

FACTORS ASSOCIATED WITH OBESITY AMONG STUDENTS AT SMA NEGERI 1 PENEHEL, TABANAN

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ABSTRACT

Background: Adolescent obesity has become an increasing public health challenge, with long-term impacts on quality of life and an elevated risk of degenerative diseases. The urgency to address this condition continues to grow due to its rising prevalence and the potential for adverse health outcomes in adulthood. This study aimed to determine the prevalence of obesity and analyze factors associated with obesity among students at SMA Negeri 1 Penehel, Tabanan.

Methods: This study employed an analytical observational design with a cross-sectional approach involving 140 respondents. Data were collected through anthropometric measurements and self-administered questionnaires assessing genetic factors, sex, physical activity level, and sleep duration. Data analysis was conducted using the Chi-square test, Fisher's Exact Test, and multivariate logistic regression analysis.

Results: The prevalence of obesity among students at SMA Negeri 1 Penehel, Tabanan was 37.1%. Bivariate analysis demonstrated significant associations between genetic factors ($p = 0.006$) and sleep duration ($p = 0.013$) with obesity. In contrast, sex ($p = 0.073$) and physical activity level ($p = 0.824$) were not significantly associated with obesity status. Multivariate analysis indicated that genetic factors were the strongest independent predictor of obesity among students ($p = 0.031$).

Conclusion: Genetic factors and sleep duration were significantly associated with obesity, with genetic factors identified as the most dominant predictor. The high prevalence of obesity underscores the importance of preventive health interventions focusing on modifiable risk factors, particularly among students with a genetic predisposition.

Keywords: Obesity, risk factors, genetic factors, sleep duration, students

INTRODUCTION

Obesity has emerged as a major global public health concern and has become a leading contributor to chronic health conditions. It is characterized by excessive accumulation of body fat, with its prevalence showing a steady upward trend over time. The World Health Organization (WHO) reported that the global prevalence of obesity has increased approximately threefold since 1975, affecting both developed and developing countries. This rising trend reflects rapid lifestyle transitions, urbanization, and shifts toward energy-dense diets and sedentary behaviors.¹ In Indonesia, the burden of obesity has increased substantially over the past decade. National health survey data from the Basic Health Research indicated that the prevalence of obesity among individuals aged over 18 years rose from 15.4% in 2013 to 21.8% in 2018.² Indonesia is currently experiencing a triple burden of malnutrition, including stunting, wasting, and obesity, which poses complex public health challenges. Among adolescents, obesity prevalence has reached 16% in those aged 13–15 years

and 13.5% in those aged 16–18 years. Adolescence represents a critical developmental period characterized by rapid physical growth, hormonal changes, and evolving behavioral patterns, making individuals particularly vulnerable to excessive weight gain.³

Obesity has been associated with an increased risk of several long-term degenerative conditions, such as cardiometabolic diseases, type 2 diabetes mellitus, musculoskeletal disorders, and selected cancers.⁴ Beyond physical health consequences, obesity also negatively affected psychological well-being, contributing to depression, stress, body image disturbances, low self-esteem, and poor quality of life.⁵ Individuals with obesity often experienced societal stigma in the form of teasing, discrimination, and social exclusion, which affected their educational attainment, employment prospects, and economic opportunities.⁶ Additionally, obesity had been

associated with impaired cognitive function in adolescents, including decreased memory, attention, and executive function.⁷

Obesity resulted from a persistent imbalance between energy intake and energy expenditure, which led to excessive fat accumulation. Sustained adipose tissue expansion promoted adipocyte enlargement and proliferation and contributed to a state of chronic low-grade inflammation, marked by immune cell infiltration and increased production of inflammatory mediators and adipose-derived hormones.^{8,9}

Energy balance was regulated through interactions between adipose tissue, gastrointestinal hormones, and central neural mechanisms, with a key role played by hypothalamic control.¹⁰ Leptin, insulin, peptide YY (PYY), and cholecystokinin (CCK) acted as anorexigenic signals that suppressed food intake, whereas ghrelin served as an orexigenic hormone that stimulated hunger. Cortisol also played an important role in energy regulation. Elevated cortisol levels, particularly during periods of stress or sleep deprivation, were associated with heightened appetite, increased visceral fat storage, and the development of insulin resistance.^{11,12}

Obesity is influenced by multifactorial interactions involving individual, physiological, socioeconomic, and environmental determinants. Biological factors such as genetics, sex, and age play an important role in determining individual susceptibility to obesity. In addition, physiological and behavioral factors, including levels of physical activity, sleep duration, and dietary patterns, significantly contribute to energy imbalance and excessive fat accumulation. Insufficient physical activity, short sleep duration, and unhealthy dietary habits characterized by high energy intake and low nutritional quality have been consistently associated with an increased risk of obesity.¹³ Furthermore, socioeconomic and environmental factors, such as urbanization, accessibility to high-calorie foods, and limited opportunities for physical activity, may exacerbate these risks, particularly among adolescents.¹⁴

However, despite the increasing prevalence of adolescent obesity in Indonesia, data regarding the associated risk factors among high school students in specific local settings remain limited, particularly in semi-urban and rural areas such as Tabanan, Bali. Understanding the contributing factors in this population is essential to support the development of targeted school-based and community-level prevention strategies. Therefore, this study aimed to determine the prevalence of obesity and to analyze the association between genetic factors, sex, physical activity level, and sleep duration with obesity among high school students at SMA Negeri 1 Penebel, Tabanan.

MATERIALS AND METHIODS

This research was designed as an analytic observational cross-sectional study conducted at SMA Negeri 1 Penebel, Tabanan, from February to April 2025. The study population consisted of all active students enrolled at SMA Negeri 1 Penebel, totaling 494 students. The minimum sample size was calculated using the Lemeshow formula with finite population correction at a 95% confidence level and 5% margin of error. A stratified random sampling technique was applied, in which the population was grouped into strata based on grade level (X–XII). The student attendance list obtained from the school administration was used as the sampling frame. Within each stratum, participants were randomly selected using the random function in Microsoft Excel. Equal allocation was applied to ensure balanced representation between male and female students within each grade level. A total of 146 students were initially selected, consisting of 36 students from grade X, 46 from grade XI, and 64 from grade XII.

Inclusion criteria were active students of SMA Negeri 1 Penebel who were willing to participate and signed informed consent prior to completing the questionnaire. Exclusion criteria included students who were currently undergoing a weight loss program, had a history of chronic diseases such as diabetes mellitus or heart disease that could affect body weight status, were absent due to illness or permission during data collection, or submitted incomplete questionnaires. Obesity was assessed using body mass index (BMI) according to the Asia-Pacific criteria. Anthropometric measurements were obtained using standardized digital scales and microtoise instruments. Data on genetic factors, sex, physical activity, and sleep duration were collected through structured questionnaires. Physical activity was assessed using the International Physical Activity Questionnaire (IPAQ), while sleep duration was evaluated using the Pittsburgh Sleep Quality Index (PSQI). Data analysis was performed using SPSS software. Descriptive analysis was conducted to summarize participant characteristics, followed by bivariate analysis using Chi-square or Fisher's exact tests. Variables with $p < 0.25$ in bivariate analysis were subsequently included in binary logistic regression to identify independent factors associated with obesity. Statistical significance was defined at $p < 0.05$. Ethical clearance was obtained from the Ethics Committee of the Faculty of Medicine, Udayana University (Approval No. 0270/UN14.2.2.VII.14/LT/2025).

RESULT

Characteristics of study participants

From 146 students who were recruited at the beginning of the study, six were excluded because of incomplete data or ineligibility. Thus, the final analysis was conducted on 140 students. The descriptive profile of the participants is summarized in Table 1.

Table 1. Characteristics Distribution of Students at SMA Negeri 1 Penebel, Tabanan

Variable	n	%
Obesity (kg/m²)		
- Obese (≥ 25)	52	37.1
- Non-obese (< 25)	88	62.9
Genetic		
- Yes	10	7.1
- No	130	92.9
Sex		
- Male	71	50.7
- Female	69	49.3
Physical Activity (METs/week)		
- Light (< 600)	38	27.1
- Moderate (600 - <1500)	64	45.7
- Vigorous (≥ 1500)	38	27.1
Sleep Duration (hour/night)		
- Insufficient (< 7)	37	26.4
- Adequate (7)	65	46.4
- Good (8 - 10)	38	27.1

Note: n = Frequency; % = Percentage

Table 1 shows that the prevalence of obesity among students at SMA Negeri 1 Penebel was 37.1% (n = 52), while 62.9% (n = 88) were non-obese. Most respondents 92.9% (n = 130) reported no family history of obesity, whereas only 7.1% (n = 10) had a positive genetic history. The sex distribution was relatively balanced, consisting of 50.7% males (n = 71) and 49.3% females (n = 69). Regarding physical activity, the majority of students (45.7%, n = 64) were categorized as having moderate activity levels, while light and and vigorous activity levels were equally represented (27.1%, n = 38 each). In terms of sleep duration, nearly half of the students (46.4%, n = 65) had adequate

sleep, followed by good sleep duration (27.1%, n = 38) and insufficient sleep (26.4%, n = 37).

Bivariate association between risk factors and obesity status

Following the descriptive analysis of respondent characteristics, bivariate analysis was conducted to evaluate the association between each independent variable and obesity status. This analysis aimed to identify variables that demonstrated a statistically significant relationship with obesity and to determine potential predictors for further multivariate analysis. The results of the bivariate analysis are presented in Table 2.

Table 2. Bivariate Analysis of Factors Associated with Obesity

Variable	Obese	Non-Obese	P
	n (%)	n (%)	
Genetic			
- Yes	8 (80.0)	2 (20.0)	0.006 ^a
- No	44 (33.8)	86 (66.2)	
Sex			
- Male	32 (45.1)	39 (54.9)	0.073 ^b
- Female	20 (29.0)	49 (71.0)	
Physical Activity (METs/week)			
- Light (< 600)	15 (39.5)	23 (60.5)	0.824 ^c
- Moderate (600 - <1500)	22 (34.4)	42 (65.6)	
- Vigorous (≥ 1500)	15 (39.5)	23 (60.5)	
Sleep Duration (hour/night)			
- Insufficient (< 7)	21 (56.8)	16 (43.2)	0.013 ^c
- Adequate (7)	18 (27.7)	47 (72.3)	
- Good (8 - 10)	13 (34.2)	25 (65.8)	

Note: a = Fisher's Exact Test; b = Chi-square Test; c = Pearson Chi-square Test

Based on the statistical analysis in Table 2, students with genetic factors had a higher prevalence of obesity (80%, n = 8) compared to those without genetic factors (33.8%, n = 44), with Fisher's Exact Test indicating a significant association (p = 0.006). The prevalence of obesity was higher among male students (45.1%, n = 32) than female students (29%, n = 20) however, the Chi-square test showed no significant association between sex and obesity (p = 0.073). The prevalence of obesity was relative similar across significant physical activity levels, including light (39.5%, n = 15), moderate (34.4%, n = 22), and vigorous activity (39.5%, n = 15), with no association observed (p = 0.824). In contrast, obesity prevalence varied significantly by sleep duration, with the highest prevalence among students with insufficient sleep (56.8%, n = 21), followed

by adequate sleep (27.7%, n = 18) and good sleep (34.2%, n = 13), and a significant association was confirmed by the Pearson Chi-square test (p = 0.013).

Multivariate analysis of independent predictors of obesity

A multivariate logistic regression analysis was performed to determine the independent factors associated with obesity after adjustment for potential confounders. Variables that demonstrated a bivariate p-value of < 0.25, including genetic history, sex, and sleep duration, were entered into the final model. The results of the multivariate analysis are summarized in Table 3.

Table 3. Multivariate Logistic Regression Analysis of Factors Associated with Obesity

Variable	P
Genetic	0.031
Sex	0.112
Sleep Duration	0.043
Adequate vs Good	0.392
Insufficient vs Good	0.143

The contribution of each factor to obesity was assessed after adjusting for the presence of other variables in the model. Genetic history emerged as the most dominant predictor of obesity (p = 0.031).

Sleep duration also showed a significant overall association with obesity (p = 0.043). However, category-specific comparisons revealed no significant differences between adequate and good sleep duration (p = 0.392) or between insufficient and good sleep duration (p = 0.143). This indicated that although sleep duration contributed to the model overall, no specific sleep category independently differed from the reference group after adjustment for

genetic history and sex. Sex was not significantly associated with obesity in the multivariate model (p = 0.112), indicating that it was not a strong independent predictor of obesity in this study.

DISCUSSION

Based on a study involving 140 students at SMA Negeri 1 Penebel, Tabanan, it was found that 37.1% (n = 52) of respondents were classified as obese. This prevalence was considered high compared to national and regional data. The Basic Health Research reported that the prevalence of obesity among Indonesian adolescents aged 16–18 years in 2018 was 13.5%.³ Other studies conducted in Bali also reported lower

prevalence rates, which found an obesity prevalence of 9.8% among students at SMA Negeri 4 Denpasar.¹⁵ And a study in Jembrana District that reported an obesity prevalence of 10.68% among adolescent girls.¹⁶ Obesity occurring during adolescence was likely to persist into adulthood, making early prevention crucial, as this condition had serious implications for chronic degenerative diseases.⁴

One of the most prominent findings of this study was the dominant role of genetic factors as predictors of obesity. Genetic factors showed a significant association with obesity in both bivariate analysis ($p = 0.006$) and multivariate analysis after controlling for other variables ($p = 0.031$). These findings were consistent with a study which reported that students with genetic predisposition had a 3.9-fold higher risk of obesity.¹⁷ The Basic Health Research also reported that children had a 40-50% risk of obesity if one parent was obese, and this risk increased to 70-80% when both parents were obese.¹⁸ This strong association reflected a complex gene environment interaction, as obesity was largely polygenic, resulting from the cumulative effects of multiple genetic variants rather than a single gene. Many obesity-related genetic variants were expressed in the central nervous system, particularly in appetite regulation, while others influenced adipocyte biology.¹⁹

Bivariate analysis showed no significant association between sex and obesity ($p = 0.073$), although the prevalence of obesity was higher among male students (45.1%) compared to female students (29.0%). This finding contrasted with several previous studies, which reported higher obesity prevalence among female adolescents. These differences were often attributed to post-pubertal hormonal changes that promoted fat accumulation.²⁰ However, the relationship between sex and obesity during adolescence was complex and varied across populations. Some studies supported the present findings, suggesting that male adolescents had higher obesity prevalence due to differences in behavioral and sociocultural factors. Female adolescents tended to be more concerned about body image and weight control, whereas male adolescents were less likely to regulate dietary intake and were more vulnerable to unhealthy eating patterns, particularly when combined with sedentary lifestyles.²¹

This study did not find a significant association between physical activity level and obesity ($p = 0.824$), which was contrary to theoretical expectations. Although physical activity played a key role in energy expenditure, similar findings had been reported in observational studies using self-reported questionnaires such as the IPAQ. This result was consistent with a study which found no significant association between physical activity and obesity among medical students at Brawijaya University.²² One possible explanation was the presence of strong unmeasured confounders, particularly dietary intake. Excessive calorie and macronutrient consumption might have outweighed the protective effects of physical activity. Additionally, the use of self-reported instruments introduced recall bias and social desirability bias, which may have led respondents to overestimate their activity levels.²²

Consistent with the study hypothesis and previous research, a significant association was found between sleep duration and

obesity in both bivariate ($p = 0.013$) and multivariate analyses ($p = 0.043$). The highest prevalence of obesity (56.8%) was observed among students with insufficient sleep duration. According to the National Sleep Foundation, adolescents required 8-10 hours of sleep per night, and shorter sleep duration contributed to obesity by increasing sedentary behaviors and snacking during extended waking hours.^{23,24} Short sleep duration also disrupted appetite-regulating hormones, characterized by decreased leptin and increased ghrelin levels, which enhanced hunger and preference for high-calorie foods.²⁵ Furthermore, sleep deprivation activated the hypothalamic-pituitary-adrenal axis, increasing cortisol production and contributing to visceral fat accumulation and insulin resistance.¹² However, not all studies showed consistent results, as research conducted in SMP Negeri 22 Surakarta found no significant association between sleep duration and obesity. These discrepancies suggested that the impact of sleep duration depended on population characteristics and the presence of other dominant confounding factors.²⁶

CONCLUSION

The prevalence of obesity among students at SMA Negeri 1 Penebel, Tabanan, was 37.1%. Genetic predisposition emerged as the strongest independent factor associated with obesity, followed by the influence of insufficient sleep duration. In contrast, sex and physical activity level did not show a significant independent association with obesity in this study population.

RECOMMENDATION

Future studies were recommended to use stronger study designs and more objective measurement tools to clarify obesity risk factors. Schools were encouraged to implement routine health screening and strengthen student education on healthy sleep and lifestyle behaviors. Local health authorities were advised to prioritize adolescent obesity prevention programs and involve parents in addressing genetic risk and promoting supportive home environments.

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