The Relationship Between Sleep Quality as A Determinant of Student Heart Rate Response in Physical Education Learning

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Abstract

Sleep quality is an important physiological factor that plays a role in the regulation of the autonomic nervous system and cardiovascular response, particularly heart rate. In students, poor sleep quality has the potential to affect heart rate response during physical activity in Physical Education, Sports, and Health (PE) learning. This study aims to analyze the relationship and influence of sleep quality on students' heart rate response in PE learning. The study uses a quantitative approach with a correlational (associative) design. It was carried out at State Vocational School 10 Semarang with a research sample consisting of 120 students (N = 120) who were selected using random sampling techniques. Sleep quality was measured using a score scale of 1–4 (PSQI Questionnaire), while heart rate was measured in beats per minute (bpm), using the Coospo H808S device (chest strap ECG). Data analysis includes descriptive statistics, Kolmogorov-Smirnov normality test, linearity test, Pearson correlation test, and simple linear regression analysis. The results showed that there was a significant negative relationship between sleep quality and heart rate ($r = -0.267$; $p = 0.003$). Regression analysis showed that sleep quality had a significant effect on heart rate with a contribution of 7.1% ($R^2 = 0.071$). These findings indicate that better sleep quality is associated with lower heart rate and a more stable cardiovascular response during PE learning. Thus, sleep quality can be considered as one of the important factors in optimizing physical education learning and student health.

How to Cite

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INTRODUCTION

Physical education and sports have become increasingly important in recent times. This is recognized as a high-priority subject in Indonesia, which answers the need for an active and healthy lifestyle (Adi, 2024; Aliriad, Apriyanto, et al., 2023). Health education is a form of character education that focuses on physical activities, with the aim of encouraging psychomotor, cognitive, and affective progress among students. Although globalization is considered to provide many advantages in the Health Care sector, changes in the increasingly complex learning system also have negative impacts (Al Mukharom et al., 2024; Ikhwani, 2017). Physical fitness has a great influence on physical activity. Each activity has a certain level of performance that remains stable if it is done regularly, which in turn affects overall physical fitness. Cardiovascular fitness in children and adolescents is related to their level of physical activity. (Gunarsa & Wibowo, 2021). Outdoor activities provide a variety of sensory stimuli and involve more active body movements compared to indoor activities (Aliriad et al., 2024). In the context of Physical Education learning, students' heart rate is often used as an indicator of exercise intensity, level of engagement, and physiological adaptation to activities. If sleep quality affects heart rate response, then a student's sleep status can determine the effectiveness of physical learning (e.g., achievement of exercise intensity targets, safety, post-exercise recovery) (de Zambotti et al., 2022). as well as long-term implications for adolescent fitness and heart health. Studies that combined sleep quality measurements (e.g. PSQI) and cardiac parameters (HR/HRV) in adolescent populations showed a significant association between poor sleep and changes in cardiac autonomic modulation (Sanchez-Sanchez et al., 2021). Therefore, physical education as a priority for a healthy lifestyle for adolescents is highly dependent on regular physical activity and good sleep quality. Poor sleep can hinder the effectiveness of exercise because it interferes with the heart response and recovery process, negatively impacting long-term heart fitness as well as health.

Sleep is a fundamental biological need that affects an individual's physical, cognitive, and emotional functioning. In adolescence, sleep patterns and quality change significantly due to biological factors (shifts in circadian rhythm), psychosocial (academic stress, use of gadgets), and environment (school start time), so many adolescents experience inadequate sleep duration and quality. This phenomenon is often called the "perfect storm" in adolescent sleep due to a combination of factors that make them susceptible to sleep deprivation (Prichard, 2020). Good quality sleep means that a person feels satisfied with their sleep and does not feel tired, lethargic, or anxious after waking up. They don't have dark circles under their eyes, red eyes, or feel the need to yawn or fall asleep frequently. They also did not have headaches. Poor sleep quality can be one of the risk factors for diabetes, and on the other hand, diabetes can cause sleep problems due to symptoms such as frequent urination at night and pain (Bingga, 2021). Sleep Disorders are a collection of conditions characterized by disturbances in the amount, quality or time of sleep in an individual (Hasibuan & Hasna, 2021). A person's sleep quality can be affected by environmental conditions, physical conditions, social media use and fast food eating lifestyle, lack of physical activity, BMI (Cahyati et al., 2025; Wiyana et al., 2023). Sleep quality also affects the regulation of the autonomic nervous system, especially the sympathetic-parasympathetic balance which is reflected in cardiovascular parameters such as resting heart rate, heart rate response to physical activity, and heart rate variability (HRV). Decreased sleep quality is associated with decreased parasympathetic modulation and other markers of cardiovascular stress (Brink-Kjaer et al., 2021). Therefore, sleep quality has the potential to affect how the heart responds to physical loads at school, for example during Physical Education (PE) lessons.

Heart rate often referred to as heart rate, is a mechanical representation that appears in the form of a beating or pulse produced by the heart muscle as a result of blood flow being pumped regularly into the systemic circulation throughout the body. This pulse rate is not fixed, but it is highly variable because it is regulated by a combination of various complex physiological aspects, including the metabolic needs of tissues for oxygen supply, chemical control mechanisms through a chemoreceptor system that is sensitive to variations in gas levels in the blood, as well as modulation of autonomic nervous system activity either through stimulation of the sympathetic nerve that increases the heart rate and through the parasympathetic nerve that lowers it in order to maintain it balance in the body (Suhendra et al., 2021) Heart rate can be interpreted as the number of contractions that occur in the ventricles of the heart in a certain period of time, which is generally calculated in beats per minute. The size of these parameters is highly variable and constantly changes depending on the body's mechanisms that adjust to the varying oxygen and nutrient

needs of the tissues (Honório et al., 2019). Heart rate, especially with regard to the parameters of the heart rate at rest, can be understood as the number of heart beats in a minute recorded when a person is in a normal state or fully rested, in the absence of intervention from significant physical or mental stress. (Suastika et al., 2021). Heart rate is therefore an active physiological indicator that shows the number of beats of the heart ventricles in one minute to flow blood and oxygen throughout the body. This number is variable, nonfixed, and can adjust to physical activity, metabolic needs, and regulation of the autonomic nervous system, both sympathetic and parasympathetic.

Thus, physical education, sports, and health are recognized as compulsory subjects at various levels of education, ranging from elementary to junior high and vocational schools. Physical education programs play an important role in promoting and maintaining students' health during their school years (Adi, Rohidi, et al., 2023). Physical activity that is supposed to be healthy can actually become a physiological burden that is counterproductive. In addition, educators in physical education have a crucial role for students in growing their physical abilities (Aliriad, Andi, et al., 2023). Students need to have excellent physical condition so that they can study well and get optimal results. As future generations, students must be in good health and fitness. Responding to the importance of physical fitness, the government has been trying to integrate physical education, sports, and health into the primary and secondary education curriculum in Indonesia (Adi, Aliriad, et al., 2023). And physical education is a major component in the global education system. In physical education policies at the international level, many countries place curriculum development as a priority that includes physical education from primary school to higher education (Adi et al., 2024) These results are expected to provide a basis for the development of teaching strategies, activity schedules, and school health interventions that are more based on students' biological readiness.

Therefore, this study was compiled to analyze the relationship and influence of sleep quality on students' heart rate responses in physical education learning. The findings of this study are expected to provide empirical evidence regarding the importance of recess time management for students to optimize their physical performance. And most Penjas research only looks at external factors (such as exercise intensity or air temperature). This study tried to prove that students with poor sleep quality experienced higher cardiovascular stress even though their workload was the same as students who got enough sleep. This provides a new perspective for Penjas teachers that the inability of students to complete movement tasks may not be due to laziness, but due to limited cardiac response due to lack of sleep.

METHODS

This study uses a quantitative approach with a correlational (associative) design which aims to analyze the relationship and influence between independent and dependent variables. The research was conducted at State Vocational School 10 Semarang with a sample of 120 respondents (N = 120) who were selected using data collection techniques (random sampling). The focus of this study involves two main variables, namely Sleep Quality as an independent variable (X) which is measured using a score scale of 1 to 4 from kuesioner (PSQI), and Heart Rate as a dependent variable (Y) measured in beats per minute (bpm), using the Coospo H808S tool (ECG chest strap).

The data analysis process is carried out in stages to ensure the validity of the results. First, a descriptive analysis was carried out to provide a statistical overview in the form of minimum, maximum, mean, and standard deviation values of each variable. Furthermore, a classical assumption test was carried out as a condition of parametric analysis, which included the Kolmogorov-Smirnov Normality Test to ensure that the data was distributed normally, as well as the Linearity Test to verify that the relationship between the two variables formed a straight line. As the final stage, a hypothesis test was carried out which included the Pearson Correlation Test to measure the strength of the relationship, as well as the Simple Linear Regression Test to estimate the magnitude of the influence of Sleep Quality on Heart Rate significantly.

First, a descriptive analysis was carried out to provide a statistical overview in the form of minimum, maximum, mean, and standard deviation values of each variable.

Red average : $\bar{x} = (\sum X)/n$

Description:
$\bar{X}$ = Average Score
$\sum X$ = Sum of all data
n = Number of subjects/respondents

Standar Deviasis=$\sqrt{(\sum(X-\bar{X})^2)/(n-1)}$

Description :
SD = Standard Deviation
X   = Individual Score
$\bar{X}$ = Average Score
n   = Number of subjects/respondents

Furthermore, a classical assumption test is carried out as a condition of parametric analysis, the Kolmogorov-Smirnov Normality Test to ensure normal distributed data which includes:

D = max | Fo(X) - Fe(X) |

Description:
D   = Nilai statistics Kolmogorov-Smironov
Fo(X) = Empirical cumulative distribution
Fe(X) =Theoretical cumulative distribution (normal)
Criteria: Normally distributed data if Sig. > 0.05

The Linearity Test is to verify that the relationship between the two variables forms a straight line.

y = a + bX

Description:
Y = Bound Variable (Heart Rate)
X = Independent Variable (Sleep Quality)
a = Constant
b = Regression Coefficient
Criteria: Linear relationship if Sig. Deviation from Linearity > 0.05

As a final stage, a hypothesis test was carried out which included the Pearson Correlation Test to measure the strength of the relationship

$r=(n\sum XY-(\sum X)(\sum Y))/\sqrt{[n\sum X^2-(\sum X)^2][n\sum Y^2-(\sum Y)^2]}$

Description:
r   = Correlation Coefficient
X = Quality of Sleep
Y = Heart Rate
n = Number of Samples
Interpretation of Value r:

0.00–0.19	very low
0.20–0.39	low
0.40–0.59	medium
0.60–0.79	strong
0.80–1.00	very strong

As well as a Simple Linear Regression Test to estimate the magnitude of the influence of Sleep Quality on Heart Rate significantly.

Regression equation
y = a + bX
Regression Coefficient (b)
$b=(n\sum XY-(\sum X)(\sum Y))/(n\sum X^2-(\sum X)^2)$

Constant (a) = $a=\bar{Y}-b\bar{X}$

Description:
a   = Constant
b   = Regression Coefficient
$\bar{Y}$ = Average X
$\bar{X}$ = Average Y
Significance Criteria: The Significance of Sig.< 0.05
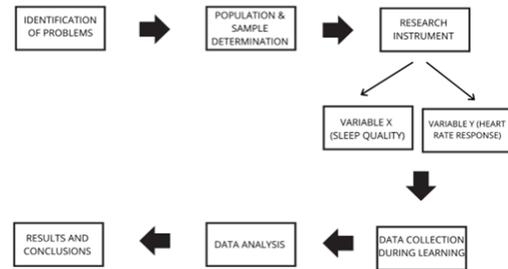

Figure 1. Research Flow Diagram of Sleep Quality and Heart Rate Response (Hsu et al., 2021).

RESULTS AND DISCUSSION

The results of the study on the relationship between sleep quality as a determinant of student heart rate response in physical education learning.

Tabel 1. Descriptive Results of Statistics

	N	Min	Max	Mean	Std. Deviation
Heart Rate	120	96	120	106.61	6.074
Quality Sleep	120	1	4	2.09	.453

Based on the results of the descriptive analysis in **Tabel 1**, for 120 respondents (N = 120), The heart rate variable showed a dynamic data distribution with an average of 106.61 bpm (SD = 6.074), which clinically indicates a condition on the verge of being above or slightly beyond the normal range of rest. Meanwhile, the sleep quality variable had an average of 2.09 with a very low degree of variance (SD = 0.453), indicating that sleep quality data tended to be homogeneous where the majority of respondents had similar conditions without extreme differences in values.

Tabel 2. Normality Test Calculation Results

	Statistic	df	Sig.	Criteria
Heart Rate	.081	120	.053	Normal
Quality Sleep	.080	120	.059	Normal

Based on the results of the normality test in **Tabel 2**, it was found that the heart rate vari-

able obtained a significance value (Sig.) of 0.053, while the sleep quality variable obtained a Sig. value of 0.059. Referring to the decision-making criteria where the data is declared normal if the Sig. value > 0.05, it can be concluded that the two main \variables in this study are normally distributed.

Tabel 3. Sleep Quality and Heart Rate Linearity Test

			Mean Square	F	Sig.	Criteria
Heart Rate Quality Sleep	Between Groups	(Combined)	50.967	1.482	.112	
		Linearity	312.243	9.080	.003	Sig
		Deviation from Linearity	35.598	1.035	.428	Sig
	Within Groups		34.387			
	Total					Linear

Based on the results of the linearity test in **Tabel 3**, the F Linearity value of 9.080 with a significance value of 0.003 wa s obtained. Since the p< value is 0.05, this result proves statistically that there is a significant relationship between sleep quality and heart rate. To ensure the strength of the linear model, a deviation test was carried out through the Deviation from Linearity value. The results of the analysis showed an F value of 1.035 with a significance value of 0.428. Referring to the test criterion where the assumption of linearity is fulfilled if the value of Sig. Deviation from Linearity > 0.05, then the number 0.428 confirms that the data model does not deviate significantly from a straight line. it can be concluded that the relationship between Sleep Quality and Heart Rate is linear.

Tabel 4. Correlation of Sleep Quality and Heart Rate

		Heart Rate	Quality Sleep
Heart Rate	Pearson Correlation	1	-.267**
	Sig. (2-tailed)		.003
	N	120	120
Quality Sleep	Pearson Correlation	-.267**	1
	Sig. (2-tailed)	.003	
	N	120	120

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

Based on the results of the correlation test in **Tabel 4**, the value of the correlation coefficient (r) was -0.267 with a significance value (Sig. 2-tailed) of 0.003. Significance values well below 0.05 (0.003 < 0.01) and the presence of a two-star mark (**) indicate that this correlation is signifi-

cant at a 99% confidence level. A correlation coefficient with a negative value (-0.267) indicates an inverse relationship with the level of strength that falls into the weak category. This means that the higher a person's heart rate, the more sleep quality tends to decrease, and vice versa.

Based on simple linear regression analysis, a simple linear regression analysis was carried out to measure the extent of the influence of the Sleep Quality variable on Heart Rate in 120 respondents. Based on the Model Summary table, a correlation coefficient value (R) of 0.267 was obtained which indicates that the relationship between variables is at a weak level. The value of the determination coefficient (R Square) of 0.071 indicates that the Sleep Quality variable contributes 7.1% to the variation in the rise and fall of Heart Rate, while the remaining 92.9% is influenced by other factors outside the scope of this study. Simultaneous significance tests through the ANOVA table produced an F value of 9.034 with a significance level (Sig.) of 0.003. Because the significance value is less than 0.05 (0.003 < 0.05), this regression model is declared significant and feasible to be used to predict the Heart Rate variable based on Sleep Quality data. Partially, based on the Coefficients table, the Sleep Quality variable had a calculated t-value of -3.006 with a significance of 0.003, which strengthens the evidence of a significant influence on Heart Rate. From the results of the calculation, the regression equation is obtained as follows:

$$Y = 114,084 - 3,576 \, X$$

This means that a constant value of 114.084 indicates the starting point of the heart rate, and a regression coefficient of -3.576 explains that for every one unit increase in the sleep quality score, the heart rate is predicted to decrease by 3.576 bpm. This confirms that better sleep quality consistently contributes to a decrease in respondents' heart rate.

Physical activity is one of the essential components to support an individual's fitness and health. When a person does exercise, it will encompass movement activities that involve physical movement (Adi, Soenyoto, Aliriad, et al., 2025). Chronic sleep disorders lead to decreased parasympathetic activity and increased sympathetic dominance, which directly contributes to increased resting heart rate as well as excessive cardiac response during physical activity (Speksnijder et al., 2024). These physiological conditions seem to be in line with the findings on the sleep quality variable. With an average score of 2.09 on a scale of 1-4, the majority of respondents were categorized as having "Poor" sleep quality. A very

low standard deviation (0.453) corroborates these findings, which means there is uniformity in sleep problems among respondents without any extreme differences between individuals. Poor sleep quality can result in a decrease in the individual's ability to remember or focus, both in the learning process and in remembering information, so to obtain optimal concentration, it is important to pay attention to sleep patterns and quality in order to concentrate effectively (Gustiawati & Murwani, 2020). The findings show that the majority of respondents have "poor" sleep quality evenly, which not only interferes with physiological conditions but also decreases cognitive function and concentration in the learning process.

Physical literacy, physical activity, and motivation are related to physical education learning outcomes. Physical literacy has a positive impact on a person's physical, psychological, social, and cognitive health (Adi, Soenyoto, Yuwono, et al., 2025) Physical literacy is an idea that is relevant for everyone, at any time, and in all locations while undergoing physical activities that are appropriate to their age, skills, and environmental culture (Septian, I. B., & Adi, 2025). However, physical activity itself affects sleep quality: regular exercise tends to improve sleep quality, while poor sleep patterns can lower physical performance and make the heart's response to exercise less efficient (Aliriad, Fahrudi, et al., 2023). This two-way interaction (physical activity ↔ sleep) makes the study of sleep quality as a determinant of students' heart rate response during PE learning important, as the results can be used to recommend teaching strategies, activity schedules, and school health interventions.

Homogeneity of poor sleep quality often occurs in student populations or individuals with high demands on physical and academic activity, leading to the accumulation of physiological and psychological fatigue (Hershner & Auckley, 2021). The high prevalence of sleep disorders in students and students due to academic demands, physical activity, and excessive use of gadgets (Pusparini et al., 2021). are more prone to fatigue, less fitness, and experience autonomic regulation disorders (sympathetic–parasympathetic), which has the potential to modify the heart rate response to exercise, for example faster climbs and slower return to rest (Khairunissa & Rahayu, 2024). This condition has the potential to inhibit the deep sleep phase which plays an important role in the restoration of heart function and regulation of the autonomic system. (Nugroho et al., 2020) reported that low sleep quality was associated with the predominance of sympathetic ner-

vous system activity, which was characterized by a high resting heart rate as well as a less stable cardiovascular response during sports activities. There is a clear pattern of relationship where high heart rate is directly proportional to the low sleep quality of respondents. (Shaffer et al., 2020) mentioning that the worse the quality of a person's sleep, the higher his resting heart rate. Physiologically, sleep deprivation and fragmented sleep lead to a decrease in parasympathetic activity (vagal tone) and increase the release of catecholamines, so that the heart rate remains high even when the body is in a state of Rest (Correia et al., 2022). This heart rate accurately reflects the amount of cardiovascular workload in the process of distributing oxygenated blood throughout the body, in order to adjust to increased metabolism and meet the energy needs of skeletal muscles that are active while moving (Ahmad et al., 2019). This condition indicates that most subjects are likely experiencing physical stress, post-activity effects, or certain health factors that trigger mild tachycardial conditions. These findings are in line with research (Zhang et al., 2021) that poor sleep quality contributes to increased sympathetic activity, which has an impact on increased resting heart rate and decreased cardiovascular stability.

Poor sleep quality correlates with increased resting heart rate and decreased exercise tolerance in adolescents, which has a direct impact on students' performance and engagement in physical education activities (Al-Khatib, 2023). This study concluded that there was a significant but weak negative relationship between Sleep Quality and Heart Rate. These findings support the physiological theory that optimal sleep quality can help lower the activity of the sympathetic nervous system, which ultimately impacts a calmer and more regular heartbeat. Interventions to improve sleep quality in students are able to reduce resting heart rates and improve heart rate response to physical activity, so it is recommended as a preventive strategy in the context of physical education and school health (Lee et al., 2024). The quality and duration of sleep play a role in physiological functions, including the regulation of energy, hormones, and autonomic nervous activity. Lack of sleep and poor quality sleep are associated with hormonal changes (leptin, ghrelin), increased appetite, as well as decreased physical activity and fitness, which can indirectly worsen the cardiovascular response to exercise and slow pulse recovery (Adi et al., 2021; Djojosaputro & Rahmawati, 2023). As well as low sleep quality can be influenced by a number of factors, one of which is the increase in internet use caused by

very fast technological advances in recent times is one of the reasons for reduced sleep time, especially among teenagers (Fachlefi & Rambe, 2021). Poor sleep quality (less than 7-8 hours or frequent awakening) has impaired autonomic nervous systems. During PE learning, students with poor sleep tend to have higher resting heart rates and slower heart rate recovery after high-intensity physical activity (Hidayat et al., 2021). Interventions to improve sleep quality are highly recommended as preventive strategies in schools. This aims to calm the activity of the sympathetic nervous system, so that students have a more regular heart rate and better physical readiness in participating in physical education activities.

This empirically proves the existence of an inverse relationship, where better sleep quality contributes to a decrease in heart rate in a more physiologically ideal direction. Although this effect was statistically significant with a p value = 0.003, the R Square value of 7.1% indicated that sleep quality was not a single or major factor in determining the respondent's heart rate. The other 92.9% variation in heart rate was most likely influenced by other external and internal factors not studied in this model, such as activity levels physical, caffeine consumption, psychological stress levels, and congenital medical conditions. This value is in line with with findings (Holmer et al., 2021) that conclude that sleep quality is a significant factor but not a single determinant in heart rate regulation. (Yuksel et al., 2020) found that other factors such as physical activity levels, psychological stress, caffeine consumption, academic load, and congenital health conditions also contribute greatly to cardiovascular responses. This study confirms that improving sleep patterns and quality can be one of the effective interventions to help stabilize cardiovascular activity, especially in keeping heart rate in the normal range.

Thus, Although the strength of the relationship is relatively weak, consistent statistical significance suggests that sleep quality still has a meaningful physiological role. Longitudinal studies (Huang et al., 2020) show that the impact of sleep quality on heart rate is cumulative, where chronic sleep disorders contribute to an increased risk of long-term cardiovascular dysfunction. This reinforces the relevance of the findings of this study in the context of early prevention of cardiovascular disorders in the young population. (Joubert et al., 2024) emphasized the importance of sleep quality improvement interventions as a preventive strategy to maintain cardiovascular health, particularly in students and individuals with high physical activity. (Adi et al., 2020) Emphasizing that physical activity is often defined as any movement of the body produced by skeletal muscles that gives rise to energy expenditure above resting values, physical activity is a complex phenomenon that is meaningfully divided into different categories and different levels of intensity.

CONCLUSION

Sleep quality has a meaningful role in influencing students' heart rate responses during physical education, sports, and health (PE) learning. The average heart rate of students in the relatively high range and sleep quality scores that tend to be low and homogeneous indicate the existence of less than optimal physiological conditions in most students. This condition indicates that impaired sleep quality has the potential to cause an increase in the activity of the sympathetic nervous system, so that the heart rate becomes higher and less stable when the body should be at rest or during structured physical activity. The results of statistical analysis showed a significant negative relationship between sleep quality and heart rate, which means that the better the sleep quality of students, the lower the heart rate heart shown. This relationship is linear and consistent with the theory of regulation of the autonomic nervous system, in which poor sleep quality decreases parasympathetic modulation and improves the cardiovascular response to physical stress. Although the strength of the relationship is relatively weak, the statistical significance obtained confirms that sleep quality remains one of the physiological determinants that affect heart rate. optimal sleep quality contributes to a more efficient and stable heart rate response during PE learning. Therefore, attention to the quality of students' sleep needs to be considered as an integral part of efforts to improve the learning effectiveness of physical education, physical fitness, and early prevention of cardiovascular disorders at school age.

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