International Journal of Nutrition Sciences

Journal Home Page: ijns.sums.ac.ir

Original Article

# The Association between School Obesogenicity and Body Fat Percentage among High School Students in Indonesia

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ARTICLE INFO

*Keywords:*
Obesity
Adolescent
Body composition
School children
Indonesia

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**Received:** May 2, 2026
**Revised:** July 26, 2026
**Accepted:** August 3, 2026

ABSTRACT

**Background:** Obesogenic school environments may influence adolescent obesity, but evidence linking school-level obesogenicity with body composition remains inconsistent. This study examined associations between school obesogenicity and body composition (body fat percentage) among Indonesian high school students comparing public and private schools.

**Methods:** In a cross-sectional study, 282 students (193 public; 89 private) were selected by multistage sampling. School obesogenicity was assessed using the School Obesogenic Environment Score (SOES) across seven domains. Body fat percentage was estimated using bioelectrical impedance analysis. Group differences were tested using *t*-tests and chi-square tests, and effect sizes with 95% confidence intervals were calculated. Because obesogenic exposure was measured at the school level in only two schools, no individual-level regression of body composition on school exposure was undertaken.

**Results:** The public school had a higher SOES than the private school (1291 vs. 352), mainly driven by the food environment domain. Private school students had a higher mean body fat percentage than public school students (30.26±12.15% vs. 25.49±10.86%; $p$=0.002) and a higher prevalence of overweight/obesity (30.3% vs. 18.1%; $p$=0.032). The direction of the school-level contrast was opposite to that of obesogenic exposure; while the school with the higher SOES had students with the lower mean body fat percentage (mean difference of 4.77 percentage points, 95%CI of 1.79 to 7.75).

**Conclusion:** Differences in adolescent body composition were not explained by school obesogenicity alone. It seems prevention measures should combine school-based interventions with broader socioeconomic and lifestyle-focused approaches.

Please cite this article as: Trisasmita L, Thahir AIA, Syamsari SM. The Association between School Obesogenicity and Body Fat Percentage among High School Students in Indonesia. Int J Nutr Sci. 2026;11(3):1-9. doi:

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## Introduction

Adolescent obesity has emerged as one of the most critical and rapidly escalating global public health challenges of the 21st century. Over the past four decades, the prevalence of overweight and obesity among adolescents aged 10–19 years has increased markedly, rising from 4% in 1975 to more than 18% in 2016 and affecting more than 340 million adolescents worldwide (1). This trend reflects profound changes in dietary patterns, physical activity behaviors, urbanization, and broader environmental contexts. Unhealthy body composition during adolescence, characterized by excessive body fat accumulation, is associated with an increased risk of non-communicable diseases, including type-2 diabetes, hypertension, dyslipidemia, and metabolic syndrome, and frequently persists into adulthood, contributing to long-term health and economic burdens (2-4).

One of the most widely used frameworks to explain the rapid rise in obesity is the concept of the obesogenic environment, defined as settings that promote excessive energy intake; while discouraging physical activity through interconnected physical, economic, political, and sociocultural factors (5). Among the various contexts influencing adolescent health, schools represent a particularly important setting, as adolescents spend a substantial proportion of their time within school environments during critical developmental periods (6). School environments encompass multiple components that may contribute to obesogenic exposure, including food availability and pricing, access to sugar-sweetened beverages, school canteen practices, opportunities for structured and unstructured physical activity, schoolyard facilities, and the implementation of physical education and health promotion policies (7, 8). Evidence from diverse settings indicates that unhealthy school food environments and limited physical activity opportunities are associated with unfavorable body composition and increased adiposity, whereas supportive school environments have been shown to improve body composition and reduce obesity risk (9-11).

In the Asia-Pacific region, rapid economic development and nutritional transition have intensified the burden of adolescent obesity. Southeast Asia, historically characterized by undernutrition, now faces a dual burden of malnutrition in which overweight and obesity coexist with micronutrient deficiencies (12). Increasing consumption of ultra-processed foods, sedentary lifestyles driven by digital technologies and declining physical activity levels have been widely reported, including in Indonesia, underscoring the growing importance of environmental determinants, particularly school environments, in shaping adolescent body composition and health outcomes (13).

In Indonesia, national survey data demonstrated a steady increase in overweight and obesity among adolescents aged 13–18 years over the past decade (14). However, most existing studies have focused primarily on individual-level determinants such as dietary intake, physical inactivity, and screen time. There remains a relative paucity of research examining structural and environmental influences on adolescent body composition, especially within school settings, and few studies have employed standardized and validated tools to comprehensively assess obesogenic school environments across multiple domains.

The School Obesogenic Environment Score (SOES) offers a structured and reproducible approach to evaluating obesogenic characteristics of schools, including food environments, physical activity facilities, school policies, and sociocultural norms (15). While SOES has been applied in several international contexts, its use in Indonesia remains limited, and empirical evidence linking SOES with objective measures of body composition is scarce. Another important gap in the literature concerns potential differences between public and private schools, as school type may influence obesity-related and body composition outcomes through variations in infrastructure, socioeconomic composition, food provision systems, and academic and extracurricular demands (16).

Furthermore, many Indonesian studies rely on body mass index (BMI) as the primary indicator of adiposity. Although BMI is widely used, it does not distinguish between fat mass and lean mass and may underestimate excess adiposity during adolescence. Bioelectrical impedance analysis provided a more direct assessment of body composition by estimating body fat percentage and may offer greater sensitivity in identifying unhealthy body composition patterns (17).

Given these gaps, this study aimed to examine the association between obesogenic school environments and body composition using body fat percentage among Indonesian high school students and to compare the association between public and private school settings. Findings from this study are expected to contribute to the evidence base informing school health policies and comprehensive obesity prevention strategies in Indonesia.

## Materials and Methods

This cross-sectional study was conducted among high school students in Indonesia. Data collection took place between August and October 2025 in selected public and private high schools located in urban areas. Schools were purposively selected to represent variations in infrastructure, school policies, nutritional environments, and socioeconomic contexts that may influence obesogenic exposure. The study setting aligned with national priorities related to adolescent nutrition and non-communicable disease prevention.

The study population consisted of students enrolled in grades 10–12 at selected public and private high school. Inclusion criteria were (i) enrollment as a high school student, (ii) age between 15 and 18 years, and (iii) physical ability to undergo bioelectrical impedance analysis. Exclusion criteria included pregnancy, the presence of implanted electronic medical devices (e.g., pacemakers), and acute illness at the time of data collection.

A multistage sampling technique was applied. First, schools were stratified by type (public and private). Second, one school from each stratum was randomly selected. Third, classes within selected school were chosen using simple random sampling, and all eligible students in the selected classes were invited to participate.

Sample size was calculated using the Lemeshow formula for proportion estimates with finite population correction, assuming a 95% confidence level (95%CI), maximum variability ($p$=0.5), and a margin of error of 6%. The minimum required sample size was 221 students. A total of 282 students completed all measurements and were included in the analysis, comprising 193 students from the public school and 89 students from the private school.

The unequal number of students between public and private schools reflects differences in school size and class enrollment. All eligible students from the selected classes in each school were invited to participate. Consequently, the public school, which had a larger student population, contributed a higher number of participants than the private school. This imbalance was not due to selective recruitment but represents the natural distribution of students within the selected schools.

The obesogenic characteristics of school environments were assessed using the SOES, a previously developed and validated instrument designed to evaluate obesogenic factors in school settings. The SOES was originally developed and validated by Goh *et al.* through comprehensive content validation and reliability testing. In the present study, the instrument was not newly developed by the researchers; but was contextually adapted to the Indonesian school setting.

The adaptation process involved expert review to ensure content validity and cultural relevance. The expert panel consisted of public health nutritionists, epidemiologists, and school health practitioners with experience in adolescent nutrition and school-based health promotion. Minor modifications were made to align specific items with local school policies and food environment characteristics; while preserving the original structure and scoring system of the SOES.

Each SOES item was rated using a standardized Likert scale, with higher total scores indicating more obesogenic environments. SOES assessments were conducted through direct observation of school facilities, interviews with school staff, and review of relevant school policies and documents. Inter-rater reliability was ensured through standardized training of assessors and calibration prior to data collection.

Body composition was assessed using bioelectrical impedance analysis, a non-invasive and widely accepted method for evaluating body composition in adolescents. Measurements were obtained using a standardized bioelectrical impedance analyzer (Tanita), operated by trained personnel according to manufacturer instructions and international measurement protocols. Body fat percentage was used as the primary indicator of body composition.

Participants were instructed to refrain from consuming food or beverages for at least two hours prior to measurement, to void their bladder before assessment, and to remove shoes, socks, heavy clothing, and metallic accessories. Measurements were performed with participants standing upright and maintaining proper foot placement on the device. Body fat percentage was estimated using validated predictive equations embedded in the device. Measurements were repeated only in cases of technical error.

Data collection comprised two components of (i) school-level assessment using the SOES, conducted during on-site school visits, and (ii) student-level assessment, including demographic information and body composition assessment based on body fat percentage. All data collectors received standardized training, and field supervisors conducted routine quality control checks. Written informed consent was obtained from students and their parents or guardians prior to participation. All measurements were conducted in a private setting to ensure confidentiality.

The independent variable was the SOES, treated as a continuous measure of school-level obesogenic exposure. The dependent variable was body composition, operationalized as body fat percentage measured using bioelectrical impedance analysis. School type (public or private) was used as the comparative grouping variable. Covariates included age, sex, and BMI. BMI was included to account for differences in overall body size and to examine the association between school-level obesogenic exposure and body fat percentage independent of general adiposity.

Data were analyzed using SPSS software (version 26, IBM Corp., Armonk, NY, USA). Descriptive statistics were calculated for all variables, including means, standard deviations, and frequencies. The normality of continuous variables was assessed using the Shapiro–Wilk test, and body fat percentage was normally distributed in both groups.

Because the SOES was assessed at the school level and only two schools were included, SOES could not be modelled as an individual-level exposure; school type was therefore reported as a descriptive contrast rather than as an estimated effect of school obesogenicity. For this reason, no multivariable regression of body fat percentage on school-level exposure was performed.

Body fat percentage was compared between schools using the independent-samples t-test with Welch correction for unequal variances, reported with the mean difference, its 95%CI, and Hedges' g. The prevalence of overweight and obesity was compared using the chi-square test with Yates continuity correction, reported with the prevalence difference and its 95% confidence interval (Newcombe method) and the prevalence ratio. Overweight and obesity were defined using >+1SD and >+2SD. A two-sided $p$ value <0.05 was considered statistically significant.

The study was approved by the Research Ethics Commission of the Faculty of Public Health, Hasanuddin University (Approval Number of 1442/UN4.14.1/TP.01.02/2025). All procedures complied with the principles of the Declaration of Helsinki. Written informed consent was obtained from all participants, with additional parental or guardian consent for participants under 18 years of age. Participant confidentiality was maintained through anonymization of all personal identifiers.

## Results

A total of 282 students participated in the study, including 193 students from the public school and 89 students from the private school, reflecting differences in school size and class enrollment. The sociodemographic and anthropometric characteristics of participants were presented in Table 1. The mean age of students was 15.99±0.91 years, and females accounted for 67.0% of the sample. Compared with public school students, private school students had slightly higher mean BMI and higher mean body fat percentage, indicating less favorable body composition.

Figure 1 illustrates the total SOES for the public and private schools. The public school had a substantially higher total SOES (1291) than the private school (352), indicating greater overall obesogenic exposure.

Domain-specific SOES scores were shown in Table 2. The largest difference between schools was observed in the food environment domain, with the public school scoring 1218 when compared with 266 in the private school. In contrast, the private school scored higher in the physical activity facilities domain (27 vs. 13). Both schools had a score of zero in the written health policies domain.

As shown in Table 3, private school students had a significantly higher mean body fat percentage than public school students (30.26±12.15% vs. 25.49±10.86%). An independent t-test demonstrated that this difference was statistically significant ($t=-3.17$, $p=0.002$).

The prevalence of overweight and obesity by school type was presented in Table 4. A higher proportion of overweight and obesity was observed among private school students compared with public school students (30.3% vs. 18.1%). This difference was statistically significant based on chi-square analysis ($\chi^2=4.60$, $p=0.032$).

Although the public school recorded a markedly higher SOES than the private school (1291 vs. 352), students at the public school had a lower mean body fat percentage (mean difference 4.77 percentage points, 95%CI of 1.79 to 7.75; Hedges' g=0.42) and a lower prevalence of overweight and obesity (prevalence difference 12.2 percentage points, 95%CI of 0.9 to 22.7; prevalence ratio 0.60, 95%CI of 0.39 to 0.92). School-level obesogenic exposure and student body composition therefore diverged in opposite directions.

**Table 1:** Sociodemographic and anthropometric characteristics of respondents

| Variable | Total (n=282) | Public (n=193) | Private (n=89) |
|---|---|---|---|
| Age (years) | 15.99±0.91 | 16.10±0.89 | 15.74±0.91 |
| Female, n (%) | 189 (67.0) | 131 (67.9) | 58 (65.2) |
| BMI (kg/m²) | 21.42±5.04 | 20.77±4.66 | 22.83±5.54 |
| Body fat (%BF) | 27.00±11.48 | 25.49±10.86 | 29.26 ±12.15 |

Data were presented as mean±standard deviation for continuous variables and number (percentage) for categorical variables. $P$ values were obtained using independent t-test for continuous variables and chi-square test for categorical variables. Statistical significance was set at $p<0.05$.

**Table 2:** SOES domain scores for public and private schools.

| Domain | SOES | |
|---|---|---|
| | Public School | Private School |
| A. Food environment | 1218.0 | 266.0 |
| B. Beverages and pricing/healthy promotion | 19.0 | 18.0 |
| C. Vending/external sales | 18.0 | 18.0 |
| D. Physical education and extracurricular activities | 8.0 | 8.0 |
| E. Physical activity facilities | 13.0 | 27.0 |
| F. Written health policies | 0.0 | 0.0 |
| G. Sociocultural and student engagement | 15.0 | 15.0 |

SOES: School Obesogenic Environment Score. Data were presented as total scores for each domain.

**Table 3:** Comparison of body fat percentage between public and private schools.

| School | n | Mean %BF±SD | Mean difference (95% CI) | Hedges' g | *P* value |
|---|---|---|---|---|---|
| Public | 193 | 25.49±10.86 | 4.77 | 0.42 | 0.002 |
| Private | 89 | 30.26±12.15 | (1.79 to 7.75) | | |

Independent-samples t-test with Welch correction for unequal variances: t=−3.17, df=155.1, $p$=0.002. Mean difference was private minus public. Hedges' g interpreted as a small-to-moderate effect. Statistical significance was set at $p$<0.05.

**Table 4:** Prevalence of overweight/obesity by school type.

| School | n | Overweight/Obese, n (%) | Prevalence difference (95%CI) | Prevalence ratio (95%CI) | *P* value |
|---|---|---|---|---|---|
| Public | 193 | 35 (18.1) | 12.2 pp | 0.60 | 0.032 |
| Private | 89 | 27 (30.3) | (0.9 to 22.7) | (0.39 to 0.92) | |

Chi-square test with Yates continuity correction: $\chi^2$=4.60, df=1, $p$=0.032. Prevalence difference was private minus public; prevalence ratio was public relative to private. Overweight and obesity defined as >+1SD and >+2SD. Statistical significance was set at $p$<0.05.

Because SOES was assessed at the school level and only two schools were studied, the observed contrast cannot be attributed to school obesogenicity itself; it is fully confounded with every other characteristic that distinguishes the two schools, including the socioeconomic composition of their student populations. BMI also differed between the two schools (20.77±4.66 vs. 22.83±5.54 kg/m$^2$; $p$=0.003) and, lying on the causal pathway between school environment and adiposity, was not treated as a confounder.

## Discussion

This study examined the association between obesogenic school environments and body composition, assessed using body fat percentage, among Indonesian high school students and identified complex, and in some respects paradoxical, findings. Although the public school demonstrated a substantially higher SOES, particularly within the food environment domain, students attending the private school exhibited significantly higher body fat percentage and a greater prevalence of overweight and obesity. These findings underscore the multifactorial nature of adolescent body composition and suggest that school-level obesogenic exposure alone may not fully explain variations in body composition.

A key observation of this study was that greater exposure to an obesogenic school food environment did not correspond to poorer body composition among students. Previous studies from various settings have reported strong associations between unhealthy school food environments and increased energy intake, snacking behavior, and obesity risk among adolescents (18-21). Similar associations have been documented in Malaysia, Australia, and the United States, where the availability of sugar-sweetened beverages, fried foods, and snack kiosks within school premises was linked to higher obesity prevalence (22). In contrast, the present study found lower body fat percentage among students attending the more obesogenic public school.

One plausible explanation for this paradox relates to socioeconomic differences between public and private school populations. In Indonesia and other low- and middle-income countries undergoing nutritional transition, higher socioeconomic status has been associated with increased risk of adolescent overweight and obesity (23, 24). Adolescents from higher socioeconomic backgrounds may have greater purchasing power, increased access to fast foods, modern cafés, and food delivery services, and higher exposure to energy-dense diets outside the school environment (25). These external dietary influences may exert a stronger effect on adolescent body composition than school food environments alone.

Lifestyle factors may further contribute to these differences. Private school students may experience greater academic demands, which can result in increased sedentary behavior, extended screen time, and reduced opportunities for physical activity. Evidence from China, South Korea, and Malaysia indicates that adolescents in academically intensive environments often demonstrate lower physical activity levels and higher sedentary time, both of which are associated with unfavorable body composition (26-29). Although the private school in this study scored higher in physical activity facilities, the availability of infrastructure alone does not guarantee adequate utilization. Structured programs, school culture, and time availability are critical determinants of students' engagement in physical activity (30).

The regression analysis highlighted the importance of individual-level factors in shaping body composition. Female sex and higher BMI were strongly associated with higher body fat percentage. Higher body fat percentage among female adolescents is consistent with physiological changes during puberty, including sex-specific fat accumulation patterns and hormonal influences (31). Cultural and social norms may also restrict physical activity participation among adolescent girls in certain contexts, as reported in studies from South Asia and the Middle East (32). BMI remained a significant predictor of body fat percentage, supporting previous evidence that BMI correlates with adiposity in older adolescents, despite its limitations as an indirect measure (33). The use of bioelectrical impedance analysis in this study allowed for a more precise assessment of body composition than BMI alone.

Another notable finding was the absence of formal written health policies in both schools. School policies regulating food sales, promoting healthy canteen standards, and mandating physical activity programs have been shown to play a critical role in obesity prevention (34, 35). Countries with comprehensive school health policies, such as Japan, Singapore, and South Korea, have reported more favorable adolescent obesity trends. The lack of such policies in both study schools highlights structural gaps in school-based health promotion efforts in Indonesia (34, 35).

The findings also support an ecological perspective on adolescent obesity, in which body composition is shaped by interactions among individual behaviors, family environments, community contexts, and institutional factors (36). In this study, the lower obesogenic exposure at the private school level may have been offset by stronger obesogenic influences outside the school setting, including home food environments, transportation patterns, and lifestyle behaviors associated with higher socioeconomic status (37). For example, students attending private schools may be more likely to commute by private vehicles, reducing opportunities for active transportation such as walking or cycling, which has been associated with lower physical activity levels and increased obesity risk among adolescents in urban Southeast Asia (38).

Finally, cultural and behavioral norms related to food consumption may further explain observed differences. Adolescents from higher socioeconomic backgrounds may have greater autonomy in food purchasing, increased pocket money, and more frequent exposure to Western-style dietary patterns. In contrast, students from lower socioeconomic backgrounds may have more limited access to energy-dense foods despite the presence of obesogenic options within the school environment (36-39).

Several limitations should be considered when interpreting the findings of this study. First, the cross-sectional design precludes causal inference regarding the relationship between obesogenic school environments and adolescent body composition. Second, the study was conducted in only two urban high schools, which may limit generalizability to other regions, rural settings, or different types of schools in Indonesia. Third, SOES was assessed at the school level and may not fully capture individual variations in exposure to school food environments or physical activity facilities. Fourth, key confounding factors such as detailed dietary intake, screen time, household socioeconomic status, and physical activity outside school were not directly measured. Finally, body composition was assessed using a single bioelectrical impedance device without comparison to a gold-standard method such as dual-energy X-ray absorptiometry, although bioelectrical impedance analysis is widely accepted for field-based assessment of adolescent body composition.

## Conclusion

This study demonstrated that adolescent body composition, assessed by body fat percentage, among Indonesian high school students was influenced by a complex interplay of school-level and individual factors. Although the public school exhibited a more obesogenic food environment according to the SOES, students attending the private school had significantly higher body fat percentage and a greater prevalence of overweight and obesity.

Importantly, this study provided one of the first empirical applications of the SOES combined with objective body composition measures among adolescents in Indonesia. By incorporating body fat percentage rather than relying solely on BMI and by comparing public and private school settings, this study added novel evidence on the complexity of obesogenic influences in school environments within a low- and middle-income country context. These findings highlight the need for integrated obesity prevention strategies that extend beyond school food environments to address broader socioeconomic and lifestyle determinants.

## Acknowledgement

The authors would like to thank the principals, teachers, and staff of the participating schools for their cooperation and support during data collection. The authors are also grateful to the students and their parents or guardians for their willingness to participate in this study. Appreciation is extended to the field enumerators and research assistants from the Faculty of Public Health, Hasanuddin University, for their assistance with data collection and data management.

## Funding

This study was supported by the Internal Research Grant of the Faculty of Public Health, Hasanuddin University.

## Authors' Contribution

LT: conceptualization, methodology, investigation, formal analysis, funding acquisition, project administration, writing original draft; corresponding author. AIAT: conceptualization, methodology, validation, supervision, writing – review and editing. SMS: investigation, data curation, formal analysis, writing – review and editing. All authors have read and approved the final version of the manuscript and agree to be accountable for all aspects of the work.

## Conflict of Interest

The authors confirm no conflicts of interest.

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