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The prevalence of metabolic syndrome in adolescents at tertiary care centre in South Tamil Nadu

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Abstract:

Background:

Metabolic syndrome (MetS) in adolescents comprises a constellation of risk factors including central obesity, hypertension, dyslipidemia, and impaired glucose regulation, increasing the risk of type 2 diabetes and cardiovascular diseases. Rising adolescent obesity and sedentary lifestyles have contributed to a growing prevalence of MetS globally and in India.

Objective:

To determine the prevalence of metabolic syndrome in adolescents attending a tertiary care center and to identify associated risk factors such as obesity, sedentary lifestyle, dietary patterns, and screen time.

Methods:

This cross-sectional study included 400 adolescents aged 10–19 years attending an outpatient department over six months. Data were collected through clinical assessment, anthropometry, blood pressure measurements, and fasting biochemical parameters. MetS was diagnosed using the International Diabetes Federation (IDF) criteria. Lifestyle habits and family history were assessed via a structured questionnaire. Data were analyzed using SPSS v25.0, with logistic regression performed to determine predictors of MetS.

Results:

The overall prevalence of MetS was 14.5%, with significantly higher rates among obese (50%)

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and overweight (16.7%) adolescents. Key risk factors included sedentary lifestyle (69% in MetS group), junk food intake ≥3 times/week (79.3%), screen time ≥2 hours/day (75.9%), and family history of diabetes (44.8%). Logistic regression revealed obesity (OR = 7.2), sedentary lifestyle (OR = 3.1), screen time (OR = 2.6), and family history of diabetes (OR = 2.3) as independent predictors.

Conclusion:

MetS is prevalent among adolescents, particularly those with obesity and poor lifestyle habits. Early screening and targeted interventions focused on physical activity, nutrition education, and behavior modification are essential to curb the long-term health consequences of adolescent MetS.

Keywords:

Metabolic syndrome, adolescents, obesity, sedentary lifestyle, screen time, insulin resistance, cardiovascular risk, IDF criteria, tertiary care, lifestyle intervention.

Introduction

Metabolic Syndrome (MetS) is a cluster of interrelated metabolic abnormalities that significantly increase the risk of cardiovascular disease and type 2 diabetes mellitus (1). In adolescents, MetS is characterized by central obesity, insulin resistance, hypertension, hypertriglyceridemia, and low high-density lipoprotein (HDL) cholesterol levels. The escalating prevalence of MetS among adolescents has become a global health concern, mirroring the rising trends in pediatric obesity. The prevalence of MetS among adolescents varies widely across different populations and is influenced by factors such as ethnicity, socioeconomic status, and lifestyle habits (2).

In India, the prevalence rates exhibit considerable heterogeneity. A study conducted in the Jammu region reported a MetS prevalence of 2.67% among adolescents, with a notable association between central obesity and MetS development (3). Conversely, research among overweight and obese schoolchildren in North India indicated a higher prevalence of 21.8%, underscoring the impact of adiposity on metabolic health (4). A systematic review and meta-analysis encompassing various Indian studies revealed prevalence rates ranging from 0.8% to 19.4%, highlighting the influence of regional and methodological differences (5).

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The rising prevalence of MetS in adolescents is closely linked to the increasing rates of obesity within this demographic. Obesity serves as a central component of MetS, with excess adipose tissue contributing to insulin resistance, dyslipidemia, and hypertension. The pathogenesis of MetS in youth is multifaceted, involving genetic predisposition, sedentary behavior, unhealthy dietary patterns, and environmental factors. Early identification and intervention are paramount, as adolescents with MetS are at a heightened risk of progressing to type 2 diabetes and cardiovascular diseases in adulthood (6).

In the Indian context, the rapid epidemiological transition characterized by urbanization and lifestyle modifications has precipitated an increase in non-communicable diseases among adolescents. Traditional diets are being supplanted by energy-dense, nutrient-poor foods, and physical activity levels have declined, contributing to the surge in obesity and MetS. A study among the Kukana tribe adolescents in Valsad district reported a MetS prevalence of 3.9%, reflecting the penetration of metabolic disorders into indigenous populations (7). Another study among North Indian adolescents found a prevalence of 5.2%, with higher rates observed in males and those aged 13–15 years (8).

The implications of MetS during adolescence are profound, extending beyond immediate health concerns. Adolescents with MetS often exhibit lower exercise capacity compared to their peers, and the presence of MetS components during youth has been linked to an increased likelihood of developing MetS, type 2 diabetes, and subclinical atherosclerosis in adulthood (9). Furthermore, the psychological burden associated with obesity and metabolic abnormalities can adversely affect mental health, leading to issues such as depression and anxiety (10).

The aim of this study is to determine the prevalence of metabolic syndrome (MetS) in adolescents attending a tertiary care center and to assess the associated risk factors, including obesity, physical activity levels, dietary habits, and socioeconomic status. By identifying the burden of MetS in this population, the study aims to highlight the need for early screening, lifestyle interventions, and preventive strategies to reduce the risk of long-term metabolic and cardiovascular complications in adolescents.

Methodology

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This study was conducted as a cross-sectional observational study at a tertiary care centre in South Tamil Nadu over a period of six months in 2024. The study population included adolescents aged 10 to 19 years, attending the outpatient department (OPD) for routine check-ups or other non-acute complaints. The sample size was calculated based on the expected prevalence of metabolic syndrome (MetS) in Indian adolescents, with an estimated prevalence of 10%–15% in previous studies. Using a 95% confidence level and a margin of error of 5%, a final sample size of 400 adolescents was determined for adequate statistical power.

Inclusion and Exclusion Criteria

Inclusion criteria:

- Adolescents aged 10 to 19 years.
- Those who provided informed consent (and assent for minors).
- Adolescents attending the OPD for routine health check-ups or non-acute medical concerns.

Exclusion criteria:

- Adolescents with known endocrine disorders (e.g., type 1 diabetes, Cushing's syndrome).
- Those on long-term medications affecting metabolic parameters (e.g., corticosteroids, antipsychotics).
- Adolescents with acute illnesses at the time of examination.

Data Collection and Measurements

Each participant underwent a **detailed clinical assessment**, including anthropometric measurements, blood pressure evaluation, and biochemical investigations.

- **A**nthropometry: Height was measured using a stadiometer with accuracy to 0.1 cm, and weight was recorded using a calibrated digital scale to the nearest 0.1 kg. Body mass index (BMI) was calculated as weight (kg)/height (m^2) and categorized based on the World Health Organization (WHO) BMI-for-age percentiles. Waist circumference (WC) was measured at the midpoint between the lower rib and the iliac crest using a

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non-stretchable measuring tape, and central obesity was defined based on the International Diabetes Federation (IDF) criteria.

- Blood Pressure (BP): BP was measured using a calibrated sphygmomanometer with an appropriately sized cuff. The mean of two readings taken five minutes apart was recorded. Hypertension was defined as systolic or diastolic BP ≥ 90th percentile for age, sex, and height (based on the National High Blood Pressure Education Program guidelines).
- Biochemical Investigations: A fasting venous blood sample (8–12 hours of fasting) was collected to analyze:
    - Fasting blood glucose (FBG) – measured using the glucose oxidase-peroxidase method.
    - Fasting lipid profile (Triglycerides, HDL cholesterol) – analyzed using enzymatic colorimetric methods.

Definition of Metabolic Syndrome

MetS was diagnosed using the International Diabetes Federation (IDF) 2007 criteria for adolescents (11,12), which requires:

1. Central obesity (waist circumference ≥90th percentile for age and sex) plus any two of the following:
    - Elevated triglycerides (≥150 mg/dL).
    - Low HDL cholesterol (<40 mg/dL in males, <50 mg/dL in females).
    - Hypertension (SBP or DBP ≥90th percentile or ≥130/85 mmHg for those aged 16 and above).
    - Impaired fasting glucose (≥100 mg/dL) or known type 2 diabetes mellitus.

Lifestyle and Behavioral Assessment

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A structured questionnaire was administered to assess:

- Dietary habits (frequency of junk food consumption, fruit/vegetable intake).
- Physical activity levels, categorized as sedentary, moderately active, or highly active based on self-reported activity duration (WHO recommendations).
- Screen time usage, with excessive usage defined as ≥2 hours/day (as per American Academy of Pediatrics guidelines).

Statistical Analysis

All collected data were entered into SPSS version 25.0 for statistical analysis. Descriptive statistics (mean, standard deviation, and frequency distribution) were used to summarize participant characteristics. Chi-square tests were applied to assess associations between categorical variables, and independent t-tests were used for continuous variables. Multivariate logistic regression was performed to identify independent predictors of MetS, adjusting for potential confounders. A p-value < 0.05 was considered statistically significant.

Results

A total of 400 adolescents participated in the study, with an almost equal distribution of males (52%) and females (48%). The mean age of the participants was 14.8 ± 2.3 years. The overall prevalence of metabolic syndrome (MetS) was 14.5% (n=58) based on the International Diabetes Federation (IDF) criteria.

Table 1: Baseline Characteristics of Study Participants

Characteristic	Mean ± SD / Frequency (%)
Age (years)	14.8 ± 2.3
Male	208 (52%)
Female	192 (48%)
BMI (kg/m²)	23.4 ± 4.5

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Overweight	84 (21%)
Obese	72 (18%)
Waist circumference ≥ 90th percentile	96 (24%)
Hypertension (SBP/DBP ≥ 90th percentile)	72 (18%)
Triglycerides ≥ 150 mg/dL	64 (16%)
HDL cholesterol < 40 mg/dL (males) / < 50 mg/dL (females)	102 (25.5%)
Fasting glucose ≥ 100 mg/dL	48 (12%)
Metabolic Syndrome (IDF criteria)	58 (14.5%)

Among the total participants, **18% were obese**, and **21% were overweight**. Central obesity (waist circumference ≥90th percentile) was found in **24%** of the adolescents. **Hypertension** was observed in **18%**, while **16% had elevated triglycerides**, and **12% had impaired fasting glucose levels**.

Prevalence of MetS by BMI Category

Table 2: Prevalence of Metabolic Syndrome Based on BMI Categories

BMI Category	Total (n)	MetS Present (n)	Prevalence (%)
Normal weight	244	8	3.3%
Overweight	84	14	16.7%
Obese	72	36	50.0%
Total	400	58	14.5%

The prevalence of MetS was significantly higher among obese adolescents (50%), compared to overweight (16.7%) and normal-weight individuals (3.3%).

Association of MetS with Lifestyle Factors

Table 3: Association Between Metabolic Syndrome and Lifestyle Factors

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Factor	MetS Present (n=58)	MetS Absent (n=342)	p-value
Sedentary lifestyle	40 (69.0%)	132 (38.6%)	**<0.001**
Junk food ≥3 times/week	46 (79.3%)	180 (52.6%)	**0.002**
Screen time ≥2 hours/day	44 (75.9%)	168 (49.1%)	**0.001**
Family history of diabetes	26 (44.8%)	88 (25.7%)	**0.004**

A sedentary lifestyle, frequent consumption of junk food, increased screen time, and a family history of diabetes were significantly associated with MetS ($p < 0.05$).

Predictors of Metabolic Syndrome (Logistic Regression Analysis)

Table 4: Multivariate Logistic Regression for Predictors of MetS

Variable	Adjusted OR	95% CI	p-value
Obesity (BMI ≥95th percentile)	7.2	3.8 – 13.5	**<0.001**
Sedentary lifestyle	3.1	1.7 – 5.5	**0.002**
Screen time ≥2 hours/day	2.6	1.4 – 4.8	**0.008**
Family history of diabetes	2.3	1.2 – 4.5	**0.012**

Obesity was the strongest predictor of MetS (OR = 7.2, $p < 0.001$), followed by sedentary lifestyle (OR = 3.1, $p = 0.002$), screen time ≥2 hours/day (OR = 2.6, $p = 0.008$), and family history of diabetes (OR = 2.3, $p = 0.012$).

Figure 1: Prevalence of Metabolic Syndrome by BMI Category

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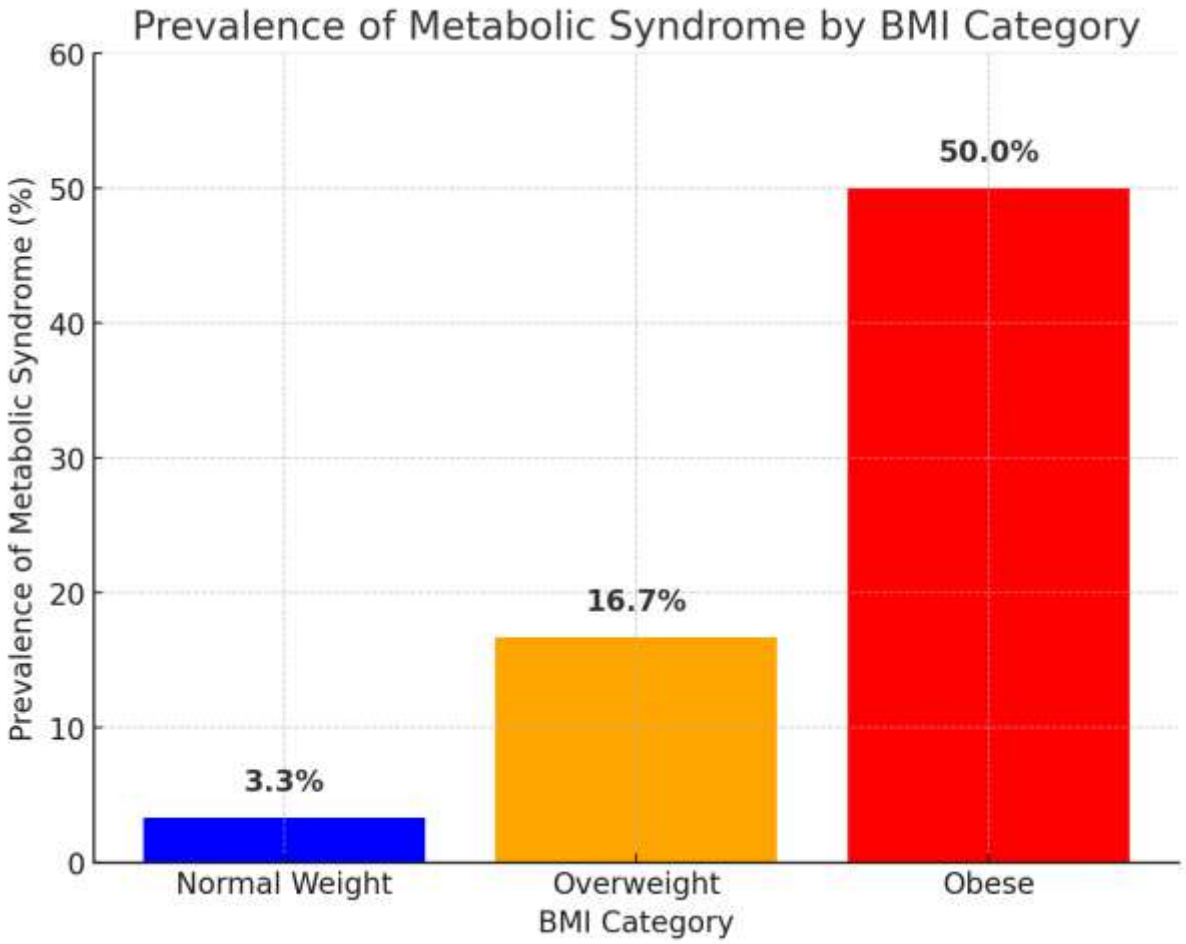
The bar graph shows a clear positive association between increasing BMI and MetS prevalence, emphasizing the role of obesity as the strongest risk factor.



Discussion

The present study sought to determine the prevalence of metabolic syndrome (MetS) among adolescents attending a tertiary care center and to identify associated risk factors. Our findings revealed a MetS prevalence of 14.5%, with a notably higher occurrence in obese (50%) and overweight (16.7%) adolescents. These results underscore the significant burden of MetS in this demographic and highlight the urgent need for targeted preventive strategies.

Comparison with Existing Literature

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The observed prevalence in our study aligns with certain regional studies but also exhibits variability when compared to others. For instance, a study conducted in North India reported a MetS prevalence of 4.2% among adolescents, with a striking 36.6% prevalence among overweight individuals (13). Another study from the Jammu region found a 2.67% prevalence in the general adolescent population, increasing to 33% among those with central obesity (14). These discrepancies may stem from differences in diagnostic criteria, demographic variations, and lifestyle factors across regions.

Risk Factors and Associations

Our study identified several factors significantly associated with MetS. The strong correlation between obesity and MetS is well-documented. Obesity serves as a central component of MetS, contributing to insulin resistance and other metabolic disturbances (15). A sedentary lifestyle, characterized by limited physical activity and prolonged screen time, has been linked to an increased risk of MetS. These behaviors contribute to weight gain and metabolic imbalances (16). Frequent consumption of junk food, high in simple carbohydrates and unhealthy fats, is associated with MetS. Such dietary patterns can lead to obesity and dyslipidemia, key components of MetS. A positive family history of diabetes was found to be a significant predictor of MetS, suggesting a genetic predisposition to metabolic abnormalities (16).

Implications for Public Health

The rising prevalence of MetS among adolescents is alarming, given its association with long-term health complications such as type 2 diabetes and cardiovascular diseases. Early identification and intervention are crucial. Implementing school-based programs that promote physical activity and healthy eating habits can be effective preventive measures. Additionally, educating families about the importance of lifestyle modifications is essential in mitigating the risk of MetS.

Strengths and Limitations

A strength of this study is its comprehensive assessment of MetS and associated risk factors within a tertiary care setting, providing valuable insights into the health status of adolescents

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seeking medical care. However, the study's cross-sectional design limits the ability to establish causality. Furthermore, as the study was conducted in a single center, the findings may not be generalizable to the broader adolescent population.

Conclusion

The study highlights a significant prevalence of MetS among adolescents, particularly those who are overweight or obese. Addressing modifiable risk factors such as physical inactivity, poor dietary habits, and excessive screen time is imperative. Public health initiatives focusing on lifestyle interventions during adolescence could play a pivotal role in reducing the burden of MetS and its associated complications in the future.

Recommendations

Given the significant prevalence of metabolic syndrome (MetS) among adolescents, there is an urgent need for early screening, preventive interventions, and lifestyle modifications to mitigate future health risks. Schools and communities should implement structured physical activity programs to reduce sedentary behaviour and promote a healthy lifestyle. Nutritional education campaigns targeting both adolescents and parents should focus on reducing the consumption of processed and high-calorie foods while encouraging a balanced diet rich in fruits, vegetables, and whole grains. Healthcare providers should routinely screen adolescents, particularly those who are overweight or obese, for metabolic risk factors to facilitate early diagnosis and intervention. Policies regulating screen time usage and promoting active commuting to schools can also be beneficial in reducing sedentary behaviours. Finally, multidisciplinary efforts involving paediatricians, nutritionists, educators, and policymakers are essential to develop and implement effective public health strategies aimed at preventing metabolic syndrome and its long-term complications.

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