

Screening of Modifiable Risk Factors of Metabolic Syndrome among Adolescents in a Selected School, Chennai: A Descriptive Cross-Sectional Survey

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Abstract: Background: Metabolic syndrome (MS) is a cluster of central adiposity, high blood pressure, hyperglycemia and dyslipidemia that begins in childhood and predicts adult cardiovascular disease and type 2 diabetes. Its modifiable precursors can be detected in schools with simple, non-invasive measurements. Objectives: To assess the biophysiological risk factors of MS among adolescent boys and girls in a selected school in Chennai and to compare them between the sexes. Methods: A descriptive cross-sectional survey was conducted among 141 adolescents aged 13–17 years (75 boys, 66 girls) selected by stratified random sampling by class from a higher secondary school. Weight, height, body mass index (BMI), waist, hip and neck circumference and blood pressure were measured, and dietary habits and physical activity were assessed. Data were analysed using frequencies, percentages, means, standard deviations, independent samples t-test and one-way ANOVA. Results: Overweight or obesity was present in 18.7% (girls 28.8%, boys 9.6%), whereas 48.9% were underweight. A high-risk waist circumference was found in 35.5%, and 24.1% had systolic blood pressure in the elevated or stage 1 hypertension range. Physical activity was low in 63.8% (girls 77.3%, boys 52.0%), and dietary habits were moderate in 75.9%. Girls had a significantly higher BMI (21.50 vs 18.92 kg/m², $p = .002$) and hip circumference ($p = .029$), while boys were taller ($p < .001$) and more active (activity score 34.40 vs 27.53, $p < .001$). Blood pressure and diet scores did not differ by sex. Conclusion: Modifiable risk factors of MS are already common in these adolescents, with a double burden of undernutrition and excess weight, and girls carry a heavier burden of adiposity and inactivity. Nurse-led school screening using BMI, waist circumference and blood pressure is feasible and can guide early prevention.

Keywords: metabolic syndrome; adolescents; obesity; waist circumference; blood pressure; physical inactivity; school screening

1. Introduction

Metabolic syndrome (MS) is a cluster of conditions, including central adiposity, dyslipidemia, hyperglycemia and hypertension, that occur together and raise the risk of type 2 diabetes and cardiovascular disease. In adults, MS is diagnosed when at least three of five components are present: central adiposity, elevated blood pressure, hyperglycaemia, elevated triglycerides and reduced high-density lipoprotein cholesterol [1]. In adolescents, the reported prevalence in low- and middle-income countries ranges from 4.2% to 15.4% in studies using the NCEP ATP III criteria and from 4.5% to 38.7% in studies using the WHO criteria, reflecting the lack of a single agreed definition [2].

The global rise in childhood overweight and obesity. According to the World Health Organization, in 2022 about 37 million children under 5 years and more than 390 million children and adolescents aged 5–19 years were overweight or living with obesity. Youth-onset obesity is linked from an early age to insulin resistance, type 2 diabetes, dyslipidaemia, hypertension and metabolic dysfunction-associated steatotic liver disease. A systematic synthesis reported that the prevalence of MS in youth with obesity averaged 29.4%, ranging from 2.1% to 74.4% across studies [3]. In low- and middle-income countries, MS has been estimated at 24.1–

56.3% among individuals with overweight and obesity, compared with 3.98–8.91% in the general population.

Paediatric obesity, once regarded as a problem of high-income countries, has reached epidemic proportions in middle- and low-income countries, including urban slums and rural areas. Several professional bodies, including the American Association of Clinical Endocrinology, the Pediatric Endocrine Society, the American Academy of Pediatrics and the Endocrine Society of India, now recognise obesity as a chronic disease. Because the components of MS arise from modifiable factors such as excess adiposity, physical inactivity and poor diet, adolescence offers a window for prevention. (1)

Biochemical testing for MS is costly and difficult to carry out in schools. Non-invasive measures that a school or community health nurse can repeat, such as BMI, waist circumference and blood pressure, can identify adolescents at risk and trigger referral. However, few studies in Chennai have screened several modifiable risk factors of MS in adults but there was a lack of studies in screening MS in adolescents. This study was therefore undertaken to assess the biophysiological risk factors of MS among adolescent boys and girls in a selected school in Chennai and to compare them between the sexes.

2. Methods

Study design and setting

A quantitative, descriptive cross-sectional survey was carried out in a All Angels higher secondary school in Chennai, Tamil Nadu. Data were collected over a period of three to four weeks.

Participants and sampling

The target population was adolescents aged 13–17 years studying in the selected school. A total of 141 adolescents were enrolled using stratified random sampling by class, with students drawn from each class roll list using random numbers. The sample comprised 75 boys (53.2%) and 66 girls (46.8%) from the VIII, IX and XI standards.

Study variables and measurements

Demographic variables were age, sex, class, religion, type and size of family, number of siblings, birth order, parental education and occupation, family monthly income, diet preference and family history of diabetes, hypertension or heart disease.

Study variables were BMI, waist circumference, blood pressure, diet, physical activity, screen time and sleep. Weight and height were measured with a calibrated weighing scale and stadiometer, and BMI was calculated as weight in kilograms divided by height in metres squared and classified as underweight, normal, overweight or obese. Waist, hip and neck circumferences were measured with a non-stretchable tape. A waist circumference above the age- and sex-specific reference value was classified as high risk. Blood pressure was measured on the right arm with the adolescent seated and rested, and was classified as normal, elevated, stage 1 or stage 2 hypertension using age-, sex- and height-based reference standards (BMI (WHO criteria, Waist -hip ratio based on cut off value for obesity (WHO), Waist circumference

(LipilekhaPatnaik (2017) Systolic blood pressure and Diastolic blood pressure (Clinical practice guideline for screening and management of high blood pressure in children and adolescents (2017))

Dietary habits (A modified Adolescents Food Habit Checklist was used to assess the dietary habits which comprised of 25 structured statements, 15 items to assess eating pattern and 10 items to assess food preferences) and physical activity (Modified Adolescents Physical Activity Questionnaire (PAQ-A It assessed the level of physical activity in the last 7 days. It is a five- point rating scale which includes 20 items on sports or dance activities) were assessed with structured questionnaires and categorised as poor, moderate or good for diet, and as nil, low, moderate, good or high for physical activity.

Ethical considerations

Permission was obtained from the school authorities, and written informed consent from parents and assent from the adolescents were obtained before data collection. Confidentiality of the data was maintained, and adolescents with elevated readings were advised to seek confirmatory evaluation.

Statistical analysis

Data were analysed using descriptive statistics (frequency, percentage, mean and standard deviation). Boys and girls were compared using the independent samples t-test, and one-way ANOVA by sex, which for two groups gives $F = t^2$. A p-value below .05 (two-tailed) was considered statistically significant.

3. Results

Demographic profile

Table 1: Selected demographic characteristics of the adolescents (N = 141)

Variable	Category	Boys (n = 75) n (%)	Girls (n = 66) n (%)	Total (N = 141) n (%)
Age (years)	13	30 (40.0)	31 (47.0)	61 (43.3)
	14	23 (30.7)	10 (15.2)	33 (23.4)
	15	12 (16.0)	10 (15.2)	22 (15.6)
	16	9 (12.0)	14 (21.2)	23 (16.3)
	17	1 (1.3)	1 (1.5)	2 (1.4)
Grade	VIII	16 (21.3)	10 (15.2)	26 (18.4)
	IX	37 (49.3)	34 (51.5)	71 (50.4)
	XI	22 (29.3)	22 (33.3)	44 (31.2)
Type of family	Nuclear	40 (53.3)	44 (66.7)	84 (59.6)
	Joint	30 (40.0)	21 (31.8)	51 (36.2)
	Broken / extended	5 (6.7)	1 (1.5)	6 (4.3)
Birth order	First born	52 (69.3)	29 (43.9)	81 (57.4)
	Second born	19 (25.3)	35 (53.0)	54 (38.3)
	Third or later	4 (5.4)	2 (3.0)	6 (4.3)
Diet preference	Vegetarian	8 (10.7)	9 (13.6)	17 (12.1)
	Non-vegetarian	61 (81.3)	51 (77.3)	112 (79.4)
	Any other	6 (8.0)	6 (9.1)	12 (8.5)
Family income / month	≤ Rs. 20,000	14 (18.7)	12 (18.2)	26 (18.4)
	Rs. 20,001–25,000	13 (17.3)	23 (34.8)	36 (25.5)
	Rs. 25,001–30,000	14 (18.7)	10 (15.2)	24 (17.0)
	≥ Rs. 30,000	34 (45.3)	21 (31.8)	55 (39.0)

Religion, family size, siblings, parental education and occupation are described in the text.

Table 1 shows the profile of the 141 adolescents. The largest age group was 13 years (43.3%), and half (50.4%) were in the IX standard. Most were Hindu (79.4%), lived in nuclear families (59.6%) with both parents (95.7%) and followed a non-vegetarian diet (79.4%). More than half were first born (57.4%), and 70.9% had one sibling. The commonest level of parental education was higher secondary (mothers 32.6%,

fathers 29.8%). Most of the mothers were homemakers (62.4%), nearly half of the fathers were private employees (47.5%), and 39.0% of families earned Rs. 30,000 or more per month.

Dietary habits and physical activity

Table 2: Level of dietary habits and physical activity among boys and girls

Variable	Level	Boys (n = 75) n (%)	Girls (n = 66) n (%)	Total (N = 141) n (%)
Dietary habits	Poor	–	2 (3.0)	2 (1.4)
	Moderate	55 (73.3)	52 (78.8)	107 (75.9)
	Good	20 (26.7)	12 (18.2)	32 (22.7)
Physical activity	Nil	1 (1.3)	1 (1.5)	2 (1.4)
	Low	38 (50.7)	50 (75.8)	88 (62.4)
	Moderate	25 (33.3)	15 (22.7)	40 (28.4)
	Good	10 (13.3)	–	10 (7.1)
	High	1 (1.3)	–	1 (0.7)

Table 2 depicts that dietary habits were moderate in 75.9%, good in 22.7% and poor in 1.4% (two girls). Physical inactivity was the most striking finding 62.4% had a low level of activity and 1.4% had none. Low or nil activity was more common among girls (77.3%) than boys (52.0%) and good or

high activity was found only among boys (13.3% and 1.3%); no girl reached these levels.

Categories of biophysiological variables

Table 3: Categories of BMI, waist circumference and blood pressure among adolescents

Risk factor	Category	Boys n (%)	Girls n (%)	Total n (%)
BMI (boys n = 73, girls n = 66)	Underweight	42 (57.5)	26 (39.4)	68 (48.9)
	Normal	24 (32.9)	21 (31.8)	45 (32.4)
	Overweight	7 (9.6)	15 (22.7)	22 (15.8)
	Obese	–	4 (6.1)	4 (2.9)
Waist circumference (n = 75, 66)	Normal	52 (69.3)	39 (59.1)	91 (64.5)
	High risk	23 (30.7)	27 (40.9)	50 (35.5)
Systolic BP (n = 75, 66)	Normal	59 (78.7)	48 (72.7)	107 (75.9)
	Elevated	3 (4.0)	9 (13.6)	12 (8.5)
	Stage 1 hypertension	13 (17.3)	9 (13.6)	22 (15.6)
Diastolic BP (n = 75, 66)	Normal	73 (97.3)	62 (93.9)	135 (95.7)
	Elevated	2 (2.7)	4 (6.1)	6 (4.3)

Table 3 depicts that, 48.9% were underweight, 32.4% normal, 15.8% overweight and 2.9% obese. Overweight or obesity was three times more frequent in girls (28.8%) than in boys (9.6%), and obesity occurred only in girls (6.1%). A high-risk waist circumference was present in 35.5% of the adolescents (boys 30.7%, girls 40.9%).

Systolic blood pressure was elevated or in the stage 1 hypertension range in 24.1% (boys 21.3%, girls 27.3%), and 15.6% were in the stage 1 range. Diastolic pressure was elevated in 4.3% (boys 2.7%, girls 6.1%). No adolescent had stage 2 blood pressure

Mean values and sex differences

Table 4: Mean and standard deviation of biophysiological variables

Modifiable Risk Factor	Boys (n = 75)					Girls (n = 66)				
	Min	Max	Range	Mean	SD	Min	Max	Range	Mean	SD
Weight (kg)	29.50	80	50.50	49.22	10.67	29.04	107.85	78.81	52.33	15.45
Height (m)	1.42	1.80	0.38	1.61	0.10	1.42	1.73	0.31	1.56	0.07
BMI (kg/m ²)	13.47	28.52	15.05	18.92	3.42	12.57	41.10	28.53	21.50	5.64
Waist Circumference (cm)	30	88	58	67.71	9.53	53	103	50	71.08	11.19
Systolic Blood Pressure (mmHg)	100	140	40	116.88	8.40	97	135	38	115.73	8.42
Diastolic Blood Pressure (mmHg)	60	83	23	72.56	4.02	56	88	32	72.52	5.89

Table 4 gives the mean values. Girls had higher mean weight (52.33 vs 49.22 kg), BMI (21.50 vs 18.92 kg/m²) and waist circumference (71.08 vs 67.71 cm), with a wider spread of

BMI (range 28.53 vs 15.05 kg/m²), whereas blood pressure was almost identical in the two groups.

Table 5: Comparison of biophysiological variables between boys and girls (independent samples t-test, N = 141)

Variable	Boys mean $\pm$ SD	Girls mean $\pm$ SD	t	df	p	Sig.
Weight (kg)	49.22 $\pm$ 10.67	52.33 $\pm$ 15.45	-1.372	113.4	.173	NS
Height (m)	1.61 $\pm$ 0.099	1.56 $\pm$ 0.068	3.873	131.8	<.001	**
BMI (kg/m ²)	18.92 $\pm$ 3.42	21.50 $\pm$ 5.64	-3.229	104.2	.002	**
Waist (cm)	67.71 $\pm$ 9.53	71.08 $\pm$ 11.19	-1.912	128.5	.058	NS
Hip (cm)	81.96 $\pm$ 7.37	85.85 $\pm$ 12.52	-2.209	102.3	.029	*
Neck (cm)	30.65 $\pm$ 2.20	30.08 $\pm$ 2.06	1.603	139	.111	NS
Systolic BP (mmHg)	116.88 $\pm$ 8.40	115.73 $\pm$ 8.42	0.812	139	.418	NS
Diastolic BP (mmHg)	72.56 $\pm$ 4.02	72.52 $\pm$ 5.89	0.052	112.6	.959	NS
Physical activity score	34.40 $\pm$ 12.35	27.53 $\pm$ 7.50	4.044	124.2	<.001	**
Eating habit score	70.07 $\pm$ 9.77	69.03 $\pm$ 7.44	0.701	139	.484	NS
Food preference score	27.22 $\pm$ 6.20	26.68 $\pm$ 3.71	0.610	138	.543	NS
Eating pattern score	43.07 $\pm$ 5.36	42.35 $\pm$ 5.08	0.813	139	.417	NS

** $p < .01$; * $p < .05$; NS, not significant.

Table 5 reveals that, boys were significantly taller than girls ($t = 3.873$, $p < .001$), whereas girls had a significantly higher BMI ($t = -3.229$, $p = 0.002$) and hip circumference ($t = -2.209$, $p = 0.029$). Boys had a significantly higher total physical activity score (34.40 vs 27.53; $t = 4.044$, $p < 0.001$). There was no significant difference in weight ($p = 0.173$), neck circumference ($p = 0.111$), systolic ($p = 0.418$) or diastolic blood pressure ($p = 0.959$), or in the eating habit ($p = 0.484$), food preference ($p = 0.543$) and eating pattern ($p = 0.417$) scores. The difference in waist circumference was borderline ($p = 0.058$).

4. Discussion

This school-based survey found that modifiable risk factors of MS were common among adolescents in Chennai, nearly one in five was overweight or obese, more than a third had a high-risk waist circumference, about a quarter had raised systolic blood pressure and almost two thirds were physically inactive. Girls carried a heavier burden of adiposity and inactivity.

Body weight status

Overweight or obesity affected 18.7% of the adolescents and was three times more frequent in girls (28.8%) than in boys (9.6%). obesity was seen only in girls. This agrees with Indian school surveys reporting rising overweight and obesity among urban adolescents, often more frequently in girls [4], and with the global trend described by the WHO. At the same time, 48.9% of the adolescents were underweight, indicating a double burden of malnutrition within a single school, where undernutrition and excess weight coexist.

Central adiposity

A high-risk waist circumference was present in 35.5% of the adolescents, more often in girls (40.9%) than boys (30.7%). This is important because central adiposity is the core component of MS and is closely linked to insulin resistance and dyslipidemia. This was supported by a similar study finding, Waist circumference identifies abdominal fat in adolescents whose BMI appears normal, and therefore adds information that BMI alone does not provide [5]. Girls showed a higher mean BMI and hip circumference, consistent with earlier pubertal onset and greater deposition of fat on the hips and trunk in girls during adolescence [6]. The sex difference in waist circumference approached but did not reach significance ($p = .058$); with a modest sample, the study

may have lacked the power to confirm a real difference, and this deserves testing in a larger sample.

Blood pressure

About one quarter (24.1%) of the adolescents had elevated or stage 1 systolic pressure, and 15.6% were in the stage 1 range, while elevated diastolic pressure was less common (4.3%). The prevalence of hypertension ranges from 0.7% in urban Bangladesh to 24.5% in urban Malaysia, with urban areas generally showing higher rates than rural areas (7)

Diet and physical activity

Most adolescents had moderate dietary habits (75.9%), and few had good (22.7%) or clearly poor (1.4%) habits. Diet scores did not differ between sexes. Physical inactivity was the most striking modifiable finding, affecting 63.8% overall and 77.3% of girls, and no girl reached a good or high level of activity. Boys scored significantly higher on physical activity ($p < .001$). Low activity among adolescents, particularly girls, has been reported in several Indian studies and is commonly attributed to academic pressure, limited school play time, screen use and social or safety constraints on outdoor activity [8].

Limitations

The study was conducted in one school with 141 participants, which limits generalizability and statistical power. Fasting glucose and lipid profile were not measured, so the prevalence of MS by a standard definition could not be estimated, and the findings describe risk factors rather than the syndrome itself.

5. Implications

Nursing practice, school and community health nurses can carry out routine screening of BMI, waist circumference and blood pressure using low-cost equipment, refer adolescents with elevated readings for confirmation and counsel adolescents and parents on balanced diet, regular physical activity, limited screen time and adequate sleep, with particular attention to girls.

Nursing education, Nursing students should be trained in accurate anthropometric and blood pressure measurement in adolescents and in the use of age- and sex-specific reference standards.

Nursing administration, annual risk screening can be built into school health programmes, with protected time for physical activity and referral pathways between schools and primary health centres. **Nursing research**, the findings provide baseline data for larger multi-school studies, studies including biochemical markers and intervention studies testing nurse-led programmes.

6. Recommendations

Future studies should

- 1) Replicate the survey with larger samples from several government and private, urban and rural schools
- 2) Nurse-led school programme on diet, activity and screen time with a control group can be conducted
- 3) A cross-sectional survey can be conducted to analyse the double burden of underweight and overweight and the reasons for low activity among girls
- 4) A longitudinal study can be conducted to follow adolescents daily physical activity in schools

7. Conclusion

Modifiable risk factors of metabolic syndrome are already present in a substantial proportion of adolescents in the selected school, about 19% were overweight or obese, 36% had a high-risk waist circumference, 24% had raised systolic blood pressure and 64% were physically inactive, while nearly half were underweight. Girls had more overweight, central adiposity and inactivity, whereas boys were taller and more active, diet and blood pressure did not differ by sex. Simple, non-invasive measurements that a nurse can repeat were sufficient to identify adolescents at risk and can support early prevention before biochemical abnormalities or disease develop.

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