



Prevalence of metabolic syndrome and its components among overweight and obese adolescents in Solapur city, Maharashtra

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Abstract

The metabolic syndrome (MetS) has become one of the major public- health challenges worldwide. Early identification of metabolic complications consists of an essential target for youth public health. We aimed to evaluate the prevalence of MetS and its components among overweight and obese adolescents.

Methods: This cross-sectional study concerned 51 overweight and obese adolescents. Anthropometric assessments, blood pressure measurement and biochemical assessment were done. MetS was defined according to the International Diabetes Federation (IDF) criteria. All data were collected during year 2018 and 2019.

Results: The prevalence of the MetS was 21.6%. There was no gender difference in prevalence of MetS ($P=0.09$). Obese subjects had the highest proportion of MetS than overweight (25% vs. 15.8%; $p=0.04$). 35.3% of subjects had at least two abnormalities of MetS. Abdominal obesity was the most common individual component of the MetS (91.3 %) followed by low HDL cholesterol (58.8%). Body mass index (BMI), Waist circumference (WC), Waist to hip ratio (WRH) and Neck circumference (NC) had partial positive correlation with Blood pressure (BP), and Triglyceride. Similarly, (BP), Triglyceride and HDL cholesterol were significantly higher in subjects with metabolic syndrome than that of subjects without metabolic syndrome ($p < 0.05$).

Conclusion: MetS is prevalent in our young population in Solapur City. The results of this study will help in planning to control these problems in the future. So we suggest better screening programs for adolescent population to control obesity and MetS.

Keywords: metabolic syndrome, obesity, prevalence, adolescent

Introduction

Metabolic syndrome (MetS) is a constellation of metabolic abnormalities that includes abdominal obesity, glucose intolerance, hypertension, elevated triglycerides and low High Density Lipoprotein cholesterol (HDL-c). This clustering is associated with increased risk of developing diabetes and cardiovascular disease (CVD) [1]. The development of MetS during adolescence may differ from that in adulthood [2]. Thus, prevalence of this entity is dependent on the definition that is used to determine inclusion as well as the composition (e.g., sex, age, and ethnicity) of the population being studied [2, 3, 4]. Recent studies have shown that the MetS develops during childhood; as a consequence of increasing rates of obesity [2, 3, 5]. In fact, the dramatic rise in childhood obesity in developing countries is considered a major driving force behind the increasing prevalence of MetS [3]. India is undergoing a socio-economic and nutrition transition especially in large cities, where lifestyles are becoming more sedentary with lower levels of physical activity, and diets with higher fat content [6, 7]. This has brought an increased risk of CVD and other chronic diseases [7]. The emergent epidemic of obesity in children and adolescents makes MetS and its sequel an important condition to study in India [7, 8]. Nevertheless, previous studies have shown that features of the MetS develop early in life and can be predictive of atherosclerotic processes in adulthood [9, 10]. However, children and adolescents are not routinely screened for MetS. The obesity and their relation to of MetS

in adolescent have been inadequately studied in India [7, 8, 11, 12].

The aim of the present study is to estimate the prevalence of the MetS and its components by gender among overweight and obese adolescents aged 15-18 years in Solapur City according to the International Diabetes Federation (IDF) guidelines definition [13].

Material and Methods

Study Population

The present study was conducted with the approval of the Ethics Committee, Dr V M government Medical College, Solapur. All participating subjects gave written consent; participants received no incentives and could withdraw from the study if they wished. All data were collected during year 2018 and 2019.

Our population was recruited from a hospital based cross-sectional study conducted by the us, and was designed to examine the prevalence of overweight and obesity among adolescents in the age group of 15-18 years, who visited our hospital for various complaints. The prevalence of overweight and obesity were 19.2% and 4.2% respectively. A total of 51 willing overweight and obese adolescents were selected according to the weight status, age and sex, to participate in the study. Complete data were obtained from 51 study subjects (28 girls and 23boys). Out of them, 32 were obese and 19 were overweight. Subjects were eligible if: (a) They were between 15 and 18 years old, (b) Body Mass Index (BMI) above or equal to the value that predicted

overweight or obesity by applying the age and sex specific International Obesity Task Force (IOTF) BMI cut off points [14], (c) No known history of chronic disease; (d) No orthopaedic disease or injury limiting physical activity; (e) No medications, which might influence cardiovascular function, lipid, or glucose metabolism. The exclusion criteria included:

- (a) Subjects who did not sign the informed consent, (b) Subject who was severely sick during the time of study or (c) Subjects who were not present on the day of study.

Data Collection

All measurements were conducted in the Non-Communicable Diseases clinic OPD in our hospital. Anthropometric standardization exercises were conducted to ensure uniform techniques. All subjects went through physical examination including, anthropometric assessments blood pressure and biochemical assessment.

Weight was measured without shoes and heavy clothes, using a Tanita electronic scale (Tanita BF 571, Tanita Corporation, Japan) and was recorded to the nearest 100 g. Standing height was measured with a suspended tape to the nearest 0.1 cm. Body mass index (BMI) was calculated as weight in kilograms divided by the square of height in meters (kg/ m²). The subjects were classified as overweight/obese by applying the age and sex (IOTF) BMI cut off points.

Waist circumference (WC) was measured in cm with a non-elastic tape applied at a point midway between the lower border of the rib cage and the iliac crest at the end of normal expiration. Hip circumference (HC) was measured in centimetres at the greater trochanter of the femur with the legs close together using a non-stretchable measuring tape. Waist to Hip ratio (WHR) was calculated by dividing WC with HC. Neck circumference was measured in the midway of the neck, between mid-cervical spine and mid anterior neck, to within 1 mm, using non-stretchable plastic tape with the subjects standing upright, head erect and eyes facing forward. In boys with a laryngeal prominence (Adam's apple), it was measured just below the prominence. Determination of pubertal development was assessed by a self-administered confidential questionnaire using diagrams illustrating the five stages of pubertal development [15]. Pubertal stage was grouped into pre-pubescent, pubescent and post-pubescent based on the WHO definition [16].

The blood pressure (BP) was measured using participants' right arm after they had been resting in a seated position for 15 minutes. Systolic blood pressures (SBP) and Diastolic blood pressures (DBP) were measured manually in mmHg with Diamond sphygmomanometer. The subject was in a seated, relaxed position and recordings were made 3 times at 10 minute intervals. The measurements were taken in millimeters of mercury and the mean value of the three recordings (not varying by more than 5 mm Hg) was

calculated. The means of three systolic and three diastolic blood pressures were recorded.

Laboratory Measurements

Blood samples were taken by venepuncture after a fasting of 12 hours. The blood was collected in anticoagulated bulbs. All laboratory analysis was carried out at the biochemistry laboratory of our hospital.

Plasma was obtained by centrifugation for 10 minutes at 2000 x g. All samples were tested for Total cholesterol, triglycerides, high density lipoprotein cholesterol (HDL-C), and glucose on a multiparametric analyzer Unicel TMDXC 600® Beckman Coulter.

Definition of Metabolic Syndrome

Subjects were classified as having metabolic syndrome according to the International Diabetes Federation (IDF) guidelines [13]. Metabolic syndrome was defined as adolescents with waist circumference greater or equal to (\geq) 90th percentile and two or more of the following components: Systolic/diastolic blood pressure \geq 130/85 mmHg,

- Fasting plasma glucose \geq 5.6 mmol/L,
- Serum triglycerides \geq 1.7 mmol/L,
- Serum HDL-C $<$ 1.03 mmol/L.

Concerning, the measure of waist circumference, we used the cut-off points recommended by Rolland-Cachera *et al* [17]. For adolescent older than 16 years, we used the IDF adult criteria [13].

Statistical Analysis

Statistical analysis was conducted using SPSS version 20 (SPSS Inc. Chicago, IL, USA). Quantitative variables were expressed as mean-standard deviation. Qualitative variables were expressed as number and (percentage). Comparisons were performed using Pearson's chi-squared for qualitative and Student's t-test for quantitative variables. P-values below 0.05 were considered to be statistically significant.

Results

A total of 51 overweight and obese adolescents, living in an urban area of Solapur city participated in this study. The proportion of males was 45.1%, and the rest being the females. According to (IOTF) BMI cut off points, 37.7 % of subjects were overweight and 62.3% obese.

The mean age of the sampled subjects was 16.8 \pm 0.69 years. There were 18 subjects in the age group 15 to 16 years and 33 in 16-18 years. All the participants had attained puberty. Mean and standard deviation of anthropometric variables and biochemical factors are presented in Table 1. The mean weight, height, WC, WHR and NC of the male students were significantly higher than those of the females (p < 0.05).

Table 1: Clinical characteristics in overweight and obese adolescents, aged 15–18 years, stratified by gender

Characteristics	Total Mean \pm SD	Boys Mean \pm SD	Girls Mean \pm SD	P values*
Age (years)	16.80 \pm 0.69	16.74 \pm 0.75	16.86 \pm 0.65	0.55
weight (kg)	90.14 \pm 16.4	99.26 \pm 16.81	82.64 \pm 11.83	0.001
Height(cm)	169.2 \pm 8.4	175.3 \pm 6.83	164.21 \pm 5.93	0.001
Body mass index (kg/m ²)	31.27 \pm 3.67	32.15 \pm 3.88	30.54 \pm 3.17	0.11
Waist circumference (cm)	95.16 \pm 12.1	102.09 \pm 13.07	89.5 \pm 7.6	0.001
Hip circumference (cm)	106.37 \pm 10.53	107.3 \pm 12.12	106.14 \pm 9.21	0.7
Waist to hip ratio	0.89 \pm 0.09	0.95 \pm 0.075	0.84 \pm 0.06	0.001

Neck circumference (cm)	35.12±3.8	38.26±2.49	32.54±2.6	0.001
Systolic blood pressure (mmHg)	123.98±9.3	126.48±9.88	121.93±8.48	0.083
Diastolic blood pressure (mmHg)	68.9±7.4	69.35±7.39	68.54±7.6	0.67
Fasting plasma glucose (mmol/L)	4.5±0.37	4.65±0.31	4.47±0.41	0.075
HDL- c (mmol/L)	1.09±0.24	1.05±0.21	1.13±0.26	0.22
Triglyceride (mmol/L)	0.91±0.51	1.05±0.49	0.8±0.5	0.05
Cholesterol (mmol/L)	3.97±0.7	4.1±0.74	3.7±0.66	0.25

* Comparison between genders, HDL-c: high-density lipoprotein cholesterol, SD, standard deviation.

Table 2 shows the prevalence of the Mets and its components, according to IDF criteria stratified by gender and weight status. The overall prevalence of the MetS was 21.6 %. There was no gender difference in prevalence of MetS (P=0.09). Twenty five percent of obese and 15.8% of overweight group met the criteria of MetS, the difference between the two groups was significant (P=0.04). Among all the components of metabolic syndrome, high WC was

most prevalent with 91.3% in males and 89.3% in females. No adolescent in our study had hyperglycaemia. Moreover, 58.8 %, 27.4 % and 9.8 % of them had decreased HDL cholesterol, elevated blood pressure and hypertriglyceridemia respectively. Prevalence of subjects with 1 or more components of MetS is presented in Figure 1. 36.9% of the overweight and 68.7 % of the obese adolescents had at least two abnormalities of the MetS.

Table 2: Prevalence of the metabolic syndrome and its components, according to International Diabetes Federation criteria, among 51 overweight and obese adolescent aged 15–18 years, stratified by gender and BMI status

Parameters	Prevalence %				
	Girls	Boys	Overweight	Obese	All Subjects
Large waist circumference	89.3	91.3	73.7	100	90.1
Elevated blood pressure	21.4	34.8	15.8	34.4	27.4
Low HDL cholesterol	64.4	52.2	52.3	62.5	58.8
High triglyceride level	10.7	8.7	10.5	9.4	9.8
Hyperglycaemia	0	0	0	0	0
Metabolic syndrome present	21.5	21.7	15.8	25	21.6

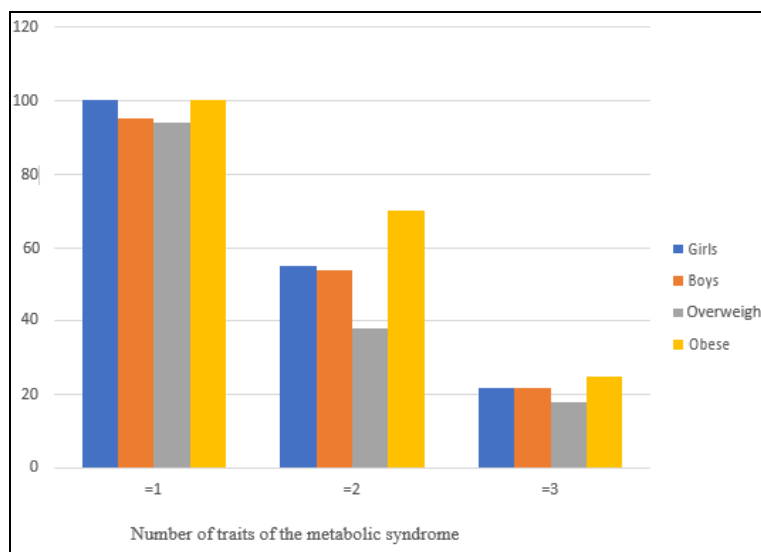


Fig 1: Prevalence of components of the metabolic syndrome, according to International Diabetes Federation criteria, among overweight and obese adolescent aged 15–18 years, stratified by gender and BMI status

While comparing anthropometric and biochemical parameters between two groups (Table 3), we notice that, BMI, WHR, BP, Triglyceride and HDL cholesterol were

significantly higher in subjects with metabolic syndrome than that of subjects without metabolic syndrome ($p < 0.05$).

Table 3: Comparisons of anthropometric and metabolic parameters between subjects with and without the metabolic syndrome

Characteristics	Metabolic Syndrome Mean ± SD	Non-metabolic Syndrome Mean ± SD	p- value
Age (years)	16.82± 0.75	16.8± 0.69	0.93
Sex (Girls/Boys)	6/5	22/18	0.7
Body weight (kg)	97.27 ±20.4	88.18±14.9	0.10
Height (cm)	170.36±9.51	168.9±8.17	0.6
Body mass index (kg/m ²)	33.19±3.89	30.73±3.32	0.04
Waist circumference (cm)	101.0±13.9	93±5.8	0.07
Hip circumference (cm)	108.00±13.2	106.30±9.83	0.07
Waist to hip ratio	0.93±0.09	0.88±0.08	0.04
Neck circumference (cm)	36.91±4.32	34.63±3.53	0.06

Systolic blood pressure (mm Hg)	135.0±5.97	120.95±7.7	0.001
Diastolic blood pressure (mm Hg)	72.45±7.1	67.93±7.25	0.07
Blood glucose (mmol/L)	4.71±0.54	4.51±0.31	0.12
HDL-c (mmol/L)	0.88±0.18	1.15±0.22	0.00
Triglyceride (mmol/l)	1.32±0.59	0.80±0.42	0.02
Cholesterol (mmol/L)	4.20±0.71	3.91±0.69	0.24

Discussion

The metabolic syndrome among overweight and obese adolescents continues to increase in both developed and developing countries and it has already become a major threat to global public health [18]. It is interesting to know the actual situation in Solapur, the emerging smart city in Maharashtra, India. To our knowledge, this is the first study addressing the prevalence of MetS and its components in this City. The number and source of Study subjects is not the ideal to try to show the prevalence in the entire city, but it would be an initial point for future studies. In this study, approximately 21.6% of adolescents met the criteria for the MetS. Our findings indicate that the prevalence of MetS among overweight and obese adolescents in Solapur City was comparable to similar studies in other countries [18, 19, 20], and was slightly lower, compared to the other surveys in India. In fact, Jamoussi *et al* [81] found that the prevalence of MetS among overweight and obese children and adolescents (6-18year) in the United States was 44.4 %.

Puberty is a crucial time for the development of the MetS, and yet it is a difficult period to identify this entity [22]. Thus, the prevalence of the MetS in adolescents may vary by sex, as it does in adults [21], but data are conflicting. In the present study, there is no sex difference in the prevalence of MetS (boys 21.7 % and girls 21.5%), which is consistent with the findings in study by Jamoussi *et al* in the United States (50.8% in males and 42.1% in females; p=0.27) as in other countries [9, 23, 24, 25]. However, in a national multiethnic study by Cook *et al* [26], the MetS was significantly more prevalent in males (6.1%) than in females (2, 1 %).

Previous studies reported that MetS may be on the rise in adolescents with increasing rates of obesity [2, 8, 23]. According to the IDF criteria, prevalence of MetS in the present study was 15.8% in overweight group and 25% in obese individuals. These observations were higher than reported prevalence for overweight and obese children and adolescents in South Korean adolescents (1.5% and 14.7%, respectively) [27], and for mildly obese and obese Japanese adolescents (1.3% and 15.6%, respectively) [28]. However, the prevalence of MetS among overweight and obese adolescents in Solapur is lower than reported prevalence of overweight and obese children and adolescents, in Chennai, India (25% and 35%, respectively) [8], Kuala Lumpur, Malaysia (11.5% and 36.6%, respectively) [29], China (23.4% and 35.2%, respectively) [30]. Our findings were also consistent with other studies [8, 20, 23, 31], which showed that, more than half overweight and obese adolescents had at least two abnormalities of metabolic syndrome, indicating that these subjects may develop MetS later in life.

Friedemann *et al* noted that obesity was associated with worse risk parameters for cardiovascular disease in school aged children [31]. The anthropometrics measurements are a useful index for estimating the risk factors associated with excess abdominal fat such as type 2 diabetes mellitus, hypertension and hyperlipidaemia [32, 33]. In the present study, we have found an association between hypertension

and anthropometric measurements such as BMI, WC, WHR and NC. Similarly it can be inferred that adolescents with high anthropometrics measurements of (BMI, WC, WHR, and NC) are more likely to have, high triglyceride. These relations between anthropometrics measurements and hypertension and/ or triglyceride level have been established in a number of cross-sectional studies [5, 31, 32, 33, 34, 35]. Our findings showed that subjects with MetS had an increase BMI and WHR measurements compared to others without MetS. It appears, in part, that central adiposity contributes to the high incidence of individual MetS components. Central obesity, considered a key component of the MetS, is a good example of the problem of defining risk levels in children and adolescent [13, 20, 32]. It was noted that, WC is a sensitive marker for abdominal obesity in the paediatric age group [20, 32]. However, WC is not widely measured in clinical practice in India. There are no reference values for waist circumferences exist for children and adolescents in India.

In accordance with other studies [8, 20, 26, 36] abdominal obesity was also the most common individual component of the metabolic syndrome among overweight and obese adolescents in Solapur. This finding will be alarming for this group because abdominal adiposity is considered high-risk fat, and it can predict the risk of Type 2 diabetes and CVD in future [2, 31]. The precise causes of the high prevalence of abdominal adiposity have not been entirely elucidated; these may be probably due to greater intake of dietary fat and the lack of sufficient physical activities. In India, food consumption patterns have changed markedly during the past 4 decades. There has been a shift from traditional eating habits, with a diet rich in cereals, fruits and vegetables to foods with undesirable composition of excessive complex carbohydrates and sugars [6, 7, 22].

Similar to the previous surveys [19, 20, 23, 25, 26, 29, 30] the prevalence of low HDL- cholesterol in this study was frequent. Our findings showed that, adolescents with MetS were reported to have low HDL cholesterol and high triglycerides than subjects without MetS, which is not contradictory to the other studies owing to the relationship between HDL-C and TG, as low HDL-C is brought about by high TG levels [31, 35].

Hypertension is recognized as an important component of the metabolic syndrome in adults, but its role in children and adolescents is not clear [22]. The prevalence of hypertension was 27.4% in this study and was consistent with recent studies [8, 19, 23, 28, 29, 30, 36] that showed that the prevalence of hypertension in overweight and obese adolescent ranged from 15% - 51 % depending on gender, age, the severity of obesity and the criteria used to define hypertension. The changes in blood pressure during puberty may be influenced also by the decrease in physical activity and changes in eating habits that are commonly seen during adolescence [21].

No adolescent in our study had hyperglycemia, which is in agreement with other studies [23, 26, 29, 36] that found that hyperglycemia is an infrequent abnormalities. However, this result contrasts with the Korean studies that found glucose

intolerance was the dominant feature of the MetS [27].

In several studies, overweight youth had low HDL cholesterol and high triglycerides and insulin, but normal glucose levels than non-overweight subjects, suggesting that glucose intolerance may develop later than other syndrome abnormalities [21, 29, 37, 38]. Thus, it may be important to assess insulin levels as well as glucose, because many with the cluster of metabolic syndrome factors will have normal glucose levels [21].

The heterogeneity of these results suggests that genetic and ethnic factors play an important role in the development of metabolic syndrome and it is important to take into account the role of these factors when assessing the different components [23].

Our study had several limitations. First, the sample size of the study, in fact the number of patients was not the ideal to try to show the prevalence of MetS among overweight and obese adolescent in the entire city. Second, the subjects were collected from our NCD clinic and not from the population as such. Others risk factors that may be associated with MetS were also not examined. In fact, we did not take into account some possible confounders such as physical activity, dietary habits, and socioeconomic status in our analysis. Similarly, family medical history including cardiovascular diseases, obesity, diabetes and hypertension was a predisposing factor for the prevalence of the MetS [37, 38, 39]. The MetS begins in childhood or in adolescent (or even earlier, in fetal life) and manifest due to interactions and accumulation of various risk factors, throughout the life course [29, 39].

Despite these limitations, our findings contribute to the understanding of the prevalence of the MetS and its components among overweight and obese adolescents aged 15 to 18 years in Solapur City.

The MetS and its many consequences will continue to increase unless we find ways to prevent obesity and the MetS in childhood and adolescence in this region.

Conclusion

Metabolic syndrome is prevalent in our young obese population in Solapur City. The results of this study may help in designing interventions aimed at modifying unhealthy lifestyle in overweight and obese adolescents which may reduce the later incidence of cardiovascular disease in adults.

The optimal approach towards decreasing the prevalence of this syndrome is lifestyle modification; healthy food habits and maintenance of high level of physical activity. Thus, a multidisciplinary approach involving parents, teachers, and media is needed to address this problem.

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