The Egyptian Journal of Hospital Medicine (April 2023) Vol. 91, Page 4590-4596

Evaluation of the Presence and Risk Factors for Pediatric Metabolic Syndrome in Obese School-Aged Children

Ghada Mohammed Abdellatef[1], Hend Mohammed Ahmed Ibrahim[1]*, Weaam Ibrahim Ismail[2], Nahed Mahmoud Helmy Khater[1]

Departments of [1]Pediatrics and [2]Clinical Pathology, Faculty of Medicine, Zagazig University, Egypt

***Corresponding author:** Hend Mohammed Ahmed Ibrahim, **Mobile:** (+20)1014058918, **E-Mail:** hends209@gmail.com

ABSTRACT

Background: There is a clear association between metabolic syndrome (MetS) in children with high risk of type 2 diabetes and cardiovascular disease later in life.

Objective: The aim of the current work was to detect prevalence of MetS and risk factors of pediatric metabolic syndrome (PMS) in obese children.

Subject and Methods: This cross-sectional study was performed at the Departments of Pediatrics and Clinical Pathology, Zagazig University Hospitals. It included 136 primary school-age children having obesity. High-density lipoprotein-cholesterol (HDL-C), fasting plasma glucose (FPG), triacylglycerols (TGs), total cholesterol (TC) and low-density lipoprotein-cholesterol (LDL-C) were assayed. Modified adult treatment panel (ATP-III) classification and cook et al definition were used for assessment of MetS in children involved in the study.

Results: A high prevalence of MetS was found in the obese children population (35.3% according to cook *et al.* definition of MetS and 26.5% according to modified ATP classification). Waist circumference was the major contributor to a metabolic syndrome where each 1 cm increase in circumference increased the risk factor of metabolic syndrome by 1.59 (P<0.0001), followed by systolic blood pressure (SBP) where each 1 mmHg increase in blood pressure led to increased risk of metabolic syndrome by 1.06 (P=0.015). Finally, total cholesterol was the third contributor where each one mg/dl increase in total cholesterol level led to increased risk of metabolic syndrome by 1.02 (P=0.035).

Conclusion: It could be concluded that childhood obesity is strongly linked to the occurrence of metabolic syndrome.

Keywords: Metabolic Syndrome, Obesity, Pediatrics.

INTRODUCTION

One of the most critical public health challenges of the 21st century is the epidemic of childhood obesity. An excess of 3 standard deviations (SD) above the median of the World Health Organization's child growth criteria is considered to be obese. Overweight is defined as a BMI greater than 2 standard deviations above the median, as established by the World Health Organization's growth criteria for children. In 2006, the rate of childhood obesity was 27.5% in the USA, 25.5% in Europe, and 12.5% in Egypt and North Africa. The rising rates of overweight and obesity in children and adults have been linked to dietary patterns that emphasize saturated fats, added sugars, and refined starches [(1)].

Two adult health risks related with pediatric metabolic syndrome (PMS) are early onset diabetes mellitus and cardiovascular diseases. School-aged children are diagnosed with PMS when three or more of the following metabolic and clinical problems coexist: insulin resistance (IR), abdominal obesity, low high-density lipoprotein (HDL), high triglycerides, high fasting blood glucose (FPG), and high blood pressure (BP) [(2)].

Eighty-five percent of overweight children go on to be overweight adults, making childhood obesity a leading cause of preventable illness and death in the adult population. Detecting MetS in young children and teenagers is crucial for reducing the global monetary and human cost of cardiovascular disease and type 2 diabetes. For the first time in human history, today's youth may not live as long as their parents did [(3)].

Gupta *et al.* [(2)] stated that children in Indian schools had a prevalence of PMS of 3.3%. In Egypt, **Soliman *et al.*** [(4)] found that 13.12% of children and adolescents were estimated to have MetS.

Overall, 17.7 percent and 13.5 percent of Port Said city's public school students in the 6-12 age range were overweight or obese [(5, 6)].

Studying the prevalence of the pediatric metabolic syndrome and its related risk factors in obese children was the focus of this study.

SUBJECTS AND METHODS

This cross-sectional study included a total of 136 school-age children having obesity with BMI ≥97%, performed at the Departments of Pediatrics and Clinical Pathology, Faculty of Medicine, Zagazig University Hospitals.

Inclusion criteria: School-aged obese children, aged 5–10 years, both sexes.

Exclusion criteria: Children with secondary causes of obesity, e.g.:

1- Genetic syndromes (e.g. Bardet-Biedl syndrome, Alstrom syndrome, Cohen syndrome, Borjeson-Forssman-Lehmann syndrome, Frohlich syndrome, as well as Prader-Willi syndrome).
2- Endocrinal causes: hypothyroidism, growth hormone deficiency, cushing Syndrome and insulinoma

Received: 22/11/2022
Accepted: 24/01/2023

3- Medication-related like, carbamazepine, phenothiazines, tricyclic antidepressants, as well as sodium valproate.
4- Troubles with eating (night-eating disorder, bulimia nervosa as well as binge-eating disorder).
5- Morbid obesity caused by prolonged tube feeding.

The children involved in the study were subjected to the following**:**

A) Complete History taking, stressing on:

- Age, sex, family monthly income, occupation, and educational qualification of parents.
- History of diseases, artificial feeding, factors contributing to the development of obesity, drugs, sedentary habits (screen time) and sleep duration and family history of obesity.
- Assessment of dietary habits and pattern.
- Assessment of physical activity: It was measured and classified as inactive, insufficiently active, active, and highly active.

B) Physical examination including:

- **Anthropometric measurements:** Weight, Height, waist circumference (WC) waist to hip ratio (WHR) as well as estimated Body mass index (BMI).
- Blood pressure.

C) Laboratory investigations:

Fasting venous blood samples were taken after obtaining the consent of one of the parents present with their kid [(7)]. Blood was distributed between an oxalate fluoride tube for FPG, and a plain tube to separate serum for lipids profile (total cholesterol, LDL-C, HDL-C, and triacylglycerols). These tests were performed on Roche Cobas 8000 auto-analyzer, c 702 module, by spectrophotometry, using the dedicated kit supplied by the manufacturer (Roche Diagnostics, Switzerland). Very low-density lipoprotein-cholesterol was calculated by dividing the triacylglycerols value by 5.

- **The included children in the study are identified to suffer from pediatric metabolic syndrome according to 2 classifications:**

1- Modified **adult treatment panel (ATP-III)** classification: When three or more of the following parameters were simultaneously present, a kid is considered to be experiencing PMS
(1) WC ≥ 90th percentile, (2) TG ≥ 150 mg/dl, (3) HDL≤ 40 mg/dl, (4) FPG ≥ 100mg/dl, and (v) hypertension ≥ 95th percentile **[(2)].**
2- **Cook *et al.*** **[(8)]** definition of pediatric metabolic syndrome: When three or more of these symptoms occur at the same time, a kid is diagnosed with PMS (1) WC ≥ 90th percentile, (2) TG ≥ 110 mg/dl, (3) HDL ≤ 40 mg/dl, (4) FPG ≥ 110 mg/dl, and (5) hypertension ≥ 90th percentile.

***Ethical Consideration*:**

This study was ethically approved by Zagazig University's Research Ethics Committee (ZU- IRB #**6927**). Written informed consent of all the participants' parents was obtained. The study protocol conformed to the Helsinki Declaration, the ethical norm of the World Medical Association for human testing.

Statistical Analysis

Information was entered into the computer and analyzed using IBM SPSS 20.0 (IBM Corp., 2017). Armonk, NY: IBM Corp., Version 25.0 of IBM SPSS Statistics for Windows. To ensure a normally distributed sample, the Shapiro-Wilk test was performed. Logistic Regression is a statistical method for analyzing the correlation between a categorical dependent variable and a set of potentially hundreds of independent variables. It's helpful when there are just two possible values for the target variable. We found that a P value of 0.05 or less was statistically significant.

RESULTS

Table (1) shows that the mean age of studied cases was 8.1 ± 1.6 years, ranged from 5 to 10 years. 55% of patients were females and 45% were males. 74.2% of cases had history of artificial feeding, 57.4% of cases had Family history of obesity, 64% of parent graduated from secondary school, 51.5% of cases had moderate family monthly income, 85.3% of cases were inactive, 70.5% of cases had screen time more than 2 hours, 13.9% of cases had sleep duration less than 8 hours at night and 94.1%, 59.6% and 82.4% of cases had lunch to school, fast or junk food and sweeten beavers respectively.

Table (1): Demographics of the studied cases (Risk factors of childhood obesity).

Variables	Obese children (N=136)
Age (Years)	
Mean ± SD	8.1 ± 1.6
Range	(5-10)
Sex	
Male	61 (45%)
Female	75 (55%)
History of artificial feeding	101 (74.2%)
Family history of obesity	78 (57.4%)
Parents education	
Preparatory school or less	8 (5.9%)
Secondary school	87 (64%)
College or post graduate	41 (30.1%)
Family monthly income	
Low	15 (11.0%)
Moderate	70 (51.5%)
High	51 (37.5%)
Physical activity	
Inactive	116 (85.3%)
Insufficiently active	4 (3%)
Active	15 (11%)
Highly active	1 (0.7%)
Screen time > 2 hours	96 (70.5%)
Sleep duration < 8 hours at night	19 (13.9%)
Dietary habits	
Taking lunch to school	128 (94.1%)
Fast or junk food	81 (59.6%)
Sweeten beavers	112 (82.4%)

Table (2) shows that the mean ± SD weight of studied cases was 54.8 ± 10.1 Kg ranged from 30 to 94 Kg while the mean ± SD height of studied cases was 112.6 ± 11.5 cm, ranged from 89 to 146 cm.

The mean ± SD BMI was 28.2 ± 2.8 (kg/m^2), ranged from 24 to 40.8 (kg/m^2),. The mean ± SD waist circumference was 76.4 ± 8.9 cm, ranged from 60 to 105 cm and mean ± SD mid upper arm circumference was 22.6 ± 4.2 cm, ranged from 16 to 34 cm, waist to hip ratio mean was 1.13 ± 0.06 and ranged from 0.86 to 1.28.

Table (2): Anthropometric measurements of the studied cases.

Variables	Obese children (N=136)
Weight (Kg)	
Mean ± SD	54.8 ± 10.1
Range	(30-94)
Height (cm)	
Mean ± SD	112.6 ± 11.5
Range	(89-146)
BMI (kg/m^2)	
Mean ± SD	28.2 ± 2.8
Range	(24-40.8)
Waist circumference (cm)	76.4 ± 8.9
Mean ± SD	(60-105)
Range	
Mid upper arm circumference (cm)	
Mean ± SD	22.6 ± 4.2
Range	(16-34)
Waist/ hip ratio	
Mean ± SD	1.13± 0.06
Range	(0.86-1.28)

Table (3) shows that 26.2%, 44.2% and 55.7% of obese boys in the study had FPG ≥ 110mg/dl, TGs ≥ 110mg/dl and HDL ≤ 40 mg/dl respectively and 83.6% and 32.7% had WC ≥ 90th percentile and HTN ≥ 90th percentile respectively. Also, 17.3%, 41.3% and 56% of obese girls in the study had FPG ≥ 110mg/dl, TGs ≥ 110mg/dl and HDL ≤ 40 mg/dl respectively and 89.3% and 29.3% had WC ≥ 90th percentile and HTN ≥ 90th percentile respectively. Totally, 21.3%, 42.6% and 55.9% of studied cases had FPG ≥ 110mg/dl, TGs ≥ 110mg/dl and HDL ≤ 40 mg/dl respectively. Also 86.8% of cases had WC ≥ 90th percentile and 30.9% had HTN ≥ 90th percentile. Number of cases had 3 or more criteria of **Cook *et al.* (2003)** definition of metabolic syndrome was 48 cases (35.3%).

Table (3): Abnormal laboratory data among the studied cases according to **Cook *et al.* (2003**) definition of metabolic syndrome.

Variables	Obese boys (N=61)	Percent	Obese girls (N=75)	Percent	Total (N=136)	Percent
FPG ≥ 110 mg/dl	**16**	**26.2%**	**13**	**17.3%**	**29**	**21.3%**
TGs ≥ 110mg/dl	**27**	**44.2%**	**31**	**41.3%**	**58**	**42.6%**
HDL ≤ 40 /dl	**34**	**55.7%**	**42**	**56%**	**76**	**55.9%**
WC ≥ 90th percentile	**51**	**83.6%**	**67**	**89.3%**	**118**	**86.8%**
HTN ≥ 90th percentile	**20**	**32.7%**	**22**	**29.3%**	**42**	**30.9%**

Table (4) shows that 36%, 19.6% and 55.7% of obese boys in the study had FPG ≥ 100mg/dl, TGs ≥ 150mg/dl and HDL ≤ 40 mg/dl respectively and 83.6% and 24.6% had WC ≥ 90th percentile and HTN ≥ 95th percentile respectively. Also, 24%, 18.6% and 56% of obese girls in the study had FPG ≥ 100mg/dl, TGs ≥ 150mg/dl and HDL ≤ 40 mg/dl respectively and 89.3% and 21.3% had WC ≥ 90th percentile and HTN ≥ 95th percentile respectively. Totally, 29.4%, 19.1% and 55.9% of studied cases had FPG ≥ 100mg/dl, TGs ≥ 150mg/dl and HDL ≤ 40 mg/dl respectively. Also 86.8% of cases had WC ≥ 90th percentile and 22.8% had HTN ≥ 95th percentile. Number of cases had 3 or more criteria of **modified ATP** classification of metabolic syndrome was 36 cases (26.5%).

Table (4): Abnormal laboratory data among the studied cases according to **Modified ATP** classification**.**

Variables	Obese boys (N=61)	Percent	Obese girls (N=75)	Percent	Total (N=136)	Percent
FPG ≥ 100mg/dl	**22**	**36%**	**18**	**24%**	**40**	**29.4%**
TGs ≥ 150mg/dl	**12**	**19.6%**	**14**	**18.6%**	**26**	**19.1%**
HDL ≤ 40mg/dl	**34**	**55.7%**	**42**	**56%**	**76**	**55.9%**
WC ≥90th percentile	**51**	**83.6%**	**67**	**89.3%**	**118**	**86.8%**
HTN ≥95th percentile	**15**	**24.6%**	**16**	**21.3%**	**31**	**22.8%**

Table (5) shows that 91.2% of studied cases had at least one criterion of MetS according to **cook *et al.* (2003)** and 87.5% of cases according to **modified ATP** classification.

Table (5): Number of studied cases having at least one criterion of metabolic Syndrome (MetS) according to the classifications used in the study.

Variables	Obese boys (N=61)	Obese girls (N=75)	Total (N=136)	Percent
Cook *et al.* definition	**56**	**68**	**124**	**91.2%**
Modified ATP classification	**49**	**70**	**119**	**87.5%**

The previous analysis revealed that waist circumference was the major contributor to metabolic syndrome where each 1 cm increase in circumference increase risk factor of metabolic syndrome by 1.59 (P<0.0001), followed by systolic blood pressure where each 1 mmHg increase in SBP leads to increased risk of metabolic syndrome by 1.06 (P=0.015). Finally, total cholesterol is the third contributor where each one mg/dl increase in total cholesterol level increase risk of metabolic syndrome by 1.02 (P=0.035). The other risk factors didn't show any significant effect in the present cohort of obese patients. P value < 0.05 was significant Table (6).

Table (6): Logistic regression multivariate analysis for the contribution of different risk factors of obese patients in metabolic syndrome.

Variables	B	S.E.	P value.	Odd ratio	95% C.I. for EXP(B)	
					Lower	Upper
Waist Cir.	0.469	0.091	**<0.0001 ***	1.599	1.337	1.912
SBP	0.061	0.005	**0.015 ***	1.063	1.012	1.116
Cholesterol	0.024	0.002	**0.035 ***	1.025	1.002	1.048
TG	0.019	0.002	0.553	1.019	.958	1.084
HDL	-0.020	0.005	0.186	0.980	.952	1.010
LDL	0.025	0.005	0.083	0.975	.948	1.003
FPG	0.000	0.016	0.996	1.000	.969	1.032
Constant	-40.414	8.207	0.000	.000		

DISCUSSION

Central obesity and/or insulin resistance (IR) are believed to be the starting points for a variety of pathogenic pathways that ultimately lead to the complete manifestation of the metabolic syndrome by increasing metabolic risk [(9)]. The early initiation of risk factors is concerning because several aspects of MetS have been shown to persist into adulthood and substantially raise the risk of type 2 diabetes and cardiovascular disease [(10)]**.**

Heart disease and early death in adults are common consequences of childhood obesity [(11)]. However, a review of a previous literature found that most studies didn't account for BMI when looking at links between juvenile obesity and metabolic syndrome, and that there's scant proof that obesity in young people is a separate risk factor for MetS or diabetes [(12)]**.**

The current study showed that studied cases mean age was 8.1 ± 1.6 years, ranged from 5 to 10 years where 55% of cases were females and 45% were males**.**

Gupta et al. [(2)] reported that among the 2100 students included, a slight majority of boys were represented (1149 to 951) in the age range of 10 to 16 years. The average age of the boys was 13.4± 1.8 years, and the average age of the girls was 13.5 ±1.8 years**.**

Our results suggested an increased prevalence of artificial feeding (74.2%) in obese children who shared in the study (The formula had a higher protein content than breast milk leading to increased growth rate and adiposity during infancy and risk of obesity later in life) and family history of obesity (57.4%) among them. This comes in agreement with Bouchard [(13)] who revealed that Childhood obesity was strongly connected to both artificial feeding and a genetic predisposition to overweight and obesity**.**

Our study showed that the majority of children have parents with moderate educational level (secondary school), but Gupta et al. [(2)] reported that Children in India who had parents with a poor education level were more likely to be overweight or obese than those whose parents had higher education levels**.**

In this study we found that the majority of children have moderate (51.5%) and high (37.5%) family income. In disagreement with our results, **Bitew *et al.*** **[(14)]** stated that there was an association between childhood obesity and low family income. The variation may be due to difference in sample size, age groups.

The present study revealed that the majority of children were physically inactive (85.3%) i.e., their energy expenditure was low. Also 70.5% of cases spent screen time more than 2 hours. This was in concordance with **Hills *et al.*** **[(15)]** who concluded that the physical inactivity was significantly associated with childhood obesity (They didn't burn extra calories through sports or other forms of physical activities. Too much time spent in sedentary activities, such as TV watching or video games playing, also contributes to develop obesity later). The current study showed that the majority of children had unhealthy high caloric dietary habits e.g fast or junk food (59.6%) and sweeten beavers (82.4%). This agreed with **Smetanina *et al.*** **[(16)]** who revealed that there was significant correlation between unhealthy dietary habits and childhood obesity.

Regarding the abnormal laboratory data among the studied cases according to **Cook *et al.*** **[(8)]** definition of metabolic syndrome, it was revealed that 21.3%, 42.6%, 55.9% of cases had FPG ≥ 110mg/dl, TGs ≥ 110mg/dl , HDL ≤ 40 mg/dl respectively. Also 86.8% of obese children had WC ≥ 90th percentile and 30.9% had HTN ≥ 90^{th} percentile. The prevalence of MetS using **Cook *et al.*** **[(8)]** definition was 48 cases (35.3%).

According to Cook's criteria **Braga-Tavares and Fonseca** **[(17)]** showed that metabolic syndrome (MetS) prevalence among obese adolescents was 15.6%. There was not a single adolescent who met all five MetS requirements, and just three (1.2 percent) met none. The most common risk factor was a large waist size (89.5%), while high fasting blood sugar levels were the least common (1.3 percent).

The current study also showed that 29.4%, 19.1%, 55.9% of cases had FPG ≥ 100mg/dl, TGs ≥ 150mg/dl, HDL ≤ 40 mg/dl respectively. Also 86.8% of obese children had WC ≥ 90th percentile and 22.8% had HTN ≥ 95^{th} percentile. The prevalence of MetS using **modified ATP** was 36 cases (26.5%).

Gupta *et al.* [2] showed that there were 13.5% have Fasting blood glucose level ≥100 (mg/dl), 9.2% have High triglyceride level (≥150 mg/dl), and 16.9% have Low HDL level (<40 mg/dl), 3.8% have Abdominal obesity (WC ≥90th percentile), and 20.5 % were hypertensive. However, **Giannini *et al.*** [18] showed that In the adolescent population, 40.4% of those who were obese and 9.4% of those who were overweight met the ATP criteria for the diagnosis of MetS.

The variations in the prevalence among the studies comparing our study with **Gupta *et al.*** [2] and **Giannini *et al.*** [18] may be due to the difference in sample characteristics including mean age and obesity severity as well as the difference in environmental factors.

Reisinger *et al.* [9] estimated of the prevalence of metabolic syndrome in children and adolescents varied widely from 0.3% to 26.4%, depending in part on the definitions employed. The lowest estimates of prevalence (0.3-9.5%) were obtained using the International Diabetes Federation (IDF) definition (19), whereas the most accurate classification (4.0-26.4 percent) was found in the work of **de Ferranti *et al.*** [20]**.**

Gupta *et al.* [2] demonstrated that 3.3% (n = 69) and 3.5% (n = 74) of school-aged children had MetS according to the IDF classification and modified-ATP classification criteria, respectively. Similarities between the IDF and modified ATP classifications of MetS risk factors in school-aged children were discovered.

Previous investigations found a MetS prevalence ranging from 0.2% to 38.9% [21]**.** Among children as a whole, the prevalence of metabolic syndrome was 3.3% (0-19.2%), among overweight children it was 11.9% (2.8-29.3%), and among obese children it was 29.2% (10-66%), according to a meta-analysis of 85 studies. Children who were neither fat nor overweight fell into a range of 0% to 1% [22]**.** The metabolic syndrome is present in about 90% of overweight and obese children and adolescents [8]**.** The current study showed that 91.2% of studied cases had at least one criterion of MetS according to **Cook *et al.*** [8] and 87.5% of cases according to **modified ATP** classification.

Also, **Hannan *et al.*** [23] demonstrated a high prevalence of dyslipidemia and metabolic syndrome in children with central obesity (60.3 percent), as defined by the ATP criteria (88.6 percent).

While, **Abou El-Ella *et al.*** [24] revealed that the prevalence of MetS among studied children with mean age of studied children was 12 ± 1.6 years was 7% of obese children according to adult definitions of MetS.

The prevalence of PMS has been observed in the range of 1.5%-9.9% across various studies [25, 26]**.** There appears to be an upward trend in the incidence of PMS, which may be related to the rising rates of childhood obesity. This could cause a rise in risk factors such as cholesterol, triglycerides, fasting blood glucose, and hypertension [27]**.**

The analysis of the contribution of different risk factors of obese patients in metabolic syndrome, showed that waist circumference is the major contributor to metabolic syndrome where each 1 cm increase in circumference increase risk factor of metabolic syndrome by 1.59 (P<0.0001), followed by systolic blood pressure (SBP) where each 1 mmHg increase in blood pressure leads to increase risk of metabolic syndrome by 1.06 (P=0.015). Finally, total cholesterol is the third contributor where each one mg/dl increase in total cholesterol level increase risk of metabolic syndrome by 1.02 (P=0.035). The other risk factors didn't show any significant effect in the present cohort of obese patients. We suggested that there was a strong linkage between high cholesterol, increased blood pressure and WC in obese children. Consumption of unhealthy fatty foods could lead to increase serum cholesterol in children which was an index of hyperlipidemia and development of obesity and cardiovascular disease such as HTN in childhood. Increased WC could be due to accumulation of adipose tissue in abdominal wall in obese children.

Strong associations between insulin resistance, hyperlipidemia, and systolic blood pressure all point to waist circumference as the most important factor [28]**.**

This coincides with **Perona *et al.*** [29] who reported that blood pressure, plasma lipids, glucose, and insulin levels were all considerably higher in children with MetS. As compared to the non-MetS group, all anthropometric indexes were significantly higher in the MetS population. As well, **Pratyusha and Rao** [30] revealed that there was significant association between metabolic syndrome in obese children and high BMI and blood pressure but in contrast to our results, they also found a significant association with LDL, HDL, TGs, and fasting glucose (This could be due to the difference in sample characteristics including mean age and obesity severity as well as the differences in environmental factors). Consistent with our findings, **Liang *et al.*** [31] found that patients with childhood obesity had an increased risk solely for abdominal obesity (as measured by a waist circumference ≥ 90th percentile), but not for any other components.

The current study had some limitations, including a small sample size, a single-center design, and a short follow-up time. Confirmation of our findings and identification of additional independent risk variables of metabolic syndrome will need larger, well followed future comparative investigations.

CONCLUSION

It could be concluded that childhood obesity is strongly linked to the occurrence of metabolic syndrome.

According to our data, the prevalence of MetS is quite high in obese youngsters (35.3% according to cook *et al.* definition of MetS and 26.5% according to modified ATP classification), hence suggesting the potential for adult issues to arise at an earlier age. Therefore, the most essential function in reducing the risk of cardiovascular disease in adulthood is the prevention and treatment of early childhood obesity, and hence the prevention of metabolic syndrome. Additionally, it is crucial to

emphasize the need for standardized diagnostic criteria of MetS in the pediatric population. The current study found that among risk factors for metabolic syndrome in obese children, waist circumference was the most important.

Supporting and sponsoring financially: Nil.
Competing interests: Nil.

REFERENCES

1. **Huang J, Qi S (2015):** Childhood obesity and food intake. World J Pediatric, 11(2):101–7.
2. **Gupta A, Sachdeva A, Mahajan N *et al.* (2018):** Prevalence of pediatric metabolic syndrome and associated risk factors among school-age children of 10-16 years living in District Shimla, Himachal Pradesh, India. Indian J Endocrinol Metab., 22(3): 373-78.
3. **Tirosh A, Shai I, Dubnov-Raz G *et al.* (2011):** Adolescent BMI trajectory and risk of diabetes versus coronary disease. N Engl J Med., 364(14): 1315–25.
4. **Soliman H, Mosaad Y, Ibrahim A (2019):** The prevalence and the clinical profile of metabolic syndrome in children and adolescents with Type 1 diabetes. Diabetes Metab Syndr Clin Res Rev., 13: 1723-1726.
5. **Ge H, Yang Z, Li X *et al.* (2020):** The prevalence and associated factors of metabolic syndrome in Chinese aging population. Scientific Reports, 10(1): 1-10.
6. **Badawi N, Abo Barakat A, El Sherbini S *et al.* (2013):** Prevalence of overweight and obesity in primary school children in Port Said city. Gaz Egypt Paediatr Assoc., 61: 31–36.
7. **Prodam F, Ricotti R, Genoni G *et al.* (2013):** Comparison of two classifications of metabolic syndrome in the pediatric population and the impact of cholesterol. J Endocrinal Invest., 36: 466-473.
8. **Cook S, Weitzman M, Auinger P *et al.* (2003):** Prevalence of a metabolic syndrome phenotype in adolescents: findings from the third National Health and Nutrition Examination Survey, 1988-1994. Archives of Pediatrics, Adolescent Medicine, 157(8): 821-827.
9. **Reisinger C, Nkeh-Chungag B, Goswami N *et al.* (2021):** The prevalence of pediatric metabolic syndrome: A critical look on the discrepancies between definitions and its clinical importance. International Journal of Obesity, 45: 12-24.
10. **Mameli C, Zuccotti G, Carnovale C *et al.* (2017):** An update on the assessment and management of metabolic syndrome, a growing medical emergency in pediatric populations. Pharmacological Research, 119: 99-117.
11. **Sypniewska G (2015):** Laboratory assessment of cardiometabolic risk in overweight and obese children. Clinical Biochemistry, 48(6): 370-376.
12. **Célind J, Ohlsson C, Bygdell M *et al.* (2019):** Childhood Body Mass Index Is Associated with Risk of Adult Colon Cancer in Men: An Association Modulated by Pubertal Change in Body Mass IndexChildhood BMI, Pubertal BMI Change, and Colorectal Cancer. Cancer Epidemiol Biomarkers Prev., 28(5): 974-979.
13. **Bouchard C (2009):** Childhood obesity: are genetic differences involved? Am J Clin Nutr., 89(5): 1494–1501.
14. **Bitew Z, Alemu A, Ayele E *et al.* (2020):** Metabolic syndrome among children and adolescents in low and middle income countries: a systematic review and meta-analysis. Diabetology Metabolic Syndrome, 12(1): 1-23.
15. **Hills A, Andersen L, Byrne N (2011):** Physical activity and obesity in children. British Journal of Sports Medicine, 45(11): 866-870.
16. **Smetanina N, Albaviciute E, Babinska V *et al.* (2015):** Prevalence of overweight/obesity in relation to dietary habits and lifestyle among 7–17 years old children and adolescents in Lithuania. BMC Public Health, 15(1): 1-9.
17. **Braga-Tavares H, Fonseca H (2010):** Prevalence of metabolic syndrome in a Portuguese obese adolescent population according to three different definitions. European Journal of Pediatrics, 169: 935-940.
18. **Giannini D, Kuschnir M, Szklo M (2014):** Metabolic syndrome in overweight and obese adolescents: a comparison of two different diagnostic criteria. Annals of Nutrition and Metabolism, 64(1): 71-79.
19. **Alberti K, Zimmet P, Shaw J (2005):** The metabolic syndrome—a new worldwide definition. The Lancet, 366(9491): 1059-1062.
20. **De Ferranti s, Gauvreau K, Rifai N *et al.* (2004):** Prevalence of the metabolic syndrome in American adolescents: findings from the Third National Health and Nutrition Examination Survey. Circulation, 110(16): 2494–2497.
21. **Agudelo G, Bedoya G, Estrada A *et al.* (2014):** Variations in the prevalence of metabolic syndrome in adolescents according to different criteria used for diagnosis: which definition should be chosen for this age group?. Metabolic Syndrome and Related Disorders, 12(4): 202-209.
22. **Friend A, Craig L, Turner S (2013):** The prevalence of metabolic syndrome in children: a systematic review of the literature. Metabolic Syndrome and Related Disorders, 11(2): 71-80.
23. **Hannan M, Haq T, Hasanat M *et al.* (2019):** Cardiometabolic Risk in Overweight and Obese Children in Bangladesh. Open Journal of Endocrine and Metabolic Diseases, 9(10): 103-117.
24. **Abou El-Ella S, Tawfik M, Abou Zouna Z *et al.* (2022):** Prevalence of metabolic syndrome in school-aged obese children. Menoufia Medical Journal, 35(3): 1248.
25. **Bhalavi V, Deshmukh P, Goswami K *et al.* (2015):** Prevalence and correlates of metabolic syndrome in the adolescents of rural Wardha. Indian J Community Med., 40:43-8.
26. **Bhat R, Paray I, Zargar S *et al.* (2015):** Prevalence of the metabolic syndrome among North Indian adolescents using Adult Treatment Panel III and pediatric International Diabetic Federation definitions. Arch Med Health Sci., 3:44. DOI:10.4103/2321-4848.154944
27. **Jung U, Choi M (2014):** Obesity and its metabolic complications: The role of adipokines and the relationship between obesity, inflammation, insulin resistance, dyslipidemia and nonalcoholic fatty liver disease. Int J Mol Sci., 15: 6184-223.
28. **Nehus E, Mitsnefes M (2019):** Childhood obesity and the metabolic syndrome. Pediatric Clinics, 66(1): 31-43.
29. **Perona J, Rio-Valle S, Ramírez-Vélez R *et al.* (2019):** Waist circumference and abdominal volume index are the strongest anthropometric discriminators of metabolic syndrome in Spanish adolescents. European Journal of Clinical Investigation, 49(3): e13060. doi: 10.1111/eci.13060.
30. **Pratyusha R, Rao K (2020):** Study of prevalence of metabolic syndrome in obese children in Konaseema region of India. Int J Contemp Pediatr., 7: 2321-25.
31. **Liang Y, Hou D, Zhao X *et al.* (2015):** Childhood obesity affects adult metabolic syndrome and diabetes. Endocrine, 50(1): 87-92.