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The relationship between body mass index, physical activity, sleep quality, and physical fitness in adolescents

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Abstract

This study aims to determine the relationship between BMI, physical activity, and sleep quality with physical fitness and the correlation between these factors. The research method used is correlational research. The subjects of this study were adolescent students aged 16-19 years. It selected subjects using purposive sampling techniques with criteria of adolescents aged 16-19, healthy conditions, and willingness to participate in research activities. The total subjects involved were 251 teenagers. The research instruments used were BMI measurement, physical activity using the PAQ-A questionnaire, sleep quality measured using PSQI, and physical fitness measured using the Indonesian Physical Fitness Test for the age range of 16-19 years. The data analysis techniques used are descriptive analysis and multiple regression tests. The results showed that BMI and physical fitness were significantly associated with an effective contribution of 4.29%, physical activity, and physical fitness had a significant relationship with an effective contribution of 46.34%, and sleep quality and physical fitness were significantly associated with an effective contribution of 2.27%. The BMI, physical activity, and sleep quality all had a significant relationship with physical fitness in adolescent students, with an effective contribution of 53.40%, meaning that it was concluded that there was a relationship between BMI, physical activity, sleep quality, and physical fitness. The results of this study answered that BMI, physical activity, and sleep quality contribute to the fitness of adolescent students.

Keywords: adolescent, BMI, physical activity, sleep quality, physical fitness.

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INTRODUCTION

At present, advancements in time have led to a significant decline in the quality of human health influenced by various factors, including lifestyle, environment, and the current technology triggering sedentary behavior in almost everyone, particularly students. Generally, behaviors impacting

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one's health start early in adulthood and can be hazardous if this period is filled with low physical activity. Students have been dominated by sedentary behavior, evidenced by 57% of male students and 61% of female students reporting being sedentary and not engaging in physical activity for 7 days. Sedentary behavior plays a significant role in students having good sleep (Alnuaimi et al., 2023; Wang & Li, 2023).

The Body Mass Index (BMI) is a classification of body composition representing an individual's health level. In the BMI scale, it is divided into four categories according to the Asian classification: Underweight (<18.5 kg/m2), normal weight (18.5-22.9 kg/m2), overweight (23-24.9 kg/m2), and obesity 1 (≥25-29.9 kg/m2). The classification of obesity based on BMI in individuals younger than 50 years has been strongly associated with multimorbidity in the late stages of life (Al-Ghamdi et al., 2018). Obesity tends to jeopardize disease-free survival (Kivimäki et al., 2022). Certain environmental influences, such as lower physical activity, trans-fat consumption, comorbidities, diabetes, hypertension, heart and endocrine disorders, malignancy, and others, adversely impact body weight and increase the Body Mass Index (Madsen et al., 2017).

An individual's BMI is crucial in determining the likelihood of future health difficulties, and maintaining a normal range is an acceptable target for a healthy life (Madsen et al., 2017). The transition to higher education often experiences unfavorable shifts towards unhealthy behaviors and weight gain (Deforche et al., 2015; Hasan et al., 2020), with students being highly susceptible to sedentary behavior. Young adults are generally receptive to maintaining good health, with educational institutions and student welfare organizations encouraging them to engage in various physical activities. According to a study, students exhibit both sedentary and active behaviors.

According to Ochoa-Avilés et al. (2014), daily food intake is strongly associated with adolescents' pathogenesis of metabolic, inflammatory, and chronic diseases. Furthermore, consuming high-solid foods and low physical exercise will increase excessive energy storage and fat

accumulation, leading to obesity and being overweight (Rose et al., 2017). For the assessment of obesity, body mass index (BMI) is usually used. Based on Fletcher et al. (2016), BMI / age is a nutritional status for adolescents and is inversely proportional to physical fitness. Physical inactivity is indicated as a significant factor in the increase in obesity and other medical conditions, especially in children and adolescents. Body Mass Index (BMI) factors significantly affect fitness levels, and low fitness levels indicate a person's high BMI (Sunarni et al., 2019). Low daily physical activity is a risk factor for increasing BMI values due to the lack of energy expenditure stored in the body. An imbalance between excess energy intake and lack of proper physical activity on an ongoing basis can increase obesity and fat deposits. Obese children tend to be less motivated to move and prefer activities that do not require much energy so as not to get tired easily. Obese children will tend to have a sedentary or sedentary lifestyle, spending most of their time sitting around with no physical activity. Due to low physical activity, obese children tend to have low physical fitness. These lifestyle changes result in dietary changes that are high in calories, fat, and cholesterol but low in fiber, as often found in fast food, which affects increasing obesity (Kankaanpää et al., 2022; Lau et al., 2013; Tuomi et al., 2014).

In addition to BMI, Biddle et al. (2019) reported that a number of factors, including genetics, gender, age, body composition, activity, and exercise, influence a person's physical fitness. Physical activity is an important prerequisite for human health. This applies to all age groups, including teenagers. Generally, it is assumed that the more active a person is, the better their physical fitness. The influence of physical activity on the health of preschool children is quite significant; therefore, it is important to give them a good understanding of the relationship between physical activity and physical fitness (Neto et al., 2014).

The term 'physical activity' refers to the movement of body parts that result in energy expenditure, an important aspect of maintaining physical and mental health and quality of life to stay healthy and fit throughout the

day (Ma'arif & Puguh Satya Hasmara, 2021). According to Fitri Ananda et al. (2021), physical activity can be defined as body movements produced by kinetic muscles requiring energy expenditure. To have good individual skills, every individual should engage in regular physical activity to maintain their stamina. Internet-connected electronic devices indirectly impact children's activities, causing them to become less active or mobile. Giving children access to internet-connected electronic devices and early introduction to this type of technology can lead to a lack of physical mobility or activity (Kobak et al., 2018).

Lack of physical activity causes students to get tired easily when doing sports and can lead to obesity. Low physical activity levels can lead to physical weakness and lack of energy when performing more intense physical activity. The body will automatically send signals to rest or sleep after a busy day with activities because it limits physical performance, resulting in decreased body energy and fatigue. After adequate sleep, the body will send a signal to wake up (Gunarsa & Wibowo, 2021). Sleep is a normal activity experienced by every individual and is an integral part of human life. Sleep is a basic and instrumental need for children's health. Sleep can be defined as a state or condition indicated by decreased motor activity, interaction with and response to the environment, certain postures (lying with eyes closed), and easily waking up (Stormark et al., 2019). In the human life span, sleep needs can vary greatly. It is recommended that school-age children sleep regularly, with a sleep duration of 9-12 hours per day (Chen et al., 2022; Lim et al., 2021).

Healthy sleep requires adequate duration, good quality, timely and regular patterns, as well as the absence of disturbances or abnormalities. Sleep quality is a frequently studied metric in the context of health (Deforche et al., 2015; Hasan et al., 2020). With good sleep quality, the body is given the opportunity to regenerate, extend the lifespan of body cells, and enhance freshness and strength, which consequently leads to high physical fitness (Allsabah et al., 2022; Safaringga & Herpandika, 2018). Good sleep quality can be observed through sleep latency, the

number and timing of awakenings, and sleep efficiency (Ohayon et al., 2017; Riemann et al., 2017). Many factors are related to sleep quality, such as physical fitness, stress, diet, lifestyle, and so on. Among these factors, sleep quality is known to be associated with physical fitness. Physical fitness is one of the vital indicators of health (Mariana et al., 2019; Munipiddin et al., 2018). Components of physical fitness associated with health include cardiorespiratory endurance, muscle strength, muscle endurance, body composition, and flexibility. Each component's status, all related to daily activities, can be enhanced through exercise (Adi et al., 2022; Kliziene et al., 2018).

This research aims to explore the relationship between body mass index, physical activity, sleep quality, and physical fitness among adolescent students. An initial analysis of the situation will aid in raising awareness among adolescents to foster healthier lifestyles and modify factors predisposing to obesity. It may also assist in creating evidence-based strategies to alleviate difficulties associated with obesity, especially among adolescents.

METHOD

This type of research research is a correlational research design, which aims to examine the relationship between two or more variables (Suharsimi, 2013). The research method used is the survey method. This study selected samples using purposive sampling, a data collection technique with special considerations (Sugiyono, 2016). The criteria used in this study were grade 11 students with a population of 251 students. The instrument used in this study is the Physical Activity Questionnaire for Adolescents (PAQ-A), according to the study (Andarge et al., 2021), which has been translated into Indonesian and modified. Based on the validity test results of each questionnaire question item, the lowest value is 0.140, and the highest is 0.730 (Andarge et al., 2021). Anwar & Hartono (2019) stated that the PAQ-A questionnaire has a validity of 0.568. The PAQ-A instrument proved reliable with a Cronbach Alpha score of 0.721. Body

mass index measurement requires height and weight measurement, then using a form containing height and weight data.

Sleep quality data was collected using questionnaires based on the Pittsburgh Sleep Quality Index (PSQI) in accordance with research developed (Setyowati & Chung, 2021). Meanwhile, the research instrument used for the Physical Fitness test was adopted from the test by the Center for Physical Fitness and Recreation in 2010 for adolescents aged 16-19 years. The validity of the Indonesian Physical Fitness Test issued by (Prayoga and Barikah, 2019) has been recognized at the national level. The validity test results of the Indonesian Physical Fitness Test for men and women are 0.884 and 0.897, respectively, while the reliability values are 0.911 for men and 0.942 for women. Data analysis techniques in this study use descriptive percentage data analysis techniques.

The normality test is performed using the Kolmogorov-Smirnov test, while the linearity test is performed using the ANOVA test (F_{test}). The calculation is performed using SPSS version 23. Based on the tolerance value, the formed value must be above 10%, while for VIF (Variance Inflation Factor), the formed value must be less than 10; Otherwise, multicollinearity will occur, and the regression model becomes invalid. The statistical test t basically shows the extent to which the influence of the individual clarifies the independent variable in describing the variation of the dependent variable. This test uses a significance level of 5% and examines the comparison between t_{count} and t_{Table}. Decision-making criteria are based on. The coefficient of determination (R2) test aims to measure the percentage of contribution of the independent variable to the state of the dependent variable.

RESULT

The data in this study consisted of BMI, which was measured by dividing body weight (kg) by the square of height (m2); physical activity, which was measured using a modified Physical Activity Questionnaire for Adolescents (PAQ-A); sleep quality, as measured by the Pittsburgh Sleep

Quality Index (PSQI) questionnaire; and physical fitness, as measured using TKJI tests for adolescents aged 16-19 years. The findings are described below.

BMI

The descriptive statistics of BMI of adolescent students aged 16 to 19 are in the Table below.

Table 1. Descriptive Statistics of BMI of adolescent students aged 16 to 19

N	Mean	Median	Mode	Std. Dev	Min	Max
251	24.60	25.64	27.15	3.09	16.73	27.62

The frequency distribution of BMI of adolescents aged 16 to 19 years is presented in Table 2 as follows.

Table 2. BMI frequency distribution for adolescents aged 16 to 19 years

Interval	Fitness Category	Frequency	Percentage
< 17.0	Underweight	5	1.99%
17.0 – 18.4	Slightly underweight	23	9.16%
18.5 – 25.0	Normal	49	19.52%
25.1 – 27.0	Overweight	99	39.44%
> 27.0	Obese	75	29.88%
	Total	**251**	**100%**

Based on the frequency distribution in Table 2, the BMI of adolescents aged 16 to 19 can be seen in Figure 1 below.

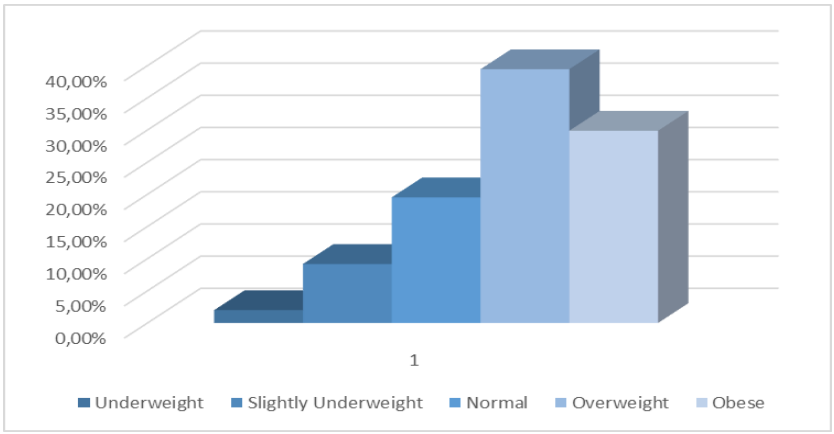

Figure 1. BMI Bar Chart for adolescents aged 16 to 19 years

Based on Table 2 and Figure 1, the BMI of adolescents aged 16 to 19 years the most significant value is the obesity category with 29.88% (75 adolescents), followed by the overweight category with 39.44% (99 adolescents), the normal category with 19.52% (49 adolescents), the slight underweight category with 9.16% (23 adolescents), and the underweight category with 1.99% (5 adolescents).

Physical Activity

Descriptive statistics of physical activity of adolescents aged 16 to 19 years are in Table 3 below.

Table 3. Descriptive statistics of physical activity of adolescents aged 16 to 19 years

N	Mean	Median	Mode	Std. Dev	Min	Max
251	2.38	2.38	2.38[a]	0.49	1.25	3.50

The distribution of physical activity frequency of adolescents aged 16 to 19 is presented in Table 4.

Table 4. Distribution of physical activity frequency of adolescents aged 16 to 19 years

Interval	Category	Frequency	Percentage
4.21-5.00	Very High	0	0.00%
3.41-4.20	High	1	0.40%
2.61-3.40	Moderate	104	41.43%
1.81-2.60	Low	104	41.43%
1.00-1.80	Very Low	42	16.73%
Total		**251**	**100%**

Based on the frequency distribution in Table 4, the physical activity of adolescents aged 16 to 19 can be seen in Figure 2 below.

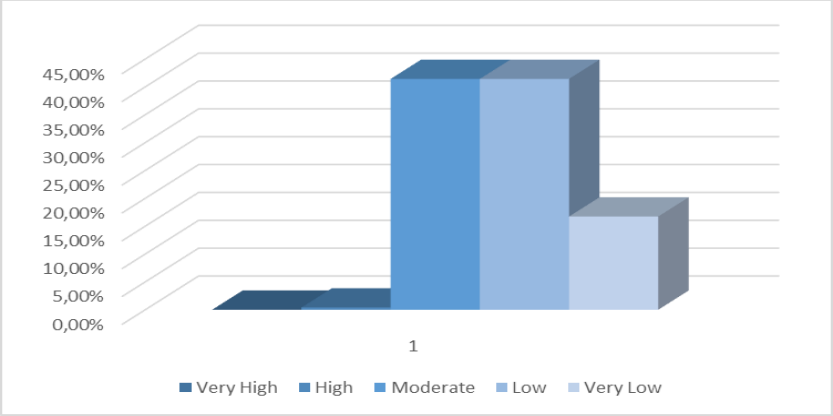

Figure 2. Physical Activity Bar Chart of adolescents aged 16 to 19

Table 4 and Figure 2 shows that the physical activity of adolescents aged 16 to 19 years of magnitude was the lowest category, with 41.43% (104 adolescents), and the moderate category, with 41.43% (104 adolescents), followed by the very low category with 16.73% (42 adolescents), and the high category with 0.40% (1 teenager). No teenagers (0.00%) fall into the very high category.

Sleep Quality

Descriptive statistics on the sleep quality of adolescents aged 16 to 19 years can be seen in Table 5 below.

Table 5. Descriptive statistics of sleep quality of adolescents aged 16 to 19 years

N	Mean	Median	Mode	Std. Dev	Min	Max
251	9.07	9.00	9.00	4.17	2.00	21.00

The frequency distribution of sleep quality of adolescents aged 16 to 19 is presented in Table 5.

Table 5. Sleep quality frequency distribution of adolescents aged 16 to 19 years

Interval	Category	Frequency	Percentage
≤ 5	Good	60	23.90%
> 5	Poor	191	76.10%
Total		251	100%

Based on the frequency distribution in Table 13, the sleep quality of adolescents aged 16 to 19 can be seen in Figure 3 below.

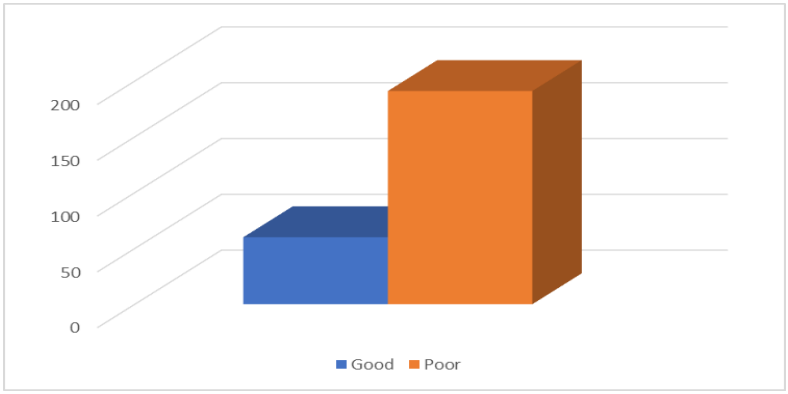

Figure 3. Sleep Quality Bar Chart for teens aged 16 to 19

Based on Table 5 and Figure 3 on the sleep quality of adolescents aged 16 to 19, the most significant value was that adolescents had poor sleep quality, with 76.10% (191 students) and 23.90% (60 students) having good sleep quality. Overall, the majority of 16- to 19-year-olds have poor sleep quality.

Physical Fitness

Descriptive statistics of physical fitness of adolescents aged 16 to 19 years can be seen in Table 6 below.

Table 6. Descriptive statistics of physical fitness of adolescents aged 16 to 19 years

N	Mean	Median	Mode	Std. Dev	Min	Max
251	12.73	13.00	14.00	1.83	9.00	18.00

Distribution of physical fitness frequency among adolescents aged 16 to 19 years Table 7, as follows.

Table 7. Physical fitness frequency distribution for adolescents aged 16 to 19 years

Interval	Category	Frequency	Percentage
22 - 25	Very Good	0	0.00%
18 - 21	Good	1	0.40%
14 - 17	Moderate	102	40.64%
10 - 13	Poor	142	56.57%
5 - 9	Very Poor	6	2.39%
Total		251	100%

Based on the frequency distribution in Table 7, the physical fitness of adolescents aged 16 to 19 can be seen in Figure 4 below.

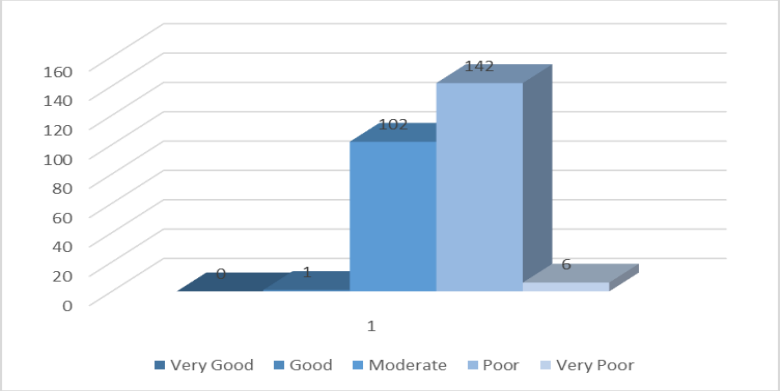

Figure 4. Physical Fitness Chart of teens aged 16 to 19

Based on Table 7 and Figure 4 on the physical fitness of adolescents aged 16 to 19, the most significant scores were poor and moderate categories, with 56.57% (142 adolescents) and 40.64% (102 adolescents), respectively. About 2.39% (6 teenagers) have very poor physical fitness, while only 1 teenager (0.40%) has good physical fitness. None of the teenagers (0.00%) fell into the category of excellent physical fitness.

Table 8. Normality test results

Variable	P	Sig.	Description
BMI (X_1)	0.100	0.05	Normal
Physical activity (X_2)	0.103		Normal
Sleep quality (X_3)	0.213		Normal
Physical fitness (Y)	0.137		Normal

Based on statistical analysis of normality tests using the Kolmogorov-Smirnov Test in Table 8, the variables BMI, physical activity, sleep quality, and physical fitness all had significance values of p > 0.05 on the normality test, meaning the data were normally distributed.

The t (partial) test aims to determine the effect of each independent variable, BMI, Physical Activity, and Sleep Quality, on the dependent variable, Physical Fitness. The partial test (t-test) analysis results are presented in Table 9 below.

Table 9. Partial test (t-test) analysis results

Variable	r_{count}	t_{count}	Sig.	Description
BMI (X_1)	0.323	2.996	0.003	Significant
Physical Activity (X_2)	0.716	14.254	0.000	Significant
Sleep Quality (X_3)	-0.267	-2.367	0.019	Significant

The BMI variable (X1) has an r_{count} of 0.323, a t_{count} of 2.996, and a significance value (sig) of 0.003. Because the significance value is 0.003 < 0.05. The result, "There was a significant relationship between BMI and Physical Fitness of adolescents aged 16 to 19 years". This means that the better the BMI, the better the physical fitness of the teenager. Furthermore, the Physical Activity variable has an r_{count} of 0.716, a t_{count} of 14.254, and a significance value (sig) of 0.000 because the significance value is 0.000 < 0.05.

Consequently, stating "There is a significant relationship between Physical Activity and Physical Fitness of adolescents aged 16 to 19 years" is accepted and has a positive value, meaning that the better the physical activity, the better the physical fitness of adolescents. Finally, the Sleep Quality variable had a sum of r -0.267, a sum of t -2.367, and a significance value (sig) of 0.019. Because the significance value is 0.019 < 0.05, "There is a significant association between Sleep Quality and Physical Fitness of adolescents aged 16 to 19. It has a negative value,

which means that the worse the sleep quality, the lower the physical fitness of adolescents aged 16 to 19.

DISCUSSION

The results showed a significant relationship between BMI and physical fitness in adolescents aged 16 to 19, with an effective contribution of 4.29%. BMI must be maintained at ideal levels by maintaining a healthy diet and physical activity with appropriate frequency and intensity (Kalyanshetti & Veluru, 2017). Because their food intake will significantly influence the nutritional status of students, the nutritional value consumed daily must at least have a balanced composition of fats, proteins, minerals, vitamins, and carbohydrates to prevent excess nutrition that leads to obesity and decreased quality of life. The nutritional status of students is always related to food intake and the nutritional content they consume daily. The nutritional status and content consumed must contain balanced nutritional values needed by the body, namely carbohydrates, fats, vitamins, proteins, minerals, water, and protein so that they can be used for daily activities (Beermann et al., 2020). The body's work function will significantly depend on the intake that enters the body. The better the intake of nutrients, the more it will support the performance of organs that will produce energy to improve body performance. However, supporting factors for physical fitness levels are not only nutritional factors but can also be influenced by exercise, age, and gender (Fühner et al., 2021).

The results showed a significant relationship between physical activity and physical fitness of adolescents aged 16 to 19 years, with an effective contribution of 46.34%. A study by (Muntaner-Mas et al., 2018) reports that the habit of doing physical activity and having good physical fitness will support students' health and benefit their cognitive and academic abilities. In addition, Cadenas-Sanchez et al. (2020) found that good muscle strength, agility, and speed correlated with children's academic ability. Physical fitness is closely related to one of the health development efforts for humans, which aims to improve human health and productivity. Physical activity to improve physical fitness must have a

strong intensity that can increase physical fitness. Physical fitness is relative and bound (not free), meaning that it is always related to the physical activity performed.

Physical activity is any body movement performed by striated muscles that release a certain amount of energy expressed in kilo-calories. Various types of work, leisure, and daily activities are all categorized as physical activities. If done regularly, physical activity can improve health. Physical activity in leisure time refers to activity in periods used by an individual to increase their total daily energy expenditure, which goes hand in hand with the desire to obtain health and fitness benefits (Caldwell et al., 2020). A study by Martin et al. (2018) showed that physical activity increases learning achievement. Physical activity is associated with improved overall health and can improve socialization and mental health capacity. In addition, studies have consistently identified specific benefits, such as improved physical and physiological health and positive health outcomes in mental health and well-being (Chekroud et al., 2018). Ohrnberger et al. (2017) found a correlation between children's mental health and patterns and frequency of physical activity. Children with less time for physical activity have a higher risk of developing mental health problems. Nazlieva et al. (2020) found that physical activity can improve the level of cognition and reduce the risk of depression among adolescents.

The results showed a significant relationship between sleep quality and physical fitness in adolescents aged 16 to 19, with an effective contribution of 2.27%. Sleep is a normal activity experienced by all individuals and becomes a regular part of human life. This is a state of rest required by all human beings. During adolescence, quality sleep becomes very important because it is a period when physical growth and development occur rapidly and require adequate rest and sleep for the body. Nevertheless, many teenagers often overlook the importance of good quality sleep without realizing that it will negatively impact their physical fitness during that period. In addition, the brain will integrate new

knowledge and form new associations when a person sleeps, resulting in a fresh mind (Baert et al., 2015).

Conversely, the quality of sleep that is less awake will have a negative impact on physical health. Conversely, students with good sleep quality will feel many positive impacts on the body, including being more resilient to disease, maintaining mental health balance, improved health, and reduced stress in various organs, both lungs, cardiovascular system, endocrine, etc. Sleep duration will affect endocrine function and metabolism. Sleep deprivation induces glucose tolerance and reduces insulin sensitivity, increasing the risk of hardening of the arteries (Faoziyah & Suharjana, 2020). Sleep is reported to be instrumental for overall physical health (Pano-Rodriguez et al., 2023). Sleep deprivation or poor sleep quality will have a negative impact on health, including mental health, such as depression and anxiety, as well as disruption of physiological functions of the body, including motor disorders, cognitive impairment, emotional disorders, and sports performance. In addition, it can lead to an increased risk of injury, poor diet, obesity, low academic achievement, and drug use (Chaput et al., 2016; Freeman et al., 2017).

The results showed a significant relationship between BMI, Physical Activity, Sleep Quality, and Physical Fitness of adolescents aged 16 to 19, with an effective contribution of 53.40%. A study by (Savanur et al., 2017) found a significant association between nutritional status, hemoglobin levels, physical activity, and physical fitness levels in students aged 11-16. It is important that a person does enough physical activity and rest to have good fitness. Lack of physical activity, along with obesity, is a significant risk factor for many chronic diseases (DiFrancisco-Donoghue et al., 2022; Fabbri et al., 2017). According to Park et al. (2020), physical activity is closely related to quality of life, health, and well-being.

On the other hand, humans who do not do physical activity according to their needs will have a higher possibility of contracting diseases caused by lack of movement (hypokinetics), such as type 2 diabetes (King et al., 2020). Low levels of physical activity increase the risk of obesity and many

other chronic diseases, including coronary heart disease, diabetes, and others (Allsabah et al., 2022). Physical activity and exercise that are measured and performed appropriately, correctly, and regularly can reduce the risk of non-communicable diseases and improve physical health and fitness. Physical fitness offers strength to a person to do productive work every day without excessive fatigue and still maintain energy reserves to enjoy his free time optimally or face sudden activities. Physical fitness is a necessity in order to be able to do all activities, especially for students who have solid activities (Allsabah et al., 2023). Students with good physical fitness will be able to perform their learning tasks optimally, whereas those with poor levels of physical fitness may need help to accept the study load. The improvement and maintenance of physical fitness cannot be separated from physical exercise that maintains the balance of physical fitness elements. Physical fitness can be improved through physical activity, so students must do physical activity in every activity (Ma'arif et al., 2023). One way to maintain physical fitness is to do physical exercise, such as aerobic fitness gymnastics, which is a sports activity that is cheap and can be done daily to support physical fitness conditions.

The results of this research will positively contribute to the body mass index, physical activity, sleep quality, and physical fitness in adolescents. Limitations of this study include the subjects needing to represent the available sample in that region sufficiently. Therefore, recommendations for further research include increasing the number of subjects and their characteristics while also implementing a protocol to ensure the proper programming of body mass index, physical activity, sleep quality, and physical fitness in adolescents.

CONCLUSION

A significant relationship existed between BMI, Physical Activity, Sleep Quality, and Physical Fitness in adolescents aged 16 to 19. Furthermore, the value of these 3 factors effectively contributes 53.40% to the Physical Fitness of adolescents aged 16 to 19 years. The study had

limitations in not considering participants' food consumption and the period before the test. In addition, this study's data collection on physical activity and sleep quality was based solely on survey results, which may have low objectivity. It is expected to add several factors that contribute to physical fitness, especially in adolescent students. Physical fitness in adolescents is very important. It is important to pay further attention to preventing diseases that attack at a young age and supporting activities during adolescence.

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