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RESEARCH

Correlation between Sleep Duration and Visual Acuity: A Single Center Study

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Abstract

Introduction: Students, especially at the senior high school level, are increasingly required to be able to develop according to predetermined standards. When the duration of learning increases, unconsciously, the duration of using the eyes also increases while the sleep duration decreases. **Purpose:** This study aims to analyze the correlation between short duration of sleep and decreased visual acuity among senior high school students. **Methods:** A cross-sectional study design was conducted, in which the students filled out questionnaires and underwent visual examination. The population was all final-year students at one of Sidoarjo Senior High School in East Java, with the age range of 16-18 years. Two variables involved in this study were sleep duration and visual acuity of the left and right eye. The data will be analyzed using Spearman Rho correlation analysis to determine the cause and effect of the two variables studied. **Results:** The sample according to the gender was 45.5% male and 54.5% female. The sample according to the age range was 76.1% in 17 years old and 23.9 % in 18 years old. The correlation test results were 0.277 and 0.009 for the correlation coefficient and the significance value for the right eye. The results were 0.234 for the correlation coefficient and 0.028 for the significance value for the left eye. There was a significant correlation between sleep duration and the visual acuity reduction. **Conclusions:** This study reveals that less sleep duration of the final year students between 16-18 years old range may be associated with reduced visual acuity among students.

Keywords: learning duration; sleep duration; decreased visual acuity

Introduction

Vision plays a crucial role in many aspects of our lives, including reaching an optimum academic performance, in which multivariate analysis reveals that 5.2% of poor academic performance is related to vision.[1] However, according to the Decree of Indonesia's Minister of Education, Culture, Research and Technology[2], a final year student in Senior High School had 7-7 ½ hours of learning duration every day. Even though the newest curriculum was said to be optimized and make the student study effectively and efficiently, the study on the implementation of Freedom Curriculum mentions that every student should study every subject that will later be related to the course or major that will be taken in the college. It means that every student spends more time studying at school, repeating the materials, and doing the homework.[3] Besides that, there is another burden where final year students must take an exam prior to entering college, in which they must take additional classes separated from school programs. Studies on the effectiveness of private tuition reveal that many students had additional learning programs outside of school, such as tutoring institutions, that can make it easier to master every single subject that is difficult to understand when in the classroom.[4] In addition, according to research in 2010 and 2015, there are 53% of elementary school students, 66% of junior high school students, and 82% of high school students use cell phones regularly every day. The teenagers seem to depend on cell phones, even bringing cell phones to bed; also, they spend around 1500 hours/year watching television (4-4 ½ hours every day).[5],[6],[7]

The length of sleep recommended by the National Sleep Foundation[8] in 2015 varies depending on age. It takes 8-10 hours per day to sleep in adolescents (aged between 14-17 years old) and 7-9 hours per day to sleep in young adults (aged between 18-25 years old).[8] The National Health Interview Survey[9] revealed that the percentage of adolescents and adults who have sleep duration ≤ 6 hours increased by 5-6% in 2014. This loss of time for sleep can be caused by various things, including self-will not to sleep and sleep disturbances such as insomnia or obstructive sleep apnea.[9] Reduced sleep duration in adolescents to adults can cause various problems. This is seen in several studies which say that reduced sleep duration in adolescents and adults can cause obesity, hypercholesterolemia, metabolic syndrome, diabetes, and visual disturbances.[10] This study aims to find a correlation between the short duration of sleep and decreased visual acuity among senior high school students.

Methods

This is an observational analysis research using the cross-sectional method. In this study, we distributed the questionnaire to respondents at the same time. The questionnaire was used to see an overview of the sleep duration from the respondents and determine the group samples based on it. The first visual acuity examination is carried out on the morning before the learning process begins to evaluate the initial visual conditions of the subject. The second examination was carried out within the same subject on the morning the following week before the learning process began. The visual acuity examination was carried out using a Snellen chart at six-meter distances for every sample. In this research, we determine the sample using a simple random sampling formula, which is a statistical technique used to select a subset of individuals from a larger population. Using n = N/(1+N(e^2)) for 374 of the total population, we were able to determine that the samples used in this study were 88 subjects.

All 88 samples were collected randomly for every class of final year students, whether they were in science or social class, to find a correlation between sleep duration and the incidence of decreased vision that was conducted at one of Sidoarjo Senior High School in East Java. The student between 16-18 years old with additional hours of study to attend the tutoring class outside school and without using eyeglasses, no other eye problems such as redness of the eye or any lump was included in this study. This study involved two variables; the dependent variable was the incidence of decreased vision in children aged 16-18 years in final year students at Sidoarjo Senior High School that was collected from direct visual acuity measurement. The visual examination result was grouped into normal if the visual acuity was 6/6 and decreased if the visual acuity was less than 6/6.[11],[12] While the independent variable was the duration of sleep that was collected from the questionnaire. The sleep duration was divided into three groups: less than six hours, 6-7 hours, and more than seven hours. This sleep duration group was the result of the percentile analysis after we collected the questionnaire data about the number of sleep durations. The data will be processed using Spearman correlation analysis, where the data used is ordinal scale, and to determine the cause and effect of the two variables studied. The test result is said to be significant if the significance level (p) is less than the specified alpha value, namely $\alpha = 0.05$.

Results

Based on the descriptive data (Table 1), the minimal amount of sleep in the sample was 4.25 hours, and the maximum amount was 8.50 hours, with an average of each student having 6.52 ± 0.81 hours of sleep duration in one day. Using percentile analysis, it was found that there were three categories of sleep duration distribution: below six hours, between 6-7 hours, and more than seven hours. This study also categorized the characteristics of the respondents based on age and sex. Based on the sex

Table 1. Subject characteristic.

Research Group	N	Percentage (%)	Min. (hours)	Max. (hours)	Mean ± Std. Deviation	Percentiles
Sleep Duration						
> 7 hours	13	14.8				33.33% (6.000 hours)
6-7 hours	63	71.6	4.25	8.50	6.52 ± 0.81	
< 6 hours	12	13.6				66.67% (7.000 hours)
Sex						
Male	40	45.5				
Female	48	54.5				
Age						
17 years old	67	76.1				
18 years old	21	23.9				

group category, female (54.5%) respondents outnumbered the male respondent (45.5%). Also, the subject in this study is mostly in 17 years old (76.1%) group compared to 18 years old (23.9%). Apparently, in one day, 71.6% of the students had 6-7 duration of sleep, while the other had more than seven hours of sleep (14.8%) and less than six hours of sleep (13.6%).

The visual measurement result of each eye in this study is shown in Table 2. According to the American Academy of Ophthalmology (AAO)[12], which mentions the normal visual acuity is 6/6, in this study, there were 32 students (36.4%) had visual acuity of 6/6, and 56 students (63.6%) had visual acuity less than 6/6 on the right eye. For the left eye, only 20 students (22.7%) had visual acuity of 6/6, and 68 students (77.3%) had visual acuity less than 6/6. Moreover, in this study, it appears that the subject's left eye had worse condition (only 22.7% had 6/6) than the subject right eye (36.4% had 6/6).

Table 2. Right and left eye visual measurement.

Visual Acuity	N (Frequency)	Percentage (%)
Right eye		
6/6	32	36.4
6/9	20	22.7
6/12	23	26.1
6/15	8	9.1
6/20	2	2.3
6/30	1	1.1
6/60	2	2.3
Left eye		
6/6	20	22.7
6/9	24	27.3
6/12	31	35.2
6/15	8	9.1
6/20	4	4.5
6/30	0	0
6/60	1	1.1

The statistical analysis result of this study (Table 3) showed that there were nine students (10.2%) who had a low visual acuity for the right eye with less than six hours duration of sleep. Meanwhile, only three students (3.4%) with more than seven hours of sleep a day had a low visual acuity within the same eye. Then, for the left eye, ten students (11.4%) had low visual acuity with less than six hours of sleep compared to five students (5.7%) with more than seven hours of sleep a day who had low visual acuity. After cross-tabulation analysis, Spearmen Rho correlation analysis was carried out between two variables, with the results shown in Table 4.

There was a significant correlation between sleep duration with the right eye visual acuity ($p = 0.009$) and left eye visual acuity ($p = 0.028$), where the correlation coefficient (0.277 for OD and 0.234 for OS) had a positive value. This indicated that the relationship between the two variables was unidirectional; thus, it could be interpreted that the longer the duration of sleep, the greater the vision. However, from Table 2, it was shown that there were around 72.3% and 76.6% of other factors that could affect the correlation between right and left eye visual acuity and sleep duration.

Discussion

Visual health is an essential aspect of overall health among students. Poor visual health can lead to physical and mental health problems, including decreased academic performance. According to the research, the visual impairment incident in children varies depending on the age group and location. Refractive errors such as myopia, hypermetropia, and asthenopia were found to be the most common cause of visual impairment in children in some studies, with several other causes such as congenital cataracts, optic nerve atrophy, and cerebral visual impairment.[13],[14],[15] A study conducted in Spain found that children with poor academic performance had worse visual health than those with good academic performance.[16] There are several factors affecting visual acuity that are mentioned by many studies, including age, existing comorbidities, congenital conditions, and daily activities.[17],[18],[19] In addition, another factor that influences the incidence of visual impairment (VI) is sleep duration, which was revealed by the multivariate study of 29.815 participants from all races that there is a significant correlation between VI and sleep duration (OR =1.6; 95% CI = 1.5 - 1.9).[20] Supported by the descriptive analysis among elderly (>50 years old) showed that 31.06% of them experienced moderate or severe visual impairment, and 46.81% of it having an abnormal sleep duration.[21]

Sleep is defined as a condition of a person's unconscious, which can be stimulated or awakened by sensory stimuli or other stimuli.[22] It is a complex physiological process that is essential for healthy cognitive function, including

Table 3. Tabulation between sleep duration and visual acuity.

			Visual Acuity OD		Visual Acuity OS	
			Normal	Low	Normal	Low
Sleep Duration	> 7 hours	Amount	10	3	8	5
		Total (%)	11.4	3.4	9.1	5.7
	6-7 hours	Amount	39	24	34	29
		Total (%)	44.3	27.3	38.6	33.0
	< 6 hours	Amount	3	9	2	10
		Total (%)	3.4	10.2	2.3	11.4
Total		Amount	52	36	44	44
		Total (%)	59.1	40.9	50	50

Table 4. Correlation between sleep duration with left and right eye vision..

			Sleep Duration Category	Right Eye Visual Acuity Category
Spearman's rho	Sleep Duration Category	Correlation Coefficient	1.000	0.277**
		Sig. (2-tailed)	.	0.009
		N	88	88
	Right Eye Vision Category	Correlation Coefficient	0.277**	1.000
		Sig. (2-tailed)	0.009	.
		N	88	88
			Sleep Duration Category	**Left Eye Visual Acuity Category**
	Sleep Duration Category	Correlation Coefficient	1.000	0.234**
		Sig. (2-tailed)	.	0.028
		N	88	88
	Right Eye Vision Category	Correlation Coefficient	0.234**	1.000
		Sig. (2-tailed)	0.028	.
		N	88	88

**. Correlation is significant at the 0.01 level (2-tailed).

memory consolidation, which can be categorized into two main phases: rapid eye movement (REM) and non-REM sleep. It is associated with electrophysiological patterns that reflect the precisely timed activity of underlying neural circuits.[23],[24] Sleep has a significant impact on human physiological and cognitive function. Sleep deprivation can negatively affect exercise performance, cause an autonomic nervous system imbalance, simulate symptoms of the overtraining syndrome, and promote immune system dysfunction.[25] Sleep inconsistency between weekends and weekdays can impair brain function and cognitive performance.[26] Lack of sleep or sleep of poor quality can disrupt circadian rhythms and may cause cognitive disorders and memory loss, facilitate false memory production, and even alter gene expression in humans. Sleep is also essential for the individual to be able to maintain body homeostasis and is an important regulator of the immune system since, during sleep, the necessary functions to maintain its balance are carried out. Decreased sleep has deleterious effects that alter the metabolism and produce an increase in the secretion of C-reactive protein, interleukin (IL)-6, and tumor necrosis factor (TNF). These cytokines activate NF-KB; therefore, sleep disturbance can be a risk factor for the development of chronic inflammatory and metabolic diseases.[27]

The guideline for sleep duration from the National Sleep Foundation[8] states that sleep duration in the age range of 14-17 years is 8-10 hours, while sleep duration in the age range of 18-25 years is 7-9 hours. Compared to this study, 76.1% of respondents were 17 years old, and 23.9% were 18 years old; it was found that all respondents should have a sleep duration between 7-10 hours. From our analysis, besides sleep duration, there are 72.3% and 76.6% of other factors that affect the visual acuity of the right eye and left eye. The study conducted among 2.419 students ages 14-18 years old in China[28] found that there is a relationship between sleep duration and poor visual acuity. According to the article[28], the biological processes controlling sleep and ocular development overlap, which may contribute to the visual acuity condition. The circadian rhythm regulates sleep through melatonin, which is controlled by mutual interactions with retinal dopaminergic circuits. Dopamine and melatonin, which are both involved in ocular circadian physiology, also regulate ocular development.[28] Some theories mention dopamine signaling on the visual pathway receptors could influence visual function; also, the visual pathways activity, such as bright light and flickering light, can alter dopamine synthesis and release.[29]

Another study conducted in 2014 concerning the relationship between sleep duration and exam scores in medical students revealed that out of the 20 respondents studied, the sleep duration was between 4.2 and 7 hours, while the average night sleep duration of all respondents was only 5.9 hours.[30] When compared a recent study conducted on grade three junior high school in three high schools in Canada in July 2017, it said that out of 35.281 respondents, 58% of female respondents had a sleep duration of <8 hours and 53.1% of male respondents had a sleep duration of <8 hours.[31] In this study, sleep duration was divided into two categories based on National Health guidelines in Canada, namely insufficient sleep duration (<8 hours) and adequate sleep duration (>8 hours).[31] In fact, in our study, two respondents had 6/60 right eye vision, and one respondent had 6/60 left eye vision, and this respondent had a sleep duration of seven hours. As previously mentioned, many theories state that lifestyle factors, namely too much close-up activity, such as reading books, looking at computer screens, playing video games, and watching television, can cause weakness of the ciliary muscles of the eyes, resulting in impaired vision muscles.[32],[33]

In Indonesia itself, sleeping patterns have become a research topic where a study shows that good sleep

patterns are 9.002 times more likely not to experience hypertension when compared to samples that have poor sleep patterns.[34] Apparently, a study on sleep quality and screen time (the amount of time used by the eye to see the computer screen and mobile phone screen) also showed that it affects the incidence of computer vision syndrome ($p = 0.001$).[35] Based on several studies conducted, the family history of myopia also plays an essential role in the condition of visual acuity accompanied by activities related to the duration of gadget use (screen time), which can cause fatigue in the eye muscle and reduce the amount of sleep.[19],[36] Research in 2009, conducted on computer informatics engineering students analyzed the relationship between computer use and decreased visual acuity and revealed that there was a positive correlation of 32.1% between the two variables.[37] In June 2017, a study about the relationship between the duration of playing video games and decreased vision, which was conducted on 76 children in an elementary school, also revealed that there was a significant relationship between the two variables studied.[38],[39] It shows that 69.7% of respondents had a normal duration of playing video games, while 30.3% of respondents had an abnormal duration of playing video games, and 36.1% of the total respondents experienced decreased vision.[38],[39] More about the factors that affect visual acuity, research conducted in 2013 on 85 respondents and used the Spearman correlation test mentioned that there was a significant relationship between age and decreased vision with a value of $p = 0.0001$.[40],[41]

In this study, we can see that sleep duration had a significant impact on final-year high school students' visual acuity, especially when they had an enormous number of visual pathways involving activities such as watching television, playing cell phones, and video games. Unlike any other study, in this research, we clearly define and calculate the sleep duration in a day, not only at nighttime, for every single sample, and from this data, we knew that some samples had a sleep duration less than they needed according to the National Sleep Foundation guidelines. With this study, hopefully, the parties involved will pay more attention to visual health in school-aged children. In the future, this research can be refined by adding other factors that are also being studied which can influence visual health.

Conclusions

From this research, we can find that 63.6% of the students had visual acuity less than 6/6 on the right eye, and 77.2% of the students had visual acuity less than 6/6 on the left eye. From this data, we know the visual health condition of school children in an area of Indonesia is not in good condition, which may be used for further evaluation later. As for sleep duration, only 14.8% of the student has more than seven hours of sleep as recommended by the National Sleep Foundation guideline. There is a significant correlation between the visual acuity of the left and right eye and the sleep duration in this study. Many factors, such as the fatigue of the ciliary muscle from the visual pathway activity, can cause it. Also, it is concluded that there are more than 70% of other factors that can influence the visual acuity of the right and left eye besides sleep duration. This research can be completed with other studies that may reveal other factors affecting visual acuity.

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