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Sleep Quality and Blood Pressure Among Senior High School Students in Purwokerto

Neni Tri Wahyuni¹, Hikmi Muharromah Pratiwi^{2,*}, Made Sumarwati²¹ Faculty of Health Sciences, Jenderal Soedirman University, Purwokerto, Central Java, Indonesia² Department of Nursing, Faculty of Health Sciences, Jenderal Soedirman University, Purwokerto, Central Java, Indonesia

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* Corresponding author. Hikmi Muharromah Pratiwi, Department of Nursing, Faculty of Health Sciences, Jenderal Soedirman University, Purwokerto, Central Java, Indonesia. E-mail address: hikmi.muharromah@unsoed.ac.id. ORCID: 0000-0001-6311-6930.

ABSTRACT

Background. Hypertension is a global health problem with a rising prevalence, including among adolescents. Poor sleep quality is a potential risk factor that may contribute to elevated blood pressure. This study aimed to analyze the relationship between sleep quality and blood pressure in vocational students in Purwokerto.

Methods. This study employed a correlational design with a cross-sectional approach. A total of 312 students were selected using stratified random sampling. The study was conducted among grade 10 and 11 students at a vocational high school in Purwokerto in November 2024. The instruments included the Pittsburgh Sleep Quality Index (PSQI) questionnaire and blood pressure measurements obtained with a digital sphygmomanometer. Data analysis involved univariate analysis and bivariate analysis using the Somers' D test.

Results. Among participants, 40.38% experienced poor sleep quality and 45.84% had blood pressure issues. A significant relationship was found between sleep quality and blood pressure ($p < 0.001$). The relationship was negative and strong, with a correlation coefficient of $r = -0.517$.

Conclusion. Poor sleep quality is associated with elevated blood pressure in adolescents. Longitudinal designs are recommended to more comprehensively understand other factors affecting blood pressure in adolescents.



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1. INTRODUCTION

Hypertension is defined as a condition in which systolic blood pressure is ≥ 140 mmHg and diastolic blood pressure is ≥ 90 mmHg. The global prevalence of hypertension is increasing annually. According to the World Health Organization (WHO) in 2023, approximately 1.28 billion adults worldwide have hypertension. In Indonesia, the prevalence rose from 25.8% in 2013 to 34.1% in 2018 (1). Hypertension is not limited to adults; its incidence is also rising among adolescents. Data from a Brazilian study (2016) indicate that 9.6% of adolescents aged 12–17 years have hypertension (2). Among Indonesian adolescents, the prevalence of hypertension and elevated blood pressure is 8% and 12.2%, respectively. According to the 2023 first-semester performance report of the Directorate General of Disease Prevention and Control, early hypertension detection coverage among individuals aged ≥ 15 years in Central Java reached 6.6%, and the Banyumas District Health Office reported 181,948 individuals aged ≥ 15 years diagnosed with hypertension in 2022 (1).

Hypertension is often called a silent killer because it can cause death without exhibiting obvious symptoms (3). Persistently high blood pressure can alter heart muscle function and increase the risk of cardiovascular disease. Uncontrolled hypertension may lead to complications including coronary heart disease, stroke, heart failure, kidney failure, peripheral vascular disease, and damage to the retinal blood vessels that can result in visual impairment (4). Therefore, early prevention through screening for the causes and risk factors of hypertension from a young age is crucial.

Hypertension in adolescents is influenced by multidimensional risk factors, including biological, genetic, behavioral, and lifestyle factors, which can be grouped into modifiable and non-modifiable categories. Non-modifiable factors include age, gender, and genetics, whereas modifiable factors—such as nutritional status and lifestyle behaviors including sleep patterns, stress levels, and physical activity—play a key role in prevention (5). Among these, sleep quality is an important modifiable factor in the development of hypertension in adolescents (6).

Sleep problems can manifest as insufficient sleep duration and disturbances, leading to poor sleep quality (7). Sleep quality refers to a person's satisfaction with their sleep, characterized by the absence of sleep deprivation symptoms and sleep-related issues (8). It is a complex phenomenon encompassing several domains, including sleep latency, sleep duration, sleep efficiency, and the use of sleep medication (2). Good sleep quality supports the body's immune system, metabolic functions, memory, learning, and other vital processes (9). However, adolescents are particularly vulnerable to sleep disturbances; in Indonesia, as many as 63% of adolescents experience poor sleep quality (10). Sleep disturbances in adolescents can result in impaired daytime concentration, increased susceptibility to illness, fatigue, and cardiovascular issues, including high blood pressure (3).

Poor sleep quality can lead to increased blood pressure. Inadequate sleep triggers stress responses, such as anxiety, which elevate norepinephrine levels and disrupt Non-Rapid Eye Movement (NREM) sleep. When NREM sleep is disturbed, sympathetic nerve activity rises, increasing heart rate, breathing rate, and blood pressure to meet the body's physiological demands in response to perceived threats (12). Normally, sympathetic activity decreases during sleep as the body relaxes, resulting in lowered blood pressure, slower pulse and breathing rates, reduced body temperature, and vasodilation.

A preliminary survey was conducted in March 2024 at SMK N 2 Purwokerto, involving 15 ninth-grade students. The results indicated that 73.33% of the students had poor sleep quality, with contributing factors including playing games and difficulty falling asleep. After blood pressure measurement, 46.67% of the students were found to have hypertension (13).

Several studies have examined the relationship between sleep quality and hypertension, but most focus on the elderly, such as those by Madeira et al. (4) and Anjani et al. (5). Studies involving adolescents, including high school and college students, have also reported a significant association between sleep quality and blood pressure. Nevertheless, Rahman and Pase (6) found no relationship between these two variables, indicating that findings on sleep quality and blood pressure remain inconsistent. In addition, no research on hypertension in adolescents has been conducted in Banyumas Regency. Therefore, this study aimed to investigate the relationship between sleep quality and blood pressure among vocational high school students in Purwokerto.

2. METHODS

2.1 Study Design

This study employed a quantitative, descriptive-analytical, correlational research design with a cross-sectional approach.

2.2 Setting and Participants

This research was conducted at a vocational high school, SMK N 2 Purwokerto, in November 2024. The sample size was determined using the Slovin formula, and the sampling technique was stratified random sampling to represent each grade. A sample of 164 participants was drawn from grade 10 and 161 from grade 11. The researcher distributed questionnaires to 332 participants; however, 20 were excluded because they were unwilling to complete the questionnaire, resulting in 312 participants. The inclusion criteria were students aged 15 to 18 years, while the exclusion criteria included students who were absent and those taking antihypertensive medication.

2.3 Instruments and Measures

The instrument used to measure the independent variable was the Pittsburgh Sleep Quality Index (PSQI) questionnaire, developed by Buysse and colleagues at the University of Pittsburgh in 1989 and translated into Indonesian by Feriani (7). The instrument consists of 9 questions grouped into 7 domains: subjective sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disturbances, medication use, and daytime dysfunction. Scores range from 0 to 21 and are classified as good (≤ 5) or poor (> 5) sleep quality.

Blood pressure was measured using a digital tensiometer (Omron) twice, with a 1–2-minute interval between readings; the final value was the average of the two measurements. Results were classified according to the 2017 American Heart Association (AHA) guidelines: normal ($<120/80$ mmHg), elevated ($120\text{--}129/80$ mmHg), stage 1 hypertension ($130\text{--}139/80\text{--}89$ mmHg), and stage 2 hypertension ($\geq 140/\geq 90$ mmHg). The validity and reliability of the PSQI were not re-tested because the questionnaire had already been validated by Agustin (8), who reported validity coefficients ranging from 0.410 to 0.831 (all exceeding the table value of 0.361) and a Cronbach's alpha coefficient of 0.84.

2.4 Data Collection Procedure

Data collection was conducted while students were attending counseling sessions so as not to disrupt teaching and learning activities. Beforehand, the researcher explained the research procedures and objectives and obtained informed consent via a Google Form. The researcher was assisted by a research assistant in taking blood pressure, height, and weight measurements and in administering the questionnaire, in accordance with established standard operating procedures. Before blood pressure measurement, students were given a 5-minute rest period, and a 1.5-minute interval was observed between measurements, during which students were asked not to speak or move much. Height was measured with students looking straight ahead and their feet against the wall. Results were recorded on paper and then transferred to the

questionnaire form, while data on respondent identity and sleep quality were collected via Google Forms.

2.5 Data Analysis

Data were processed, analyzed, and presented using computer software. Participant characteristics were analyzed univariately using median, minimum, and maximum values because the data were not normally distributed, as indicated by a Kolmogorov-Smirnov test p -value of 0.00 for age. Frequencies and percentages were used to describe sleep quality, blood pressure, gender, smoking status, family history of hypertension, physical activity, and body mass index. The relationship between sleep quality and blood pressure was analyzed bivariately using the Somers' D test, with a significance level of $p < 0.05$.

2.6 Ethical Considerations

This study received ethical approval from the Health Research Ethics Committee, Faculty of Health Sciences, Jenderal Soedirman University, under approval number 1629/EC/KEPK/X/2024. The researchers explained the research procedures and objectives and obtained informed consent via a Google Form, having previously obtained informed assent from the homeroom teachers of the grade 10 and 11 students.

3. RESULTS

The characteristics of the participants included age, gender, caffeine consumption, smartphone use, smoking history, family medical history, frequency and type of physical activity, and body mass index (BMI), as summarized in Table 1.

Table 1. Characteristics of Study Participants ($n = 312$)

Variable	n	%
Age (years)		
Median (min-max): 16 (15-18)		
Gender		
Male	254	81.41
Female	58	18.59
Caffeine consumption		
Never	170	54.45
1-2 cups/day	133	42.65
3-5 cups/day	9	2.90
Smartphone use		
<1 hour/day	7	2.24
2-4 hours/day	86	27.56
>4 hours/day	219	70.20
History of smoking		
No	175	56.09
Yes	137	43.91
Family history of hypertension		
No	221	70.83
Yes	91	29.17
Frequency of physical activity		
1-2 times/week	179	57.38
3-4 times/week	109	34.93

>5 times/week	24	7.69
Type of physical activity		
Mild	155	49.70
Moderate	132	42.30
Heavy	25	8.00
Body mass index (BMI)		
Underweight	118	37.82
Normal	153	49.03
Overweight	28	8.97
Obese	13	4.17

n = frequency; % = percentage; min = minimum; max = maximum.

The median age of participants was 16 years (range 15-18). The majority were male (254; 81.41%). Most reported no family history of hypertension (221; 70.83%), and 153 (49.03%) had a normal body mass index.

Table 2. Overview of Sleep Quality and Blood Pressure Among Students of SMK N 2 Purwokerto ($n = 312$)

Variable	n	%
Sleep quality		
Poor	181	58.01
Good	131	41.99
Blood pressure		
Normal	169	54.16
Elevated	66	21.15
Stage 1 hypertension	63	20.20
Stage 2 hypertension	14	4.49

n = frequency; % = percentage.

Most participants (181; 58.01%) had poor sleep quality, while 131 (41.99%) had good sleep quality. For blood pressure, 169 participants (54.16%) were within the normal range, 66 (21.15%) were elevated, 63 (20.20%) had stage 1 hypertension, and 14 (4.49%) had stage 2 hypertension.

A cross-tabulation of sleep quality and blood pressure is presented in Table 3.

Table 3. Relationship Between Sleep Quality and Blood Pressure Among Students of SMK N 2 Purwokerto

Blood pressure	Poor sleep, n (%)	Good sleep, n (%)
Normal	60 (19.23)	109 (34.94)
Elevated	53 (16.99)	13 (4.17)
Stage 1 hypertension	56 (17.95)	7 (2.24)
Stage 2 hypertension	12 (3.85)	2 (0.63)
Total	181 (100)	131 (100)

Somers' D test: $p < 0.001$; $r = -0.517$. n = frequency; % = percentage.

Normal blood pressure was more common among students with good sleep quality. Conversely, elevated blood pressure was more frequent among those with poor sleep quality (16.99%) than good sleep quality (4.17%); the same pattern held for stage 1 hypertension (17.95% vs. 2.24%) and stage 2 hypertension (3.85% vs. 0.63%). The analysis showed a significant, negative, and strong relationship between sleep quality and blood pressure ($p < 0.001$;

$r = -0.517$): the poorer the sleep quality, the higher the blood pressure.

4. DISCUSSION

This study shows that the majority of participants had poor sleep quality, consistent with Keswara et al. (2019), who found that 64.7% of adolescents had poor sleep quality and 35.3% had good sleep quality. Most participants experienced daytime dysfunction, which is often caused by a decline in night-time sleep quality; affected individuals tend to feel lethargic and sleepy during daily activities (9). Sleep quality in adolescents can be influenced by several factors, including unhealthy lifestyle habits such as smoking and consuming caffeinated beverages (10). Excessive smartphone use is another factor, as the blue light emitted can reduce melatonin levels in the body.

The majority of participants used smartphones for more than four hours per day, which is considered high usage and may contribute to poor sleep quality. This aligns with research (11) indicating that using smartphones before bed and for extended periods can reduce sleep quality. Staying up until the early hours of the morning often causes adolescents to lose track of time and miss their bedtime (12), which may further reduce sleep quality through sleep deprivation and a tendency to wake up late (13). Reduced sleep quality can lead to daytime concentration difficulties and cardiovascular problems (14).

A total of 21.15% of participants were categorized as having elevated blood pressure, 20.20% as stage 1 hypertension, and 4.49% as stage 2 hypertension. These results reflect the trend of hypertension in adolescents reported by Kurnianto et al. (15), who found an 8% prevalence. According to the Indonesian Health Survey (2023), the prevalence of hypertension among individuals aged ≥ 15 years was 30.7%. Hypertension in adolescents is influenced by modifiable and non-modifiable factors. Regular blood pressure monitoring is crucial for early detection, and early preventive measures can reduce the future risk of hypertension and related diseases (16).

This study shows that sleep quality was associated with students' blood pressure. Sleep quality exhibited a significant negative relationship with blood pressure ($p < 0.001$) and a strong correlation ($r = -0.517$); poorer sleep quality was associated with higher blood pressure. This aligns with Sajjadih et al. (17), who reported that poor sleep quality was negatively associated with both blood pressure and heart rate. The results are further supported by Faradila (18) and Kusumaningrum et al. (19), indicating that poor sleep quality can elevate blood pressure through an imbalance in the homeostatic system. This imbalance can disrupt the circadian rhythm by increasing sympathetic nerve activity (20); when the circadian rhythm is irregular, cortisol production rises, stimulating an increase in steroid hormones in the blood, which in turn leads to excessive adrenaline production and increased cardiac output.

Decreased sleep quality can also result from insufficient NREM and REM sleep. Disruption of NREM sleep diminishes the body's restorative functions, leading to elevated cortisol levels and increased sympathetic nervous system activity (21,22). Similarly, disruption of REM sleep activates the "fight or flight" response through heightened adrenaline levels, further enhancing sympathetic activity (23). This stimulation, together with elevated adrenaline, induces vasoconstriction by impairing fat metabolism, resulting in increased peripheral resistance and elevated blood pressure (24). Consequently, increased sympathetic activity raises heart rate, respiratory rate, and blood pressure to meet the body's physiological demands when responding to stress or perceived threats (25).

This study has several limitations. Blood pressure was measured only during a single visit, which may not capture variations over time, and the cross-sectional design prevents causal interpretation. In addition, several confounding factors—such as diet, sodium intake, stress, physical activity, caffeine consumption, smoking behavior, BMI, smartphone use, and family history of hypertension—were not fully controlled or analyzed. Sleep quality was assessed using a self-reported questionnaire, which may introduce recall bias.

Despite these limitations, the findings highlight the importance of sleep quality as a modifiable factor associated with blood pressure among adolescents. The results imply that school-based hypertension prevention programs should include sleep hygiene education, regular blood pressure screening, reduction of excessive smartphone use, and promotion of healthy lifestyle behaviors. Future studies should employ longitudinal designs and multivariate analysis to better understand the causal pathway and other factors influencing adolescent blood pressure.

5. CONCLUSION

This study demonstrated a significant and strong correlation between sleep quality and blood pressure among students of SMK N 2 Purwokerto, with poorer sleep quality associated with higher blood pressure. Based on these results, students are advised to reduce smartphone use and replace it with productive activities such as studying and resting, to engage in physical activity at least three to four times per week, and to adopt a healthy lifestyle to prevent future illness.

The school is expected to collaborate with nurses from the East Purwokerto 2 Health Center to develop programs such as blood pressure screening and youth posyandu (integrated health posts), and to organize a curriculum that supports student health. Health-center nurses should provide education on the negative impacts of excessive smartphone use, the importance of physical activity, and sleep hygiene. Future researchers are encouraged to employ

longitudinal designs to gain a more comprehensive understanding of other factors affecting blood pressure in adolescents.

DATA AVAILABILITY STATEMENT

The datasets generated and/or analyzed during the current study are available from the corresponding author upon reasonable request.

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CONFLICT OF INTEREST

The authors declare no competing interests.

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