Socioeconomic Gradient and Anthropometric Risk: Central Obesity among Adolescents in Aceh, Indonesia

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Abstract

Central obesity is a critical risk factor for future cardiometabolic disorders in adolescents, particularly in low- and middle-income settings such as Indonesia. This cross-sectional study examined the prevalence and determinants of central obesity among adolescents in Aceh Barat and Nagan Raya, Indonesia. A total of 167 senior high school students were recruited using purposive sampling, which allowed representation from multiple schools but limits generalizability beyond the study population. Data on waist circumference, family income, physical activity, screen time, and body mass index (BMI) were collected using standardized procedures. Central obesity was defined based on age- and gender-specific waist circumference cut-offs according to International Diabetes Federation criteria. Associations were examined using chi-square tests and binary logistic regression. The prevalence of central obesity was 15.0%. In bivariate analysis, adolescents from middle–high income families (OR = 3.23; 95% CI: 1.35–7.75) and those classified as overweight based on BMI (OR = 40.30; 95% CI: 12.69–127.98) had significantly higher odds of central obesity. However, in multivariate analysis, only BMI remained independently associated with central obesity (AOR = 0.02; 95% CI: 0.005–0.083), while socioeconomic status, physical activity, and screen time were no longer statistically significant.

Keywords: Adolescents, Body Mass Index, Obesity Central, Socioeconomic Status, Screen Time.

INTRODUCTION

In recent decades, the number of young people who are overweight has become a serious global health issue, especially in developing countries. WHO data from 2022 shows that over 390 million children and adolescents aged 5–19 were overweight, a sharp increase compared to previous years (WHO, 2022) UNICEF's findings indicate that roughly 20% of school-age children and teenagers globally are now overweight or obese, presenting an escalating challenge with severe consequences for their long-term metabolic and cardiovascular well-being (UNICEF, 2023). These patterns underscore the importance of region- and context-tailored studies to gain deeper insight into the factors driving obesity among adolescents across different economic and geographic environments.

The rise in obesity cases today is largely linked to the increased use of technological devices that replace physical activity. Adolescents spend more time on screens, such as televisions, computers, and smartphones, which reduces their physical activity, increases

calorie intake, and disrupts sleep. Research shows that high screen time is associated with larger waist size in children and adolescents, although its direct link to central obesity is still unclear (Ghasemirad et al., 2023). Similar findings report that adolescents with the longest screen time duration are 1.27 times more likely to be overweight or obese (Haghjoo et al., 2022), emphasizing the correlation between obesity and screen time.

Besides the overuse of digital devices, socioeconomic status (SES) has been seen as a determinant of obesity in adolescents. Children from families with higher income or wealth often have greater access to high-calorie processed foods, but also vary in opportunities for physical activity, depending on the built environment and lifestyle. In Indonesia, studies have reported that screen time, physical activity, and consumption of energy-dense foods are associated with obesity among adolescents. For example, a study in East Jakarta found that screen time, junk food consumption, and low physical activity were significantly related to adolescent obesity (Rezeki et al, 2023).

A meta-analysis from Asia (children and adolescents aged 5-19 years) concluded that screen time of more than 2 hours per day increases the risk of overweight/obesity with an adjusted OR of approximately 1.63 (95% CI: 1.13–2.35) (Mayarestya et al., 2021). In Indonesia, research in Yogyakarta shows that screen time > 2 hours/day is significantly associated with obesity in junior high school students, with an OR of ~2.6 (CI: 1.16-5.75) (Utami et al., 2018).

Despite the increasing number of studies on adolescent obesity in Indonesia, most existing research has primarily focused on general obesity measured by body mass index (BMI), relied on national survey data, or been conducted in urban settings**.** There remains a lack of empirical evidence examining central obesity using waist circumference in combination with socioeconomic status and behavioral factors such as physical activity and screen time, particularly in rural and semi-rural Indonesian contexts such as Aceh Barat and Nagan Raya**.** Moreover, the extent to which socioeconomic gradients and lifestyle behaviors interact with anthropometric indicators to influence central obesity among Indonesian adolescents remains poorly understood. Addressing this gap is essential to inform context-specific school-based prevention strategies.

A meta-analysis of RCTs (*Randomized Controlled Trials*) on children and adolescents with overweight/obesity shows that physical exercise programs (aerobic/moderate/low intensity classes, ≥ 3 sessions per week, duration ≥ 50 minutes/session, for ≥ 12 weeks) significantly reduce BMI, waist circumference, and body fat percentage (Zhou et al., 2025). Research in Brazil (abdominal obesity prevalence) found that physical activity is significantly

associated with abdominal obesity, although the prevalence is lower than in international studies (Cavalcanti et al., 2010).

This research analyzed data from the 2018 Indonesian Health Survey to assess the prevalence of overweight and obesity among children aged 5–17 years across 514 districts and cities in Indonesia, taking into account geographical and socioeconomic characteristics. The findings revealed that districts with higher income levels exhibited a markedly greater prevalence of overweight and obesity compared to the least affluent districts. Furthermore, boys residing in the wealthiest areas were 1.24 times more likely to be overweight and 1.26 times more likely to be obese than those living in the poorest regions (Sulistiadi et al., 2023)

Other studies show that private school students (who are usually associated with higher socioeconomic backgrounds) have a higher prevalence of overweight, especially in schools located in urban areas compared to suburban areas. Although direct income variables (income) or "pocket money" were measured, the findings show that higher socioeconomic status (private schools/urbanization) correlates with overweight (Sarintohe et al., 2022).

Many studies use BMI or general overweight/obesity categories (based on BMI) as the primary measure, as they are easier to obtain. However, the use of waist circumference/abdominal obesity (or waist-to-height ratio) provides a more specific picture of metabolic risk, as abdominal fat distribution is more closely related to cardiometabolic risk. Studies in Asia and developing countries increasingly emphasize the importance of measuring central obesity (de Oliveira et al., 2023).

Therefore, this study aims to determine the prevalence of central obesity among senior high school adolescents in Aceh Barat and Nagan Raya, Indonesia, and to examine its association with socioeconomic status, body mass index, physical activity, and screen time**.** By integrating anthropometric, socioeconomic, and behavioral factors, this study seeks to contribute context-specific evidence to support school-based obesity prevention strategies in rural Indonesian settings.

METHODS

A cross-sectional study design was employed with students in their final years of secondary school from Aceh Barat and Nagan Raya districts in Indonesia. The research protocol received approval from Teuku Umar University's institutional review board for ethical compliance. Before collecting any data, written parental or guardian consent was secured, along with voluntary agreement from each student participant. Participants were selected using purposive sampling to ensure inclusion of students from multiple schools representing different

community settings. While this approach limits generalizability, it was considered appropriate for exploratory analysis in a setting with limited prior data. The sample size was comparable to previous adolescent obesity studies in Indonesia and was deemed sufficient to detect meaningful associations in bivariate and multivariate analyses.

Central obesity was defined using age- and gender-specific waist circumference cut-offs according to the International Diabetes Federation (IDF) criteria for children and adolescents. BMI was calculated and categorized using WHO growth reference standards. Family income was categorized based on the provincial minimum wage (UMP) of Aceh into low (<UMP) and middle–high (≥UMP). Physical activity was assessed using a questionnaire adapted from the Global Physical Activity Questionnaire (GPAQ) and categorized as active (≥150 minutes/week of moderate-to-vigorous activity) or inactive. Screen time was defined as average daily screen exposure and categorized as high (≥2 hours/day) or low (<2 hours/day). Physical activity and screen time were self-reported and pre-tested for clarity, acknowledging potential recall bias. First, a bivariate analysis was used to look at basic relationships between variables. Then, a multivariate logistic regression was carried out to adjust for other influencing factors and to find which variables independently predict central obesity. Some variables were included in the model even if they were not significant in the bivariate analysis, because past research and theory suggest they are important.

RESULT

Data were analyzed for 167 high school students (N = 167). The descriptive statistics for the anthropometric variables were as follows: mean weight 52.85 kg (SD = 13.08), mean height 159.25 cm (SD = 8.47), and mean waist circumference 71.13 cm (SD = 11.22). Based on the waist circumference category 25 students (25/167) were identified as having central obesity (prevalence = 15.0%), while 142 students were not at risk.

Table 1. Descriptive Statistics of Anthropometric Variables

Variable	N	Minimum	Maximum	Mean	SD
Weight (kg)	167	33.7	112.0	52.85	13.08
Height (cm)	167	136.3	181.0	159.25	8.47
Waist circumference (cm)	167	52	117	71.13	11.22

Table 2 shows that there was a significant relationship between family income and central obesity ($\chi^2 = 7.401$; $p = 0.007$). The prevalence of central obesity was higher in the upper-middle-income group (15/60 = 25.0%) than in the low-income group (10/107 = 9.4%). There was no significant relationship between central obesity and gender ($p = 0.155$), physical activity ($p = 0.305$), or screen time ($p = 0.114$). The strongest association was found between

BMI category (overweight) and central obesity (highly significant χ^2, $p < 0.001$): most overweight students also had central obesity.

This study looked at how common central obesity is among 167 senior high school students in Aceh Barat and Nagan Raya, Indonesia. The results show that family income and being overweight (based on BMI) are strongly linked to central obesity. However, gender, physical activity, and screen time did not show a significant connection in this group. Each factor is explained further in relation to previous research.

Table 2. Distribution of central obesity by selected characteristics and Chi-square test results

Variable	Category	Obesity central		No obesity central		Total (N)	p (Chi-square)
		n	(%)	n	(%)		
Gender	Female	16	18.8	69	81.2	85	0.155
	Male	9	11.0	73	89.0	82	
Family Income	Middle-high	15	25.0	45	75.0	60	0.007*
	low	10	9.3	97	90.7	107	
Physical activity	Have activity	16	13.2	105	86.8	121	0.305
	No activity	9	19.6	37	80.4	46	
Screen	High	22	17.5	104	82.5	126	0.114
	Low	3	7.3	38	92.7	41	
BMI categorical	Overweight	16	72.7	6	27.3	22	<0.001*
	Non-overweight	9	6.2	136	93.8	145	

Values are presented as n (% within category).
**Chi-square test, p < 0.05 considered statistically significant*

Although family income was positively associated with central obesity in bivariate analysis, this association was attenuated and reversed in the multivariate model due to the choice of reference category and adjustment for BMI. This indicates that the relationship between socioeconomic status and central obesity may be mediated through overweight status rather than acting as an independent effect. The adjusted odds ratio for BMI (AOR = 0.02) reflects coding direction, where non-overweight served as the reference category, confirming that overweight adolescents had substantially higher odds of central obesity.

Table 3. Binary Logistic Regression Analysis of Factors Associated with Central Obesity among Adolescents (n = 167)

Variable Independent	B	SE	Wald	p-value	AOR (Exp(B))	95% CI for AOR
Gender (female)	-0.784	0.623	1.582	0.208	0.457	0.13–1.60
Family income (middle-upper)	-1.016	0.599	2.874	0.090	0.362	0.11–1.14
Physical activity (having)	-0.226	0.649	0.122	0.727	0.797	0.22–2.82
Screen time ≥ 2 hours/day	-1.226	0.866	2.005	0.157	0.293	0.05–1.66
BMI(Overweight/Obese)	-3.896	0.678	33.016	<0.001	0.020	0.005–0.083

DISCUSSION

Socio-Economic Status (Family Income)

Students from wealthier families were more likely to have central obesity (OR = 3.23; p = 0.007). This matches national findings that children in richer areas tend to have higher rates of overweight and obesity than those in poorer areas (Sulistiadi et al., 2023). The difference may be due to lifestyle factors, such as easier access to processed, high-calorie foods and more sedentary entertainment. Likewise, adolescents in private schools, often linked to higher socioeconomic status, were found to have higher rates of overweight compared to students in public schools (Sarintohe et al., 2022).

Findings revealed that 7.99% of participants were obese (95% CI: 7.20–8.78%). Additional examination through the normalized concentration index yielded a coefficient of 0.075 (95% CI: 0.047–0.103), demonstrating that obesity prevalence was disproportionately higher among individuals from wealthier socioeconomic backgrounds ($p < 0.05$). This finding suggests there is an imbalance in the distribution of obesity based on welfare levels, whereby individuals from more affluent economic groups tend to have a greater risk of obesity (Xu et al., 2022).

Studies (Moschonis et al., 2022) conducted in six European countries showed that the prevalence of overweight and obese children reached nearly 25% of the total participants. Multivariate logistic regression analysis revealed that children living in low-income countries had a 2.11 times higher risk of obesity than those living in high-income countries (95% CI: 1.62–2.74). In addition, children from families with low parental education levels and unstable employment have a higher prevalence of obesity. In middle-income countries or those experiencing economic crises, obesity was more prevalent among groups with a high socioeconomic status. It means the relationship between family income and obesity is not linear but is influenced by a country's economic context and lifestyles associated with economic prosperity.

Meanwhile, a Study in Germany (Rattay et al., 2022) reinforced that family socioeconomic status (income, education, and parental employment) is closely correlated with adolescent health status, including the risk of obesity. In this study, more than 70% of the influence of socioeconomic status on adolescent health was mediated by family factors such as parental emotional well-being, family cohesion, and family health behaviors (e.g., physical activity and smoking). Thus, Adolescents from low-income families face not only financial challenges but also family environments that may be less supportive of healthy living. High parental stress, less active parenting, and sedentary habits can indirectly raise their risk of

central obesity. In contrast, adolescents from wealthier families usually have better access to healthy foods, exercise facilities, and experience less social and economic stress.

In Aceh, higher household income may facilitate access to energy-dense foods, sedentary entertainment, and motorized transport, while structured opportunities for physical activity remain limited. These contextual factors may contribute to higher overweight prevalence, which in turn increases central obesity risk.

BMI Categorical

After carrying out multivariate adjustment, BMI emerged as the only independent predictor of central obesity, underscoring its dominant role in adolescent adiposity patterns. The crude association between family income and central obesity appears to be confounded by BMI, suggesting an indirect socioeconomic pathway.

Overweight status based on BMI was strongly correlated with central obesity ($p < 0.001$), with 72.7% of overweight students also presenting central obesity compared to only 6.2% among non-overweight peers (OR = 40.30; 95% CI: 12.69–127.98). This reinforces waist circumference as a complementary metric: although BMI and waist circumference are correlated, BMI cannot fully capture fat distribution (Putra et al., 2025). Past studies show that adolescents who are overweight or obese based on BMI have a much higher risk of developing metabolic syndrome if they also have excess fat around the waist. Our findings suggest that measuring waist circumference should be included in school health checks to better identify students at risk. Similarly, Factors Influencing Nutritional Status in Overweight and Obese Adolescents in East Kalimantan found a high prevalence of overweight/obesity (BMI based) among adolescents, with strong associations with both diet and physical activity (Kamaruddin et al., 2023).

The study in Korea found that the combination of high BMI and large waist circumference significantly increased the risk of metabolic syndrome, hypertension, diabetes, and dyslipidemia compared to individuals with a normal BMI without central obesity. Individuals with a BMI ≥ 30 kg/m² and central obesity had an odds ratio (OR) of 35.95 for metabolic syndrome in men and 29.22 in women, indicating that the combination of high BMI and central fat distribution worsens cardiometabolic risk (Yoo et al., 2017).

Furthermore, a study by in Nepal reinforced these findings by showing that 34.2% of women with a normal BMI also had central obesity (WC ≥ 80 cm). Some individuals with normal weight (BMI < 25 kg/m²) had waist circumferences that exceeded the risk threshold. BMI alone is insufficient to describe body fat distribution, and waist circumference

measurement should be an important component of the early detection of metabolic risk (Yogal et al., 2025).

Similarly, a study involved 2,312 adults in China with normal BMI and found a prevalence of central obesity of 58.3%, with a significant increase in the risk of hypertension and dyslipidemia (AOR, 1.55 and 1.84, respectively). The authors concluded that BMI cannot stand alone as an indicator of obesity, as individuals with normal body weight can have substantial abdominal fat accumulation and be at risk for metabolic disorders (Feng et al., 2021)

Similar results were obtained in the Atherosclerosis Risk in Communities (ARIC) study using the Targeted Maximum Likelihood Estimation (TMLE) approach. In this study, the effect of BMI on cardiovascular disease was significantly reduced after controlling for central obesity. This means that the influence of BMI on cardiovascular risk is largely mediated by central fat, and reducing waist circumference can reduce the proportion of BMI's effect on heart disease by more than 90% (Saadati et al., 2021)

In our study, the large magnitude of OR suggests that overweight status is one of the most potent risk factors for central obesity, implying that BMI category might serve as a proxy for identifying adolescents at high risk of central adiposity. Nonetheless, it is critical to measure waist circumference directly, as BMI does not distinguish between fat and lean mass or fat distribution.

Gender Differences

There was no significant difference in central obesity prevalence observed between females (18.8%) and males (11.0%) ($p = 0.155$), although females had slightly higher odds (OR = 1.88; 95% CI: 0.78–4.54). Studies on gender differences in adolescent central obesity are inconsistent: some report a higher prevalence among girls due to hormonal and behavioral factors, while others show no significant differences. The lack of statistical significance in our study may be influenced by sample size and suggests that interventions should be gender-inclusive. Another meta-analysis of lifestyle interventions reported that gender did not significantly moderate intervention effects on waist circumference or other adiposity measures, suggesting that while biological and behavioral differences exist, the risk factors may operate similarly for male and female adolescents in many settings (Mast et al., 2023).

Teenage girls tend to have a higher risk of central obesity than boys. This is due to hormonal changes during puberty, particularly an increase in GnRH hormones, which trigger fat accumulation in the abdominal area. In addition, a decrease in estrogen levels at a certain age also contributes to an increase in central fat in women (Putri et al., 2022)

Physical Activity

No statistically significant relationship was found between physical activity and central obesity (p = 0.305). Although this may appear unexpected, comparable null associations have been documented in studies where physical activity relies on self-report measures and lacks precise assessment methods.. It is possible that differences in activity levels were insufficiently large to detect associations, or that screen time and dietary factors exert a stronger influence. Objective measures (e.g., accelerometry) or more granular categories of activity intensity could clarify these relationships in future studies.

Low physical activity is a major risk factor for central obesity. A sedentary lifestyle causes an energy imbalance, calorie consumption exceeds calorie expenditure, leading to fat storage, especially in the abdominal area. Limited time for exercise and prolonged sitting habits can exacerbate this condition(Kurnia Saraswati et al., 2020).

Our findings revealed no statistically significant relationship between exercise levels and abdominal adiposity (p = 0.305). This result differs from numerous research studies that identify sedentary behavior as a contributing factor to excess weight and abdominal fat accumulation. For instance, a 2024 investigation examining predictors of excess body weight among urban and rural teenagers in Indonesia's Banten Province found that insufficient exercise was a major predictor of elevated BMI in young people (Perdanawati et al., 2024). The difference in our findings may stem from how physical activity was measured (self-report vs objective), or limited variation in physical activity levels among participants. Moreover, cultural factors, school schedules, environmental constraints (e.g., safe play/recreational areas), and possible over-reporting/recall bias might dilute observable associations in cross-sectional data.

Screen Time Duration

Likewise, screen time duration did not show a statistically significant relationship with central obesity (p = 0.114), though the prevalence was higher in the high screen time group (22/126; 17.5%) compared to the average group (3/41; 7.3%). Recent meta-analyses suggest that prolonged screen time is associated with modest increases in waist circumference and overweight risk . The lack of significance here may reflect sample size limitations or unmeasured confounders (e.g., dietary habits during screen use). Nonetheless, the observed trend warrants further investigation, particularly considering the rapid growth of digital media use among Indonesian adolescents. For instance, the Indonesian study *Physical activity and sedentary behaviour of female adolescents in Indonesia: A multi-method study* (2020) reported

very high sedentary/screen-based behaviour among female adolescents, particularly non-school days, but did not directly establish a link with central obesity (Andriyani et al., 2022)

The lack of significant associations for physical activity and screen time may reflect self-reported measurement limitations, limited behavioral variability, and cultural patterns of activity among adolescents. Objective measurement tools and dietary assessment should be considered in future studies.

Public Health Implication

The associations between family income, BMI category, and central obesity suggest that socioeconomic and anthropometric indicators are key targets for adolescent obesity prevention in Aceh. While screen time and physical activity were not statistically significant in this sample, existing literature supports their role, and interventions should still address these behaviors. School-based health education, policies limiting excessive screen time, and promotion of structured physical activity may help reduce central obesity prevalence.

This study uniquely integrates anthropometric, socioeconomic, and behavioral factors to examine central obesity among adolescents in a rural Indonesian setting, addressing a critical evidence gap in national adolescent health research. Limitations include the cross-sectional design, purposive sampling, self-reported behavioral data, potential residual confounding, and the absence of dietary and pubertal stage assessment.

CONCLUSION

This study demonstrates that overweight status based on body mass index (BMI) was the only factor independently associated with central obesity among adolescents in Aceh Barat and Nagan Raya after adjustment for socioeconomic and behavioral variables. Although family income, physical activity, and screen time showed associations in bivariate analyses, these factors did not remain statistically significant in the multivariate model, indicating possible confounding effects.

These findings highlight the importance of early identification of overweight adolescents using combined anthropometric indicators, particularly BMI and waist circumference, in school settings. School Health Programs are therefore recommended to integrate routine waist circumference measurements alongside BMI screening, enabling early detection of central obesity and more targeted preventive interventions. Priority should be given to adolescents with an overweight status, while broader health promotion efforts should continue to address lifestyle behaviors across socioeconomic groups.

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