Factors influencing adolescent BMI a study between rural and urban areas in Mamuju regency

Factores que influyen en el IMC adolescente: un estudio entre zonas rurales y urbanas en Mamuju

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Abstract

Introduction: this study examines factors influencing adolescent obesity in Mamuju Regency. It focuses on urban–rural differences.
Objective: this study examines factors influencing adolescent obesity in urban and rural Mamuju Regency.
Methodology: a quantitative, cross-sectional correlational design was used with 320 students from 44 vocational high schools in remote villages and central urban Mamuju. Participants were selected via purposive sampling, targeting schools with at least 20 cases of obesity. Data were collected through a virtual survey using Google Forms, covering sociodemographic data, physical activity (IPAQ-short), mental health indicators (DASS-42), sleep quality (PSQI), and BMI. The analysis involved descriptive statistics, Spearman's rank correlation, Mann-Whitney tests, and ordinal regression (IBM SPSS Statistics).
Results: results showed that in urban adolescents, sleep quality significantly correlated with BMI (p = 0.01, OR = 2.295), as did the physical activity (p = 0.04, OR = 2.365) and stress levels (p = 0.38, OR = 1.343). Among rural adolescents, physical activity (p = 0.02, OR = 3.197), sleep quality (p = 0.07, OR = 2.967), and stress levels (p = 0.25, OR = 2.981) were significantly associated with BMI.
Discussion: lifestyle influences adolescents' nutritional status in Mamuju Regency, with sleep quality and physical activity affecting BMI in urban areas, while physical activity is key in rural areas. Targeted interventions are essential to reduce obesity.
Conclusions: the findings emphasize the role of lifestyle factors like sleep quality, physical activity, and stress in managing BMI among adolescents, highlighting the need for targeted interventions to reduce obesity.

Keywords

Adolescents; body mass index; physical activity; sleep quality; stress.

Resumen

Introducción: este estudio examina los factores que influyen en la obesidad adolescente en Mamuju, enfocándose en las diferencias entre zonas urbanas y rurales.
Objetivo: este estudio analiza los factores que afectan la obesidad adolescente en las zonas urbanas y rurales de Mamuju.
Metodología: se utilizó un diseño cuantitativo, transversal y correlacional con 320 estudiantes de 44 escuelas de Mamuju, seleccionados por muestreo intencional en escuelas con al menos 20 casos de obesidad. Los datos se recolectaron mediante una encuesta virtual (Google Forms) que incluyó datos sociodemográficos, actividad física (IPAQ-corto), salud mental (DASS-42), calidad del sueño (PSQI) e IMC, y se analizaron con estadísticas descriptivas, correlación de Spearman, pruebas de Mann-Whitney y regresión ordinal (IBM SPSS).
Resultados: los resultados mostraron que, en adolescentes urbanos, la calidad del sueño (p = 0.01; OR = 2,295), la actividad física (p = 0.04; OR = 2,365) y el estrés (p = 0.38; OR = 1.343) se correlacionaron con el IMC. En adolescentes rurales, la actividad física (p = 0.02; OR = 3.197), el sueño (p = 0.07; OR = 2.967) y el estrés (p = 0.25; OR = 2.981) se asociaron con el IMC.
Discusión: el estilo de vida influye en el estado nutricional de los adolescentes en Mamuju, afectando el IMC en zonas urbanas y rurales. Se requieren intervenciones para reducir la obesidad.
Conclusiones: los hallazgos destacan el impacto de factores como el sueño, la actividad física y el estrés en el IMC adolescente, resaltando la necesidad de intervenciones para reducir la obesidad.

Palabras clave

Adolescentes; índice de masa corporal; actividad física; calidad del sueño; estrés.

Introduction

In 2030, Indonesia will experience a demographic bonus in which the number of individuals in the productive age group (15-64 years) surpass the number of non-productive age group (Mukri, 2018). Demographic bonus refers to a condition where the young population is larger than the old population (Umar, 2017). Indonesia is one of the developing countries in the world that faces problems with malnutrition, namely obesity. Based on Riskesdas 2018 data, it was recorded that 16.6% of adolescents aged 13-15 years were obese (Riskesdas, 2018). By 2030, an estimated 9 million children and adolescents aged 5-19 will be obese in Indonesia (Cho et al., 2018). During adolescence, various biological, psychological, and social changes can affect daily living habits, including physical activity, sleep patterns, stress levels, and nutritional status (Joshi et al., 2023).

The sociodemographic factors of adolescents in urban and rural areas have a significant impact on their lifestyles (Santos Labrador & Melero Ventola, 2023). Life for urban adolescents is often characterized by restricted space and time, which can lead to unhealthy lifestyles. These limitations may hinder their opportunities for physical activity. Additionally, the high exposure to digital media in urban environments can negatively impact sleep quality, while the increased academic pressures can elevate stress levels among adolescents living in these areas (Sismoyo, 2022).

Teenagers in rural areas face unique but significant challenges. While they typically have more space for physical activities, limited access to sports facilities and recreational options frequently hinders them (Christiana et al., 2021). Additionally, low digital literacy in rural areas can restrict access to health information. The demands of household chores and family responsibilities can contribute to both physical and mental strain. These factors may negatively impact sleep quality and increase stress levels among rural adolescents (Maita et al., 2024).

Engaging in physical activity is crucial for maintaining adolescents' physical, mental health and BMI (Estrada-Araoz et al., 2024). The World Health Organization advises that adolescents engage in at least 60 minutes of moderate to vigorous physical activity every day (WHO, 2019). Regular physical activity helps maintain an ideal body weight and reduces the risk of cardiovascular disease. It also improves sleep quality, lowers stress, and reduces BMI (Wilson et al., 2022). Good sleep quality is also crucial for maintaining body mass index during adolescence ((Grimaldi et al., 2023)). Getting sufficient sleep is essential for maintaining hormonal balance, particularly hormones controlling appetite, such as leptin and ghrelin. When sleep quality declines, these hormones' production becomes imbalanced, leading to increased appetite and excessive calorie consumption (Akhlaghi & Kohanmoo, 2023). Stress in teenagers can originate from several sources, including academic pressure, social demands, and the rapid physical and emotional changes during puberty. A heavy workload, exam preparation, and high expectations for achievement can all contribute to significant mental stress for young people (Doane et al., 2023).

In addition, pressure from the social environment, such as the desire to be accepted by peer groups, family expectations, and social media's influence, can also cause stress (Bai et al., 2024). Stress during adolescence has a significant effect on body mass index (Kipp et al., 2021). When adolescents experience stress, their bodies respond by increasing the production of the hormone cortisol. When cortisol is secreted in high amounts over time, it can affect metabolic processes and increase appetite, especially for foods high in sugar and fat. As a result, this can lead to excessive calorie consumption, which may contribute to a higher body mass index (Kuckuck et al., 2023).

Investigating the relationships between physical activity, sleep quality, stress levels, and Body Mass Index in adolescents is crucial, as these factors are interconnected and provide a comprehensive view of adolescent health (Smout et al., 2024). Adolescent health is crucial to fostering a productive and quality generation for the nation (Baltag & Banerjee, 2024).

The lifestyle differences between adolescents living in villages and cities significantly impact their health and well-being. In Mamuju Regency, this difference is seen in the broader access to nature and open spaces for village adolescents, which supports higher physical activity habits. On the other hand, denser and more dynamic urban life often limits physical activity and increases social and academic pressures, potentially leading to higher stress levels. Urban lifestyles also usually introduce teenagers to more intense use of digital media, which can affect adolescent sleep quality.

Body mass index is an essential component in viewing adolescents' health status. Non-ideal BMI can trigger various health problems, both short-term and long-term. This study analyzes the factors influencing BMI in vocational high school students in the Mamuju district by considering the differences between rural and urban areas.

Method

Various variables, including physical activity, stress levels, sleep quality, and body mass index (BMI). These variables were assessed objectively through numerical data and statistical methods. The study employed a non-experimental design, observing the variables in their natural state without manipulation (Miftah, 2017). In addition, this study is correlational with a cross-sectional design, aiming to determine possible relationships between research variables where data are collected at one point in time.

Participants

The research location is in the urban and rural of Mamuju Regency, which consists of 44 vocational high schools. The study population was 6841 high school students registered as students in 2024. A sample of 320 students was selected using the purposive sampling method to ensure data representativeness with the criteria of vocational high schools that have an obesity incidence of 15 students in a school.

Procedure

Data collection was conducted through a virtual survey using Google Forms. This survey was specifically designed to gather information related to the research variables. It consisted of five main parts:

The first section includes sociodemographic data, such as gender, age, and location of residence, which helps provide context for the research results and a more detailed analysis of variables based on demographic characteristics. The second part uses the International Physical Activity Questionnaire (IPAQ-short), which consists of 7 items to evaluate daily activity, including vigorous physical activity, moderate physical activity, walking, and sitting time for 1 week (Macfarlane et al., 2007). The third part utilized the Depression, Anxiety, and Stress Scale (DASS-42), which assesses the severity of these emotional symptoms through 42 items rated on a Likert scale. (Gandasari, 2024). The fourth part adopted the sleep quality scale (PSQI), which evaluates subjective sleep quality, sleep latency, nighttime sleep duration, sleep efficiency, sleep disturbances, use of sleeping medication, and daytime activity disturbances. The PSQI consists of 7 items rated on a Likert scale (Kurniawan & Meiyanti, 2021). The fifth section uses the Body Mass Index measurement to assess students' nutritional status. BMI is calculated using the formula: body weight (in kilograms) divided by the square of height (in meters). The BMI categories adhere to the standards established by the Ministry of Health of the Republic of Indonesia (Kemenkes, 2014).

Data analysis

The data collection procedure was carried out systematically. The researcher obtained permission from the school and invited students to participate via WhatsApp messages. These messages included a link to the survey, an explanation of the study's purpose, and detailed instructions on how to complete it. The survey was closed after reaching 320 student participants. Data analysis was conducted using IBM SPSS Statistics version 25.0, including descriptive and inferential analysis. Descriptive analysis was used to describe the essential characteristics of the sample, such as gender, age, and place of residence.

Results related to physical activity, depression, anxiety, stress, sleep quality, and BMI are presented in visual form for straightforward interpretation. Kolmogorov-Smirnov test was applied to test the normality of the data. The non-parametric analysis includes the Mann-Whitney test to identify differences between groups based on gender and residence and the Kruskal-Wallis test to compare variables between age groups. The Ordinal Regression Test analyzes the relationship between ordinal scale dependent variables and one or more independent variables. This test helps determine the factors contributing significantly to the dependent variable. The principles of research ethics in Indonesia conducted this study. Students received a clear explanation of the study's purpose and the potential risks and benefits involved. Their consent was obtained voluntarily, and their right to withdraw from the study at any time was fully respected. Additionally, measures were implemented to protect privacy and confidentiality, ensure anonymity, and secure information management.

Results

This study used 320 students, 160 from rural and 160 from urban areas. The results of Table 1 show a significant age difference between students in urban and rural areas. The average age of students in urban areas is 15.38 ± 0.76 years, while students in rural areas have a higher average age, which is 16.29 ± 0.92 years. Most students in both areas are 17 years old, with a percentage of 57% in urban areas and 59% in rural areas. Gender differences are also seen, although not significant. There are more female students in urban areas (60%) than in rural areas (57%), while more male students are found in rural areas (43%) than in urban areas (40%).

Table 1. Characteristic of student (N=320)

Socio-demographic	Category	Urban (160) Mean ± SD	Rural (160) Mean ± SD	P-Value
Age		15.38 ± 0.76	16.29 ± 0.92	0.00#
	15	49 (30%)	29 (18%)	
	16	22 (13%)	37 (23%)	
	17	89 (57%)	94 (59%)	
Gender				0.02#
	Male	64 (40%)	70 (43%)	
	Female	96 (60%)	90 (57%)	

Mann-Whitney

Table 2. Characteristic of Variable the urban and rural adolescent characteristic

Variable	Category	Urban (160)	Rural (160)
Physical activity			
	High	69 (43%)	104 (65%)
	Moderate	58 (36%)	37 (23%)
	Low	33 (21%)	19 (12%)
Stress level			
	Normal	20 (12%)	41 (25%)
	Moderate	52 (32%)	32 (20%)
	Severe	70 (43%)	78 (48%)
	Very severe	18 (13%)	10 (7%)
Quality sleep			
	Good	72 (45%)	114 (71%)
	Bad	88 (55%)	46 (29%)
BMI			
	Underweight	8 (12%)	33 (21%)
	Normal	112 (70%)	97 (61%)
	Overweight	30 (18%)	30 (18%)

Based on the data in Table 2, significant differences exist between urban and rural adolescents regarding physical activity, stress levels, sleep quality, and BMI status. Rural adolescents tend to be more

physically active, with 65% reporting high physical activity compared to 43% in urban areas. Additionally, the incidence of low physical activity is lower in rural areas (12%) than in urban areas (21%). This suggests that rural communities engage more frequently in health-promoting physical activities. In terms of stress levels, urban adolescents generally experience higher stress. Specifically, 43% of urban adolescents reported severe stress levels, with 13% experiencing very severe stress. Conversely, while 48% of rural adolescents also reported severe stress, a more significant percentage (25%) reported normal stress levels compared to urban adolescents, where only 12% reported everyday stress. This indicates that urban life may be more stressful, potentially increasing the risk of stress-related disorders. Regarding sleep quality, rural adolescents demonstrate better overall sleep. A significant 71% of rural adolescents reported good sleep quality, whereas only 45% of their urban counterparts reported the same. This disparity may be influenced by higher noise levels, pollution, and stress in urban environments, which can disrupt sleep. Finally, when examining BMI status, a majority of urban adolescents (70%) have a normal BMI, although a noteworthy 18% are categorized as obese. In contrast, while the obesity rate among rural adolescents is similar, there is a higher prevalence of underweight adolescents in rural areas (21%) compared to urban areas (12%). This suggests differences in diet and lifestyle, potentially linked to access to healthy food and active living.

Table 3. Participants characteristic variable in urban and rural

Variable	Category	Area	Statistic	
			Mean ± Sd	P-Value
Physical activity		Urban	1727.6 ± 1367.8	0.00*
		Rural	3353.9 ± 2851.8	
	High	Urban	551.5 ± 686.1	0.00#
		Rural	701.2 ± 662.9	
	Moderate	Urban	460.5 ± 556.9	0.04#
		Rural	551.5 ± 686.1	
	Low	Urban	701.2 ± 662.9	0.22#
		Rural	460.5 ± 556.9	
Sleep quality		Urban	7.7 ± 6.0	0.00*
		Rural	5.01 ± 4.6	
	Sleep duration	Urban	7:30 ± 1:48	0.24#
		Rural	7:01 ± 1:30	
	Bed time (hh:mm)	Urban	22:14 ± 1:22	0.03#
		Rural	21:59 ± 1:08	
	Wake time (hh:mm)	Urban	06:08 ± 0:53	0.38#
		Rural	05:35 ± 0:43	
Stress level		Urban	26.62 ± 13.68	0.11*
		Rural	27.91 ± 15.35	
	Depression	Urban	9.9 ± 4.84	0.17#
		Rural	8.9 ± 4.61	
	Anxiety	Urban	7.9 ± 5.5	0.114#
		Rural	8.7 ± 5.7	
	Stress	Urban	8.2 ± 4.6	0.22#
		Rural	8.14 ± 6.13	
Body mass index		Urban	23.29 ± 3.16	0.02*
		Rural	20.41 ± 2.57	
	Underweight	Urban	17.1 ± 0.8	0.44#
		Rural	17.8 ± 0.4	
	Normal	Urban	21.9 ± 1.8	0.15#
		Rural	21 ± 1.6	
	Overweight	Urban	26.5 ± 1.3	0.63#
		Rural	25.7 ± 2.2	

* Spearman's Rank
# Mann-Whitney

Based on the data analysis in Table 3, several significant differences were found between adolescents in urban and rural areas. Overall, the physical activity of adolescents in rural areas (3353.9 ± 2851.8

METs) was significantly higher than that of urban adolescents (1727.6 ± 1367.8 METs, p-value = 0.00). In the high physical activity category, the average rural (701.2 ± 662.9 METs) was also higher than urban (551.5 ± 686.1 METs, p-value = 0.00). Physical activity at a moderate level also showed significant differences, with rural adolescents (551.5 ± 686.1 METs) being more active than urban (460.5 ± 556.9 METs, p-value = 0.04). Low physical activity showed a significant difference (p-value = 0.22). In terms of sleep quality, urban adolescents have worse sleep quality scores (7.7 ± 6.0) compared to rural (5.01 ± 4.6), with a significant difference (p-value = 0.00). In addition, urban adolescents' bedtimes tend to be later (22:14 ± 1:22) than rural adolescents (21:59 ± 1:08), with a significant difference (p-value = 0.03). Sleep duration also differs significantly between urban (7:30 ± 1:48) and rural (7:01 ± 1:30, p-value = 0.24), as does wake-up time (urban: 06:08 ± 0:53; rural: 05:35 ± 0:43, p-value = 0.38). There was a significant difference in overall stress levels between urban (26.62 ± 13.68) and rural (27.91 ± 15.35, p-value = 0.11). Similarly, depression scores (urban: 9.9 ± 4.84; rural: 8.9 ± 4.61, p-value = 0.17) and anxiety (urban: 7.9 ± 5.5; rural: 8.7 ± 5.7, p-value = 0.114) did not show any significant difference. Specific stress levels also showed significant differences between urban (8.2 ± 4.6) and rural (8.14 ± 6.13, p-value = 0.22). From the aspect of body mass index , although urban adolescents had a higher average BMI (23.29 ± 3.16) compared to rural (20.41 ± 2.57), this difference was significant (p-value = 0.02).

Table 4. Kruskal-Wallis test

Variable	Group	Statistic
	Age (N 320)	Sig
PA	15 (78)	0.00*
	16 (59)	
	17 (183)	
SQ	15 (78)	0.40*
	16 (59)	
	17 (183)	
LS	15 (78)	0.214
	16 (59)	
	17 (183)	
BMI	15 (78)	0.00*
	16 (59)	
	17 (183)	

Table 4 of the Kruskal-Wallis test shows significant differences in several variables based on age group. Physical activity (PA) has a significance value of 0.00 ($p < 0.05$), indicating that there are differences in the level of physical activity between the age groups of 15, 16, and 17 years. A similar thing happened to sleep quality (SQ), with a significance value of 0.040 ($p < 0.05$), indicating that age affects the quality of sleep in adolescents. Body Mass Index also showed a significant difference with a p-value of 0.00 ($p < 0.05$), indicating a variation in BMI based on age group. However, for the level of life stress (LS), the results showed no significant difference with a significance value of 0.214 ($p > 0.05$). This indicates that life stress levels are relatively similar among the age groups of 15, 16, and 17 years.

Table 5. Ordinal regression analysis urban determinant of BMI

Predictor	Body mass index urban students			
Variable	(95%CI)			
	Coefficient	Sig	Lower	Upper
Sleep quality	2.295	0.01*	0.627	2.837
Physical activity	2.365	0.04*	1.342	5.665
Stress level	1.343	0.38*	1.295	5.040
Constant	-4,985	0.01		

Analysis of Table 5 ordinal regression in urban adolescents showed that sleep quality had a significant relationship with BMI (p=0.01, OR=2.295, 95% CI: 0.627–2.837). Physical activity was significantly related to BMI (p=0.04, OR=2.365, 95% CI: 1.342–5.665). Stress level showed a significant relationship

with BMI (p=0.38, OR=1.343, 95% CI: 1.295–5.040), which showed that stress level significantly affected BMI in urban students.

Table 6. Ordinal regression analysis rural determinant of BMI

Predictor	Body mass index rural students			
Variable	(95%CI)			
	Coefficient	Sig	Lower	Upper
Physical activity	3.197	0.02*	1.469	6.246
Sleep quality	2.967	0.07*	0.523	7.376
Stress level	2.981	0.25*	0.671	1.636
Constant	-4.675	0.00*		

Analysis of Table 6 ordinal regression in rural adolescents showed that Physical activity showed a significant relationship with BMI (p=0.02, OR=3.197, 95% CI: 1.469–6.246). Sleep quality significantly correlated with BMI (p=0.07, OR=2.967, 95% CI: 0.523–7.376). And Stress level showed a significant relationship with BMI (p=0.25, OR=2.981, 95% CI: 0.671–1.636).

Discussion

This study aims to identify factors that influence body mass index in adolescents in urban and rural areas in Mamuju district. The analysis results show that one of the dominant factors influencing BMI conditions in urban adolescents is sleep factors. This finding aligns with research by Triplett et al., (2024) which confirms a significant relationship between sleep quality and duration and a person's weight status, especially in the adolescent age group. Adolescence is a critical phase in physical development and body metabolism (Harkness et al., 2024). Adolescents who sleep less than 6 hours per night have a higher risk of obesity than those who sleep more than 8 hours per night (Grimaldi et al., 2023; Morgan et al., 2024). Environmental factors play an important role in influencing the sleep quality of adolescents in urban areas (Shirzad et al., 2022). Urban noise pollution is a common problem affecting sleep quality among adolescents. High noise levels are associated with later bedtimes and reduced sleep duration, possibly contributing to sleep deprivation (Ganatra, 2024).

Morgan et al., (2024) revealed that adolescents living in areas with high noise levels are more susceptible to sleep pattern disorders. This disruption not only impacts the quality of rest but also contributes to increased stress and anxiety (Najmaldin Ezaldin Hassan, 2024). The research results by Rogers et al., (2024) show that lack of sleep can disrupt the hormones that regulate hunger and satiety, namely leptin and ghrelin. Leptin signals satiety, while ghrelin is responsible for increasing hunger. Lack of sleep will decrease leptin levels and increase ghrelin levels, which leads to increased food intake and the risk of weight gain (Konuksever & Şahinduran, 2024).

Urban teenagers tend to have high consumption patterns of fast food and sweet drinks, especially those with poor sleep patterns (Lee et al., 2024). This is supported by research conducted by Akhlaghi & Kohanmoo, (2023) which shows that adolescents with poor sleep duration tend to consume more calories in processed, high-fat, and high-sugar foods, contributing to increased BMI. In addition, poor sleep quality in adolescents is associated with decreased physical activity levels. (Machado-Rodrigues et al., 2025). The results of research conducted by Aliah et al., (2023) showed that urban adolescents who experience sleep disorders tend to feel more tired during the day, which leads to decreased motivation to do physical activity. This decrease in physical activity directly impacts the body's energy balance, where the energy consumed is greater than the energy expended, thus causing an increase in BMI (Liu & Li, 2024).

The following analysis shows that physical activity is closely related to the increase in BMI of urban adolescents. This phenomenon indicates that low levels of physical activity in urban environments contribute to the increase in BMI of adolescents, which can have an impact on long-term health risks, such

as obesity and metabolic diseases. (Wulandari et al., 2025). Urban teenagers spend more time on sedentary activities, such as watching television, playing games, or using digital devices for long periods. These habits reduce their chances of engaging in physical activities that can burn calories and maintain the body's energy balance (Zink et al., 2024). Research conducted by Kolunsarka et al., (2024) showed that adolescents who do more sedentary activities have a higher risk of experiencing increased BMI than those who are physically active. In addition, easy access to motorized vehicles and public transportation in urban areas also reduces their opportunities to walk or cycle, which are simple but effective forms of physical activity in managing weight.

In addition to mobility factors, urban environments less supportive of physical activity also contribute to the increase in adolescent BMI. Limited green open spaces, sports fields, and fitness facilities leave adolescents with few options for regular exercise. On the other hand, rapid urbanization often reduces the availability of public areas that can be used for physical activity (Sheng et al., 2025). This aligns with research conducted by Bringolf-Isler et al., (2024) which shows that children and adolescents with limited access to sports facilities and parks tend to exercise less and are at greater risk of being overweight.

The following analysis shows that stress levels are closely related to the increase in BMI of urban adolescents. Stress experienced by adolescents can trigger physiological and behavioral changes that have an impact on weight regulation. Factors such as academic pressure, social demands, and unhealthy lifestyles are the primary triggers of stress among urban adolescents, which ultimately contribute to weight gain (Aulianti & Puspitasari, 2021).

Physiologically, chronic stress can activate the body's stress response system, primarily by activating the hypothalamic-pituitary-adrenal axis. Activation of the HPA axis increases the secretion of the hormone cortisol, known as the stress hormone (Duncan et al., 2024). Excess cortisol can increase appetite and a preference for high-calorie foods, such as fatty and high-sugar foods. This makes adolescents more susceptible to energy surpluses, contributing to weight gain and higher BMI (Kuckuck et al., 2023). In addition, stress can also inhibit the body's metabolism and increase fat accumulation, especially in the abdominal area. Research shows that adolescents with high levels of stress are more likely to experience increased visceral fat, which is associated with metabolic health risks such as insulin resistance and hypertension (Batur, 2025).

In addition to biological mechanisms, stress also impacts changes in adolescent eating behavior. Many adolescents who experience stress tend to consume more significant amounts of food or choose high-calorie foods as a form of coping mechanism against the pressure they face, a phenomenon known as emotional eating (Megiani et al., 2025). In urban environments, access to fast food and high-sugar drinks is effortless, making it easier for stressed teenagers to choose unhealthy eating patterns. Consuming fast food that is high in trans fats and added sugars can increase the risk of obesity and other metabolic disorders (Nadila et al., 2024). In addition to affecting eating patterns, stress also impacts decreasing physical activity. Teenagers who experience academic pressure or social problems tend to spend more time on sedentary activities, such as playing games, watching television, or using social media, rather than doing physical activities that can help maintain adolescent weight (Sukatemin et al., 2025). The combination of high stress, unhealthy diet, and lack of physical activity can create a vicious cycle that leads to a significant increase in BMI. If left untreated, this condition can increase the risk of adolescents becoming obese in adulthood.

The results of the analysis show that physical activity significantly influences adolescents' body mass index in rural areas. This reflects how an active lifestyle and rural environment contribute to adolescent weight management through increased energy expenditure and healthier food consumption patterns. This aligns with research conducted by Malik & Chatterjee, (2023) showing that adolescents in rural areas have higher physical activity levels than urban adolescents. This physical activity is not only limited to sports but also includes various daily activities, such as walking, working in the fields, and doing

household chores that require physical energy. The high frequency of these activities contributes significantly to increased daily energy expenditure, which ultimately helps maintain energy balance and supports more optimal weight management.

One of the factors that drives high physical activity in rural areas is limited access to motorized transportation. Rural adolescents tend to walk or cycle to school and other activity places. In addition, they also participate in various household chores, such as fetching water, washing clothes manually, and helping parents with agricultural or livestock activities (Christianto, 2018). These activities increase daily energy expenditure and form more active lifestyle habits compared to urban adolescents.

Differences in transportation patterns between rural and urban areas also significantly influence physical activity levels. Rural adolescents are more likely to walk or use bicycles as their primary means of transportation, while urban adolescents rely more on motorized vehicles and public transportation. As a result, urban adolescents tend to have a more sedentary lifestyle, with their daily physical activity being more limited compared to rural adolescents (Zainuddin et al., 2024).

In addition, limited access to technology-based entertainment in rural areas also increases physical activity. Rural adolescents spend more time outside the home playing or exercising (Katanic et al., 2023).

Furthermore, the analysis results show that sleep quality affects the BMI of rural adolescents. This finding indicates that good sleep patterns contribute to metabolic balance, optimal hormone regulation, and healthier weight management. Conversely, sleep disturbances or insufficient sleep duration can disrupt physiological processes related to energy metabolism and appetite, resulting in unhealthy weight gain or loss (Christoph et al., 2017). A study by Hsieh et al., (2023) showed that adolescents with shorter sleep duration tend to have a higher risk of obesity due to uncontrolled increased calorie intake. In addition to hormonal influences, poor sleep quality can affect adolescents' physical activity levels. Adolescents who experience sleep disorders or have insufficient sleep often feel tired during the day, making them reluctant to do physical activity. The study by Christiana et al., (2021) showed that adolescents in rural areas have more daily physical activities involving housework, farming, or long-distance travel by walking or cycling, and lack of energy due to suboptimal sleep can reduce their involvement in these activities. As a result, daily energy expenditure is lower, which can lead to energy imbalance and impact weight gain. Furthermore, environmental factors in rural areas can also contribute to varying sleep quality. This is in line with research conducted by Olorunmoteni et al., (2024) which shows that adolescents in rural areas tend to have better sleep quality compared to adolescents in urban areas due to a quieter environment, minimal light and noise pollution, and a rhythm of life that is more in harmony with the natural cycle of day and night. However, some factors can disrupt the sleep quality of rural adolescents, such as the demands of household chores that must be done in the morning, irregular sleep hours due to involvement in social activities or family work, and the use of electronic devices before bed which is starting to increase among rural adolescents.

Furthermore, the analysis results show that stress levels affect the BMI conditions of rural adolescents. As a psychological factor, stress can affect the body's physiological systems, including the metabolic system, diet, and physical activity, ultimately impacting weight balance. Although rural adolescents live in a more natural environment and tend to have a more active lifestyle than urban adolescents, they are still susceptible to stress due to various factors, such as academic pressure, household demands, limited access to educational and entertainment facilities, and family economic conditions (Francis et al., 2024). This phenomenon can also be experienced by adolescents living in rural areas, where psychological stress often arises due to environmental demands or less supportive socio-economic conditions. Rural adolescents often face various stressors, such as discrimination, adverse childhood experiences, victimization, and limited access to social and economic resources (Azkiya et al., 2022). These pressures, if not balanced with adequate coping mechanisms, can significantly increase adolescents' vulnerability to psychological disorders such as depression. The results of Kuckuck et al., (2024) show that stress can trig-

ger increased levels of cortisol, the stress hormone. Cortisol plays a role in regulating energy metabolism, but excessive levels over a long period can cause increased appetite, especially for foods high in sugar and fat. This often leads to uncontrolled weight gain. Rural adolescents who experience chronic stress tend to have a preference for high-calorie foods as a coping mechanism, which ultimately increases the risk of obesity.

The findings of this study emphasize the importance of addressing the mental health of rural adolescents as part of a more comprehensive weight management strategy. Intervention programs that emphasize stress management, such as coping skills training, increasing social support, and promoting physical activity to manage stress, need to be developed to help adolescents cope with the stresses of their lives without experiencing negative impacts on energy balance and weight. It can be concluded that lifestyle plays an important role in determining the nutritional status of adolescents, both in urban and rural areas of Mamuju Regency. In urban adolescents, sleep quality and physical activity significantly affect body mass index, while stress levels contribute to a lesser extent. Meanwhile, in rural adolescents, physical activity is the most dominant factor, followed by sleep quality and stress. These findings emphasize that to reduce the number of adolescent obesity, an approach is needed tailored to the environment's characteristics—with a focus on improving sleep quality, consistent physical activity, and stress management. This targeted intervention can strategically create a healthier and fitter young generation wherever they live.

Conclusions

The results of this study indicate that in urban adolescents, sleep quality, physical activity, and stress levels have a significant relationship with BMI. Meanwhile, in rural adolescents, physical activity, sleep quality, and stress are significantly related to BMI. These findings indicate that lifestyle factors such as sleep, physical activity, and stress play an important role in managing BMI in adolescents, both in urban and rural areas. Although the current study provides new empirical data on factors influencing BMI in urban and rural adolescents, it has several limitations. First, self-reporting may have influenced the results because some students may have intentionally intended to show that they were doing more physical activity than they were. This also applies to the questionnaires on stress levels and sleep quality, which are subjective and may be influenced by students' perceptions to provide exaggerated answers. Second, forthcoming investigations concerning adolescent body mass index should be predicated upon theoretical frameworks to elucidate the behavioral transformations in adolescents that may facilitate the implementation of efficacious interventions. Using a theory-driven methodology, research can explore the various factors influencing lifestyle choices, such as dietary habits, medical history, environmental quality, economic conditions, and levels of nutritional knowledge among adolescents. This approach will provide a more comprehensive understanding of how these factors interact and change over time. As a result, it will facilitate targeted and sustainable research initiatives aimed at managing and preventing obesity among adolescents in both urban and rural settings.

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References

Akhlaghi, M., & Kohanmoo, A. (2023). Sleep deprivation in development of obesity, effects on appetite regulation, energy metabolism, and dietary choices. *Nutrition Research Reviews*, 1–21. https://doi.org/10.1017/S0954422423000264

Aliah, A., Bachtiar, F., Agustiyawan, A., & Sirada, A. (2023). RELATIONSHIP BETWEEN PHYSICAL ACTIVITY AND SLEEP QUALITY IN ADOLESCENTS. *Indonesian Journal of Health Development*, *5*(2), 102–108. https://doi.org/10.52021/ijhd.v5i2.124

Aulianti, T., & Puspitasari, R. (2021). Hubungan antara tingkat stres dan akitivitas fisik dengan status gizi pada usia remaja di Tangerang. *Alauddin Scientific Journal of Nursing*, *2*(1), 24–31.

Azkiya, M. W., Sulistyono, R. E., Mashuri, M., & Rahmawati, P. M. (2022). DETERMINANT FACTOR OF DEPRESSION IN RURAL ADOLESCENT: A LITERATURE REVIEW. *Nurse and Health: Jurnal Keperawatan*, *11*(2), 226–239. https://doi.org/10.36720/nhjk.v11i2.372

Bai, H., Liu, J., Bai, W., & Cao, T. (2024). Social pressures and their impact on smartphone use stickiness and use habit among adolescents. *Heliyon*, *10*(7), e29111. https://doi.org/10.1016/j.heliyon.2024.e29111

Baltag, V., & Banerjee, A. (2024). Leveraging the Priority Indicators to Promote Comprehensive Adolescent Health Approaches. *Journal of Adolescent Health*, *74*(6), S12–S14. https://doi.org/10.1016/j.jadohealth.2023.12.001

Batur, A. F. (2025). A Critical Review on the Association Between Visceral Adiposity Index and Stress Urinary Incontinence in Women. *Neurourology and Urodynamics*, *44*(1), 253–254. https://doi.org/10.1002/nau.25583

Bringolf-Isler, B., Hänggi, J., Kayser, B., Suggs, L. S., de Hoogh, K., Dössegger, A., & Probst-Hensch, N. (2024). Does growing up in a physical activity-friendly neighborhood increase the likelihood of remaining active during adolescence and early adulthood? *BMC Public Health*, *24*(1), 2883. https://doi.org/10.1186/s12889-024-20373-4

Cho, N. H., Shaw, J. E., Karuranga, S., Huang, Y., da Rocha Fernandes, J. D., Ohlrogge, A. W., & Malanda, B. (2018). IDF Diabetes Atlas: Global estimates of diabetes prevalence for 2017 and projections for 2045. *Diabetes Research and Clinical Practice*, *138*, 271–281. https://doi.org/10.1016/j.diabres.2018.02.023

Christiana, R. W., Bouldin, E. D., & Battista, R. A. (2021). Active living environments mediate rural and non-rural differences in physical activity, active transportation, and screen time among adolescents. *Preventive Medicine Reports*, *23*, 101422. https://doi.org/10.1016/j.pmedr.2021.101422

Christianto, D. A. (2018). Hubungan Aktivitas Fisik Terhadap Kejadian Obesitas Berdasarkan Indeks Massa Tubuh Di Desa Banjaroyo. *Berkala Ilmiah Kedokteran Duta Wacana*, *3*(2), 78.

Christoph, M. J., Grigsby-Toussaint, D. S., Baingana, R., & Ntambi, J. M. (2017). Physical activity, sleep, and BMI percentile in rural and urban Ugandan youth. *Annals of Global Health*, *83*(2), 311–319.

Doane, L., Hastings, P., Parra, L. A., & Hoyt, L. T. (2023). Adolescence and Early Adulthood in Context. *Psychoneuroendocrinology*, *153*, 106140. https://doi.org/10.1016/j.psyneuen.2023.106140

Duncan, P. J., Romanò, N., Nair, S. V, McClafferty, H., Le Tissier, P., & Shipston, M. J. (2024). Long-term, Dynamic Remodelling of the Corticotroph Transcriptome and Excitability After a Period of Chronic Stress. *Endocrinology*, *165*(12). https://doi.org/10.1210/endocr/bqae139

Estrada-Araoz, E. G., Quispe-Mamani, Y. A., Ayay-Arista, G., & Yupanqui-Pino, E. H. (2024). Depresión, ansiedad y estrés como predictores del disfrute de la actividad física en estudiantes universitarios: un estudio transversal (Depression, anxiety, and stress as predictors of physical activity enjoyment in university students: a cross-sectional. *Retos*, *61*, 164–172. https://doi.org/10.47197/retos.v61.109802

Francis, L. A., Rollins, B. Y., Epel, E. S., & Lozinski, R. H. (2024). Stress-induced eating in rural adolescents: Unique variability among boys and adolescents with obesity. *Appetite*, *203*, 107705. https://doi.org/10.1016/j.appet.2024.107705

Ganatra, P. (2024). Intersecting impacts: urban noise pollution on sleep quality and mental health outcomes. *INTER-NOISE and NOISE-CON Congress and Conference Proceedings*, *270*(2), 9876–9886. https://doi.org/10.3397/IN_2024_4315

Gandasari, M. F. (2024). Peran Aktivitas Fisik Terhadap Terjadinya Tingkat Depresi, Kecemasan, dan Stres Pada Siswa Sekolah Menengah Atas. *Innovative: Journal Of Social Science Research*, *4*(3), 11246–11260. https://doi.org/10.31004/innovative.v4i3.11889

Gonçalves, I. da S. A., Filgueiras, M. D. S., Moreira, T. R., Thomé, M. S., Paiva, G. L. D., Almeida, G. P. de, Cotta, R. M. M., Campos, T. do N., Freitas, D. M. de O., Novaes, J. F. de, Oliveira, A. F. de, & Costa, G. D. da. (2024). Interrelation of Stress, Eating Behavior, and Body Adiposity in Women with Obesity: Do Emotions Matter? *Nutrients*, *16*(23), 4133. https://doi.org/10.3390/nu16234133

Grimaldi, M., Bacaro, V., Natale, V., Tonetti, L., & Crocetti, E. (2023). The Longitudinal Interplay between Sleep, Anthropometric Indices, Eating Behaviors, and Nutritional Aspects: A Systematic Review and Meta-Analysis. *Nutrients*, *15*(14), 3179. https://doi.org/10.3390/nu15143179

Harkness, A., Perez-Amparan, E., Camacho, L., Fan, R., Kerr, E., Arra, N., Durley, I., Tager, L., Bland-Boyd, B., Müller-Oehring, E., Nagata, J., Baker, F., & Kiss, O. (2024). 0132 Effects of Sleep Behavior, Obesity, and Sex on Well-Being and Mental Health Problems in Adolescents. *SLEEP*, *47*(Supplement_1), A58–A58. https://doi.org/10.1093/sleep/zsae067.0132

Hsieh, P. P., Sindhu, F. C., Dewi, M. R., & Sidhiarta, I. G. L. (2023). Hubungan antara durasi tidur dengan kejadian obesitas pada anak: sebuah tinjauan sistematis. *Intisari Sains Medis*, *14*(1), 229–236. https://doi.org/10.15562/ism.v14i1.1303

Joshi, S., Mardik, S., Verma, P., Rajagopalan, H., Siddiqui, M. H., & Lachyan, A. (2023). Variability in Health Impact: Examining Lifestyle and Dietary Habits Across Different Stages of Adolescence: A Comprehensive Literature Review. *European Journal of Nutrition & Food Safety*, *15*(11), 41–47. https://doi.org/10.9734/ejnfs/2023/v15i111354

Katanic, B., Bjelica, D., Stankovic, M., Milosevic, Z., Vukovic, J., & Mekic, A. (2023). Anthropometric Characteristics and Weight Status of Early Adolescents (Aged 12–14) in Montenegro; Urban–Rural and Regional Differences. *Children*, *10*(10), 1664.

Kemenkes, R. I. (2014). Peraturan Menteri Kesehatan Republik Indonesia Nomor 41 Tahun 2014 Tentang Pedoman Gizi Seimbang. *Jakarta: Kementerian Kesehatan Republik Indonesia*, 1–96.

Kipp, C., Wilson, D. K., Sweeney, A. M., Zarrett, N., & Van Horn, M. L. (2021). Effects of Parenting and Perceived Stress on BMI in African American Adolescents. *Journal of Pediatric Psychology*, *46*(8), 980–990. https://doi.org/10.1093/jpepsy/jsab025

Kolunsarka, I., Beets, M., Huhtiniemi, M., & Jaakkola, T. (2024). 212 Multi-trajectory analysis of changes in physical activity, BMI and cardiorespiratory fitness in adolescence. *European Journal of Public Health*, *34*(Supplement_2). https://doi.org/10.1093/eurpub/ckae114.089

Konuksever, Y. E., & Şahinduran, Ş. (2024). The Effects of Leptin and Ghrelin Hormones on Metabolism. *Mehmet Akif Ersoy Üniversitesi Sağlık Bilimleri Enstitüsü Dergisi*. https://doi.org/10.24998/maeusabed.1592677

Kuckuck, S., Lengton, R., Meeusen, R. E. H., van der Valk, E. S., Hillegers, M. H. J., Penninx, B. W. J. H., Kavousi, M., Visser, J. A., Boon, M. R., van den Berg, S. A. A., & van Rossum, E. F. C. (2024). Perceived Stress, Hair Cortisol, and Hair Cortisone in Relation to Appetite-Regulating Hormones in Patients with Obesity. *Obesity Facts*, 1–8. https://doi.org/10.1159/000542079

Kuckuck, S., van der Valk, E. S., Scheurink, A. J. W., van der Voorn, B., Iyer, A. M., Visser, J. A., Delhanty, P. J. D., van den Berg, S. A. A., & van Rossum, E. F. C. (2023). Glucocorticoids, stress and eating: The mediating role of appetite-regulating hormones. *Obesity Reviews*, *24*(3). https://doi.org/10.1111/obr.13539

Kurniawan, C., & Meiyanti, M. (2021). Sleep quality and attention of senior high school students. *JKKI: Jurnal Kedokteran Dan Kesehatan Indonesia*, 208–216.

Lee, J.-Y., Moon, S., Cho, S.-H., Kim, H., Kang, H.-J., Kim, S.-Y., Ryu, S., Kim, J.-M., Shin, I.-S., & Kim, S.-W. (2024). The Relationship Between Fast Food Consumption and Daily Lifestyle Changes During

School Closures Following the COVID-19 Pandemic: A Cross-Sectional Study Among Adolescents in Korea. *Psychiatry Investigation*, *21*(6), 610–617. https://doi.org/10.30773/pi.2023.0283

Liu, D., He, J., & Li, H. (2024). The relationship between adolescents' physical activity, circadian rhythms, and sleep. *Frontiers in Psychiatry*, *15*. https://doi.org/10.3389/fpsyt.2024.1415985

Macfarlane, D. J., Lee, C. C. Y., Ho, E. Y. K., Chan, K. L., & Chan, D. T. S. (2007). Reliability and validity of the Chinese version of IPAQ (short, last 7 days). *Journal of Science and Medicine in Sport*, *10*(1), 45–51.

Machado-Rodrigues, A. M., Rodrigues, D., Gama, A., Nogueira, H., Fernandes, H. M., Stabelini Neto, A., Fernandes, R., & Padez, C. (2025). Can the Urban Lifestyle Impact on Children BMI and Healthy Sleep? *American Journal of Human Biology*, *37*(1). https://doi.org/10.1002/ajhb.24210

Maita, K. C., Maniaci, M. J., Haider, C. R., Avila, F. R., Torres-Guzman, R. A., Borna, S., Lunde, J. J., Coffey, J. D., Demaerschalk, B. M., & Forte, A. J. (2024). The Impact of Digital Health Solutions on Bridging the Health Care Gap in Rural Areas: A Scoping Review. *The Permanente Journal*, *28*(3), 130–143. https://doi.org/10.7812/TPP/23.134

Malik, A. S., & Chatterjee, K. (2023). A cross-sectional study to compare levels of physical activity among adolescents in rural and urban areas of Western Maharashtra. *Medical Journal Armed Forces India*, *79*, S237–S243. https://doi.org/10.1016/j.mjafi.2022.10.003

Martens, A., Duran, B., Vanbesien, J., Verheyden, S., Rutteman, B., Staels, W., Anckaert, E., Gies, I., & De Schepper, J. (2021). Clinical and biological correlates of morning serum cortisol in children and adolescents with overweight and obesity. *PLOS ONE*, *16*(10), e0258653. https://doi.org/10.1371/journal.pone.0258653

Megiani, I. N., Forte, A. H. R., Ferreira, L. P. de M., Chagas, K. F., Oliveira, B. M. P. de, Mendes, A. D. F., Pinto, A. de M. G., & Fernandes, J. M. D. da S. (2025). Medical and psychoanalytical epidemiological analysis of bodily and emotional impact between overeating and restrictive eating during adolescence. *Brazilian Journal of Health Review*, *8*(1), e76814. https://doi.org/10.34119/bjhrv8n1-187

Miftah F. (2017). Mixed Methods: Pengantar Dalam Penelitian Olahraga. *Jurnal Penelitian Olahraga*, *3*(May 2017), 16–2017. https://doi.org/10.29407/js

Morgan, T., Basalely, A., Singer, P., Castellanos, L., & Sethna, C. B. (2024). The association between sleep duration and cardiometabolic risk among children and adolescents in the United States (US): A NHANES study. *Child: Care, Health and Development*, *50*(3). https://doi.org/10.1111/cch.13273

Mukri, S. G. (2018). Menyongsong Bonus Demografi Indonesia. *'ADALAH*, *2*(6). https://doi.org/10.15408/adalah.v2i6.8223

Nadila, P., Tambunan, T. J. R., Ingtiyas, F. T., & Ginting, L. (2024). Impact of Junk Food on Adolescent Health: Strategies to Promote Healthy Eating in Educational Environments. *Journal Corner of Education, Linguistics, and Literature*, *4*(001), 111–119. https://doi.org/10.54012/jcell.v4i001.368

Najmaldin Ezaldin Hassan. (2024). NOISE POLLUTION AND ITS EFFECTS ON HUMAN HEALTH: A REVIEW. *EPRA International Journal of Multidisciplinary Research (IJMR)*, 24–37. https://doi.org/10.36713/epra18872

Olorunmoteni, O. E., Gómez-Olivé, F.-X., Fatusi, A. O., & Scheuermaier, K. (2024). Multidimensions of sleep health among in-school adolescents in rural and urban areas in southwestern Nigeria. *Sleep Health*, *10*(1), S170–S179. https://doi.org/10.1016/j.sleh.2023.11.006

Organization, W. H. (2019). *Global action plan on physical activity 2018-2030: more active people for a healthier world*. World Health Organization.

Parikh, R., Sapru, M., Krishna, M., Cuijpers, P., Patel, V., & Michelson, D. (2019). "It is like a mind attack": stress and coping among urban school-going adolescents in India. *BMC Psychology*, *7*(1), 31. https://doi.org/10.1186/s40359-019-0306-z

Regis, M. F., Oliveira, L. M. F. T. de, Santos, A. R. M. dos, Leonidio, A. da C. R., Diniz, P. R. B., & Freitas, C. M. S. M. de. (2016). Urban versus rural lifestyle in adolescents: associations between environment, physical activity levels and sedentary behavior. *Einstein (Sao Paulo)*, *14*, 461–467.

Riset Kesehatan Dasar (Riskesdas). (2018). Laporan Riskesdas 2018 Nasional. In *Lembaga Penerbit Balitbangkes* (p. hal 156).

https://repository.badankebijakan.kemkes.go.id/id/eprint/3514/1/Laporan Riskesdas 2018 Nasional.pdf

Rogers, E. M., Banks, N. F., & Jenkins, N. D. M. (2024). The effects of sleep disruption on metabolism, hunger, and satiety, and the influence of psychosocial stress and exercise: A narrative review. *Diabetes/Metabolism Research and Reviews*, *40*(2). https://doi.org/10.1002/dmrr.3667

Santos Labrador, R. M., & Melero Ventola, A. R. (2023). Variables asociadas a la motivación hacia la práctica de actividad física en adolescentes (Variables associated with motivation to engage in physical activity in adolescents). *Retos*, *50*, 925–930. https://doi.org/10.47197/retos.v50.96892

Sheng, J., Xiang, Z., & Ban, P. (2025). How do neighborhood environments impact adolescent health: a comprehensive study from subjective and objective perspectives using machine learning method. *Frontiers in Public Health*, *12*. https://doi.org/10.3389/fpubh.2024.1507711

Shetty, S., Duesman, S. J., Patel, S., Huynh, P., Toh, P., Shroff, S., Das, A., Chowhan, D., Keller, B., Alvarez, J., Fisher-Foye, R., Sebra, R., Beaumont, K., McAlpine, C. S., Rajbhandari, P., & Rajbhandari, A. K. (2024). Sex-specific role of high-fat diet and stress on behavior, energy metabolism, and the ventromedial hypothalamus. *Biology of Sex Differences*, *15*(1), 55. https://doi.org/10.1186/s13293-024-00628-w

Shirzad, W., Mohammad Mukhlis, B., Samiullah, S., & Samsoor, P. (2022). A Comprehensive Review of Noise Pollution and its Impact on the Urban Environment. *Kardan Journal of Engineering and Technology*. https://doi.org/10.31841/KJET.2022.26

Sismoyo, A. M. (2022). *Hubungan Adiksi Penggunaan Smartphone Dengan Kualitas Tidur Remaja Di Man 2 Kota Semarang*. Universitas Islam Sultan Agung Semarang.

Smout, S., Champion, K. E., O'Dean, S., Halladay, J., Gardner, L. A., & Newton, N. C. (2024). Adolescent Lifestyle Behaviour Modification and Mental Health: Longitudinal Changes in Diet, Physical Activity, Sleep, Screen Time, Smoking, and Alcohol Use and Associations with Psychological Distress. *International Journal of Mental Health and Addiction*. https://doi.org/10.1007/s11469-024-01350-9

Sukatemin, S., Muhalla, H. I., Muarrofah, M., Utari, D. A., & Fitriani, V. Y. (2025). Sedentary Lifestyle and the Threat of Obesity Among Young People. *The Journal of Academic Science*, *2*(1). https://doi.org/10.59613/3cjm3157

Triplett, O. M., Morrell, H. E. R., & Van Dyk, T. R. (2024). Insomnia severity and obesity mediated by health behaviors in adolescents. *Journal of Pediatric Psychology*. https://doi.org/10.1093/jpepsy/jsae098

Umar, M. A. (2017). *Bonus Demografi Sebagai Peluang Dan Tantangan Di Era Otonomi Daerah. Genta Mulia, 8 (2), 90–99*. https://www.kemenkopmk.go.id/hasil-survei-penduduk-2020-peluang-indonesia-maksimalkan-bonus-demografi

Wilson, D., Driller, M., Winwood, P., Clissold, T., Johnston, B., & Gill, N. (2022). The Effectiveness of a Combined Healthy Eating, Physical Activity, and Sleep Hygiene Lifestyle Intervention on Health and Fitness of Overweight Airline Pilots: A Controlled Trial. *Nutrients*, *14*(9), 1988. https://doi.org/10.3390/nu14091988

Wulandari, G., Abdullah, A., & Arifin, V. N. (2025). Analisis Faktor Kejadian Obesitas pada Pelajar Tata Boga di Sekolah Menengah Kejuruan Negeri 3 Kota Banda Aceh. *Jurnal Promotif Preventif*, *8*(1), 37–46.

Zainuddin, Z., Ma'arif, I., & Prasetyo, G. (2024). Tingkat aktivitas fisik berdasarkan tempat tinggal perkotaan dan pedesaan. *Bravo's: Jurnal Program Studi Pendidikan Jasmani Dan Kesehatan*, *12*(2).

Zink, J., Booker, R., Wolff-Hughes, D. L., Allen, N. B., Carnethon, M. R., Alexandria, S. J., & Berrigan, D. (2024). Longitudinal associations of screen time, physical activity, and sleep duration with body mass index in U.S. youth. *International Journal of Behavioral Nutrition and Physical Activity*, *21*(1), 35. https://doi.org/10.1186/s12966-024-01587-6

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