.61	38.35 ±6.85	0.345
Back strength (kg)	98.26 ±19.87	105.4 ±25.05	0.392
Sit-up (rep/min)	43.24 ±6.72	40.92 ±8.41	0.409
Push-up (rep/min)	35.11 ±13.26	41.00 ±14.87	0.263
Repetition jump (rep/min)	91.24 ±12.83	87.23 ±8.83	0.344
Sit and reach (cm)	8.84 ±7.93	8.76 ±11.41	0.983
20-m shuttle run (rep)	73.76 ±17.43	69.77 ±22.08	0.584
VO_2 max (ml/kg/min)	51.46 ±4.56	49.95 ±5.47	0.416

According to physical fitness in both groups

There were no significant differences in physical fitness between the two groups Table 3).

Pearson's correlation coefficients

The correlation coefficients of sleep quality and cardiopulmonary endurance. A negative correlation was found between the PSQI global score and VO_2max (r=−0.488, *p* = 0.005) (Figure 1).

DISCUSSION

The main finding of this study that negative correlation between the PSQI global score and VO_2max. In addition, PSQI global score, PSQI sleep quality, PSQI sleep onset latency, and PSQI sleep duration were significant differences in the two groups.

Adolescents are at increased risk of many sleep disorders, such as insomnia, daytime sleepiness, chronic nightmares, and delayed sleep

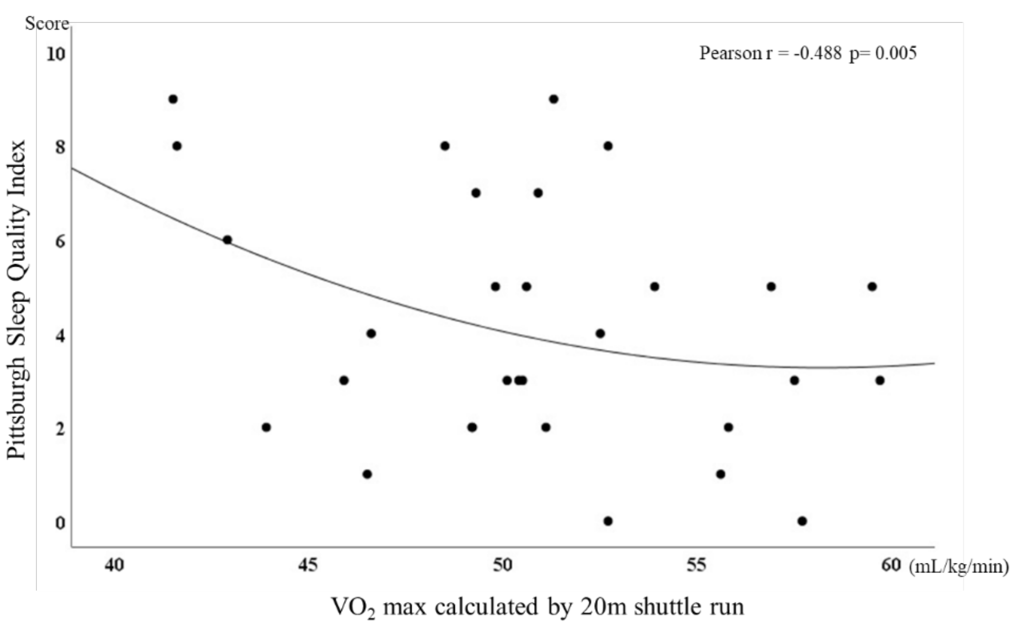

Figure 1. Pearson's correlation coefficients for sleep quality and cardiopulmonary endurance.

syndrome [13]. These are means of not getting enough sleep and their sleep patterns are characterized by staying up late [14]. The causes of increased cardiovascular health complications in at-risk adolescents are negative habits, poor physical fitness, low physical activity, and lack of sleep [15]. Also, poor sleep can cause problems in many aspects of young adults' life [16]. Chang and Chen [17] reported that the health-related physical fitness of college students showed low sleep quality and decreased total sleep time. Oudegeest-Sander et al. [18] demonstrate that a strong relationship between energy consumption and sleep efficiency has been found in young adults. We found that even if participating in regular physical activity, negative correlation between the PSQI global score and VO_2max. Sleep disturbances are associated with general cardiovascular diseases such as atrial fibrillation and heart failure [19]. Increasing chemical sensory receptor reflective sensitivity in critical components during the breathing cycle of sleep disorders may lead to long-term reactions with low ventilation, reduced cardiac output, low lung capacity, and large slopes between atmospheric and alveolar CO_2 tension [20]. Epidemiologic studies have shown that cardiovascular risk factors in adulthood are present in childhood and that early prevention may be important in reducing subsequent risk factors [21]. Thus, sleep quality and cardiopulmonary endurance in adolescence are very important and need to be improved.

The Pittsburgh Sleep Quality Index (PSQI) is a well-established measure of sleep disturbance and is widely applied across the population [22]. And it is PSQI demonstrates psychometric properties suitable for use in clinical trials targeting youth and young adults [23]. We also used the PSQI questionnaire for male high school students. Found that PSQI global score, PSQI sleep quality, PSQI sleep onset latency, PSQI sleep duration, and PSQI daytime dysfunction were significant differences in the good sleep group and poor sleep group. Zhou et al reported significantly higher PSQI global score and PSQI sleep quality comparisons with poor sleep and non-poor sleep high school students [24]. Baran et al. [25] reported significantly higher PSQI global score, PSQI sleep latency, and PSQI Sleep disorders in obese children and adolescents. There is also increasing evidence of an association between shortened sleep duration, longer sleep onset latency, daytime dysfunction, and/or poor sleep quality even if participating in regular physical activity.

Childhood and adolescence are crucial moments of life because dramatic physiological and psychological changes occur at these ages [26]. Physical fitness is usually considered to be a multidimensional structure that encompasses five components: cardiovascular endurance, muscle strength, muscle endurance, flexibility, and body composition [27]. The higher level of physical fitness the better overall health and academic performance in adolescence [28]. In this study measured muscle strength, muscle endurance, flexibility, cardiovascular endurance, and body composition. We did not find significant differences in physical fitness between the good sleep group and the poor sleep group. The reason for this result is that we enrolled participants who participated in regular physical activities (3 days of physical activities such as handball, volleyball, soccer, and basketball per week) for over a 1 year. Previous studies demonstrate that over the 4 weeks of exercise and physical activity are improving physical fitness in adolescents [29, 30]. Continuity of exercise or physical activity participation will be important for the maintenance of later health and welfare in later life [31].

The present study has some limitations. We did not the direct analysis of VO_2max. The 20-m shuttle run used in this study is used globally as a cardiopulmonary endurance index, and VO_2max was calculated using the estimated equation. However, direct analysis of VO_2max should be considered in future studies. Another limitation is that the sample size was relatively small, and further studies with larger populations are required to validate our findings.

CONCLUSIONS

This study indicates that an association between the poor sleep quality and cardiopulmonary endurance. In addition, shortened sleep duration, longer sleep onset latency, and daytime dysfunction led to poor sleep quality in even if participating in regular physical activity. Therefore, these findings provide preliminary evidence that adolescents who have poor sleep quality are required that necessary to continue exercise or physical activity to improve cardiopulmonary endurance.

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