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Association Between Body Fat Percentage and Blood Pressure Among Adolescents: A School Based Cross Sectional Study

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ABSTRACT

Background: Adolescent adiposity and elevated blood pressure are important cardiometabolic concerns. Body mass index does not distinguish fat mass from fat free mass, which limits its usefulness as a standalone indicator of adiposity.

Purpose: To assess the association between body fat percentage and blood pressure categories among adolescents.

Methods: This cross-sectional observational study included 245 students from two junior high schools in Kediri, Indonesia. Body fat percentage was measured by bioelectrical impedance analysis, and blood pressure was measured using an automatic monitor blood pressure. Descriptive statistics and Spearman rank correlation were used.

Results: Mean age was 13.44 ± 0.93 years; mean body fat was 20.45 ± 5.90%; and mean systolic and diastolic blood pressures were 110.21 ± 13.38 and 70.49 ± 8.48 mmHg, respectively. Overall, 196 students (80.0%) were categorized as having high or very high body fat, and 48 (19.6%) had non-normal blood pressure categories. The reported correlation was weak ($\rho = 0.297$; $p < 0.001$).

Conclusion: Body fat and blood pressure categories were associated in this sample. School-based assessment may combine body composition and blood pressure screening, with follow-up confirmation of abnormal blood pressure results.

Keywords : Adolescents, Blood pressure, Body composition, Body fat percentage, School health screening

BACKGROUND

High blood pressure in children and adolescents is increasingly viewed as a public health problem because it can persist into adulthood and increase cardiovascular risk. Recent meta-analyses estimate the prevalence of persistent hypertension in children and adolescents at around 3.9–4.3% when confirmed by repeated measurements, while the prevalence of high blood pressure at a single visit is higher (Ruan et al., 2025; Zhou et al., 2026). Obesity and excess adiposity are important factors, as they can activate the sympathetic nervous system, renin

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angiotensin aldosterone system, sodium retention, inflammation, and vascular dysfunction that contribute to increased blood pressure (Jeong & Kim, 2024; Clayton et al., 2023).

In adolescence, these risks occur alongside rapid changes in body composition, puberty, physical activity patterns, sedentary behaviour, sleep, and food consumption. Sleep, sedentary time, physical activity, and dietary patterns may accompany changes in adolescent adiposity (Gale et al., 2025; Kracht et al., 2023; Robles et al., 2024). School programs that combine physical activity, nutrition education, and behaviour modification can also lower blood pressure in children and adolescents, making schools an important setting for early detection and prevention (Hassan et al., 2024; Contardo Ayala et al., 2024).

BMI is still the most commonly used anthropometric indicator in screening because it is simple and inexpensive. However, BMI does not distinguish between fat mass and fat-free mass. BMI-based classifications can miss children and adolescents with high adiposity and unfavourable cardiometabolic profiles even if they do not meet the criteria for obesity based on BMI (Zapata et al., 2023). Body fat percentage can provide additional information about adiposity; research shows that body fat indicators can identify cardiometabolic risks that BMI may not detect (de Morais et al., 2023; Cota et al., 2022).

Bioelectrical impedance analysis (BIA) is a practical method for assessing body composition in a school setting because it is non-invasive, fast, and portable. However, BIA results are influenced by hydration status, tool configuration, prediction equations, and population characteristics and developmental stages (Orsso et al., 2022). At the same time, blood pressure measurement in adolescents also requires standardization of rest periods, cuff sizes, arm positions, and repeated measurements so screening results can be interpreted appropriately (Lurbe et al., 2023).

The relationship between body composition and blood pressure varies in adolescents. Bai et al. (2022) showed different patterns in the relationship between body fat percentage and blood pressure by sex, while Kwarteng et al. (2023) reported that puberty can modify the relationship between body components and blood pressure. These findings underscore the importance of local data and caution when interpreting bivariate relationships in a sample of adolescents undergoing rapid physiological change.

School-based evidence in Indonesia directly linking body fat percentage with blood pressure categories remains limited. This study examines whether body fat percentage, which can complement BMI, is associated with blood pressure status among junior high school students. Specifically, it aims to assess the association between body fat and blood pressure categories and describe participants' body fat percentage, systolic and diastolic blood pressures, and blood pressure classifications. These findings may inform school nursing screening and follow-up services.

METHODS

Design and Setting

This quantitative observational study used a cross-sectional design to examine body fat percentage and blood pressure at one point in time. It involved students from two junior high schools in Kediri, Indonesia. Data collection was conducted on August 26 and September 2, 2026.

Participants and Sampling

The final sample included 245 students aged 12–16 years (mean age 13.44 ± 0.93 years). Eligible students were actively enrolled and willing to participate. Exclusion criteria were fever or acute infection; known heart, kidney, or endocrine disease; and medication use that could affect blood pressure.

Instruments and Data Collection

Body fat percentage was measured by bioelectrical impedance analysis (BIA), following the device manufacturer's instructions. Blood pressure was measured with an automatic monitor after participants had rested while seated for five minutes. The arm was held at heart level, and cuff size was selected according to arm circumference. The procedure followed recommended principles for pediatric blood pressure assessment (Lurbe et al., 2023).

The study dataset applied sex-specific body fat categories: for males, low (<10%), normal (10% to <20%), high (20% to <25%), and very high (≥25%); for females, low (<20%), normal (20% to <30%), high (30% to <35%), and very high (≥35%). These categories were coded from 1 (low) to 4 (very high).

The dataset categorized blood pressure as normal (systolic <120 and diastolic <80 mmHg), prehypertension (systolic 120–139 and/or diastolic 80–89 mmHg), stage 1 hypertension (140–159 and/or 90–99 mmHg), and stage 2 hypertension (≥160 and/or ≥100 mmHg). Categories were coded from 1 to 4. These are the dataset's thresholds and do not constitute a diagnosis of pediatric hypertension without age-appropriate clinical assessment and confirmation (Lurbe et al., 2023; Chhabria et al., 2024).

Data Analysis

Continuous variables were summarized using means, standard deviations, 95% confidence intervals, medians, and ranges. Categorical variables were described using frequencies and percentages. The study used Spearman rank correlation to assess the association between ordinal body fat and blood pressure categories. Results were reported for all 245 participants.

Ethical Considerations

Ethical approval was reported under approval No. 139.3/3/VIII/EC/KEP/UNIK/2026 (2026). After obtaining the guardian's consent, students received information about the research regarding the purpose, procedures, voluntary participation and signed an assent form.

RESULTS

Table 1 presents the characteristics of the 245 adolescents. The sample comprised 126 males (51.4%) and 119 females (48.6%), with students from grades 7–9.

Table 1. Characteristics of participants (N = 245)

Characteristic	Category	n	%
Sex	Male	126	51.4
	Female	119	48.6
School grade	Grade 7	113	46.1
	Grade 8	65	26.5
	Grade 9	67	27.3

Characteristic	Category	n	%
Reported history of hypertension in older adults	Yes	62	25.3
	No	183	74.7

Note. Percentages are based on N = 245; totals may differ from 100% because of rounding.

Participants had a mean age of 13.44 ± 0.93 years (range 12–16). The mean body fat percentage was 20.45 ± 5.90%, and mean systolic and diastolic blood pressures were 110.21 ± 13.38 and 70.49 ± 8.48 mmHg, respectively (Table 2).

Table 2. Descriptive statistics of continuous variables

Variable	Mean ± SD	95% CI	Median	Range
Body fat (%)	20.45 ± 5.90	19.70–21.19	21.10	7.8–34.9
Systolic BP (mmHg)	110.21 ± 13.38	108.52–111.89	110.00	72–159
Diastolic BP (mmHg)	70.49 ± 8.48	69.43–71.56	70.00	46–96
Age (years)	13.44 ± 0.93	13.32–13.55	13.00	12–16
BMI (kg/m²)	20.93 ± 4.58	20.36–21.51	20.00	13.9–37.6

Note. BP = blood pressure; BMI = body mass index; SD = standard deviation; CI = confidence interval. Values have been rounded for consistent presentation.

In the study's categories, 197 participants (80.4%) had normal blood pressure, whereas 48 (19.6%) were classified as having non-normal blood pressure. Among participants, 196 (80.0%) were in the high or very high body fat groups (Table 3).

Table 3. Distribution of blood pressure and body fat categories (N = 245)

Variable	Category	n	%
Blood pressure	Normal	197	80.4
	Prehypertension	42	17.1
	Stage 1 hypertension	6	2.4
Body fat	Very high	32	13.1
	High	164	66.9
	Normal	36	14.7
	Low	13	5.3

Cross-tabulation revealed different blood pressure distributions across body fat categories. Among 32 students with very high body fat, 30 had normal blood pressure. In contrast, 6 of the 13 students in the low body fat group had normal blood pressure (Table 4).

Table 4. Cross-tabulation of body fat and blood pressure categories

Body fat category	Normal	Prehypertension	Stage 1	Total
Very high	30	2	0	32
High	139	23	2	164
Normal	22	13	1	36
Low	6	4	3	13
Total	197	42	6	245

The analysis reported a Spearman correlation coefficient of 0.297 with $p < 0.001$ ($N = 245$). The results supported a statistical relationship between body fat categories and blood pressure, but the association was weak.

DISCUSSION

The study reported a statistically significant but weak association between body fat and blood pressure categories among adolescents. Excess adiposity may be related to higher blood pressure through sympathetic activation, renin angiotensin aldosterone system activity, sodium retention, inflammation, and vascular dysfunction (Jeong & Kim, 2024; Clayton et al., 2023).

Activation of the sympathetic nervous system. Enlarged adipose tissue produces adipokines, including leptin. In obesity, leptin signaling can enhance sympathetic nervous system activity, leading to an increased heart rate, blood vessel constriction, and the release of renin by the kidneys. Consequently, blood pressure tends to rise. (Parvanova et al., 2023)

Activation of the renin–angiotensin–aldosterone system (RAAS). Adipose tissue does not merely store energy; it can also produce components of the RAAS, such as angiotensinogen. Activation of the RAAS increases levels of angiotensin II,which causes vasoconstriction as well as aldosterone, which promotes the retention of sodium and water by the kidneys. Both processes increase blood volume and blood pressure. (Parvanova et al., 2023; Shariq & McKenzie, 2020)

Sodium retention and impaired renal function. Visceral fat and fat surrounding the kidneys can exert pressure on renal structures, hindering the kidneys' ability to excrete sodium. Hyperinsulinemia, sympathetic activation, and the RAAS also enhance sodium reabsorption. Sodium retention draws water into the circulatory system, expanding intravascular volume and raising blood pressure. (DeMarco et al., 2014; Parvanova et al., 2023)

Low-grade chronic inflammation and oxidative stress. As adipocytes enlarge and become dysfunctional, adipose tissue produces an increased amount of pro-inflammatory mediators, such as TNF-α and IL-6, while producing fewer protective factors, such as adiponectin. This inflammation and oxidative stress can damage the vascular endothelium and increase peripheral vascular resistance. (DeMarco et al., 2014; Kang, 2013)

Endothelial dysfunction and vascular stiffness. A healthy endothelium produces nitric oxide to facilitate the relaxation of blood vessels. Adipose tissue dysfunction can reduce the bioavailability of nitric oxide and promote vasoconstriction. Consequently, blood vessels become less capable of dilating, resistance to blood flow increases, and blood pressure rises. (DeMarco et al., 2014)

Associations between body composition and blood pressure can differ by sex and pubertal development. Bai et al. (2022) identified sex-related differences, while Kwarteng et al. (2023) found that puberty modified these associations. Because this study included adolescents aged 12–16 years and had a nearly balanced sex distribution, future analyses should consider stratification and adjustment for developmental characteristics.

The proportion classified as high or very high body fat (80.0%) should be interpreted cautiously. BIA estimates vary with hydration, device algorithms, sex-specific thresholds, and participant characteristics (Orsso et al., 2022). Although prior studies indicate that BMI alone can miss excess adiposity and cardiometabolic risk (Zapata et al., 2023; de Morais et al., 2023;

Cota et al., 2022), this study did not directly compare the predictive performance of BMI and BIA.

In the dataset, 48 participants (19.6%) had non-normal blood pressure categories, comprising 17.1% with prehypertension and 2.4% with stage 1 hypertension. These results are screening classifications rather than confirmed pediatric hypertension. Meta-analyses report lower prevalence when elevated blood pressure is confirmed with repeated measurements (Ruan et al., 2025; Zhou et al., 2026). Accurate diagnosis requires appropriate follow-up measurements (Lurbe et al., 2023; Chhabria et al., 2024).

Limitations

The cross-sectional design precludes causal inference, and sampling from two junior highschools limits generalizability.

Implications for Nursing Practice

School nurses may consider body composition data alongside BMI and blood pressure when identifying students who could benefit from counseling and follow-up. Screening findings should be confirmed clinically rather than interpreted as diagnoses. School-based physical activity, nutrition, and behavioral strategies offer potential benefits for cardiovascular health (Hassan et al., 2024; Contardo Ayala et al., 2024), and sleep and sedentary patterns deserve attention (Gale et al., 2025; Kracht et al., 2023). Future research should analyze continuous body fat and systolic/diastolic pressure values and use appropriately adjusted statistical models.

CONCLUSION

Among 245 adolescents, 80.0% were categorized as having high or very high body fat, and 19.6% had non-normal blood pressure screening categories. A weak statistical association between body fat and blood pressure categories was reported. These findings suggest that school nursing assessments may consider body composition alongside blood pressure, with repeat measurements and clinical confirmation where indicated.

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AUTHOR CONTRIBUTIONS

Research design: Yeni LNA, Arif NE, Endang MY; data collection: Yeni LNA, Arif NE, Endang MY; data analysis: Endang MY, Arif NE; manuscript drafting and revision: Arif NE. All authors have approved the final manuscript for publication.

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CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

DECLARATION OF AI USE

During manuscript preparation, ChatGPT (OpenAI, GPT-6) was used to assist with journal template formatting and language editing. The authors remain responsible for reviewing the output and ensuring the accuracy and integrity of the article.

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