ICMH Journal 2020; 11(1): 14–21

Original Article

Prevalence of Metabolic Syndrome and Associated Risk Factors Among Adolescent Students of a Selected School in a Peri-urban Community

S M Zahid Hassan Arefin[1], Ifthakhar Ahmed[2], Abidul Haque[3], Ayesha Nazneen[4], Wahida Khanom[5], M.A. Mannan[6], Anup Kumar Saha[7], Md. Abdur Rahman[8], Farhana Jahan[9]

Abstract

Background and objectives

Metabolic syndrome (MetS), defined as a constellation of five risk factors (obesity, hyperglycemia, decreased high-density lipoprotein (HDL), raised triglyceride, and high blood pressure) is being increased globally among children and adolescents. Very few studies have focused on MetS in children and adolescents in our community. This study, therefore, was designed to assess the prevalence of MetS and its associated risk factors among adolescent school-going children in our community.

Methods

Three hundred three school children, aged 12-16 years of age, were enrolled in this cross-sectional study. Modified NCEP-ATP III criteria were used to define metabolic syndrome. WHO STEPS chronic disease risk factor surveillance guideline- (questionnaire, physical and biochemical measurements) was followed to prepare the questionnaire. Anthropometry (weight, height, and waist circumferences) and blood pressure were measured for each participant. Physical activity was measured according to the Global Physical Activity Questionnaire (GPAQ) method. Fasting blood samples were collected for measurements of blood glucose, high-density lipoprotein (HDL), and triglyceride.

Results

The overall prevalence of MetS was 13.9%, significantly more in boys than in girls (17.6 vs 8.7). Prevalence of high fasting plasma glucose, high triglyceride and low HDL was found 16.2% (21.6% in boys and 8.7% in girls, p-value <0.05), 44.2% (63.6% in boys and 17.3% in girls, p-value <0.05) and 42.9% (27.8% in boys and 63.8% in girls, p-value <0.05) respectively. About one-fifth (18.8%) of the students were found obese, with almost equal prevalence in boys and girls (19.9% vs 17.3%). About one-third (30.4%) of the students had central obesity, almost equal in both sexes (29% of boys and 32.3% of girls). Blood pressure (BP) was raised in 11.2% of the students (more in boys than in girls- 14.8 vs 6.3%, p-value less than 0.05). The prevalence of MetS and all the component risk factors except low HDL was found significantly higher among overweight and obese than non-obese students. Prevalence of low physical activity was 8.8% (more in girls-14% than in boys-5.2%, p-value <0.05). None of the students took adequate fruit and vegetable but almost all of them took a higher amount of oil and salt than the recommended value, 92.4%, and 98.3% respectively.

Conclusion

The prevalence of metabolic syndrome and component risk factors among adolescent school students was found high in this study. Their dietary habit was also found opposite of what is expected. Attention should be paid to safeguarding this generation from developing cardiovascular diseases and diabetes.

Keywords: *Metabolic Syndrome, Adolescent School Children, NCEP-ATP III Criteria.*

Authors:
1. Associate Professor, Epidemiology and Biostatistics, Institute of Child and Mother Health (ICMH), Matuail, Dhaka.
2. Assistant Professor, Pediatrics, ICMH.
3. Professor, and Head of the Department, Epidemiology and Biostatistics, ICMH.
4. Assistant Professor, Epidemiology and Biostatistics, ICMH
5. Professor, and Head of the Department, Pediatrics, ICMH.
6. Professor and Executive Director, ICMH.
7. Associate Professor, Biochemistry and Joint Director, ICMH.
8. Statistician, ICMH.
9. Consultant, MPL-Ibrahim General Hospital, Narayangonj.

Correspondence: Dr. S M Zahid Hassan Arefin, Associate Professor, Epidemiology and Biostatistics, ICMH.
Email: zarefin2@gmail.com.

Introduction

Metabolic syndrome (MetS) is a constellation of obesity, hyperglycemia, decreased high-density lipoprotein (HDL), increased triglyceride, and high blood pressure which may also raise the risk of developing type 2 diabetes mellitus and cardiovascular diseases (CVDs).[1] It is a significant global public health issue, a reliable indicator of cardiovascular disease (CVD), and linked to a higher risk of CVD-related mortality. The risk of type 2 diabetes and cardiovascular disease is approximately five and two times higher in people with metabolic syndrome, respectively.[2] In addition to these two modifiable risk factors, metabolic syndrome has been related to obesity and a sedentary lifestyle.[3]

Previously It was believed to be an adult condition associated with cardiovascular morbidity and mortality.[4] It has recently been recognized as a childhood ailment.[4,5] As people get older, their chance of developing metabolic syndrome increases from less than 10% in their 20s to 40% in their 60s.[5] However, metabolic syndrome symptoms might start to show up in children. Early detection and treatment of MetS are expected to lower adult morbidity and mortality as well as the overall burden of type II diabetes and CVD.

A Swedish doctor by the name of Kylin[4] first identified it in the 1920s and showed how gout, hypertension, and hyperglycemia are all related. Later in 1947, Vague[5] demonstrated a connection between central adiposity and the metabolic anomalies discovered in CVD and T2DM. In 1988, Reaven[6] identified a group of risk factors for diabetes and CVD and called it “syndrome X”. For the combination of upper body fat, glucose intolerance, hypertriglyceridemia, and hypertension, Kaplan[7] called the syndrome “the lethal quartet” in 1989.

The term “metabolic syndrome,” first used by the National Cholesterol Education Program (NCEP) in 2001, refers to the coexistence of three of the five risk factors for heart disease—central obesity, hyperglycemia, hypertriglyceridemia, high-density lipoprotein (HDL), and hypertension.[8] The metabolic syndrome was defined similarly by several organizations, including the American Association of Clinical Endocrinologists (AACE)[9], World Health Organization (WHO)[10], European Group for the Study of Insulin Resistance (EGIR)[11], International Diabetes Federation (IDF)[12], and National Cholesterol Education Program (NCEP)[8]. The NCEP, AACE, and modified WHO criteria are all linked to cardiovascular events among an aged American population, notwithstanding disagreements over which of these definitions is best.[13-15] The only definitions that have indicated that the cut-off points for waist circumference (WC) should be based on ethnicity are the modified NCEP ATP III7 and the IDF11 definitions. Additionally, Malaysian studies[16,17] show that the modified NCEP-ATP III was better able to recognize MetS. Considering these facts, the amended NCEP-ATP III criteria for identifying MetS were applied to this study.

As MetS is itself a combination of risk factors that eventually leads to the development of non-communicable diseases (NCD), other risk factors of NCDs are also risk factors for the development of MetS. These associated risk factors include physical inactivity, unhealthy diet (low fruit and vegetable; high salt and oil consumption), and overweight obesity.[18]

Materials and methods

Subjects and sampling*:* A total of 303 (176 boys and 127 girls) adolescent school children aged 12-16 years participated in this cross-sectional study. A well-reputed high school was selected randomly from a list of all nearby high schools. As there were many sections in each grade, two sections from grades VIII & IX were selected randomly. A consent form detailing the study and objectives was given to each student for their parents/guardians and the signed consent form was obtained from the students. Students failing to submit the signed consent form, fasting for less than 8 hours, and taking medications such as insulin, androgens, or anabolic steroids which might alter metabolic profile, were excluded from the study.

Definitions and Measurements

Definition of Metabolic Syndrome: Metabolic syndrome was defined using NCEP-ATP III criteria, modified by Cook et al.[19] and Wan et al.[20] in 2007. It defines MetS as three or more of the following:

- Fasting triglyceride (TG) ≥ 110 mg/dL.
- HDL cholesterol <40 mg/dL.
- Waist Circumference (WC) ≥ 90th percentile for age and sex, according to national reference curves
- Systolic blood pressure (SBP) and/or diastolic blood pressure (DBP) ≥ 90th percentile for sex, age and height,
- Fasting Blood Glucose ≥ 100 mg/dL.

For 10 to <16 years old, most of the WC charts available are for the American and European populations. No uniform chart for the Asian population is currently available. For this study, a WC chart developed in India for south Indian children was used.[21]

Anthropometric measurements

Height, weight, and waist circumference were measured to calculate their body mass index (BMI), thereby obesity. The standing height was measured with a stadiometer without shoes. The body weight was measured using a digital weighing scale Beurer PS240. With the students' privacy protected, waist circumference was measured to the closest 0.1 cm over loose clothing using non-elastic flexible tape at a point halfway between the lowest rib and the iliac crest. Weight in kg/height in square meters was used to determine body mass index (BMI). In a sitting position, with the calf at the level of the heart, blood pressure was assessed using a mercury sphygmomanometer and an adequately sized cuff. A second reading was taken five minutes after the first one. The student's blood pressure was calculated based on the average of the two readings. A third reading was taken if there was a difference between the first two readings of more than 5 mm of Hg.

Blood collection and laboratory analysis

Students were asked to fast overnight, and fasting blood samples were collected by a registered blood collection technician and transferred to the central biochemistry laboratory of ICMH within 4 hours following standard protocol. Blood was analyzed by an automated biochemistry analyzer- Humastar 600, made by Human Diagnostics, Germany.

Measurement of physical activity

The WHO Global Physical Activity Questionnaire technique was used to measure physical activity.[22] The respondents were questioned about their weekly and daily strenuous and moderate activities while at work and during their free time, as well as their transportation-related activities and time spent sitting idle. Every kind of physical activity was converted into minutes per day. Following that, the overall duration was transformed into metabolic equivalents (MET minutes/week). One MET, which is equal to 1 kcal/kg/hour of caloric expenditure, was defined as the energy used to sit still for one minute. The STEPS calculation method was used to determine MET-minute. To calculate the overall physical activities in MET minutes, all MET minutes for various types of physical activity were put together. Then, different levels of physical activity were classified as high, moderate, and low. A high level of physical activity was defined as 3000 MET minutes or more per week, a moderate level as 600 MET minutes to 3000 per week, and a low level as less than 600 MET minutes per week.

Low fruit and vegetable consumption: Intake of fewer than 5 servings a day was considered low fruit and vegetable consumption. Servings were measured by showing the pictorial show cards or using measuring cups.[23]

High salt and oil consumption: To measure high salt and oil consumption, participants were asked about how much oil and salt they usually buy in a month and converted that amount to per person per day by dividing the total quantity by the number of family members and thirty. Salt intake of more than 5 grams/day was considered high.[24] Oil consumption of more than 25 ml (for men) and more than 20 ml (for women) was considered high.[25]

Overweight obesity: BMI ≥ 25 was considered overweight and ≥ 30 as obese.[26]

Data analysis

Data were analyzed using Statistical Package for Social Science (SPSS version 21). Univariate, bivariate, and multivariate analysis was done. The obtained information was presented in the form of tables and graphs. Descriptive statistics such as mean, SD, frequency, and percentage were used as applicable. The student's t-test and χ^2 test was done for continuous and categorical data respectively. The statistical tests were considered significant at a level of $p \leq 0.05$.

Ethical Consideration

Informed signed written consent from the parents of each student was obtained before data collection. The study was approved by the Institutional Review Board of ICMH (Memo number: ICMH/ Admin/ 1584) on 10th April 2019.

Results

Prevalence of Metabolic syndrome: A total of 303 adolescent school students participated in this study. Boys predominate over girls, 176(58.0%) vs 127(42.0%) respectively. The mean age of participants was 14.79±0.47 years. The overall prevalence of MetS was 13.9% and was more common in boys 31(17.6%) than in girls 11(8.7%). The difference was statistically significant ($P < 0.05$). The prevalence was still higher among overweight-obese students, it was 36.8%.

The prevalence of component risk factors and the proportion of students with one or more risk components: The component with most high prevalence was high triglyceride (44.2%), followed by low HDL (42.9%), central obesity (30.4%), high fasting glucose (16.2%), and raised BP (10.9%) respectively (Table I). Boys had significantly more risk components than girls except in the case of central obesity ($P < 0.05$).

At least one risk component was present in 39.9% of the students. Three risk components were present in 9.6% and four in 4.3% of the students respectively, which combinedly was the overall prevalence of MetS. No students had all five components present and there was no significant difference between boys and girls ($P < 0.05$) (Table II).

The prevalence of associated risk factors ontributing to the development of MetS: Most of the students were found physically active. Prevalence of low physical activity was 8.8% (more in girls-14% than in boys-5.2%, p-value <0.05). About one-fifth 57(18.8%) of the students were found overweight or obese according to BMI, with prevalence almost equal in boys and girls (19.9% vs 17.3%). None of the students took adequate fruit and vegetable but almost all of them took a higher amount of oil and salt than the recommended value, 92.4%, and 98.3% respectively. Blood pressure was raised in 33(10.9%) of the students (more in boys than in girls- 14.8% vs 6.3%, p-value less than 0.05) (Table III).

Prevalence of MetS and component risk factors among overweight/obese students: The prevalence of MetS and all the component risk factors except low HDL was found significantly higher among overweight and obese than non-obese students, which was 36.8% vs 8.5% for MetS, 70.2% vs 21.1% for central obesity, 19.3% vs 9.3% for raised BP (SBP or DBP), 26.3% vs 13.8% for high fasting glucose and 59.6 vs 40.7 for high TG. The prevalence of low HDL was found higher among non-obese than obese students (44.3% vs 36.8%), though the difference was not significant (Table IV).

Table I: Prevalence of Metabolic syndrome and component risk factors by sex

MetS and Component Risk Factors	Boys (n=176)	Girls (n=127)	All (n=303)	*p*-value
Metabolic Syndrome	31(17.6)	11(8.7)	42(13.9)	0.026
Central obesity	51(29.0)	41(32.3)	92(30.4)	0.537
Low HDL	49(27.8)	81(63.8)	130(42.9)	0.001
Raised BP (SBP or DBP)	26(14.8)	8(6.3)	34(11.2)	0.021
High Fasting Glucose	38(21.6)	11(8.7)	49(16.2)	0.003
High Triglycerides	112(63.6)	22(17.3)	134(44.2)	0.001

Table II: Proportion of students with one or more risk components

Frequency of MetS components	Boys (n=176)	Girls (n=127)	All (n=303)	*p*-value
No risk component	26(14.8)	27(21.3)	53(17.5%)	
One	67(38.1)	51(40.2)	118(38.9)	
Two	52(29.5)	38(29.9)	90(29.7)	
Three	21(11.9)	8(6.3)	29(9.6)	
Four	10(5.7)	3(2.4)	13(4.3)	0.185
Five	0	0	0	

Table III: Prevalence of Contributing factors for developing metabolic syndrome by sex

Contributing factors	Boys (n=176)	Girls (n=127)	All (n=303)	*p*-value
Low physical activity	9(5.2)	17(14.0)	26(8.8)	0.008
Overweight or obese	35(19.9)	22(17.3)	57(18.8)	0.573
High oil intake	115(90.6)	165(93.8)	280(92.4)	0.300
High salt intake	125(98.4)	173(98.3)	298(98.3)	0.930

Table IV: Comparison of MetS and component risk factors among non-obese and overweight/obese students

MetS and Component Risk Factors	Overweight or Obese	Not Overweight or Obese	*P*- value
MetS	21(36.8)	21(8.5)	0.001
Central obesity	40(70.2)	52(21.1)	0.001
Raised BP (SBP or DBP)	11(19.3)	23(9.3)	0.032
Low HDL	21(36.8)	109(44.3)	0.305
High Fasting Glucose	15(26.3)	34(13.8)	0.021
High Triglycerides	34(59.6)	100(40.7)	0.009

Discussion

This study was done to find out the prevalence of MetS and component risk factors among adolescent school-going children of a semiurban community. The overall prevalence of MetS was 13.9%. Prevalence of high fasting plasma glucose, high triglyceride, low HDL, central obesity, and raised BP was found at 16.2%, 44.2%, 42.9%, 30.4%, and 11.2% respectively. About one-fifth (18.8%) of the students were found overweight- obese, with almost equal prevalence in boys and girls (19.9% vs 17.3%). The prevalence of MetS and all the component risk factors except low HDL was found significantly higher among overweight and obese than non-obese students.

A study in Saudi Arabia showed the prevalence of MetS among school children was 16.7%.[27] Another study done by Brufani et al[28] among Italian children found a prevalence of 12%. A cross-sectional study conducted by Al-Daghri[29] in KSA on a large sample of 1,231 healthy children aged 10–18-year-olds using the NCEP III definition showed a prevalence rate of 9.4%. These findings were consistent with the current study. the prevalence of MetS was higher among boys than girls (3.9% of boys versus 3.5% of girls). This difference could be attributable to differences in sex hormones, such as testosterone and sex hormone-binding globulin (SHBG), which are strongly expressed during puberty.[30]

The prevalence of high fasting glucose was 16.2% in this study, which was much higher (50%) in the study done in KSA.[27] This may be due to the use of different diagnostic parameters in the two studies. IDF criteria was used in the KSA study. Another study among Palestinian children showed a very similar (15.8%) prevalence.[30] The study done among Saudi Arabian school children showed a little higher (22.2%) prevalence of high fasting glucose.[27] This may be due to different dietary habits and socioeconomic conditions.

The current study showed a very high prevalence of high triglyceride (44.2%) and low HDL (42.9%). Several other studies among children showed a lower prevalence of high TG- 16.7%[27], 5.5%[31], 3.4%[32], 19.0%[33] and 6.4%[34]. The prevalence of low HDL in the above-mentioned studies was 13.9%, 27.1%, 10.66%, 18.9% and 43.2% respectively.[27, 31-34] The difference was mostly due to the use of IDF criteria. In IDF, the cutoff point for high TG is 150 mg/dL, whereas, in NCEP-III criteria, the cutoff point is 110mg/dL. The study in Jammu and Kashmir, India, and the study in Brazil used the NCEP-III criteria. Here the difference may be due to variations in sample size, dietary habits, and lifestyle.

About one-third (30.4%) of the students in the current study had central obesity, which was quite high compared to other studies. A study in UAE by Haroun D et al.[31] showed a prevalence of 15.1%. Another study among Brazilian schoolchildren showed a prevalence of 11.3%.[34] The difference was probably due to the use of the Indian chart in the current study and the US chart in other studies. The prevalence of raised BP in this study was 11.2%, which was very similar to other studies. The study in UAE showed a prevalence of 15.1%.[31]

Study done by Fadzlina et al.[33] showed the prevalence of raised systolic and diastolic BP as 15.1% and 13.2% respectively.

No students in this study had all the five components of MetS. This finding was consistent with the study done by Singh et al.[32] and BragaTavares et al.[35]

The current study showed a high prevalence of MetS and component risk factors among overweight-obese students, which was 36.8% for MetS, 70.2% for central obesity, 19.3% for raised BP (SBP or DBP), 26.3% for high fasting glucose, 36.8% for low HDL, and 59.6% for high TG. A study done by Mohsin et al.[36] in Bangladesh also showed similar prevalence except for high TG, which was 36.6% for MetS, 16.7% and 21.1% for raised SBP and DBP respectively, 16.7% for high fasting glucose, 49.0% for low HDL, and 39.7% for high TG. The lower prevalence of high TG in the study was probably due to the use of IDF criteria in which the cutoff point for high TG is higher than NCEP.

There are certain limitations in the present study. The sample size was very small, and students were taken from a single school. So, it cannot represent a community. Also, there are controversies regarding the definition of metabolic syndrome for adolescents. The cutoff points vary considerably in different definitions. The biochemical environment of the body begins to change during this period of life. Many hormones start working during adolescence. These may have an impact on individual components of MetS. So, the focus should be given to healthy lifestyles, healthy dietary habits, and weight reduction rather than individual components of MetS.

Conclusion

The prevalence of metabolic syndrome and the component risk factors among adolescent school students was found high in this study. These rates were further higher among overweight-obese students. Students' dietary habit was also found unhealthy. The focus should be given to students' dietary habits and weight reduction.

Conflict of interest:

The authors declared no conflicts of interest.

Acknowledgments

We thank the participating students and their families for taking part in the study. We also thank the school authority, especially Mr. Sohrab, Assistant Headmaster, Shamsul Haque Khan School and College for his valuable support in facilitating access to the schools and conducting the study. We are also grateful to Dr. Md. Shahnoor Karim, Assistant Professor, and Dr. Muhammad Ariful Haque, Assistant Professor of the Lab Medicine department of ICMH for their immense support and labor in laboratory analyses of the blood samples. Special thank goes to Dr. Abu Hasnat Md. Sayam and Dr. Sharmin Younus for data collection and field management.

Author contributions

SMZHA, AH, and AN conceptualized and designed the study. SMZHA was the principal investigator of this study and drafted, reviewed, and revised the manuscript. IA was involved in data collection and reviewed the manuscript. WK, MAM, AR, and FJ were involved in the analysis and interpretation of data and reviewed the manuscript. AKS was involved in blood sample analysis and interpretation of data. All authors contributed to revising and improving the manuscript. All authors read and approved the final manuscript.

Funding

Funding for this research was obtained from the ICMH research fund. Research Grant Number: ICMH/ Admin/ 722.

References

1. Lee L, Sanders RA. Metabolic syndrome. *Pediatr Rev*. 2012 Oct;33(10):459-66; quiz 467-8. DOI: 10.1542/pir.33-10-459. PMID: 23027600; PMCID: PMC4109314.
2. Grundy SM, Cleeman JI, Daniels SR, Donato KA, Eckel RH, Franklin BA, Gordon DJ, Krauss RM, Savage PJ, Smith SC Jr. et al. Diagnosis and management of the metabolic syndrome: an American Heart Association/National Heart, Lung, and Blood Institute Scientific Statement. *Circulation*. 2005;112:2735–2752. Doi: 10.1161/CIRCULATIONAHA.105.169404
3. Sarrafzadegan N, Kelishadi R, Baghaei A, Hussein Sadri G, Malekafzali H, Mohammadifard N, Rabiei K, Bahonar A, Sadeghi M, O'Laughlin J. Metabolic syndrome: An emerging public health problem in Iranian Women: Isfahan Healthy Heart Program. *International Journal of Cardiology*. 2008;**131**:90–96. Doi: 10.1016/j.ijcard.2007.10.049.
4. Friend A, Craig L, Turner S (2013) The prevalence of metabolic syndrome in children: A systematic review of the literature. *Metab Syndr Relat Disord* 11(2): 71-80.
5. Chinali M, De Simone G, Roman MJ, Best LG, Lee ET, et al. (2008) Cardiac markers of pre-clinical disease in adolescents with the metabolic

syndrome: The strong heart study. *J Am Coll Cardiol* 52(11): 932-938.

6. Cheng AY, Leiter LA. Metabolic syndrome under fire: weighing in on the truth. *Can J Cardiol.* 2006 Apr;22(5):379-82. DOI: 10.1016/s0828-282x (06)70921-7. PMID: 16639471; PMCID: PMC2560531.
7. Vague J. Sexual differentiation. A factor affecting the forms of obesity. *Presse Medicale.* 1947;**30**: S39–S40. [Google Scholar]
8. Reaven G. Role of insulin resistance in human disease. *Diabetes* 1988. ;37:1595 -607 [PubMed] [Google Scholar]]
9. Kaplan N. The deadly quartet: Upper body obesity, glucose intolerance, hypertriglyceridemia, and hypertension. *Arch Int Med*. 1989; 7:1514–20.
10. Expert Panel on Detection, Evaluation, And Treatment of High Blood Cholesterol In Adults (May 2001). "Executive Summary of the Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III)". *JAMA: the Journal of the American Medical Association* 285 (19): 2486–97.
11. Einhorn D, Reaven GM, Cobin RH, Ford E, Ganda OP, Handelsman Y, Hellman R, Jellinger PS, Kendall D, Krauss RM, Neufeld ND, Petak SM, Rodbard HW, Seibel JA, Smith DA, Wilson PW. American College of Endocrinology position statement on the insulin resistance syndrome. *Endocr Pract.* 2003 May-Jun;9(3):237-52. PMID: 12924350.
12. Alberti KG, Zimmet PZ. Definition, diagnosis, and classification of diabetes mellitus and its complications. Part 1: diagnosis and classification of diabetes mellitus provisional report of a WHO consultation. *Diabet Med*. 1998 Jul;15(7):539-53.
13. Balkau B, Charles MA. Comment on the provisional report from the WHO consultation. European Group for the Study of Insulin Resistance (EGIR). *Diabet Med.* 1999 May;16(5):442-3.
14. Zimmet P, Alberti KGM, Kaufman F, Tajima N, Silink M, Arslanian S, Wong G, Bennett P, Shaw J, Caprio S. The metabolic syndrome in children and adolescents? An IDF consensus report. *Pediatric Diabetes* [Internet]. Wiley; 2007 Oct;8(5):299–306. Available from: http://dx.doi.org/10.1111/j.1399-5448.2007.00271.x
15. Vinluan CM, Zreikat HH, Levy JR, Cheang KI. Comparison of different metabolic syndrome definitions and risks of incident cardiovascular events in the elderly. *Metabolism.* 2012 Mar;61(3):302-9. doi: 10.1016/j.metabol.2011.07.002. Epub 2011 Aug 15. PMID: 21840552; PMCID: PMC3218249.
16. Saif-Ali R, Kamaruddin NA, Al-Habori M, Al-Dubai SA, Ngah WZW. Relationship of the metabolic syndrome defined by IDF or revised NCEP ATP III with glycemic control among Malaysians with Type 2 Diabetes. *Diabetol Metab Syndr.* 2020 Aug 5;12:67. DOI: 10.1186/s13098-020-00575-7. PMID: 32774471; PMCID: PMC7405365.
17. Moy FM, Bulgiba A. The modified NCEP ATP III criteria may be better than the IDF criteria in diagnosing Metabolic Syndrome among Malays in Kuala Lumpur. *BMC Public Health* 10, 678 (2010). https://doi.org/10.1186/1471-2458-10-678
18. World Health Organization. Introduction. In: WHO STEPwise approach to Chronic disease risk factor surveillance (STEPS) [Internet]. Geneva; 2008. p. 1–17. Available from: http://www.who.int/chp/steps/en/
19. Cook S, Weitzman M, Auinger P, Nguyen M, Dietz WH. Prevalence of metabolic syndrome phenotype in adolescents: findings from the third National Health and Nutrition Examination Survey, 1988–1994. *Arch Pediatr Adolesc Med*. 2003;157(8):825–827.
20. Wan NJ, Mi J, Wang TY, Duan JL, Li M, Gong CX, Du JB, Zhao XY, Cheng H, Hou DQ, Wang L. [Metabolic syndrome in overweight and obese school children in Beijing]. Zhonghua Er Ke Za Zhi. 2007 Jun;45(6):417-21. Chinese. PMID: 17880785.
21. Kuriyan R, Thomas T, Lokesh DP, Sheth NR, Mahendra A, Joy R, Sumithra S, Bhat S, Kurpad AV. Waist circumference and waist for height percentiles in urban South Indian children aged 3-16 years. *Indian Pediatr*. 2011 Oct;48(10):765-71. DOI: 10.1007/s13312-011-0126-6. Epub 2011 Mar 15. PMID: 21555800.
22. World Health Organization (WHO). Global Physical Activity Questionnaire (GPAQ) Analysis Guide [Internet]. Geneva: World Health Organization. 2012. Available from: www.who.int/chp/steps/resources/GPAQ_Analysis_Guide.pdf
23. El-Saharty S, Ahsan KZ, Koehlmoos TL, Engelgau MM. Tackling Noncommunicable Diseases in

Bangladesh: Now is the Time.: Direction in Development. Washington, DC: World Bank; 10.1596/978-0-8213-9920-0 License: Creative Commons Attribution CC BY 3.0. World Bank Publications; 2013. 1–13.

24. World Heart Federation. Cardiovascular disease Risk factors [Internet]. Geneva: World Heart Federation; 2012. Available from: http://www.world-heart-federation.org/heart-facts/fact-sheets/cardiovascular-disease-risk-factors/
25. Islam S N, Khan N I, Aktaruzzaman N. Food composition table and database for Bangladesh with special reference to selected ethnic food. In Dhaka.: Institute of Nutrition and Food Science, Dhaka University; 2012.
26. WHO Consultation of Obesity. Obesity: preventing and managing the global epidemic: report of a WHO consultation. Geneva: WHO, 2000.
27. Aldhafiri FK. Prevalence of Metabolic syndrome among school children in Majmaah city, Kingdom of Saudi Arabia. *Majmaah J Heal Sci*. 2017; 5(2): 34-44.
28. Brufani C, Fintini D, Giordano U, Tozzi AE, Barbetti F, Cappa M. Metabolic syndrome in Italian obese children and adolescents: stronger association with central fat depot than with insulin sensitivity and birth weight. *Int J Hypertens* 2011; 2011:257168.
29. Al-Daghri NM. Extremely high prevalence of metabolic syndrome manifestations among Arab youth: A call for early intervention. *Eur J Clin Invest*. 2010; 40:1063–6.
30. Damiri B, Alhala AA, Najjar L, Alqadome S (2018) Metabolic Syndrome and its Risk Factors among Overweight and Obese Palestinian Schoolchildren using IDF and NCEP-ATP/III Definitions. *Ann Clin Lab Res* Vol.6 No.3: 242
31. Haroun D, Mechli R, Sahuri R. *et al.* Metabolic syndrome among adolescents in Dubai, United Arab Emirates, is attributable to the high prevalence of low HDL levels: a cross-sectional study. *BMC Public Health* **18**, 1284 (2018). https://doi.org/10.1186/s12889-018-6215
32. Singh N, Parihar RK, Saini G, Mohan SK, Sharma N, Razaq M. Prevalence of metabolic syndrome in adolescents aged 10-18 years in Jammu, J and K. *Indian J Endocrinol Metab.* 2013 Jan;17(1):133-7. DOI: 10.4103/2230-8210.107849. PMID: 23776866; PMCID: PMC3659880.
33. Fadzlina A, Harun, F, Nurul Haniza, M. *et al.* Metabolic syndrome among 13-year-old adolescents: prevalence and risk factors. *BMC Public Health* **14** (Suppl 3), S7 (2014). https://doi.org/10.1186/1471-2458-14-S3-S7.
34. Seki M, Matsuo T, Carrilho AJF. Prevalence of metabolic syndrome and associated risk factors in Brazilian schoolchildren. *Public health nutrition*. 2009; 12:947-52.
35. Braga-Tavares H, Fonseca H. Prevalence of metabolic syndrome in a Portuguese obese adolescent population according to three different definitions. *Eur J Pediatr* 2010; 169:935-40.
36. Mohsin F, Baki A, Nahar J, Akhtar S, Begum T, Azad K, Nahar N. Prevalence of Metabolic Syndrome among Obese Children and Adolescents. *Birdem Med J* [Internet]. 2012 Oct. 25 [cited 2022 Oct. 22];1(1):21-5. Available from: https://www.banglajol.info/index.php/BIRDEM/article/view/12382