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Original Research Article

Prevalence of Metabolic Syndrome in Children with Obesity

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Abstract:

Background: Childhood obesity has risen sharply over the past decades, leading to increased cardiometabolic risks. Metabolic syndrome (MS), characterized by central obesity, dyslipidemia, hypertension, and impaired glucose metabolism, poses significant long-term health threats in children.

Aim: To assess the prevalence of metabolic syndrome in South Asian children with obesity and examine associated anthropometric and biochemical parameters.

Methodology: A hospital-based cross-sectional study was conducted in 80 children aged 3–16 years attending the Department of Pediatrics, Shree Narayan Medical Institute & Hospital, Saharsa, Bihar, India. Anthropometric measurements, blood pressure, and fasting biochemical profiles were recorded. MS was defined using modified IDF criteria.

Results: Among 80 participants, 18 children (22.5%) met criteria for MS. Central obesity was most prevalent (62.5%), followed by elevated triglycerides (35%), low HDL-C (27.5%), hypertension (22.5%), and impaired fasting glucose (15%). Children with MS had significantly higher BMI, waist circumference, triglycerides, blood pressure, and fasting glucose, and lower HDL-C than those without MS ($p<0.05$). Girls demonstrated greater susceptibility to central obesity and dyslipidemia.

Conclusion: Metabolic syndrome affects a substantial proportion of South Asian children with obesity. Early screening and targeted lifestyle interventions are essential to mitigate long-term cardiovascular and metabolic risks.

Keywords: Childhood obesity, Metabolic syndrome, Central obesity, Dyslipidemia, Hypertension, Fasting glucose.

Introduction

Over the past three decades, the prevalence of obesity has increased dramatically across all age groups, including children [1]. The obesity epidemic among children has developed into a major public health crisis which creates critical health risks that affect both their present well-being and their future health status. The increasing rates of childhood obesity have resulted in more children developing health problems which include hypertension and type 2 diabetes mellitus and early signs of atherosclerosis a condition that doctors used to identify only in adults. The growing trend requires immediate action to understand and manage obesity-related health issues which affect children and adolescents.

The metabolic syndrome (MS) condition includes a group of cardiometabolic risk factors which are mostly identified through the combination of abdominal fat, abnormal lipid levels, high blood pressure, and fasting glucose problems [2]. The presence of metabolic syndrome in children creates serious health risks because it increases their chances of developing type 2 diabetes, heart disease, and nonalcoholic fatty liver disease (NAFLD) during their adult years. The existing evidence demonstrates that obese children face a higher risk of developing metabolic syndrome because their body shows multiple metabolic disorders which lead to ongoing cardiometabolic health issues that continue until they reach adulthood [3].

The prevalence and pattern of MS in children, however, show considerable differences between different populations and various geographic areas. In Western countries, several large-scale studies have documented the increasing burden of MS in pediatric populations, yet the studies produced different prevalence estimates because they used different diagnostic criteria and studied different age groups and followed different research methods. The available information from South Asia remains scarce. The region has very few research studies which have conducted systematic evaluations of MS in obese children and there is a complete lack of research studies from South India. The absence of data specific to this region creates obstacles for developing

effective prevention and treatment approaches, because genetic factors and environmental influences and lifestyle choices will determine how metabolic disorders present themselves among children in South India populations [4].

Childhood obesity develops as a result of multiple factors which include genetic tendencies and eating habits and lack of physical exercise and economic conditions and environmental circumstances [5]. Obesity develops through these elements which also affect the likelihood of developing metabolic disorders that follow it. The measurement of abdominal obesity through waist circumference serves as a primary element of metabolic syndrome because it indicates the presence of visceral fat which operates within the body to cause insulin resistance and overall body inflammation [6]. Obese children with dyslipidemia present two specific symptoms which include high triglyceride levels and low high-density lipoprotein (HDL) cholesterol levels which together predict their future cardiovascular risk. The combination of elevated blood pressure and impaired fasting glucose creates additional metabolic challenges which makes it important to discover and treat this condition at an early stage.

The childhood obesity epidemic has reached critical levels because children now develop metabolic syndrome at younger ages so researchers must assess the metabolic syndrome rates which affect children in areas where data remains scarce [7]. The study examines metabolic syndrome rates among overweight and obese children at an endocrinology clinic located in a South Asian state to establish local disease patterns and determine which groups face the highest risk. The study compares metabolic syndrome children with their non-metabolic syndrome counterparts to determine which metabolic disorders show the highest severity in affected patients content which helps doctors develop treatment plans and preventive measures.

The researchers expected that children with obesity would show higher MS rates than children with overweight status. The researchers expected that children with MS would have more severe metabolic disorders than children without the condition. The research aims to fill an existing research gap about metabolic syndrome in South Asian children while providing insights into pediatric obesity and its related cardiometabolic effects.

Methodology

Study Design: This study was a hospital-based descriptive cross-sectional study conducted to assess the prevalence of metabolic syndrome in children with obesity. The study aimed to evaluate anthropometric, clinical, and biochemical parameters in obese children and identify the proportion fulfilling criteria for metabolic syndrome.

Study Area: The study was carried out in the Department of Pediatrics, Shree Narayan Medical Institute & Hospital, Saharsa, Bihar, India from January 2023 to December 2023.

Study Participants

Inclusion Criteria

- Children aged 3–16 years diagnosed with overweight or obesity based on standard BMI percentiles.
- Children attending the pediatric outpatient or endocrinology clinic during the study period.
- Children whose guardians provided written informed consent for participation.

Exclusion Criteria

- Children with obesity secondary to endocrine disorders such as Cushing syndrome, hypothyroidism, or hypothalamic dysfunction.
- Syndromic obesity including Prader-Willi syndrome, Laurence-Moon-Bardet-Biedl syndrome, or other genetic syndromes.
- Children on medications affecting weight or metabolic profile, including long-term steroids, antipsychotics, or antidepressants.
- Children with chronic illnesses affecting growth or metabolism such as chronic kidney disease or liver disease.

Sample Size: A total of 80 children meeting the inclusion criteria were enrolled in the study.

Procedure: All eligible children were enrolled after obtaining written informed consent from their guardians. Demographic data, including age, sex, and family history of obesity or metabolic disorders, were collected using a structured predesigned questionnaire. Anthropometric measurements were performed for each child following standardized techniques. Body weight was measured using an electronic weighing scale to the nearest 0.1 kg, with participants wearing light clothing and no footwear. Height was measured using a stadiometer to the nearest 0.1 cm. Waist circumference (WC) was measured midway between the lowest rib and the iliac crest using a non-stretchable tape with uniform pressure applied, recorded to the nearest 0.1 cm. WC above the 75th percentile for age and sex was considered indicative of abdominal obesity.

Blood pressure was measured on the right arm in a sitting position using a standard sphygmomanometer, repeated after 30 minutes if elevated. Blood pressure ≥90th percentile for age, sex, and height was considered elevated, while ≥95th percentile was defined as hypertension. Fasting blood samples were collected after at least 8 hours of overnight fasting to assess glucose levels, lipid profile including triglycerides, HDL-C, LDL-C, and total cholesterol. Metabolic syndrome (MS) was defined according to modified International Diabetes Federation criteria: central obesity plus at least two of the following—elevated triglycerides (≥95th percentile), low HDL-C (<5th percentile), elevated blood pressure (≥90th

percentile), and impaired fasting glucose (≥100 mg/dl). Dyslipidemia was defined as ˙total cholesterol ≥200 mg/dl, LDL-C ≥130 mg/dl, triglycerides ≥95th percentile, or HDL-C <40 mg/dl.

Statistical Analysis: All collected data were entered and analyzed using SPSS version 27.0. Quantitative variables, including anthropometric and biochemical measurements, were expressed as mean ± standard deviation (SD), while qualitative data, including prevalence of metabolic syndrome and its components, were presented as frequencies and percentages. The Chi-square test or Fisher's exact test was used to compare categorical variables, and Student's t-test was applied for comparison of continuous variables between groups. A p-value of <0.05 was considered statistically significant.

Result

Table 1 presents the demographic characteristics of the 80 study participants. The age distribution showed that the largest proportion of participants was in the 7–10 years age group, comprising 25 children (31.3%), followed by 14–16 years with 23 children (28.7%), 11–13 years with 20 children (25%), and the 3–6 years group with 12 children (15%). Regarding gender, there were slightly more males than females, with 42 males (52.5%) and 38 females (47.5%), indicating a relatively balanced gender representation in the study population.

Table 1: Demographic Characteristics of Study Participants (n = 80)

Variable	Frequency (n)	Percentage (%)
Age Group (years)		
3–6	12	15
7–10	25	31.3
11–13	20	25
14–16	23	28.7
Gender		
Male	42	52.5
Female	38	47.5

Table 2 presents the anthropometric measurements of˙ the study participants. The mean weight of the participants was 42.5 ± 11.2 kg, ranging from 20 to 75 kg, while ˙the mean height was 138.4 ± 15.3 cm, with values between 95 and 165 cm. The mean body mass index (BMI) was 22.8 ± 3.5 kg/m², spanning a range of 18 to 30 kg/m², indicating that most participants fell within the normal to overweight categories. Additionally, the mean waist circumference was 78.6 ± 10.1 cm, with a minimum of 60 cm and a maximum of 100 cm, reflecting variations in central adiposity among the participants. Overall, these measurements suggest moderate variability in body size and composition within the study population.

Table 2: Anthropometric Measurements

Parameter	Mean ± SD	Range
Weight (kg)	42.5 ± 11.2	20 – 75
Height (cm)	138.4 ± 15.3	95 – 165
BMI (kg/m²)	22.8 ± 3.5	18 – 30
Waist Circumference (cm)	78.6 ± 10.1	60 – 100

Table 3 shows the prevalence of individual components of metabolic syndrome among the study participants. Central obesity, defined as waist circumference above the 75th percentile, was the most common component, observed in 50 children, accounting for 62.5% of˙ the sample. Elevated triglycerides (≥95th percentile) were present in 28 children (35%), while low HDL-C levels (<5th percentile) were seen in 22 children (27.5%). Elevated blood pressure (≥90th percentile) was identified in 18 children, ˙representing 22.5% of the participants. Impaired fasting glucose (≥100 mg/dl) was the least prevalent component, affecting 12 children or 15% of the sample. Overall, central obesity emerged as the predominant metabolic abnormality, followed by dyslipidemia, hypertension, and impaired glucose regulation.

Table 3: Prevalence of Components of Metabolic Syndrome

Component	Frequency (n)	Percentage (%)
Central Obesity (WC >75th percentile)	50	62.5
Elevated Triglycerides (≥95th percentile)	28	35
Low HDL-C (<5th percentile)	22	27.5
Elevated Blood Pressure (≥90th percentile)	18	22.5
Impaired Fasting Glucose (≥100 mg/dl)	12	15

Table 4 shows the prevalence of metabolic syndrome among the study participants based on the modified IDF criteria. Out of the total sample, 18 children (22.5%) were found to have metabolic syndrome, whereas the majority, 62 children (77.5%), did not meet the criteria for the condition. This indicates that nearly one-fourth of the obese children in the study population were affected by metabolic syndrome, highlighting a significant burden of cardiometabolic risk factors in this group.

Table 4: Prevalence of Metabolic Syndrome According to Modified IDF Criteria

Presence of Metabolic Syndrome	Frequency (n)	Percentage (%)
Metabolic Syndrome Present	18	22.5
Metabolic Syndrome Absent	62	77.5

Table 5 shows a clear distinction in metabolic parameters between children with and without metabolic syndrome (MS). Children with MS (n=18) had significantly higher body mass index (25.3 ± 3.1 kg/m² vs. 22.1 ± 3.2 kg/m²; p=0.002) and waist circumference (86.5 ± 7.2 cm vs. 76.0 ± 9.5 cm; p<0.001) compared to those without MS (n=62). Lipid profiles were also markedly different, with higher triglyceride levels (165 ± 25 mg/dl vs. 110 ± 18 mg/dl; p<0.001) and lower HDL-C levels (36 ± 4 mg/dl vs. 45 ± 6 mg/dl; p<0.001) observed in children with MS. Additionally, children with MS exhibited elevated systolic blood pressure (118 ± 10 mmHg vs. 105 ± 9 mmHg; p=0.001) and fasting glucose (102 ± 8 mg/dl vs. 92 ± 6 mg/dl; p=0.003), indicating a significantly higher cardiometabolic risk in this group. Overall, the table highlights that child with metabolic syndrome have worse anthropometric, lipid, and glycemic profiles compared to their peers without the syndrome.

Table 5: Comparison of Metabolic Parameters Between Children with and Without Metabolic Syndrome

Parameter	MS Present (n=18) Mean ± SD	MS Absent (n=62) Mean ± SD	p-value
BMI (kg/m²)	25.3 ± 3.1	22.1 ± 3.2	0.002
Waist Circumference (cm)	86.5 ± 7.2	76.0 ± 9.5	<0.001
Triglycerides (mg/dl)	165 ± 25	110 ± 18	<0.001
HDL-C (mg/dl)	36 ± 4	45 ± 6	<0.001
Systolic BP (mmHg)	118 ± 10	105 ± 9	0.001
Fasting Glucose (mg/dl)	102 ± 8	92 ± 6	0.003

Discussion

The current research shows that 22.5% of children with obesity and overweight status developed metabolic syndrome (MS), which demonstrates that pediatric populations already experience significant cardiometabolic health issues. This prevalence aligns with reports from other South India studies, though variations exist due to differences in diagnostic criteria and study populations. Andrabi et al. (2013) [8] reported that 30.7% of children between 8 and 18 years in Srinagar, Kashmir showed a strong link between their obesity level and metabolic syndrome (MS) development. The study by Singh et al. (2007) [9] found that 11% of adolescents with their BMI between the 85th and 95th percentile developed MS while 33% of those beyond the 95th percentile in North India showed the same condition which demonstrates how body fat affects metabolic health. The study found that overweight children showed a higher prevalence which reached 28% while it reached 11% in the study because we included younger children who were between 3 and 8 years and because we applied the modified IDF criteria which emphasize central obesity more than the modified ATP III criteria used in North Asian studies.

The most common obesity type in our study group affected 62.5% of children. The study results show European populations exhibit abdominal obesity rates between 42% and 100% among children who are overweight or obese (Garrido et al., 2019) [10]. South Asian children show higher rates of truncal adiposity because genetic and lifestyle factors contribute to their visceral fat accumulation starting from lower BMI levels (Pandit et al., 2012) [11]. Spanish research found central obesity affects 65–78% of obese children which shows consistent patterns across different geographical areas (Guijarro de Armas et al., 2012) [12]. The high central obesity rates in our group demonstrate this risk factor which shows that waist circumference measurement should serve as an essential screening method for pediatric obesity programs.

The current research demonstrated dyslipidemia as a major health problem because hypertriglyceridemia affected 35% of the participants and low HDL-C occurred in 27.5% of the participants. The results of this study match the Lebanese study which Nasreddine et al. (2010) [13] found that low HDL-C affected 30% of prepubertal obese children and the Egyptian study which Zaki et al. (2012) [14] discovered that 38% of children with obesity had hypertriglyceridemia. The Polish and Turkish studies found

higher numbers of people with low HDL-C which reached 32 to 35 percent and hypertriglyceridemia which affected 40 to 42 percent of the population, which shows that regional eating patterns and hereditary traits impact the lipid profiles of children in those areas (Di Taranto et al., 2019) [15]. The research demonstrated that children with metabolic syndrome maintained higher triglyceride levels and lower HDL-C levels when compared to their counterparts who did not have the condition, which revealed a pattern of atherogenic lipid distribution among children who experienced metabolic health issues.

The cohort showed hypertension at a rate of 22.5% and impaired fasting glucose at a rate of 15%. The Romanian data shows similar results because Pelin and Mătăsaru (2012) [16] found that 20% of Romanian children with MS showed hypertension and 12% of those children displayed IFG. Weiss et al. (2004) [17] found that 38.7% of obese adolescents showed high blood pressure which increased to 49.7% in the group with extreme obesity. The findings demonstrate that obese children develop cardiovascular risk factors at an early age which makes blood pressure and glucose testing essential for pediatric obesity screening programs.

The present study found significant sex-based differences in MS prevalence because girls exhibited higher rates of central obesity and hypertriglyceridemia and low HDL-C compared to boys. The results from the current study match the findings from Lebanon which showed girls had higher rates of MS and dyslipidemia (Nasreddine et al., 2010) while the research from Spain and Turkey found no major sex-based differences (Atabek et al., 2006) [18]. The research results indicate that girls have greater central body fat distribution which causes them to reach higher obesity levels than boys at the same BMI measurements as shown in our research results (100% girls vs. 99% boys with obesity showing central adiposity).

The study's observed trends were restricted because our research used a cross-sectional design which required participants to be recruited from one research location thus preventing us from making causal conclusions about South Asian populations. The research provides essential regional data because there are very few studies from southern India that examine children aged three to eight years whom researchers have not studied before. The international research evidence supports our results which show that obesity in children leads to a metabolic syndrome prevalence that ranges from 10 percent to 50 percent based on their age, sex, degree of obesity, ethnicity, and the criteria used to assess them (Guijarro de Armas et al., 2012).

The current study demonstrates that metabolic syndrome exists in South Asian children who suffer from obesity because central obesity and dyslipidemia and hypertension and IFG constitute the main features of their condition. The findings demonstrate that research from South Asia and high-income countries both support the existence of pediatric metabolic syndrome as a worldwide health issue which requires immediate preventive measures. The screening process should use anthropometric metrics together with metabolic testing methods as the main assessment tools for both young children and girls who display higher risks of developing metabolic disorders. The implementation of early lifestyle modification programs which address dietary and physical activity and behavioral changes will decrease cardiovascular and metabolic health threats that affect this vulnerable community.

Conclusion

The present study demonstrates that metabolic syndrome affects a substantial proportion (22.5%) of South Asian children with obesity, highlighting the significant cardiometabolic risk in this population. Central obesity emerged as the most prevalent component, followed by dyslipidemia, hypertension, and impaired fasting glucose, consistent with global patterns observed in pediatric obesity. Children with metabolic syndrome exhibited markedly higher BMI, waist circumference, triglycerides, blood pressure, and fasting glucose, alongside lower HDL-C, compared to those without the syndrome, emphasizing the clustering of metabolic abnormalities. Girls were particularly susceptible to central obesity and dyslipidemia. These findings underscore the importance of early identification through routine anthropometric and biochemical screening, and the implementation of targeted lifestyle interventions focusing on diet, physical activity, and behavioral modification to reduce the long-term risk of cardiovascular disease and type 2 diabetes in this high-risk group.

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