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Metabolic Syndrome among Overweight and Obese Children and Adolescents in Georgia: A Hospital-Based Study

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Research Article

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Abstract

Objectives: The aim of this study was to determine the prevalence of individual features of the metabolic syndrome in children and adolescents with obesity referred to a central hospital unit.

Methods: We studied children and adolescents referred to our Paediatric Endocrine Unit for evaluation of their weight. Subjects were included if body mass index (BMI) exceeded the 85th centile for age and sex and excluded if diabetes was known to be present. We assessed blood pressure, fasting blood glucose, lipid profiles, leptin, plasma c-peptide, and insulin resistance using homeostasis model assessment for insulin resistance (HOMA-IR).

Results: From a study population of 115 children and adolescents, obesity was present in 90 (76.9%); the remainder being classified as overweight (23.1%). Dyslipidaemia was present in 51%, hypertension in 22% and impaired glucose tolerance or insulin resistance in 70%. Metabolic syndrome was found in 40% of the study group, classified by modified WHO or ATP-III criteria. The number of features of the metabolic syndrome correlated with BMI percentile ($r=0.61$, $p<0.001$), with waist circumference (WC) ($r=0.47$, $p<0.001$) and with HOMA-IR ($r=0.44$, $p<0.001$).

Conclusion: Our results indicate a high prevalence of metabolic syndrome in overweight and obese children and adolescents referred to our unit. Further studies are needed to investigate whether these results are generalisable to the general Georgian population.

Keywords: Visceral Obesity; Metabolic Syndrome; Children; Adolescents

Abbreviations: BMI: body mass index; HOMA-IR: Homeostasis Model Assessment for Insulin Resistance; WC: Waist Circumference; MetS: Metabolic Syndrome; IR: Insulin Resistance; ATP: Adult Treatment Panel; CDC: Centers for Disease Control and Prevention; FPI: Fasting Plasma Insulin; PPI: Postprandial Plasma Insulin; HDL: High-Density Lipoprotein; IGT: Impaired Glucose Tolerance; NCDs: Non-Communicable Diseases.

Background

Metabolic syndrome (MetS) is a cluster of various symptoms including obesity (or visceral obesity), hyperglycaemia, dyslipidaemia and elevated blood pressure, which are often associated with an insulin resistance (IR). Its definition and criteria for adults are reasonably defined. But in the case of children and adolescents, there is no standardization of the diagnostic criteria for metabolic

syndrome [1-4]. There is no consensus for reference values for the anthropometric and metabolic parameters to be used during childhood and adolescence [5]. This may be due, in part, to the changes in growth and development during childhood and adolescence affecting the cut-off values for the individual components of the metabolic syndrome [6]. Modifications of the adult criteria used in WHO and National Cholesterol Education Program's Adult Treatment Panel (ATP) - III definitions are commonly used [7,8]. The International Diabetes Federation (IDF) proposed paediatric criteria for children aged 10 -16 years, preferring not to diagnose metabolic syndrome in those less than 10 years of age [9].

There is general agreement that the rising prevalence of obesity is associated with the increase in metabolic syndrome and type 2 diabetes mellitus in children and adolescents [10-12]. Weight gain in adults is generally characterized by growth of fatty tissues. But weight gain in children and adolescents is associated with the growth of all tissues and is not necessarily associated with obesity [13,14]. Waist circumference, a surrogate measure of visceral fat, shows the most consistent association with adverse lipid levels and insulin resistance [15]. Obesity and, especially, visceral obesity has a key role as a risk-factor of MetS and related comorbidities [12].

There is a paucity of data regarding the prevalence of MetS in Georgia. In 2014, 56% of females and 54% of males in Georgia were overweight (body mass index of 25 or more), representing a slight increase since 2010 for both sexes [11]. However the metabolic impact of the increasing prevalence of obesity is uncertain particularly in the younger age groups. The aim of this study therefore was to study metabolic characteristics in obese children and adolescents. To the best of our knowledge, this is the first report on metabolic syndrome in this population from Georgia.

Methods

The study protocol was approved by the Board of National Institute of Endocrinology (IRB 461/1607) and conducted according to the ethical standards of the institution and the Declaration of Helsinki. Written informed consent from parents and/or guardians and written assent from children (where appropriate) and adolescents were obtained.

Subjects

We studied 117 children and adolescents between ages 8-15 years who were referred by their family practitioner or paediatrician to our Paediatric Endocrine Unit for the evaluation of the weight. Inclusion criteria were a body-mass index (BMI) defined as weight in kilograms divided by the square of the height in meters that exceeded the 85th percentile for their age and sex. Exclusion criteria were the known presence of diabetes and the use of medications that alter blood pressure, glucose or lipid metabolism.

Anthropometric Measurements

Body weight and height were measured using a calibrated scale. BMI percentile for age and sex, established by the U.S. Centers for Disease Control and Prevention (CDC) was used [16]. We defined overweight as BMI between 85th and 95th centile and obesity as equal to or greater than the 95th BMI percentile. Severe obesity in childhood was defined as the 99th BMI percentile or 120% of the 95th percentile [17,18].

Procedures

The subjects consumed a diet containing at least 250 g of carbohydrates per day for three days before the study and refrained from vigorous physical activity. They were evaluated at 8 a.m., after a 12-hour, overnight fast. Their weight and height were measured, and their BMI was calculated. Blood pressure was measured three times while the subjects were seated, and the last two measurements were averaged for analysis. Baseline blood samples were obtained from subjects while they were fasting, with the use of an indwelling venous line for measurement of levels of glucose, insulin, lipids, leptin. An oral glucose-tolerance test was then performed with the administration of 1.75 g of glucose per kilogram of body weight.

Biochemical Analysis

Plasma glucose levels (fasting plasma glucose: FPG, postprandial plasma glucose: PPG) were determined by glucose oxidase method and measured with the use of the YSI 2700 STAT Analyzer (Yellow Springs Instruments). Serum lipids (total cholesterol, HDL-cholesterol, LDL-cholesterol, VLDL-cholesterol, Triglycerides) were measured with the use of an Auto Analyzer (model 747–200, Roche–Hitachi). Plasma C-peptide, fasting plasma insulin (FPI), postprandial plasma insulin (PPI) and Leptin levels were measured with the use of an Enzyme-linked Immuno-Sorbent Assay kits (R&D Systems). HOMA-IR (homeostasis model assessment for insulin resistance) was calculated according to the formula [glucose (mg/dl)/18 x insulin (mUI/ml)]/22.5. Insulin resistance (IR) was defined as present when HOMA >3.1 [19].

MetS Definitions

The criteria we used to diagnose the metabolic syndrome were modified from those of the National Cholesterol Education Program's Adult Treatment Panel III (ATP III) and the World Health Organization. Because body proportions

normally change during pubertal development and may vary among persons of different races and ethnic groups, differences in waist-to-hip ratios are difficult to interpret in children. We therefore defined obesity on the basis of a threshold BMI that exceeded the 95th percentile for age and sex. Elevated systolic or diastolic blood pressure was defined as a value that exceeded the 95th percentile for age and sex.

Abnormalities in the fasting levels of triglycerides and high-density lipoprotein (HDL) cholesterol were adjusted for age, sex, and race or ethnic group (>95th percentile for triglycerides; <5th percentile for HDL cholesterol). Impaired glucose tolerance (IGT) was defined as a glucose level greater than 140 mg/dl (7.8 mmol/l) but less than 200 mg/dl (11.1 mmol/l) at two hours.

Children and adolescents in our study were classified as having the metabolic syndrome if they met three or more of the following criteria for age and sex:

- WC≥90th percentile;
- triglyceride level > 95th percentile, an HDL cholesterol level < 5th percentile;
- systolic or diastolic blood pressure > the 95th percentile;
- IGT or IR. The degree of IR was determined with the use of a homeostatic model assessment (HOMA-IR).

Statistical Analysis

The data were analysed using SPSS software, version 21.0 (IBM). Results are presented as Mean ± SD. Difference between groups has been evaluated statistically by two-tailed Student's t test. P<0.05 was considered as significant. Correlation analysis was carried out by simple regression analysis using Pearson coefficient (r).

Results

From a study population of 115 children and adolescents, obesity was present in 90 (76.9%); the remainder being classified as overweight (23.1%). The prevalence of dyslipidaemia (51.3%), hypertension (22%) and impaired glucose tolerance or insulin resistance (70.1%) are shown in Table 1. There were 28 children (23.9%) with at least one feature of the metabolic syndrome, 39 (33.3%) with two features, 36 (30.8%) with three criteria and 10 (8.6%) with four criteria. Metabolic syndrome, defined by the presence of three or more criteria was therefore present in 46 (40%) of this cohort.

The most frequent combination of metabolic syndrome criteria was obesity and impaired glucose tolerance/ insulin resistance which were found in 22 (18.8%) subjects. The least common combination was dyslipidaemia and hypertension without other features of the metabolic syndrome (1 patient) or obesity and hypertension in the absence of other features (1 patient). The number of features of the metabolic syndrome correlated with BMI percentile (r=0.6125, p<0.001), with waist circumference (WC) (r=0.4669, p<0.001) with WC/ height (r=0.4669, p<0.001) and with HOMA-IR (r=0.4416, p<0.001).

	MetS feature and Number of MetS features	
	MetS Feature	**n (%)**
1	Obesity	90 (76.92%)
2	Dyslipidemia	60 (51.28%)
3	Hypertension	22 (18.80%)
4	IGT or IR	82 (70.09%)
	Number of MetS features	
5	None	4 (3.42%)
6	1 feature	28 (23.93%)
7	2 features	39 (33.33%)
8	3 features	36 (30.77%)
9	4 features	10 (8.55%)
	Combination of MetS features	
10	Obesity + IGT or IR	22 (18.80%)
11	Obesity + Dyslipidemia	11 (9.40%)
12	Obesity + Hypertension	1 (0.85%)
13	IGT or IR + Dyslipidemia	4 (3.42%)
14	Dyslipidemia + Hypertension	1 (0.85%)
15	Obesity + IGT or IR + Dyslipidemia	29 (24.79%)

Table 1: MetS features and their distribution by both definitions.

Discussion

The overall prevalence of MetS in our study cohort using the modified National Cholesterol Education Program's Adult Treatment Panel or World Health Organization criteria was 40%. We observed only minor and insignificant differences in prevalence comparing the two definitions. Similar high prevalences have been noted in other studies of obese children with values of 42.5% [20] and 45-48% [21] using WHO and modified ATP III criteria. By contrast, the reported prevalence of MetS from a large study of five European countries ranged from 16.4% to 35.7% [22]. Differences in defining MetS may partly explain the discrepancies. We used age and sex-adjusted centiles to define MetS which take into account physiological changes in growth and development and are more appropriate in pediatric populations. Other studies using IDF criteria have defined MetS based on two

cut-off values.

We observed a high prevalence of insulin resistance which correlated with the number of features of metabolic syndrome. Insulin resistance is thought to mediate the metabolic disturbances found in children with obesity and metabolic syndrome [23]. Adverse lipid profiles and hypertension appeared less frequently than that observed in adults with MetS perhaps because of the shorter duration of exposure to insulin resistance in children. The strongest correlation with features of MetS in our study was BMI centile. This is in agreement with several previous studies showing that the prevalence of MetS in children or adolescents rises with the degree of obesity. Among US adolescents, the prevalence of MetS was reported to be 32.1% in those with BMI at or above the 95th centile compared with only 0.1% for those with a BMI<85th centile [24].

The rise in obesity is related to the fact that children and adolescents are growing in an obesogenic environment, caused by an imbalance in energy resulting from changes in food types, availability, accessibility and commercialization, as well as a decline in physical activity due to more time spent in front of a screen and in sedentary leisure [25-28]. Overweight and obesity are the main contributors to the burden of chronic diseases in the population [29,30]. The major causes of death in Georgia are related to non-communicable diseases (NCDs) including circulatory diseases and diabetes. The concern about the high prevalence of obesity is related to the later development of comorbidities and complications generated by overweight. Fat accumulation is associated with the presence of arterial hypertension and metabolic alterations, such as the increase of triglycerides and glycaemia, and reduced HDL-cholesterol, comorbidities of high values in the present study.

Since the metabolic syndrome is asymptomatic at this stage of life, it can easily be overlooked even by health professionals. Therefore, emphasizing the importance of preventive and curative care in adolescents is crucial, as well as promoting healthy eating habits and practicing physical activity, which are among the main factors for the prevention of CVDs [31,32]. In this sense, family and school are considered focus areas for interventions aimed at promoting healthy lifestyle.

Limitations of this study are acknowledged. Data from the clinic may not be representative of the general Georgian population and larger studies from different parts of the country are needed. It would be interesting, for example, to compare adolescents with younger children in a larger study with sufficient statistical power. Similarly, a comparison between overweight and obese children or adolescents might reveal differences in parameters of the metabolic syndrome. We did not have sufficient numbers in each subgroup to make meaningful comparisons.

In conclusion, we have demonstrated a high prevalence of metabolic syndrome in overweight and obese children and adolescents attending our unit. These individuals are at increased risk of cardiovascular complications and diabetes. Lifestyle interventions encouraging physical activity and healthy diets are urgently needed if we are to avert complications in adult life.

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References

1. Brambilla P, Lissau I, Flodmark CE, Moreno LA, Widhalm K, et al. (2007) Metabolic risk-factor clustering estimation in children: to draw a line across pediatric metabolic syndrome. Int J Obes 31(4): 591-600.

2. Olza J, Gil Campos M, Leis R, Bueno G, Aguilera CM, et al. (2011) Presence of the metabolic syndrome in obese children at prepubertal age. Ann Nutr Metab 58(4): 343-350.

3. Mellerio H, Alberti C, Druet C, Capelier F, Mercat I, et al. (2012) Novel modeling of reference values of cardiovascular risk factors in children aged 7 to 20 years. Pediatrics 129(4): 1020-1029.

4. Al Hamad D, Raman V (2017) Metabolic syndrome in children and adolescents. Transl Pediatr 6(4): 397-407.

5. Ahrens W, Moreno LA, Marild S, Molnár D, Siani A, et al. (2014) Metabolic syndrome in young children: definitions and results of the IDEFICS study. Int J Obes 38(2): 4-14.

6. Da Costa RF, Santos NS, Goldraich NP, Barski TF, Andrade KS, et al. (2012) Metabolic syndrome in obese adolescents: a comparison of three different diagnostic criteria. J Pediatr 88(4): 303-309.

7. Grundy SM, Brewer HB Jr, Cleeman JI, Smith SC Jr, Lenfant C (2004) Definition of metabolic syndrome: report of the National Heart, Lung and Blood Institute/ American Heart Association conference on scientific issues related to definition. Arterioscler Thromb Vasc Biol 24(2): 13-18.

8. Alberti KG, Zimmet P, Shaw J (2006) Metabolic syndrome-a new worldwide definition. A consensus statement

from the International Diabetes Federation. Diabet Med 23(5): 469-480.

9. Zimmet P, Alberti G, Kaufman F, Tajima N, Silink M, et al. (2007) The metabolic syndrome in children and adolescents. Lancet 369(9579): 2059-2061.

10. Weiss R, Bremer AA, Lustig RH (2013) What is the metabolic syndrome and why are children getting it?. Ann N Y Acad Sci 1281(1): 123-140.

11. WHO (2017) Georgia: Profile of Health and well-being.

12. Weiss R, Dziura J, Burgert TS, Tamborlane WV, Taksali SE, et al. (2004) Obesity and the metabolic syndrome in children and adolescents. N Eng J Med 350(23): 2362-2374.

13. Dobashi K (2016) Evaluation of Obesity in School-Age Children. J Atheroscler Thromb 23(1): 32-38.

14. Choi DH, Hur YI, Kang JH, Kim K, Cho YG, et al. (2017) Usefulness of the Waist Circumference-to-Height Ratio in Screening for Obesity and Metabolic Syndrome among Korean Children and Adolescents: Korea National Health and Nutrition Examination Survey, 2010–2014. Nutrients 9(3): 256.

15. Freedman DS, Serdula MK, Srinivasan SR, Berenson GS (1999) Relation of circumferences and skin fold thickness to lipid and insulin concentrations in children and adolescents: the Bogalusa Heart Study. Am J Clin Nutr 69(2): 308-317.

16. Kuczmarski RJ, Ogden CL, Guo SS, Grummer Strawn LM, Flegal KM, et al. (2002) 2000 CDC growth charts for the United States: methods and development. Vital Health Statistics 11 (246): 1-190.

17. Barlow SE (2007) Expert Committee Recommendations Regarding the Prevention, Assessment, and Treatment of Child and Adolescent Overweight and Obesity. Pediatrics 120(4): 164-192.

18. Flegal KM, Wei R, Ogden CL, Freedman DS, Johnson CL, et al. (2009) Characterizing extreme values of body mass index-for-age by using the 2000 Centers for Disease Control and Prevention growth charts. Am J Clin Nutr 90(5): 1314-1320.

19. Keskin M, Kurtoglu S, Kendirci M, Atabek ME, Yazici C (2005) Homeostasis model assessment is more reliable than the fasting glucose/insulin ratio and quantitative insulin sensitivity check index for assessing insulin resistance among obese children and adolescents. Pediatrics 115(4): 500-503.

20. Druet C, Dabbas M, Baltaske V, Payen C, Jouret B, et al. (2006) Insulin resistance and metabolic syndrome in obese French children. Clin Endocrinol 64(6): 672-678.

21. Dhuper S, Cohen HW, Daniel J, Gumidyala P, Agarwalla V, et al. (2007) Utility of the modified ATP III defined metabolic syndrome and severe obesity as predictors of insulin resistance in overweight children and adolescents: a cross-sectional study. Cardiovasc Diabetol 6: 4.

22. Bokor S, Frelut ML, Vania A, Hadjiathanasiou CG, Anastasakou M, et al. (2008) Prevalence of metabolic syndrome in European obese children. Int J Pediatr Obes 3(suppl2): 3-8.

23. Hannon TS, Rao G, Arslanian SA (2005) Childhood obesity and type 2 diabetes mellitus. Pediatrics 116(2): 473-480.

24. Duncan GE, Li SM, Zhou XH (2004) Prevalence and trends of a metabolic syndrome phenotype among US adolescents 1999-2000. Diabetes Care 27(10): 2438-2443.

25. Ochoa Sangrador C, Ochoa-Brezmes J (2018) Waist-to-height ratio as a risk marker for metabolic syndrome in childhood. A meta-analysis. Pediatr Obes 13(7): 421-432.

26. WHO Report of the commission on ending childhood obesity. Geneva: World Health Organization. 2016.

27. Dias DF, Loch MR, Ronque ERV (2015) Perceived barriers to leisure-time physical activity and associated factors in adolescents. Cien Saude Colet 20(11): 3339-3350.

28. De Assuncao Bezerra MK, Freese de Carvalho E, Souza Oliveira J, Pessoa Cesse EA, Cabral de Lira PI, et al. (2018) Health promotion initiatives at school related to overweight, insulin resistance, hypertension and dyslipidemia in adolescents: a cross-sectional study in Recife, Brazil. BMC Public Health 18(1): 223.

29. Kearns K, Dee A, Fitzgerald AP, Doherty E, Perry IJ (2014) Chronic disease burden associated with overweight and obesity in Ireland: the effects of a small BMI reduction at population level. BMC Public Health 14: 143.

30. De Onis M, Martínez Costa C, Nunez F, Nguefack Tsague G, Montal A, et al. (2012) Association between WHO cut-offs for childhood overweight and obesity and cardiometabolic risk. Public Health Nutr 16(4): 625-630.

31. Xavier HT, Izar MC, Faria Neto JR, Assad MH, Rocha VZ, et al. (2013) V Diretriz Brasileira de Dislipidemias e Prevenção da Aterosclerose. Arqivos Brasileiros de

Cardiologia 101(1): 1-20.

32. Falkner B, Lurbe E, Schaefer F (2010) High blood pressure in children: clinical and health policy implications. J Clin Hypertens 12(4): 261-276.