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Sugar-Sweetened Beverages Intake and Sedentary Behavior Drive Overweight Trends: A Study of Urban and Rural Adolescents in East Java, Indonesia

Konsumsi Minuman Manis dan Perilaku Sedentari Mendorong Tren Kegemukan: Studi pada Remaja Perkotaan dan Pedesaan di Jawa Timur, Indonesia

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ABSTRACT

Background: Overweight and obesity are growing concerns in developing countries, including Indonesia. Excessive food intake and lack of physical activity are major contributing factors to this issue.
Objectives: This study aims to analyze the relationship between physical activity levels, dietary patterns, and nutritional status among adolescents living in rural and urban areas.
Methods: This cross-sectional study involved 261 adolescents (120 males, 141 females) aged 12–14 years from East Java, Indonesia. Physical activity was assessed using the Physical Activity Questionnaire for Children (PAQ-C), while dietary intake was measured using daily recall and a food frequency questionnaire (FFQ). Nutritional status was determined based on BMI-for-age Z-scores.
Results: More than 20% of adolescents were overweight (Z-score > 2), with a prevalence of 21% in rural areas and 31% in urban areas. Urban adolescents consumed more sugary drinks, had longer screen time, and slept less than their rural counterparts (p-value<0.05). Overall physical activity levels were significantly higher among rural adolescents. Key risk factors for overweight status included sugary drink consumption (OR 2.32), high-fat food intake (OR 1.61), low physical activity (OR 0.09), and prolonged screen time (OR 1.21).
Conclusions: Differences in lifestyle between rural and urban adolescents impact their nutritional status. Targeted interventions to promote physical activity and reduce sugary drink consumption, especially in urban areas, are crucial for preventing overweight and improving adolescent health.

INTRODUCTION

Overweight and obesity are significant nutritional issues affecting both developed and developing countries. According to WHO (2018), 39% of the global population is overweight, and 13% is obese, conditions that carry a higher risk of mortality compared to normal weight[1]. Indonesia is among the countries face significant challenges related to overweight and obesity. The proportion of individuals classified as overweight or obese has risen sharply from 2007 to 2018, with obesity increasing by 11.3% over the past decade[2]. East Java is one of the provinces significantly impacted by issues of overweight and obesity. In 2018, the number of obesity cases in East Java reached 16% of the population, a significant increase from 11% in 2013. According to Ministry of Health data, obesity in East Java continued to rise, reaching 16.2% in 2023. Although this increase is not statistically significant, it still reflects a growing trend in obesity prevalence, highlighting the ongoing public health concern[2]. This issue is also becoming increasingly

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prevalent among the productive-age population and adolescents. Data show that adolescents aged 13–15 years have an overweight prevalence of 8.3% and an obesity prevalence of 2.5%. These rates continue to rise annually in both urban and rural areas.

Adolescents represent a transitional age group that is particularly vulnerable to nutritional and health issues due to the critical period of growth and development they undergo[3]. Several factors contribute to the rising rates of overweight among adolescents. Obesity often originates from poor dietary quality and high morbidity during the first 1,000 days of life, compounded by excessive energy intake[4,5,6]. Consistently high fat consumption over time significantly increases the risk of overweight and obesity, resulting in gradual weight gain. Adolescents in urban areas of developed countries are particularly susceptible to obesity due to higher fast-food consumption and lower physical activity levels. Excessive energy intake from carbohydrates and fats contributes to fat accumulation, especially from high-energy-density foods. Additionally, individuals with obesity may experience difficulty metabolizing fatty foods, leading to increased fat storage[7].

This condition is exacerbated by various enabling and reinforcing factors, such as environmental influence socio-economic status, and inequities in healthcare access and services[8]. Low physical activity levels and sedentary behavior are significant contributors to obesity among adolescents. There is a strong relationship between prolonged sitting time, low physical activity, and poor nutritional status[9]. Exposure to screen media is a major driver of sedentary behavior, substantially increasing the risk of obesity in children and adolescents[10]. A sedentary lifestyle refers to a pattern of daily activity that does not meet recommended physical activity standards. Individuals with such lifestyles often forgot regular exercise in favor of prolonged energy-conserving activities.

Several mechanisms may explain the link between media exposure and obesity, including reduced physical activity, increased energy intake, eating while watching TV or using phones, and insufficient sleep[10]. In many developed and developing countries, adolescents' screen time exceeds 6–7 hours per day, far surpassing the WHO's recommended limit of 2 hours. Children engaging in sedentary behaviors, such as watching TV or using a computer for ≥4 hours daily, are 2.5 times more likely to become obese compared to those with ≤1 hour of such activity[11]. A 2019 study conducted in Surabaya and Jombang found that most adolescents exhibited moderate to low levels of physical activity, which correlated significantly with reduced fitness levels. Physical activity plays a crucial role in balancing energy intake and expenditure, helping to prevent weight gain and maintain overall health[12].

Sidoarjo and Banyuwangi were selected as representative study locations to capture the differences between urban and rural settings in East Java. Sidoarjo represents an urban area, while Banyuwangi represents a rural region. Both locations were chosen due to their obesity prevalence, which exceeds the East Java average of 16.2%[13]. This study aimed to analyze the differences in obesity patterns between urban and rural areas, focusing on the relationships between dietary intake, physical activity levels, and sedentary behavior among obese adolescents. In urban areas, higher income levels but physical activity options are limited, and there is an abundance of unhealthy food choices. Meanwhile, in rural areas, income is more limited, and the availability of unhealthy food options is also a concern, but opportunities for physical activity may be more accessible in some contexts. The results are expected to provide insights into region-specific factors contributing to obesity and inform tailored intervention strategies.

METHODS

Study Design

This study employed a cross-sectional design to explore the relationship between sugar-sweetened beverage consumption, sedentary behavior, and the trend of overweight among adolescents in urban and rural areas of East Java, Indonesia. Data were collected through structured questionnaires to assess patterns of sugar-sweetened beverage consumption and levels of physical activity, along with anthropometric measurements to determine the nutritional status of respondents. The analysis aimed to identify differences and associations between these variables while considering contextual factors distinguishing urban and rural adolescents.

Study Areas and Participants

This study was conducted in urban and rural areas of East Java, Indonesia (Figure 1), targeting adolescents aged 12–14 years. The urban site was a densely populated city with greater access to technology and processed foods, while the rural area was primarily agricultural with limited access to modern amenities. A total of 278 adolescents (123 boys and 155 girls) were selected through random sampling. The random sampling was conducted by selecting schools from both urban and rural areas, followed by randomly choosing grade within each school. Within the selected grade, students were randomly chosen to participate. After cleaning the initial sample for missing or incomplete data, the final dataset included 261 participants. Parental consent was obtained for all participants prior to data collection.

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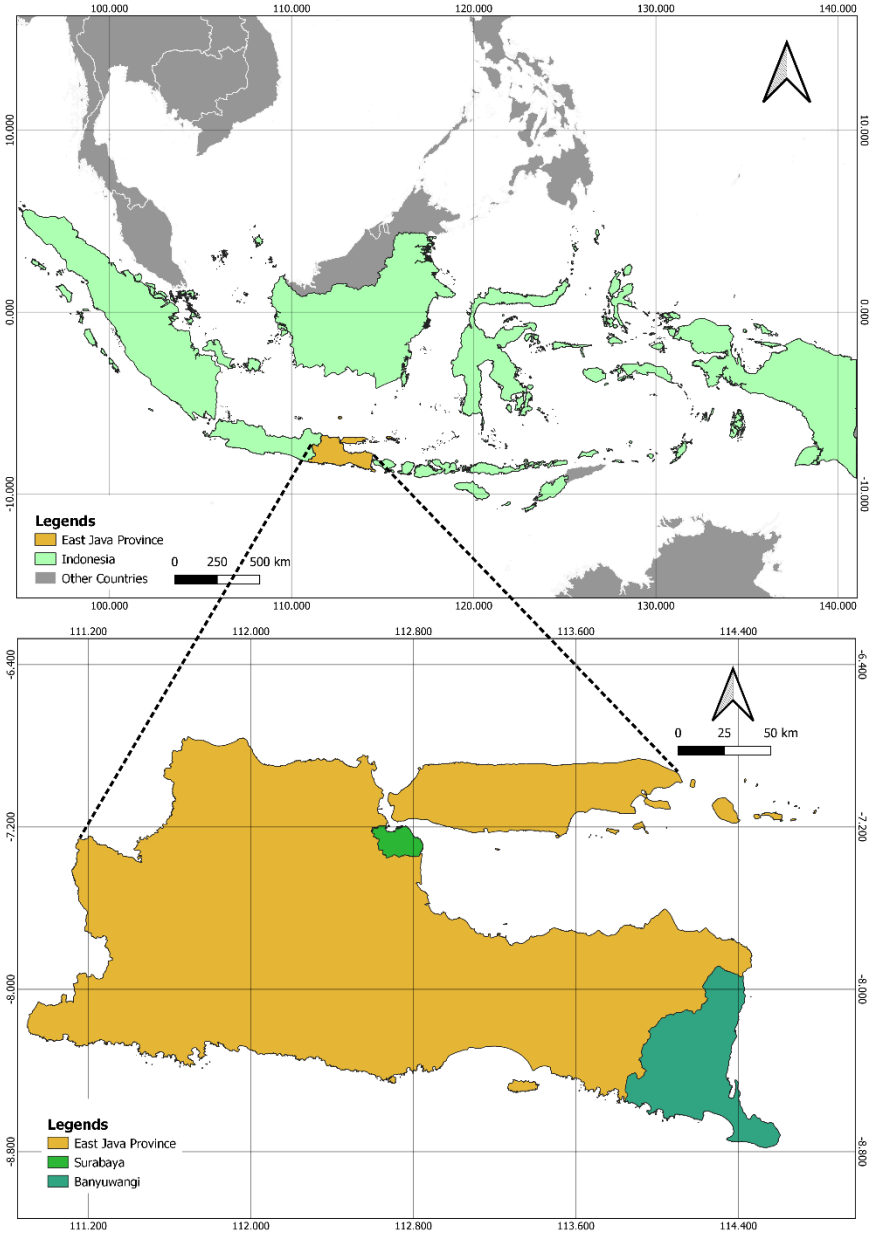

Figure 1. Map of study location

Data Collection

Sociodemographic and Physical Activity Assessment

Data collection was carried out using a structured questionnaire to obtain comprehensive information on participants' sociodemographic characteristics and lifestyle factors. The sociodemographic section included variables such as gender, age, parental education levels, and household income. The lifestyle variables section focused on key behavioral aspects, including daily screen time, napping duration, sleep duration, and physical activity levels. Physical activity data were self-reported using the validated Physical Activity Questionnaire for Children (PAQ-C), which captures activity levels across various timeframes (e.g., leisure time, school hours, and weekends)[14]. Screen time and sleep duration were recorded as averages for weekdays and weekends to account for variations in daily routines. To ensure data accuracy, the questionnaire included clear instructions and prompts.

Nutritional Intake

Dietary intake was assessed through a combination of two days non-consecutive weekday and weekend 24-hour dietary recall methods to capture potential variations in daily consumption patterns. Participants were asked to recall all foods and beverages consumed over the previous 24 hours, including portion sizes, preparation methods, and any additional ingredients. To enhance accuracy, trained enumerators guided participants through the recall process using visual aids (portion size images). Dietary patterns were assessed using the Semi-Quantitative Food Frequency Questionnaire (FFQ). Participants were asked about their intake of various food and drink items, including sweet

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beverages, fatty snacks, coffee, tea, instant noodles, and other commonly consumed items. Dietary behavior was assessed using the question, "How often do you consume?" Participants could choose from six response options: ">1 time/day," "1 time/day," "3–6 times/week," "1–2 times/week," "≤3 times/month," or "never." For the purposes of this study, dietary behavior was subsequently classified into two categories: less than once per day (<1 time/day) and at least once per day (≥1 time/day).

Anthropometric Measurements

Nutritional status was assessed using weight and height to calculate Body Mass Index-for-Age (BMI-for-Age) Z-scores. This measurement followed standardized procedures outlined by the World Health Organization[15] to ensure accuracy, reliability, and consistency across all participants. To enhance measurement reliability, all research assistants underwent training, and duplicate measurements were taken to minimize observer bias. The averages of these duplicates were used for analysis.

Data Analysis

Data were analyzed using JMP Pro 17 (SAS Institute Japan) for statistical analysis and Q-GIS (3.30) for generating the map figure. Descriptive statistics summarized participant characteristics, while bivariate chi-square tests examined associations between sociodemographic factors, lifestyle behaviors, and nutritional status. Multivariate logistic regression was used to identify factors influencing overweight and obesity, with BMI-Z scores as the dependent variable. Independent variables included dietary behavior, physical activity levels, screen time, napping duration, and sleep duration. These factors were computed using the stepwise forward method to determine those that were significantly associated with overweight. The p-value threshold for entry and removal from the model was 0.25 and 0.1, respectively.

Ethics

Ethical approval for the study was obtained from the Health Research Ethics Committee, Faculty of Nursing, Airlangga University (No: 2126-KEPK) on November 6, 2020. Written informed consent was obtained from all participants' parents or guardians before data collection.

RESULTS AND DISCUSSIONS

Sociodemographic characteristics

The socio-demographic characteristics of the study participants are shown in Table 1. The gender distribution was balanced overall, with 44% male and 52% female adolescents. The average age of participants was 12.8 ± 0.75 years, with similar values between urban (12.7 ± 0.69 years) and rural adolescents (12.9 ± 0.75 years). Notably, a larger proportion of participants were in the 12-year age group (54%). Parental education levels were generally high, with 88% of mothers and 89% of fathers completing at least 10 years of education. In this study, there were no significant differences in parental education between rural and urban areas, nor any association with nutritional status. This may be due to the higher proportion of parents with higher education. However, urban parents had slightly higher educational attainment than rural parents, reflecting better access to educational opportunities in urban areas. Higher parental education is often associated with increased awareness and adoption of healthy lifestyle practices, potentially contributing to differences in adolescent behavior and health outcomes observed in this study[16]. Promoting nutrition knowledge among adolescent and parents can support the development of healthy eating habits and improved dietary intake[17,18].

This study also identified significant economic disparities between urban and rural households. Approximately 37% of households earned below the minimum wage, with rural areas accounting for a much higher proportion (50%) compared to urban areas (19%). Conversely, 60% of households earned above the minimum wage, predominantly in urban areas (89%) versus rural areas (50%). These findings underscore the economic divide that likely influences adolescents' access to health-promoting resources such as nutritious foods, extracurricular activities, and healthcare services[19]. Maternal and paternal occupations further highlighted differences in economic stability. Among urban mothers, 39% had regular income, compared to only 23% in rural areas. Similarly, urban fathers were more likely to have regular employment (60%) than rural fathers (53%). Regular income in urban areas suggests greater economic security, which may influence lifestyle and health behaviors, including the ability to afford structured physical activities or healthier diets. However, despite higher incomes, urban households may also allocate more spending to processed foods, which can affect dietary quality. Food purchasing patterns are known to mediate income differences in dietary intake quality[19].

These socio-demographic findings underscore the dual burden of nutritional and behavioral challenges faced by adolescents in urban and rural settings. In rural areas, economic constraints and lower parental education levels may limit access to nutritious foods and health education[20]. Conversely, urban adolescents, despite better economic resources, may face lifestyle risks associated with sedentary behavior and higher consumption of unhealthy foods and beverages[19,21]. Interventions aimed at improving adolescent health should address these socio-demographic disparities.

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Table 1. Socio-demographic characteristics of study participants (N=261)

Characteristics	Total		Urban		Rural		Median (IQR)	p-value
	N	%	n	%	n	%		
Adolescent's sex								
Male	120	46	50	50	70	44		0.435
Female	141	54	51	50	90	56		
Adolescent's age [median (IQR)]							12.8 ± 0.75	
Adolescent's grade (year of age)								
12	147	56	62	60	85	53		0.237
13	114	44	39	40	75	47		
Mother's education								
≤ 9 years	22	8	1	1	21	13		0.053
≥ 10 years	239	92	100	99	139	87		
Father's education								
≤ 9 years	19	7	1	1	18	11		0.065
≥ 10 years	242	93	100	99	142	89		
Mother's occupation								
Regular income	76	29	39	39	37	23		0.122
No/irregular income	185	71	62	61	123	77		
Father's occupation								
Regular income	145	54	61	60	84	53		0.065
No/irregular income	116	43	40	40	76	47		
Household monthly income								
≤ Minimum Wage**	99	37	19	19	80	50		0.031*
> Minimum Wage	162	63	82	89	80	50		

*p-value significant (p-value<0.05)

**Minimum wage of Sidoarjo City = IDR 4,638,582/USD 290 per month, Banyuwangi City = IDR 2,638,628/USD 165 per month (East Java Province Government, 2023)

Overweight and obesity trends among urban-rural adolescents

The results of this study reveal a concerning trend where urban adolescents are at a higher percentage of obesity compared to their rural counterparts, despite socio-economic advantages such as higher household income and parental education. In urban areas, 31% of adolescents were classified as overweight or obese, while only 21% of rural adolescents fell into the same category (Figure 2). This paradox underscores the significant role that lifestyle factors and residency play in the rising rates of overweight and obesity[22]. Urbanization leads to changes in food environments that contribute to unhealthy weight gain. In urban areas, adolescents have greater access to energy-dense, processed foods, including sugary snacks, fast foods, and sugary beverages, which are often aggressively marketed through mass media[23,24]. The availability and affordability of such foods, compared to healthier options, increase the likelihood of poor dietary choices.

Moreover, urban adolescents tend to have more sedentary lifestyles, with longer screen time and fewer opportunities for physical activity. The convenience of screen-based entertainment, including television, video games, and social media, often displaces time that could be spent engaging in physical exercise. Studies have shown that prolonged screen time is associated with higher calorie consumption, particularly from unhealthy food options, and less participation in outdoor activities. This lifestyle, compounded by the availability of unhealthy food options, significantly elevates the risk of obesity among urban adolescents. Additionally, urban adolescents may face time constraints due to academic pressures or after-school activities, leaving them with limited opportunities for physical activity outside the home. These factors contribute to a cycle of poor dietary habits and reduced physical activity, exacerbating the obesity trend in urban areas[25].

Data from this study support the need for tailored interventions that take into account the socio-economic, cultural, and environmental contexts of both urban and rural populations. For example, educational campaigns in urban and rural areas should focus on addressing specific themes related to their unique challenges and promoting healthier food choices. Previous studies have shown that interventions targeting adolescents can have a positive impact on nutritional status and dietary behavior[26]. Understanding the complex interplay between socio-demographic factors, lifestyle choices, and environmental influences is crucial for effectively combating adolescent obesity in both urban and rural Indonesia.

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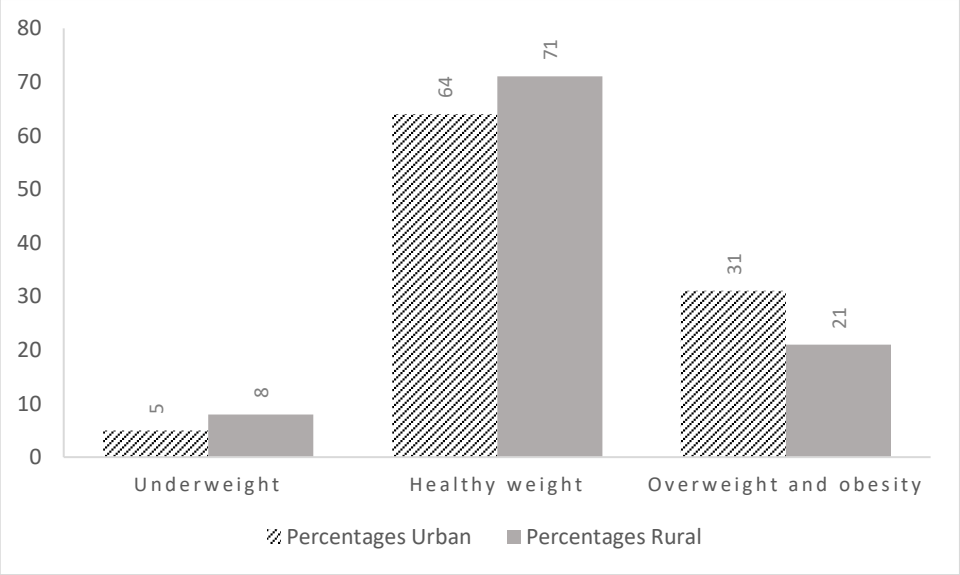

Figure 2. The percentage of nutrition status (BMIZ) stratified by urban-rural area. p-values from chi-square test in urban and rural areas were <0.05

Sweet Beverages, Fatty Foods, and Overweight Risks

Our findings indicate that urban adolescents consume more sugar-sweetened beverages (67%) and fatty foods (57%) than their rural peers (45%) (Table 2). The results of this study reveal significant differences in dietary behaviors between urban and rural adolescents, particularly regarding the consumption of sugar-sweetened beverages and their potential impact on overweight and obesity. As shown in Table 2, the consumption of sugar-sweetened beverages was notably higher among urban adolescents, with 67% of them drinking sugary beverages at least once per day, compared to 45% in rural adolescents (p-value<0.05). This higher frequency of sugary beverage consumption in urban areas is concerning, as excessive intake of sugary drinks has been widely associated with increased energy intake, poor diet quality, and higher risks of obesity and related health issues[27].

Logistic regression analysis showed that adolescents who consume sweetened beverages have a higher risk of being overweight, with an odds ratio of 2.32 (Table 4). However, the consumption of fatty foods was not significantly associated with overweight in rural adolescents, whereas it was significant in urban adolescents with an odds ratio of 1.67. This finding suggests that residence may act as an effect modifier rather than a confounder, as the association between dietary factors and overweight varies between urban and rural settings. The higher consumption of sweetened beverages among adolescents in both urban and rural areas may be attributed to several factors, including easier access, peer influence, and aggressive marketing[28,29]. Fatty food and sugary drinks are often promoted through mass media and are readily available in stores, making them an attractive option for adolescents especially in urban area. Interestingly, the prevalence of overweight and obesity was higher in urban adolescents (31%) compared to rural adolescents (21%), which may reflect differences in lifestyle, including dietary habits and access to unhealthy food options. This finding underscores the importance of considering residence in targeting public health interventions.

On the other hand, rural adolescents consumed fatty fried food less frequently, but this did not completely shield them from obesity risks. Although 45% of rural adolescents consumed fatty food at least once per day, which is lower than in urban areas, a significant proportion (45%) still consumed sugary beverages. These dietary patterns may contribute to the rising trend of obesity in rural areas. Previous studies have indicated that overweight has started to rise as a concern in rural areas[30]. These findings highlight that overweight threatens the younger generation in both urban and rural areas, and this issue must be addressed promptly to prevent further health complications.

Table 2. Percentages of dietary behavior of adolescent by urban-rural area

Variables	Total (n=261)		Urban		Rural		p-value*
	n	%	n	%	n	%	
Sugar sweetened beverages							
< 1 time/day	121	46	33	33	88	55	0.021*
≥ 1 time/day	140	54	68	67	72	45	
Fruit Juice							
< 1 time/day	180	69	66	65	114	71	0.393
≥ 1 time/day	81	31	35	35	46	29	

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Variables	Total (n=261)		Urban		Rural		p-value*
	n	%	n	%	n	%	
Coffee/ Tea consumption							
< 1 time/day	234	90	93	92	141	88	0.962
≥ 1 time/day	27	10	8	8	19	12	
Milk and dairy products							
< 1 time/day	97	37	44	44	53	33	0.040*
≥ 1 time/day	190	73	67	66	123	77	
Instant noodle							
< 1 time/day	233	89	89	88	144	90	0.723
≥ 1 time/day	28	11	12	12	16	10	
Fatty fried food							
< 1 time/day	131	50	43	43	88	55	0.032*
≥ 1 time/day	129	50	57	57	72	45	
Vegetable and food							
< 5 portion/day	210	80	79	78	131	82	0.056
≥ 5 portion/day	51	20	22	22	29	18	

*p-value significant (p-value<0.05)
**NS = Not Significant

Physical Activity and Screen time

The results related to physical activity and sedentary behavior revealed differences between urban and rural adolescents. As shown in Table 3, rural adolescents reported significantly higher physical activity during their spare time (2.1 ± 0.4 hours/day) compared to their urban counterparts (1.3 ± 0.7 hours/day, p-value<0.05). Additionally, rural adolescents exhibited higher physical activity levels during weekends (2.7 ± 0.4 hours) than urban adolescents (2.5 ± 0.3 hours, p-value<0.05). However, urban adolescents reported significantly higher physical activity after school (2.5 ± 1.1 hours) compared to rural adolescents (2.2 ± 0.8 hours, p-value<0.05). These findings suggest that rural adolescents may have more opportunities for physical activity during their spare time and weekends, likely due to the availability of outdoor spaces[31]. In contrast, urban adolescents may be more dependent on sedentary activities, such as screen time, which was significantly higher in urban adolescents (5.5 ± 3.7 hours/day) compared to rural adolescents (4.8 ± 3.8 hours/day, p-value<0.05).

Based on logistic regression in Table 4, physical activity and screen time have the potential to increase the risk of overweight and obesity in both urban and rural adolescents. The increase in screen time may contribute to a more sedentary lifestyle, leading to reduced physical activity and higher obesity risk[31,32]. Urban adolescents tend to engage in more sedentary activities, such as watching television or using electronic devices, which exacerbates the problem of physical inactivity. The average screen time in urban areas was 5.5 hours per day, compared to 4.8 hours in rural areas, and this higher screen time correlates with reduced opportunities for physical activity, leading to an increased risk of obesity. This aligns with a report by the CDC (2024), which revealed that more than 50% of adolescents have screen time exceeding 4 hours/day[33]. High levels of screen time have been linked to adverse health outcomes, including poor sleep habits, fatigue, and symptoms of anxiety and depression[34]. These environmental factors, combined with higher access to fast food, create an obesogenic environment in urban areas that contribute to the higher prevalence of overweight and obesity.

In rural areas, despite having lower obesity rates overall (21%), increasing trends of overweight and obesity are starting to emerge. Adolescents in rural areas have traditionally been more active, with greater opportunities for outdoor physical activities, such as walking or cycling. However, these patterns are changing due to economic transitions and shifts in lifestyle. Adolescents from rural areas often exhibit lower levels of physical activity because they lack sufficient peers for physical play, have fewer sports fields and centers to engage in physical activities, and have limited access to various sports clubs compared to urban adolescents[35]. Interestingly, despite the higher screen time observed in urban adolescents, there were no significant differences between the two groups in terms of napping time or sleep duration, with both urban (7.1 ± 2.1 hours) and rural adolescents (7.3 ± 1.3 hours) reporting similar sleep patterns. This suggests that while sedentary behavior may also contribute to obesity in rural areas, previous research in rural Mexico found that adolescents in these areas also tend to have a sedentary lifestyle[36]. Based on these findings, a tailored approach is needed for rural areas. Sedentary behavior is not only a threat in urban areas but also in rural areas, requiring a specific approach to address this issue.

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Table 3. Percentages of physical activity and sedentary behavior among adolescents in urban-rural area

Variables	Total			Urban			Rural			p-value
	N	%	M±SD	n	%	M±SD	n	%	M±SD	
Physical activity										
Low	74	28		39	39		35	22		0.001*
Moderate	135	52		50	50		85	53		
High	52	20		12	11		40	25		
Sleep duration										
Short sleep (<7 hours)	52	20		23	22		29	18		0.322
Adequate (>7 hours)	209	80		78	78		131	82		
Napping Time										
No/short nap (<1 hour)	135	52		44	44		91	57		0.0743
Long nap (>1 hour)	126	48		57	56		69	43		
Screen time										
Low (<1 hour)	11	4		1	1		10	6		0.050*
Moderate (2-4 hours)	91	35		24	23		67	42		
High (>4 hours)	159	61		76	76		83	52		
Physical activity										
PA at spare time			1.7±0.6			1.3±0.7			2.1±0.4	0.043
PE Class			2.1±0.8			2.1±0.8			2.1±0.8	0.073
Break time			1.5±0.7			1.5±0.9			1.6±0.4	0.475
Lunch time			1.5±0.2			1.5±0.3			1.5±0.2	0.233
After school			2.3±0.9			2.5±1.1			2.2±0.8	0.021*
Evening			1.3±1.2			1.2±1.2			1.3±0.5	0.588
Weekend			2.6±0.3			2.5±0.3			2.7±0.4	0.032*
Overall PAQ-C			1.7±0.5			1.6±0.4			1.8±0.6	0.053
Sleep and screen time										
Screen time			5.2±3.8			5.5±3.7			4.8±3.8	0.045*
Napping time			1.2±1.2			1.2±1.1			1.1±1.3	0.679
Sleep duration			7.2±1.7			7.1±2.1			7.3±1.3	0.568

*p-value significant (p-value<0.05)

Table 4. Logistic regression analysis of factor associated with overweight

Characteristics	Urban and Rural		Urban		Rural	
	AOR^	CI†	AOR	CI	AOR	CI
Sugar sweetened beverages and food						
< 1 time/day	2.32*	1.28-4.15	2.43*	1.55-4.59	2.15*	1.10-4.05
≥ 1 time/day						
Fatty fat						
< 1 time/day	1.62*	1.09-2.93	1.73*	1.10-3.12	1.48	0.95-2.30
≥ 1 time/day						
Physical activity level						
Low	0.09*	0.02-0.16	0.08*	0.02-0.14	0.12*	0.02-0.27
Moderate/ high						
Screen Time Duration						
Low	1.21*	1.07-2.18	1.35*	1.10-1.75	1.13*	1.05-1.60
Moderate/ high						

^AOR, Adjusted Odd Ratio; †CI, confidence interval
*AOR indicates a statistically significant p-value (<0.05)

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This study has several limitations. First, the sample size and representativeness may be constrained, as the research focused on specific urban and rural areas rather than a broader national sample. This could impact the generalizability of the findings. However, the selected study areas reflect typical urban and rural settings in Indonesia, providing insights that may be applicable to similar contexts. Second, data collection relied on self-reported measures for physical activity, dietary intake, screen time, and sleep patterns, which may be subject to recall bias. Participants might have difficulty accurately recalling their behaviors, especially dietary intake and physical activity levels. Social desirability bias could also influence responses, particularly for screen time and physical activity, potentially leading to overreporting of healthier habits or underreporting of screen use. Regarding physical activity assessment, the study used the Physical Activity Questionnaire for Children (PAQ-C) due to its age-appropriate design for early adolescents. Third, the study did not include objective assessments of physical activity (e.g., using accelerometers) or detailed evaluations of the quality of dietary intake. Additionally, environmental factors, such as access to recreational spaces or the quality of food sources, were not explored, which may influence the observed behaviors and outcomes. Despite these limitations, this study provides valuable insights into the impact of high energy intake, low physical activity, and prolonged screen time on obesity trends among adolescents in urban and rural Indonesia. The findings underscore the importance of addressing lifestyle factors to promote healthier behaviors and inform targeted public health strategies for reducing obesity prevalence in diverse settings.

CONCLUSIONS

This study highlights significant disparities in lifestyle behaviors between urban and rural adolescents in East Java, Indonesia, affecting their nutritional status. Urban adolescents consume more sweetened beverages and fatty foods, have longer screen time, and engage in less physical activity. Meanwhile, rural adolescents are more physically active, which may help counter sedentary risks. However, increasing screen-based activities and changing lifestyles in rural areas could elevate these risks. Obesity remains a concern for both groups. These findings emphasize the need to consider environmental influences, as evolving lifestyles may contribute to rising sedentary behavior and related health risks.

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CONFLICT OF INTEREST AND FUNDING DISCLOSURE

The authors declare there is no conflict of interest. This research was funded by the Early-Career Researcher Grant *(Penelitian Dosen Pemula/PDP Number 1403, 2020)* at Universitas Airlangga.

AUTHOR CONTRIBUTIONS

Conceptualization: MAR, SIP; Formal analysis: NUZ; Funding acquisition: MAR; Investigation: MAR, SIP, WS; Methodology: MAR, SIP; Project administration: WS; Visualization: NUZ; Writing—original draft: MAR, SIP; Writing—review and editing: NUZ, WS. All authors have read and agreed to the published version of the manuscript.

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