Sleep Quality, Blood Pressure, and Body Mass Index Among Adolescents: A Cross-Sectional Study

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Abstract. Sleep problems are common during adolescence, but their relationship with cardiovascular and nutritional indicators is not always consistent across settings. This study examined whether sleep quality was related to blood pressure and body mass index (BMI) among students at SMAN 7 Malang, Indonesia. A cross-sectional survey was conducted from March to December 2024 among 300 students aged 15-18 years who were selected by stratified random sampling. Sleep quality was assessed using the Indonesian Pittsburgh Sleep Quality Index (PSQI). Blood pressure was obtained with a digital sphygmomanometer, while BMI was calculated from measured height and weight and interpreted using age- and sex-specific percentiles. Descriptive analysis and Spearman rank correlation were used. Most participants were female (69.3%), and 71.0% were classified as having poor sleep quality. Even so, 72.3% had normal blood pressure and 82.0% had normal BMI. Sleep quality was not significantly correlated with blood pressure ($r = -0.020$; $p = 0.729$) or BMI ($r = 0.040$; $p = 0.247$). The absence of significant correlations does not reduce the practical importance of the high prevalence of poor sleep. School-based education, screening, and broader lifestyle support remain warranted.

Keywords: Adolescents, Blood pressure, Body mass index, Pittsburgh Sleep Quality Index, Sleep quality.

1 Introduction

For adolescents, sleep is not simply a period of rest. It supports growth, recovery, concentration, emotional regulation, and day-to-day physical functioning. The National Sleep Foundation recommends 8-10 hours of sleep each night for this age group, yet many adolescents sleep less because of schoolwork, screen use, academic demands, and irregular routines [1]. When sleep is inadequate or fragmented, stress-related pathways and hormones involved in appetite and metabolism may also be affected [2], [3]. Therefore, sleep health is best understood as a combination of duration, timing, continuity, and efficiency. In young adolescents, more favorable objectively measured sleep characteristics have been linked with better cardiometabolic profiles [4].

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Adolescence is also a period when early cardiovascular and nutritional risks can begin to appear. Elevated blood pressure at this age may continue into adulthood and contribute to later cardiovascular and kidney disease [5], [6]. Likewise, overweight and obesity during adolescence are associated with metabolic, psychosocial, and functional consequences [7]. Sleep may influence both blood pressure and BMI through several pathways, including sympathetic nervous system activity, cortisol regulation, leptin and ghrelin balance, food intake, and physical activity [3], [8]. For example, lower sleep efficiency has been associated with higher systolic blood pressure and a greater likelihood of prehypertension in otherwise healthy adolescents, even after obesity and sleep-disordered breathing were considered [9].

Previous studies have reported mixed findings. Some studies found an association between poor sleep quality and higher blood pressure or higher BMI among adolescents and young adults, while other studies did not demonstrate significant relationships [10]–[13]. The inconsistency may reflect differences in age, setting, sleep measurement, blood-pressure procedures, nutritional status, and statistical adjustment. Evidence from systematic reviews suggests that shorter sleep is associated with higher adolescent blood pressure and with later overweight or obesity, but the degree of association varies considerably across studie [14]–[16]. However, Indonesian school-based data remain limited. This study investigated the relationship of sleep quality with blood pressure and BMI among adolescents at SMAN 7 Malang.

2 Methods

2.1 Study Design and Setting

This study used a quantitative correlational design with a cross-sectional approach. Data were collected at SMAN 7 Malang, Indonesia, between March and December 2024.

2.2 Population and Sample

The target population consisted of 1,119 SMAN 7 Malang active students. Slovin's formula with a 5% margin of error produced a minimum sample requirement of 295. To ensure adequate representation across grades X, XI, and XII, 300 students were selected using stratified random sampling. Students were included when they were 15-18 years old, actively enrolled, and had provided informed consent. Those who were absent during data collection or were experiencing acute complaints such as fever, dizziness, or nausea were not included.

2.3 Instruments and Measurements

Sleep quality was measured using the Indonesian version of the Pittsburgh Sleep Quality Index (PSQI). The instrument contains 19 self-rated items grouped into seven com-

ponents: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbance, use of sleeping medication, and daytime dysfunction [17]. The Indonesian version has shown acceptable psychometric performance, with a Cronbach's alpha of 0.79 and content validity of 0.89 [18].]. A global score below 5 was interpreted as good sleep quality, while a score of 5 or more indicated poor sleep quality.

Blood pressure was measured with a Sinocare digital sphygmomanometer, with an accuracy of approximately +/-3 mmHg. Before measurement, each participant sat comfortably and rested for five minutes. Results were classified as normal, pre-hypertension, stage 1 hypertension, or stage 2 hypertension using adolescent blood-pressure criteria [19]. Body weight was measured to the nearest 0.1 kg using an Onemed digital scale, and height was measured to the nearest 0.1 cm using a microtoise. BMI was calculated as weight in kilograms divided by height in meters squared and categorized by age- and sex-specific percentiles: underweight (<=5th percentile), normal (6th-94th percentile), and obesity (>=95th percentile) [20].

2.4 Data Analysis and Ethics

Data were processed in SPSS version 25.0. Descriptive statistics summarized participant characteristics and the distribution of sleep quality, blood pressure, and BMI. Because the variables were not normally distributed, Spearman rank correlation was used for the two main analyses: sleep quality with blood pressure and sleep quality with BMI. Ethical approval was granted by the Health Research Ethics Committee, Faculty of Health Sciences, Universitas Brawijaya (No. 24F171111094M). Participation was voluntary, and confidentiality was maintained throughout the study.

3 Results

3.1 Respondent Characteristics

Three hundred adolescents took part in the study. The median age was 16 years, with an age range of 15-18 years. Most participants were female, did not report a family history of hypertension, did not smoke, consumed coffee 1-4 times per month, and had a moderate level of physical activity.

Table 1. Respondent characteristics (n = 300)

Characteristics	Frequency (n)	Percentage (%)
Sex		
- Male	92	30.7
- Female	208	69.3
Age, median (min-max)	16 (15-18) years	
Family history of hypertension		
- Yes	74	24.7
- No	226	75.3

Smoking habit		
- Smoker	31	10.3
- Non-Smoker	269	89.7
Coffee consumption		
- Never	88	29.3
- 1-4 times/month	150	50.0
- 5-8 times/month	44	14.7
- Everyday	18	6.0
Physical activity		
- Low	61	20.3
- Moderate	197	65.7
- High	42	14

3.2 Sleep Quality, Blood Pressure, and BMI

Poor sleep quality was identified in 213 students (71.0%). Blood pressure was normal in 217 students (72.3%); 51 (17.0%) were categorized as pre-hypertensive, 19 (6.3%) as stage 1 hypertensive, and 13 (4.3%) as stage 2 hypertensive. For BMI, 246 students (82.0%) were in the normal category, 18 (6.0%) were underweight, and 36 (12.0%) were obese.

Table 2. Distribution of sleep quality, blood pressure, and body mass index (n = 300)

Variable	Frequency (n)	Percentage (%)
Sleep quality		
- Good	87	29.0
- Poor	213	71.0
Blood Pressure		
- Normal	217	72.3
- Pre-hypertension	51	17.0
- Stage 1 hypertension	19	6.3
- Stage 2 hypertension	13	4.3
Body Mass Index		
- Underweight	18	6.0
- Normal	246	82.0
- Obesity	36	12.0

3.3 Relationship between Sleep Quality, Blood Pressure, and BMI

Spearman analysis did not show a significant relationship between sleep quality and blood pressure ($r = -0.020$; $p = 0.729$). The relationship between sleep quality and BMI was also not significant ($r = 0.040$; $p = 0.247$).

Table 3. Spearman correlation between sleep quality, blood pressure, and body mass index

Variables	r	p-value
Sleep quality and blood pressure	-0.020	0.729
Sleep quality and body mass index	0.040	0.247

Note: Spearman rank correlation was used because the data were not normally distributed. A p-value < 0.05 was considered statistically significant.

4 Discussion

This study found that most adolescents at SMAN 7 Malang had poor sleep quality. This result is broadly similar to reports from other Indonesian senior high school populations [21], [22]. Several everyday factors may contribute, including academic workload, psychological stress, caffeine intake, prolonged technology use, and inconsistent sleep schedules. In this study, half of the respondents consumed coffee 1-4 times per month, while 6.0% reported daily consumption. These figures are descriptive and cannot be interpreted as evidence of causation, but caffeine is still relevant because it may delay sleep onset and impair sleep quality in adolescents [23]. International literature also shows that adolescent sleep disturbance often coexists with other cardiovascular risk indicators, including elevated BMI and hypertension [24].

Most students had normal blood pressure, which is reassuring, but it should not obscure the proportion already classified as pre-hypertensive or hypertensive. The generally young age of the sample and the vascular elasticity typical of adolescence may partly explain the predominance of normal values. Nevertheless, elevated blood pressure in adolescence may persist over time, so routine school-based screening remains important [5], [6].

BMI was also normal for most participants, although both underweight and obesity were present. Nutritional status during adolescence reflects many interacting influences, including diet, physical activity, genetics, stress, and sleep. Because adolescent obesity is linked to metabolic, cardiovascular, and psychosocial consequences [7]. Therefore, health promotion programs should address not only sleep but also balanced nutrition, physical activity, and stress management.

The study did not identify a significant relationship between sleep quality and blood pressure. Similar results have been reported in other adolescent samples [12], [25]. A plausible physiological pathway still exists; poor sleep can increase sympathetic activity and alter hormonal regulation. However, adolescent blood pressure is also shaped by sodium intake, psychological stress, smoking, heredity, physical activity, and the conditions under which blood pressure is measured. Because these factors were not fully controlled, any independent contribution of sleep quality may have been difficult to detect. Other studies have found that short sleep or reduced sleep efficiency is associated with elevated blood pressure [9], [14]. A recent population-based study also reported that short sleep duration and obesity independently, and particularly in combination, increased the likelihood of hypertension among Korean adolescents [26]. Differences in measurement and covariate adjustment may explain why results vary between studies.

Sleep quality was also not significantly related to BMI. This finding is consistent with several studies in adolescent or student populations [13], [27]. Although insufficient sleep may affect appetite through leptin and ghrelin, BMI is influenced more directly by total energy intake, food choices, physical activity, sedentary behavior, stress, and

genetic susceptibility. These variables were not measured comprehensively in the present study. In contrast, prospective meta-analyses generally indicate that short sleep predicts later overweight or obesity [15], [16]. A recent longitudinal synthesis also found that longer sleep duration and better sleep quality were associated with lower BMI, fat percentage, and obesity risk over time [28]. The difference from the present results may relate to the cross-sectional design, reliance on a global subjective PSQI score, and the relatively limited variation in BMI within this sample.

Several limitations should be considered when interpreting the findings. First, the cross-sectional design cannot establish whether sleep patterns preceded changes in blood pressure or BMI. Second, sleep quality was measured using self-report rather than actigraphy or another objective method. Third, all participants came from one school, which limits generalizability. Finally, potentially important factors such as dietary and sodium intake, screen time, academic stress, and objectively measured physical activity were not included in multivariable analysis. Future research would benefit from multicenter recruitment, repeated or objective sleep assessment, and models that account for behavioral, psychosocial, and socioeconomic factors.

From a nursing perspective, the high prevalence of poor sleep still deserves attention even though the correlations were not significant. School and community nurses are well positioned to screen for sleep problems together with blood pressure, BMI, smoking, caffeine use, physical activity, and psychosocial stress. Practical school programs may include sleep-hygiene education, counseling on evening screen exposure and caffeine, regular blood-pressure and BMI checks, and clear referral pathways for students with persistent sleep complaints or abnormal findings. Collaboration among nurses, teachers, parents, and primary-care services would make these efforts more sustainable.

5 Conclusion

Most participants reported poor sleep quality, whereas normal blood pressure and normal BMI were the most frequent findings. Sleep quality was not significantly associated with either blood pressure or BMI in this sample. These results should not be interpreted as evidence that sleep is unimportant. The combination of widespread poor sleep and the presence of elevated blood pressure and obesity in a proportion of students supports continued school-based education, routine screening, and integrated lifestyle promotion. Future studies should use longitudinal multicenter designs, objective or repeated sleep and physical-activity measures, and multivariable analysis that includes diet, sodium intake, academic stress, screen time, smoking, caffeine consumption, and other relevant confounders.

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