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Original Research Article

Metabolic syndrome in children with overweight and obesity: a hospital based cross sectional study

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ABSTRACT

Background: Objective of the research was to study metabolic syndrome (MS) in children with overweight and obesity.
Methods: A cross sectional descriptive study was carried out on 264 children aged 3-16 years with overweight and obesity attending the endocrinology clinic of a tertiary care hospital in South India from January 2016 to March 2018. Children with and without MS were compared.
Results: Out of 264 children with overweight or obesity, 80 had MS (30.3%). Among children with obesity, proportion of patients with MS (40.5% versus 24.2%, p=0.012), hypertriglyceridemia (54.8% versus 37.5%, p=0.013), low high density lipoprotein cholesterol (HDL-C) (42.9% versus 28.1%, p=0.027) and dyslipidemia (78.6% versus 59.4%, p=0.004) were higher among girls versus boys. Proportion of patients with elevated systolic blood pressure (BP) (18.8% versus 4.3%, p<0.0001), elevated diastolic BP (34.5% versus 5.4%, p<0.0001), impaired fasting glucose (16.2% versus 7.6%, p=0.033), hypertriglyceridemia (85% versus 26.6%, p<0.0001), low HDL-C (75% versus 15.2%, p<0.0001) and dyslipidemia (97.5% versus 57.1%, p<0.0001) were higher in those with MS versus those without.
Conclusions: MS noted in younger children with overweight and obesity in the current study is concerning as these children are at increased risk for hypertension, type 2 diabetes and cardiovascular disease in early adulthood leading to huge economic burden on the country. It is therefore of utmost importance to take necessary steps to identify these children, manage obesity effectively before MS sets in and initiate preventive measures thereby ensuring a healthy young generation in the coming years.

Keywords: Children, Adolescents, Obesity, Overweight, Metabolic syndrome

INTRODUCTION

Marked increase in the prevalence of obesity among all age groups including children have been observed over the last 3 decades.[1] The rising trend in childhood obesity has witnessed a parallel increase in hypertension, type 2 diabetes mellitus (T2D), and subclinical atherosclerosis among children with obesity, which were thought to occur only in adults.[2-7] Metabolic syndrome (MS) is characterized by clustering of cardiometabolic risk factors: abdominal obesity, dyslipidemia, elevated blood pressure and impaired fasting glucose.[1] Children with MS are at high risk of developing T2D, cardiovascular disease and nonalcoholic fatty liver disease (NAFLD) in later life.[8,9] Very few studies from South Asia have assessed MS among children with obesity and none from South India.[10,11] We aimed to determine the prevalence of MS among children with overweight and obesity attending endocrinology clinic in a South Indian State and to compare those with MS and without MS. We hypothesized that prevalence of MS will be higher in those with obesity vs. those with overweight and the metabolic abnormalities will be higher in those with MS compared to those without MS.

METHODS

A hospital based descriptive cross-sectional study was carried out in children of 3-16 years with overweight or obesity attending the endocrinology clinic of Institute of Maternal and Child Health, Government Medical College, Kozhikode, Kerala, India from January 2016 to March 2018. Study was approved by the institutional ethics committee.

Inclusion criteria was children of ages 3-16 years with overweight or obesity of exogenous causes attending the endocrinology clinic during the study period. Children with obesity due to diseases such as Cushing syndrome, hypothyroidism or hypothalamic disease, syndromic causes such as Prader Willi syndrome, Laurence Moon Bardet Biedel syndrome or medication such as steroids, antipsychotics or antidepressants were excluded from the study. Children were enrolled for the study after getting written informed consent from the guardians. A diagnosis of overweight and obesity were made based on the Indian Academy of Pediatrics (IAP) reference percentiles proposed for Asian Indian Children with a BMI >23 kg/m^2 and >27 kg/m^2 adult equivalent cut off for overweight and obesity respectively for children aged 5-16 years and World Health Organization (WHO) growth charts for children <5 years.[12,13]

Clinical and demographic data were collected using a preformed questionnaire. Anthropometric measurements were taken for each subject. Electronic weighing machine was used for measuring body weight to an accuracy of 0.1 kg with the participants wearing light clothes and no foot wears and stadiometer for measuring height to an accuracy of 0.1 cm. Waist circumference (WC) was measured midway between the lowest rib cage and the iliac crest with a non-stretchable tape (applying uniform pressure on the tape), to the nearest 0.1 cm, with the subject in a standing position and no clothes covering the measuring area.[14] WC cut-offs as proposed by Kuriyan et al (WC>75th centile) were used to identify children with abdominal obesity.[15] General and systemic examinations were done on all children. Blood pressure (BP) was taken in the right upper limb in the sitting position and was repeated 30 minutes later if found to be high. Repeatedly measured systolic or diastolic BP ≥90th percentile for the child's age, gender and height was considered as elevated BP and BP ≥95th percentile as hypertension.[16]

Blood sample was collected after an overnight fast of at least 8 hours for blood sugar and lipid panel. MS was defined as per the international diabetes federation with the following modifications: An individual aged 3–16 years has metabolic syndrome if he or she has central adiposity plus at least two of the following criteria: triglycerides levels ≥95th percentile (0-9 years ≥100 mg/dl; 10-19 years ≥130 mg/dl), HDL cholesterol level (HDL-C) <5th percentile (<40 mg/dl), systolic BP (SBP) or diastolic BP (DBP) ≥90th percentile for the age, gender and height, and fasting blood glucose ≥100 mg/dl (impaired fasting glucose-IFG).[15,17-19,24] Hypercholesterolemia (≥200 mg/dl), hypertriglyceridemia, high LDL cholesterol (LDL-C) or low HDL-C was accepted as dyslipidemia.[18]

Statistical analysis

Statistical analysis was performed by statistical package for the social sciences (SPSS) version 16.0. Qualitative data was presented as frequency and percentage and quantitative data as mean±standard deviation (SD). Chi square test or Fisher's exact test was used to compare qualitative data and quantitative data was compared using Student's t test and a p value <0.05 was considered statistically significant.

RESULTS

Clinical and demographic factors of the study population are given in Table 1. Study group included 264 children: 212 with obesity and 52 with overweight. Majority of the study participants were males (n=163, 61.7%), prepubertal (n=156, 59%) and aged 10-13 years (n=147, 55.7%). Mean age of the children with obesity was significantly lower than that of children with overweight (9.5±2.8 y versus 11.5±2.1, p<0.0001). Family history of obesity was noted in 178 children (67.4%). Family history of hypertension, dyslipidemia, T2D and heart attack were seen in 64%, 53.4%, 70.4% and 39.4% of study subjects, respectively. Among the study participants, 47 children had elevated SBP, DBP or both (17.8%) and 26 children had IFG (9.8%), one had FBS (0.4%) in the diabetes range (146 mg/dl). Proportion of children with central adiposity was significantly higher among children with obesity versus children with overweight (99.5% versus 84.6%, p<0.0001). Out of 264 children, 80 had MS (30.3%) and majority of them were prepubertal (n=49, 61.2%).

Boys versus girls

Boys predominated in both children with obesity (128 versus 84) and overweight (35 versus 17) (Table 2). Mean age was significantly lower for girls vs. boys in children with obesity (8.8±2.6 years versus 10±2.8 years, p=0.002) and overweight (10.6±2.6 years versus 12±1.6 years, p=0.022). Among children with obesity proportion of participants with MS was higher among girls versus boys (40.5% versus 24.2%, p=0.012). Patients with hypert-riglyceridemia (54.8% versus 37.5%, p=0.013), low HDL (42.9% versus 28.1%, p=0.027) and dyslipidemia (78.6% versus 59.4%, p=0.004) were also higher among girls versus boys among children with obesity.

Children with MS and without MS

Sixty-five children with obesity (30.7%) and 15 children with overweight (28.8%) had MS (n=80). Children with and without MS (n=184) were compared (Table 3). Proportion of patients with elevated SBP (18.8% versus 4.3%, p<0.0001), elevated DBP (34.5% versus 5.4%, p<0.0001), IFG (16.2% versus 7.6%, p=0.033), hypert-

riglyceridemia (85% versus 26.6%, p<0.0001), low HDL-C (75% versus 15.2%, p<0.0001) and dyslipidemia (97.5% versus 57.1%, p<0.0001) were higher in those with MS compared to those without MS. High WC, hypertriglyceridemia and low HDL were the most frequent MS components present in children with MS or without MS.

Table 1: Clinical and demographic factors of the study population.

Variables	All, n (%)	Obese, n (%)	Overweight, n (%)	P value
Number	264	212	52	
Age, years	9.9±2.8	9.5±2.8	11.5±2.1	<0.0001†
BMI, kg/m^2	24.1±3.2	24.8±3.1	21.4±1.8	<0.0001†
Sex				
Boys	163 (61.7)	128 (60.4)	35 (67.3)	0.357
Girls	101 (38.3)	84 (39.6)	17 (32.7)	
Age group (years)				
3-5*	26 (9.8)	24 (11.3)	2 (3.8)	
6-9	83 (31.4)	76 (35.8)	7 (13.5)	0.634
10-13	147 (55.7)	108 (50.9)	39 (75)	0.037#
14-16	8 (3)	4 (1.9)	4 (7.7)	0.018#
MS components				
WC above the cut-off	255 (96.6)	211 (99.5)	44 (84.6)	<0.0001†
SBP ≥90th percentile	23 (8.7)	22 (10.4)	1 (1.9)	0.056
DBP ≥90th percentile	36 (13.6)	31 (14.6)	5 (9.6)	0.346
IFG	27 (10.2)	19 (9)	8 (15.4)	0.171
Hypercholesterolemia	68 (25.8)	50 (23.6)	18 (34.6)	0.103
Hypertriglyceridemia	117 (44.3)	94 (44.3)	23 (44.2)	0.989
Elevated LDL-C	69 (26.1)	50 (23.6)	19 (36.5)	0.057
Low HDL-C	88 (33.3)	72 (34)	16 (30.8)	0.662
Dyslipidemia	183 (69.3)	142 (67)	41 (78.8)	0.096
MS	80 (30.3)	65 (30.7)	15 (28.8)	0.799

BMI – body mass index; DBP- diastolic blood pressure; IFG – impaired fasting glucose; HDL – high density lipoprotein; LDL – low density lipoprotein; MS – metabolic syndrome; WC – waist circumference, * reference category, † significant at 1% level, # significant at 5% level

Table 2: Demographic factors and MS components, boys versus girls.

Patient characteristics	Children with obesity, n (%)			Children with overweight, n (%)		
	Boys, n=128	**Girls, n=84**	**P**	**Boys, n=35**	**Girls, n=17**	**P**
Age, years	10±2.8	8.8±2.6	0.002#	12±1.6	10.6±2.6	0.022#
BMI, kg/m^2	25.04±3.1	24.4±3.1	0.135	21.5±1.5	21.2±2.4	0.572
Age group						
3-5*	14 (10.9)	10 (11.9)		0	2 (11.8)	
6-9	33 (25.8)	43 (51.2)	0.202	4 (11.4)	3 (17.6)	0.278
10-13	78 (60.9)	30 (35.7)	0.181	27 (77.1)	12 (70.6)	0.111
14-16	3 (2.3)	1 (1.2)	0.481	4 (11.4)	0	0.067
MS components						
WC above the cutoff	127 (99.2)	84 (100)	0.604	28 (80)	16 (94.1)	0.248
SBP ≥90th percentile	12 (9.4)	10 (11.9)	0.555	1 (2.9)	0	0.673
DBP ≥90th percentile	16 (12.5)	15 (17.9)	0.28	4 (11.4)	1 (5.9)	0.467
IFG	14 (10.9)	5 (6)	0.214	4 (11.4)	4 (23.5)	0.413
Hypercholesterolemia	26 (20.3)	24 (28.6)	0.166	11 (31.4)	7 (41.2)	0.488
Hypertriglyceridemia	48 (37.5)	46 (54.8)	0.013#	16 (45.7)	7 (41.2)	0.757
High LDL-C	26 (20.3)	24 (28.6)	0.166	15 (42.9)	4 (23.5)	0.175
Low HDL-C	36 (28.1)	36 (42.9)	0.027#	12 (34.3)	4 (23.5)	0.43
Dyslipidemia	76 (59.4)	66 (78.6)	0.004#	27 (77.1)	14 (82.4)	0.483
MS	31 (24.2)	34 (40.5)	0.012#	12 (34.3)	3 (17.6)	0.33

BMI- body mass index; DBP-diastolic blood pressure; IFG- impaired fasting glucose; HDL-C high density lipoprotein cholesterol; LDL-C-low density lipoprotein cholesterol; MS–metabolic syndrome; WC–waist circumference, *reference category # significant at 5% level

Table 3: Children with MS and without MS.

Patient characteristics	Those with MS, n=80 (%)	Those without MS, n=184 (%)	P
Age, years	9.5±2.8	10.1±2.8	0.101
BMI, kg/m^2	24.1±3.1	24.2±3.2	0.831
Sex			
Boys	43 (26.4)	120 (73.6)	0.078
Girls	37 (36.6)	64 (63.4)	
Age group			
3-5*	8 (10)	18 (9.8)	
6-9	31 (38.8)	52 (28.3)	0.541
10-13	40 (50)	107 (58.2)	0.708
14-16	1 (1.2)	7 (3.8)	0.403
MS components			
WC above the cutoff	77 (96.2)	178 (96.7)	0.547
SBP ≥90th percentile	15 (18.8)	8 (4.3)	<0.0001†
DBP ≥90th percentile	26 (32.5)	10 (5.4)	<0.0001†
IFG	13 (16.2)	14 (7.6)	0.033$^{\#}$
Hypercholesterolemia	24 (30)	44 (23.9)	0.299
Hypertriglyceridemia	68 (85)	49 (26.6)	<0.0001†
High LDL-C	23 (28.8)	46 (25)	0.524
Low HDL-C	60 (75)	28 (15.2)	<0.0001†
Dyslipidemia	78 (97.5)	105 (57.1)	<0.0001†

BMI- body mass index; DBP-diastolic blood pressure; IFG- impaired fasting glucose; HDL-C high density lipoprotein cholesterol; LDL-C-low density lipoprotein cholesterol; MS–metabolic syndrome; WC–waist circumference, *reference category # significant at 5% level

DISCUSSION

Current cross sectional study involving 264 children and adolescents aged 3-16 years attending Pediatric Endocrinology clinic of a tertiary care hospital, South India observed that about one third of patients with obesity and overweight had MS. Proportion of participants with MS, hypertriglyceridemia, low HDL-C and dyslipidemia were higher in girls versus boys among children with obesity. Those with elevated SBP and DBP, IFG, hypertriglyceridemia, low HDL-C and dyslipidemia were significantly higher in those with MS compared to those without MS.

Various studies reported a prevalence of MS ranging from 3% to 62% among children with overweight and obesity.[5,10,11,21-34] The wide range in the prevalence of MS reported by the prior studies might be due to the differences in definition of MS and cutoffs used by various studies as well as the differences in patient characteristics. Most of these studies were from Europe and North America and only 2 studies were from South Asia.[10,11] South Asians are thought to be at increased risk of developing MS owing to body fat patterning characterized by excess adiposity and truncal obesity seen in this population compared to Caucasians.[35] Even among South Asians, prevalence of MS may vary based on region, degree of urbanization, socioeconomic and cultural factors.[35] Both the studies from South Asia were from 2 North Indian cities.[10,11] MS was found in about 1/3rd of the children aged 8-18 years old with obesity from Sri Nagar, Kashmir while a community based cross sectional survey assessing MS on school going children aged 12-17 years from Chandigarh observed MS in more than 1/3 of those with BMI ≥95th percentile and in about 1/10th of those with BMI between 85th and 95th percentile.[10,11] Ours is the first study from South India assessing MS among children with obesity and overweight and we observed a higher prevalence of MS among children with overweight compared to the Chandigarh study (28% versus 11%).[11] Both the North Indian studies used the modified adult treatment panel III criteria while the current study used modified IDF criteria to define MS and our study population involved more younger patients which might explain the difference in the prevalence of MS among children with overweight between our study and Chandigarh study.[10,17]

Almost all the study subjects had central adiposity in the current study and those with central adiposity was higher among children with obesity vs. children with overweight. Similar observation was made by 2 different studies from Spain.[28,30] A systematic review and meta-analysis of observational studies on the prevalence of MS among children with overweight and obesity in affluent countries found that prevalence of abdominal obesity ranged between 42-100%.[33] High prevalence of truncal adiposity noted in the current study is not surprising as higher abdominal obesity have been observed among South Asians compared to Caucasians.[35]

Proportion of patients with MS, hypertriglyceridemia, low HDL-C and dyslipidemia were higher in girls versus boys among children with obesity in the current study. Higher prevalence of MS among girls versus boys was reported by

a study from Lebanon similar to our study while studies from Poland, Spain and Turkey observed no significant difference in the prevalence of MS by sex.[24,25,30,31] Our observation was also in contrast to the finding by Juárez-López, et al that showed no difference in terms of prevalence of MS, hypertriglyceridemia and low HDL levels between boys and girls.[20] Higher prevalence of MS observed in girls vs boys among children with obesity in the current study might be related to the difference in fat distribution in both sexes. Compared to boys prevalence of truncal adiposity was more in girls with obesity (100% versus 99% boys) and overweight (94% versus 80% boys).

The most common MS defining components among those with MS were central adiposity, hypertriglyceridemia and low HDL levels in the current study, similar to the observations made by prior studies.[24,29,33] Chandigarh study reported low HDL as the most common constituent of MS in the study participants.[11] Central adiposity was the least common constituent in this study in contrast to our observation.[11] Hypertriglyceridemia, elevated blood pressure and IFG were reported as the most common MS components in Romanian children aged 7-18 years with obesity and MS.[21] Again, the differences noted between the studies might be related to the differences in the definitions used to define central adiposity and MS components as well as the racial and ethnic differences of the study population.

Though not statistically significant, prevalence of MS was more among children with obesity compared to children with overweight in the current study (30.75 versus 28.8%, p=0.8). Various studies have reported a direct relation of MS prevalence with the degree of obesity.[10,22,34] Andrabi et al in his study on children of Srinagar city of Kashmir noticed that prevalence of MS was higher among obese subjects compared to overweight and normal weight subjects (30.7% versus 2.5% and 0.5%, respectively).[10] Sangun et al reported more than 2 fold increase in the prevalence of MS among children with BMI >2.5 SDS compared to those with BMI <2.5 SDS.[22] Weiss et al observed that MS was present in 38.7% and 49.7% of adolescents with obesity and severe obesity respectively.[5]

Present study observed a significantly higher proportion of patients with elevated SBP and DBP, IFG, hypertriglyceridemia, low HDL levels and dyslipidemia in those with MS group compared to those without. Similar observations were made prior studies.[10,23,25] Andrabi et al reported higher prevalence of truncal adiposity, IFG, low HDL and hypertriglyceridemia among children from Srinagar, Kashmir with MS versus those without MS while a study from Egypt on children with obesity reported higher prevalence of hypertension and dyslipidemia in those with MS compared to those without MS.[10,23] A study from Poland on 591 obese children reported higher prevalence of hypertension, low HDL levels and hypercholesterolemia in children with MS compared to children without MS.[25]

Major limitation of the current study was the lack of a control group. This was a cross-sectional study and hence did not allow causal or temporal inferences. Another limitation was its being a single institution study. However, this is the first study on the prevalence of MS among children with overweight and obesity from South India and the first study from India that looked into the prevalence of MS among children aged 3-8 years. India is a very diverse country with 29 states, each with their own unique languages and culture. A recent population based study on the prevalence of MS among adolescents in India reported wide variability across states owing to differences in lifestyles, degree of urbanization and socioeconomic factors.[36] Very few studies from India had addressed the prevalence of MS among children with obesity and both were from North India.[10,11]

CONCLUSION

Current study from South India observed MS even in younger children with overweight and obesity which is really concerning as these children are at increased risk for hypertension, T2D, NAFLD and cardiovascular disease in early adulthood which in turn leads to huge economic burden on the country. It is therefore of utmost importance to take necessary steps to identify these children early, manage obesity effectively before MS sets in and initiate preventive measures thereby ensuring a healthy young generation in the coming years.

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