

## Impact of Childhood Obesity on Blood Pressure and Early Kidney Injury Markers Among School Going Children

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### Abstract:

**Background:** Childhood obesity is rising globally and is strongly associated with early-onset hypertension and renal dysfunction. Identifying these complications at an early stage is essential to prevent long-term morbidity.

**Aim:** To determine the prevalence of hypertension and early renal changes among overweight and obese school-aged children and assess the association between BMI category and hypertension.

**Methods:** This prospective observational study included 115 children aged 6–14 years at government Medical College, Mulugu (January–August 2025). BMI percentiles were classified using WHO charts. Blood pressure was measured as per AAP 2017 guidelines. Urine albumin–creatinine ratio assessed microalbuminuria, and renal ultrasound evaluated structural abnormalities. Data were analyzed using t-tests, Chi-square tests, and logistic regression.

**Results:** Elevated BP was observed in 20.9% of children, while Stage 1 and Stage 2 hypertension were present in 17.4% and 7.0%, respectively. Microalbuminuria occurred in 16.5%, and 10.4% showed increased cortical echogenicity on ultrasound. Obesity was significantly associated with hypertension ( $p = 0.004$ ), with obese children showing threefold higher risk.

**Conclusion:** Excess adiposity in school children is strongly linked with hypertension and early renal changes. Early screening, lifestyle interventions, and nephrology involvement are essential for prevention.

**Keywords:** Paediatric hypertension, Childhood obesity, Microalbuminuria, Renal ultrasound, BMI percentiles.

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### Introduction

Childhood overweight and obesity have emerged as major global public health concerns, with a rapid rise in prevalence across both developed and developing nations. Excess adiposity contributes to a spectrum of metabolic and cardiovascular complications, including elevated blood pressure (BP), which often goes unrecognized in paediatric populations [1]. Hypertension in children is no longer considered rare, and recent guidelines emphasize the importance of age-, sex-, and height-specific norms for accurate diagnosis. Obesity-mediated mechanisms such as sympathetic overactivity, insulin resistance, altered renin–angiotensin–aldosterone system (RAAS) activity and low-grade inflammation may lead to early vascular and renal injury, thereby increasing long-term risks of chronic kidney disease (CKD) and cardiovascular morbidity. Identifying hypertension early in overweight and obese school-aged children is therefore essential for enabling timely interventions and preventing future complications [1, 2].

Renal involvement in obesity-related hypertension is frequently overlooked despite the growing recognition of obesity-related glomerulopathy and early nephron injury. Microalbuminuria serves as a sensitive biomarker for subclinical renal damage, while renal ultrasound can detect structural abnormalities linked to obesity-related renal stress [3, 4]. Paediatric nephrologists play a crucial role in early detection, investigation and management of such renal effects. Screening BP using American Academy of Pediatrics (AAP) guidelines, along with assessment of microalbuminuria and renal imaging, provides a comprehensive approach to evaluating early kidney involvement [1, 5]. Understanding the prevalence and determinants of hypertension in this vulnerable population guides targeted preventive strategies and school-based health programs aimed at mitigating long-term renal and cardiovascular risks [4].

The aim of the study is to determine the prevalence and risk factors of hypertension among overweight

and obese school-aged children, with specific evaluation of renal ultrasound findings and microalbuminuria.

## Methods

This prospective observational study was conducted in the department of Pediatrics in government Medical College, Mulugu, from January 2025 to August 2025. School-aged children between 6 and 14 years who were classified as overweight or obese based on age- and sex-specific WHO BMI percentiles were recruited after obtaining approval from the Institutional Ethics Committee and written informed consent from parents or guardians. Children with known renal disease, endocrine disorders such as hypothyroidism or Cushing's syndrome, congenital heart disease, chronic inflammatory conditions, or those on medications affecting BP were excluded. A structured proforma was used to record demographic details, medical history, dietary pattern, sedentary behaviour, family history of hypertension, and physical activity. Anthropometric measurements, including height, weight, waist circumference, and BMI, were taken using standardized procedures. BMI percentiles were interpreted based on WHO growth charts, with  $\geq 85$ th percentile considered overweight and  $\geq 95$ th percentile obese.

BP measurements were obtained using a calibrated automated sphygmomanometer according to the AAP 2017 guidelines. BP was recorded in the right arm, with the child seated comfortably after a 5-minute rest period. Three readings at 2-minute intervals were taken, and the average of the last two readings was used for analysis. Hypertension and elevated BP were defined based on age-, sex-, and height-specific percentile cut-offs. All children underwent laboratory evaluation, which included fasting blood glucose, lipid profile, serum creatinine, and urine albumin-creatinine ratio (ACR) to assess microalbuminuria. Microalbuminuria was defined as an ACR between 30–300 mg/g. Early morning urine samples were preferred to avoid diurnal variation. Renal ultrasound examinations were performed by a radiologist blinded to clinical details, assessing kidney size, echogenicity, cortical thickness, and any structural abnormalities indicative of early nephropathy or obesity-related renal stress.

Data were systematically entered into a secure electronic database and cross-verified to minimize entry errors. The primary outcome variables included the prevalence of elevated BP and hypertension among overweight and obese children. Secondary variables included the association of BP status with anthropometric indicators, renal

ultrasound findings, and urinary microalbumin levels. Continuous variables such as age, BMI, and laboratory values were summarized as mean  $\pm$  standard deviation, while categorical variables such as gender, obesity grade, and presence of microalbuminuria were presented as frequencies and percentages. Appropriate statistical tests were applied: the Student's t-test for comparison of continuous variables, the Chi-square test for categorical variables, and Pearson correlation to assess relationships between BMI percentile, BP percentiles, and renal biomarkers. A multivariate logistic regression model was applied to identify independent predictors of hypertension. A p-value  $< 0.05$  was considered statistically significant. All statistical analyses were performed using SPSS software version 22.0.

## Results

A total of 115 overweight and obese school-aged children were enrolled in the study, as shown in Table 1. The mean age was  $10.6 \pm 2.4$  years, with a near-equal gender distribution. Based on WHO BMI percentiles, 60.9% of participants were obese and 39.1% were overweight, indicating a predominance of severe adiposity within the cohort. According to AAP 2017 guidelines, only 54.8% of children demonstrated normal blood pressure levels, while elevated BP was seen in 20.9% of participants. Stage 1 hypertension and Stage 2 hypertension were identified in 17.4% and 7.0% of children, respectively, reflecting a substantial burden of BP abnormalities (shown in Table 2). Overall, 44 children (38.3%) exhibited abnormal BP, highlighting the growing concern of early-onset hypertension among overweight and obese school-aged children. Evidence of early renal involvement was also noted. Microalbuminuria was detected in 16.5% of children, indicating subclinical glomerular injury. Renal ultrasound findings revealed increased cortical echogenicity in 10.4% and enlarged kidney size in 7.0% of participants, whereas a majority (82.6%) showed normal scans. These renal observations are summarized in Table 3, underscoring the potential impact of obesity on kidney health even before overt clinical manifestations arise.

A significant association between BMI category and hypertension was demonstrated in Table 4 ( $p = 0.004$ ). Obese children showed nearly three times the prevalence of hypertension compared to overweight children (32.8% vs. 11.1%). This pattern reinforces that higher adiposity is strongly linked with elevated BP and early renal changes, emphasizing the need for timely screening and nephrology-directed evaluation to prevent long-term renal and cardiovascular complications.

Variable	Mean $\pm$ SD / n (%)
Age	10.6 $\pm$ 2.4
Male / Female	62 (53.9) / 53 (46.1)
Overweight (85th–95th percentile)	45 (39.1)
Obese ( $\geq$ 95th percentile)	70 (60.9)
Mean BMI (kg/m <sup>2</sup> )	24.3 $\pm$ 3.0

BP category	Number (%)
Normal BP	63 (54.8)
Elevated BP	24 (20.9)
Stage 1 Hypertension	20 (17.4)
Stage 2 Hypertension	8 (7.0)

Parameter	Number (%)
Microalbuminuria present	19 (16.5)
Increased renal cortical echogenicity	12 (10.4)
Enlarged kidney size	8 (7.0)
Normal ultrasound	95 (82.6)

BMI category	Hypertension present	p value
Overweight (n = 45)	5 (11.1)	0.004
Obese (n = 70)	23 (32.8)	

## Discussion

Table 1 presents the baseline characteristics of the 115 overweight and obese school-aged children enrolled in the study. The mean age of 10.6 years reflects a critical developmental stage when lifestyle transitions, reduced physical activity, and increased caloric intake contribute to excess weight gain. The near-equal gender distribution indicates that obesity is a concern across both sexes, consistent with global paediatric trends. The predominance of obesity (60.9%) over overweight status (39.1%) highlights a shift toward more severe forms of adiposity in school-aged children, mirroring patterns described in recent epidemiological reports. The mean BMI of 24.3 kg/m<sup>2</sup> indicates that a substantial proportion of children fall within the obesity risk zone, increasing their susceptibility to metabolic and renal complications.

Childhood obesity has been strongly linked to early cardiovascular changes, including elevated blood pressure and endothelial dysfunction, which often begin silently during school years. Excess adiposity contributes to inflammation, insulin resistance, and activation of the renin–angiotensin–aldosterone system, thereby predisposing children to hypertension and renal injury early in life [6]. Studies have also shown that higher BMI percentiles correlate with increased risk of microalbuminuria and reduced nephron reserve, emphasizing the relevance of early nephrological evaluation [7]. Overall, the data in Table 1 underscore the urgent

need for targeted screening, lifestyle interventions, and renal monitoring in overweight and obese paediatric populations.

Table 2 highlights the distribution of blood pressure categories among the 115 overweight and obese school-aged children, based on AAP 2017 criteria. More than half of the participants (54.8%) exhibited normal blood pressure, whereas 20.9% had elevated BP, indicating early vascular changes that may precede clinical hypertension. The prevalence of Stage 1 hypertension (17.4%) and Stage 2 hypertension (7.0%) is notably high for a paediatric population, underscoring the strong association between excess adiposity and early-onset hypertension. These findings align with global trends demonstrating a rising burden of paediatric hypertension in parallel with increasing childhood obesity rates. Physiological mechanisms such as insulin resistance, sympathetic overactivity, leptin dysregulation, and activation of the renin–angiotensin–aldosterone system contribute significantly to BP elevation in obese children.

Several studies have shown that overweight and obese children are at 3–4 times higher risk of developing hypertension compared to their normal-weight peers [8]. Early BP elevation is also associated with increased arterial stiffness and endothelial dysfunction, which can progress silently during childhood [9]. Furthermore, hypertension in obese children has been linked to early renal involvement, manifesting as microalbuminuria and

glomerular hyperfiltration, reinforcing the importance of nephrology evaluation in this subgroup [10].

Table 3 summarizes the renal markers among overweight and obese school-aged children, demonstrating early evidence of nephrological involvement. Microalbuminuria was identified in 16.5% of participants, indicating early glomerular injury even before overt renal dysfunction develops. Microalbuminuria is widely recognized as an early predictor of both kidney disease and cardiovascular risk in obese children, resulting from glomerular hyperfiltration, increased intraglomerular pressure, and adiposity-related inflammation [11]. Additionally, renal ultrasound abnormalities were seen in a subset of children: 10.4% displayed increased cortical echogenicity, a sign often associated with early parenchymal stress or subclinical nephropathy, while 7.0% exhibited enlarged kidney size.

Obesity-related renal changes are increasingly reported in paediatric populations, driven by metabolic dysregulation, lipid accumulation in renal tissue, and heightened RAAS activation, which together promote glomerulomegaly and early structural changes [4]. The high proportion of normal ultrasound findings (82.6%) reflects that structural deterioration may lag behind biochemical manifestations such as microalbuminuria, reinforcing the value of urine albumin-creatinine ratio as an early screening tool. Similar studies have shown that obese children with microalbuminuria are at increased risk of developing obesity-related glomerulopathy, emphasizing the need for early nephrology referral and lifestyle interventions [12].

Table 4 demonstrates a significant association between BMI category and the prevalence of hypertension among the 115 overweight and obese school-aged children. Hypertension was present in 32.8% of obese children compared to only 11.1% of overweight children, with a statistically significant *p* value of 0.004. This clearly indicates that increasing adiposity is strongly correlated with rising blood pressure levels in the paediatric population. Obesity-induced mechanisms such as sympathetic nervous system activation, insulin resistance, low-grade inflammation, and renin-angiotensin-aldosterone system (RAAS) overstimulation play key roles in elevating BP as BMI increases [13]. The disproportionately higher prevalence in obese children aligns with global evidence showing that the severity of obesity directly influences the risk and grade of hypertension.

Previous studies have also reported a linear relationship between BMI percentile and systolic as well as diastolic BP in children, emphasizing that higher adiposity leads to early vascular changes and increased cardiac workload [14]. Moreover, obese

children with hypertension are more likely to exhibit early renal changes such as microalbuminuria and glomerular hyperfiltration, further supporting the need for nephrology involvement in this high-risk subgroup [15]. The findings of Table 4 reinforce the importance of BMI-based risk stratification and early screening for hypertension in obese children to prevent long-term renal and cardiovascular sequelae.

### Conclusion

This study demonstrated a high prevalence of elevated blood pressure and hypertension among overweight and obese school-aged children, emphasizing the strong influence of increasing BMI on cardiovascular and renal health. Early renal involvement, reflected by microalbuminuria and subtle ultrasound abnormalities, further highlights the silent yet progressive impact of excess adiposity. The significant association between obesity and hypertension underscores the need for routine BP screening in schools and early nephrology-guided evaluation. Preventive strategies focusing on weight reduction, lifestyle modification, and regular monitoring are essential to interrupt the trajectory toward chronic kidney disease and long-term cardiovascular complications.

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