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Metabolic Syndromes in Overweight/ Obese School-Age Children

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Abstract

The research aimed at studying the phenomenological structure of metabolic syndromes in overweight and obese school-age children. The cohort of 210 students participated in the cross-sectional study. Among them 84 children (40%) were overweight/obese and 126 students (60%)—with normal weight. The incidence of abdominal obesity and arterial hypertension were studied and lipid profile was assessed in obese children. The results of research revealed the early manifestation of abdominal obesity (14.3%-16.7%), arterial hypertension (the elevation of systolic pressure—27.4%, the increase in diastolic pressure—10.7%) and hypercholesterolemia (9.5%) in the population of overweight/obese school age children, which allows to take prompt corrective actions on metabolic syndrome and reduce the risk of its formation.

Keywords

children, overweight, abdominal obesity, arterial pressure, lipid metabolism

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Introduction

Along with the growing prevalence of obesity developed at children age, the problem of metabolic syndrome, associated with it, is gaining topicality.[1] Obesity represents the significant risk- factor for the diseases such as arterial hypertension (17%), type 2 diabetes (44%), dyslipidemia (57.8%), ischemic heart disease (23%), carbohydrate metabolism disorders (30.2%), and oncological pathology (7-41%).[2] The majority of metabolic syndromes is formed at children age and is characterized by a long-term asymptotic course.[3,4] The researches conducted by American Diabetes Association (ADA) confirm the increase in metabolic syndrome rate (12%) at an earlier age and 32% of them is associated with obesity.[5]

The most pernicious form of obesity represents its abdominal type, which is frequently the concomitant of insulin -resistance, hyperinsulinemia, dyslipidemia, hyperandrogeny, and hirsutism. Abdominal obesity is recognized as the accurate predictor of evolution of the cardiovascular system.[6] Moreover, the identification of abdominal obesity in children with the normal body mass index clearly indicates the existence of detrimental metabolic profile.[7,8] The prevalence rate of abdominal obesity in girls makes up 33.2% and it amounts to 28.2%—in boys.[9,10]

Arterial hypertension belongs to the prevailed form of metabolic syndrome in overweight and obese children (50%). At the same time, the risk of hypertension is distinctly correlated with BMI (Body Mass Index), especially when BMI percentile exceeds 95.[11] In metabolic profile the dyslipidemia, under whose conditions the atherogenic deviation of lipid spectrum as well as the alteration of hemostasis and hemorheology occur, is given priority by some of the authors. Lipid metabolic disorders were detected in 12% to 17% of obese children. In general, metabolic syndrome was identified in 10% of overweight/obese children.[8,12]

Abdominal obesity, arterial hypertension and lipid metabolic disorders create the so-called cluster of metabolic syndrome, which playing the compellingly predictive role in forming the type 2 diabetes, atherosclerosis and the pathology of cardiovascular system represents the topical problem at the present stage.[13,14] Occasioned by the above mentioned, the timely manifestation and correction of metabolic disorders in overweight and obese children assumes the great significance.

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The aim of study was to investigate the phenomenological structure of metabolic syndrome in overweight and obese school-age children.

Material and Methods

The whole of 250 students aged from 7 to 17 were conducted the cross-sectional screening study. Body mass index (BMI) and BMI standard deviation (SDS) was applied in order to assess the nutritional status. The cohort of 201 children were involved in the study. Eighty-four overweight/obese students (SDS BMI >1.5) were included in the main, experimental group, and the control group consisted of 126 students with the normal body mass index (BMI $\pm$ 1).

The inclusion criteria for the experimental group were as follows: The confirmed diagnosis of overweight and obesity, the age from 7 to 17, the informed consent of a patient.

The exclusion criteria from the study were the following: Secondary obesity (endocrine, iatrogenic, syndromic), acute gastrointestinal disease, oncological pathology, mental health disorders, exacerbation of chronic pathology.

With the aim of manifesting the metabolic phenomena in the studied cohort, the investigations were conducted into the incidence of abdominal obesity as well as arterial hypertension and the assessment of lipid profile was carried out.

In order to diagnose abdominal obesity, there were applied the anthropometric data and their indices: waist circumference, waist/height index and waist/hip index. The following cut-points were accepted to confirm abdominal obesity: the value of waist circumference was determined to be $\geq$90 percentile, the waist/height index $>$44 cm irrespective of age and sex,[15] the waist/hip index in girls $>$0.8 and in boys $>$0.9.[2]

Systolic and diastolic blood pressure was determined on the basis of 2 to 3 fold measurement through applying Korotkoff method during 7 to 10 days interval. Systolic blood pressure $>$130 and diastolic BP $>$ 85 were considered as systolic and diastolic hypertension.[16]

The study of lipid range was conducted utilizing Biochemistry Automated Analyzer (cobas c 111 /Roche). The following was determined: total cholesterol (TC), the norm: $<$5.2 mmol/L; low-density lipoproteins (LDL-C), the norm: boys $>$1.45 mmol/L, girls $>$1.68 mmol/L; high-density lipoproteins (HDL-C) the norm: $<$3.3 mmol/L; triglycerides (TRIGL), the norm: $<$1.7 mmol/L; the Atherogenic Index TC/ HDL-C $<$ 3.0.

The statistical analysis of research findings were carried out through using Microsoft Excel 2010 and SPSS/v12 software packages. Arithmetic mean (MEAN) and standard deviation (M $\pm$ SD) were determined for uniformly distributed variables. The absolute risk ratio (RR) with 95% confidence interval (CI) was defined for the metabolic phenomena associated with overweight and obesity (CI). The reliable critical value (P) was considered to be $<$.05.

Table 1. Anthropometric Characteristics of Studied Children.

Anthropometric parameters	Overweight/obesity (n = 84)	Normal weight (n = 126)
Height (cm)	164.2 $\pm$ 10.8	162.3 $\pm$ 12.8
Weight (kg)	73.7 $\pm$ 9.9	60.6 $\pm$ 46.2
BMI (kg/m^2)	27.2 $\pm$ 2.2	21.3 $\pm$ 2.0
BMI SDS	1.6 $\pm$ 0.4	0.8 $\pm$ 2.0
Arm circumference	26.0 $\pm$ 6.6	24.5 $\pm$ 21.8
Chest circumference (cm)	85.4 $\pm$ 10.8	77.2 $\pm$ 11.2
Waist circumference (cm)	59.8 $\pm$ 7.6	54.1 $\pm$ 7.9
Hip circumference (cm)	81.2 $\pm$ 14.4	76.4 $\pm$ 9.6
Waist/height index	0.4 $\pm$ 0.1	0.36 $\pm$ 0.02
Waist/hip index	0.80 $\pm$ 0.1	0.70 $\pm$ 0.09

The Study Results

The whole of 210 children were included in the research. The mean age of the studied cohort was 13.9 $\pm$ 0.4 years. The majority represented Georgian nationality. The sex ratio was male-biased (62.4% boys and 37.6% girls).

In order to diagnose abdominal obesity, anthropometric parameters were studied including waist circumference (cm), waist/height index and waist/hip index (Table 1).

Mean waist circumference averaged to 59.8 $\pm$ 7.6 cm, and 90 percentile was 68.6 cm. Greater than 90 percentile indicator was manifested in 12 of the overweight/obese patients (14.3%), that denoted the existence of abdominal obesity in these children.

The second index, which is frequently used to diagnose abdominal obesity in adolescents, is the waist-to-height ratio (waist/height index). The index is applied not only to identify the abdominal obesity, but it serves as proxy for assessing the metabolic and cardiovascular risks at children age as well. In contrast to the waist circumference, the waist/height index does not necessitate the determination of percentiles according to gender. The elevated waist/height index ($>$0.44 cm) was manifested in 13 cases (15.5%) and 14 of the patients (16.7%) were detected the increase in waist/hip index. Based on our findings, the indicators of waist circumference, waist/height and waist/hip ratios confirmed the existence of abdominal obesity in 14.3% to 16.7% of overweight and obese children, respectively.

Table 2. Indicators for Systolic and Diastolic Arterial Pressure in Studied Cohort.

	Overweigh/obesity (n = 84)	Normal weight (n = 126)			
Systolic pressure	119.0 ± 13.6	108.2 ± 23.5			
Diastolic pressure	70.5 ± 10.3	63.2 ± 14.9			
Pulse	88.4 ± 16.3	83.2 ± 20.6			
			RR	CI	*P*
Systolic pressure >130	23 (27.4%)	11 (8.7%)	1.95	1.34-2.54	.001
Diastolic pressure > 85	9 (10.7%)	7 (5.6%)	1.45	0.76-2.14	.265
Increase in both pressure	9 (10.7%)	3 (2.4%)	1.98	1.09-2.53	.025

Table 3. Lipid Profile in Obese Children (n = 22).

Indicators (mg/dL)	Obese children	Norm
Total cholesterol	4.52 ± 1.0	< 5.2 mmol/L
MSL	1.43 ± 0.5	<3.3 mmol/L
Triglycerides	1.31 ± 0.8	<1.7 mmol/L
DSLP	3.20 ± 1.0	>1.45 mmol/L
Atherogenic Index	2.33 ± 1.0	<3.0

Both in overweight/obese and in children with normal weight the mean indicator of arterial pressure and pulse rate ranged within the age norms. For the purpose of revealing the increased indicators for systolic and diastolic arterial pressure, the criteria developed for British pediatric population were applied: systolic pressure >130 mmHg, and diastolic pressure >85 mmHg (Table 2).

About 27.4% of overweight and obese children were detected the reliably elevated indicator for systolic pressure ($P < .001$). The mean diastolic pressure indicator fluctuated within the norm, the increase was identified in 10.7% of cases. The reliably high incidence of simultaneous elevation of systolic and diastolic pressure (10.7%) was manifested in overweight and obese children ($P < .025$).

The study of lipid profile was conducted in 22 obese patients (Table 3).

The mean of lipid spectrum did not exceed the scope of age norm. At the same time, the elevation of total cholesterol was noteworthy in 8 cases, which made up 9.5% of overweight and obese children. The increase in triglycerides was detected in 4 patients (4.8%). Low density lipoproteins were reduced only in one case, and the quantitative changes of high density lipoproteins was not identified at all. The mean of atherogenic index averaged to 2.33 ± 1.0. The above-normal level of atherogenic index was manifested in 4 of the children (4.8%).

Physical examination demonstrated, that striae (28.6%) ($P < .001$) and acne (21.4%) ($P < .008$) were worth noting in overweight/obese children. The signs of sexual maturation were noticeable in 13.1% ($P < .029$). Acanthosis (1.2%) and alopecia (1.2%) were manifested only in overweight and obese children.

In the structure of chronic morbidity of overweight and obese children the incidence of the following diseases outnumbered the data of control group: respiratory diseases (23.7% and 9.5%), chronic tonsillitis (16.7% and 12.7%), digestive system pathology (17.9% and 6.3%), and scoliosis (11.9% and 7.1%), respectively (Figure 1).

In terms of the nervous system, pathological changes were not manifested. Asthenia and depressed mood were detected in 8.3% of participants, 6% of children were developed low self-esteem, and 2.4% of them were identified cognitive disorders.

Anthropometrics were studied in parents and other family members as well. The majority of mothers were overweight (38.1%), and 13.1% of them were obese. 44.1% of fathers were overweight, and obesity was manifested in 16.7% of them. As regards the mothers of children with normal weight, 23% of them were manifested overweight and 12.7% were obese, 38.9% of fathers were overweight and obesity was detected in 25.4% of them. In respect of chronic morbidity, it is worth noting, that in the group of overweight/obese children 10.7% of fathers were detected diabetes mellitus, not a single case of which was manifested in mothers of that group at all. Cardiovascular diseases were represented by small share (3.6%). The high incidence of diabetes mellitus was noteworthy in second-degree relatives (33.3%) that exceeded the data of the group of children with normal weight (13.5%) (RR: 1.83, CI: 1.27-2.44, *P*: .001).

Discussion

Hence, our materials demonstrated the existence of the following phenomena of metabolic syndrome in

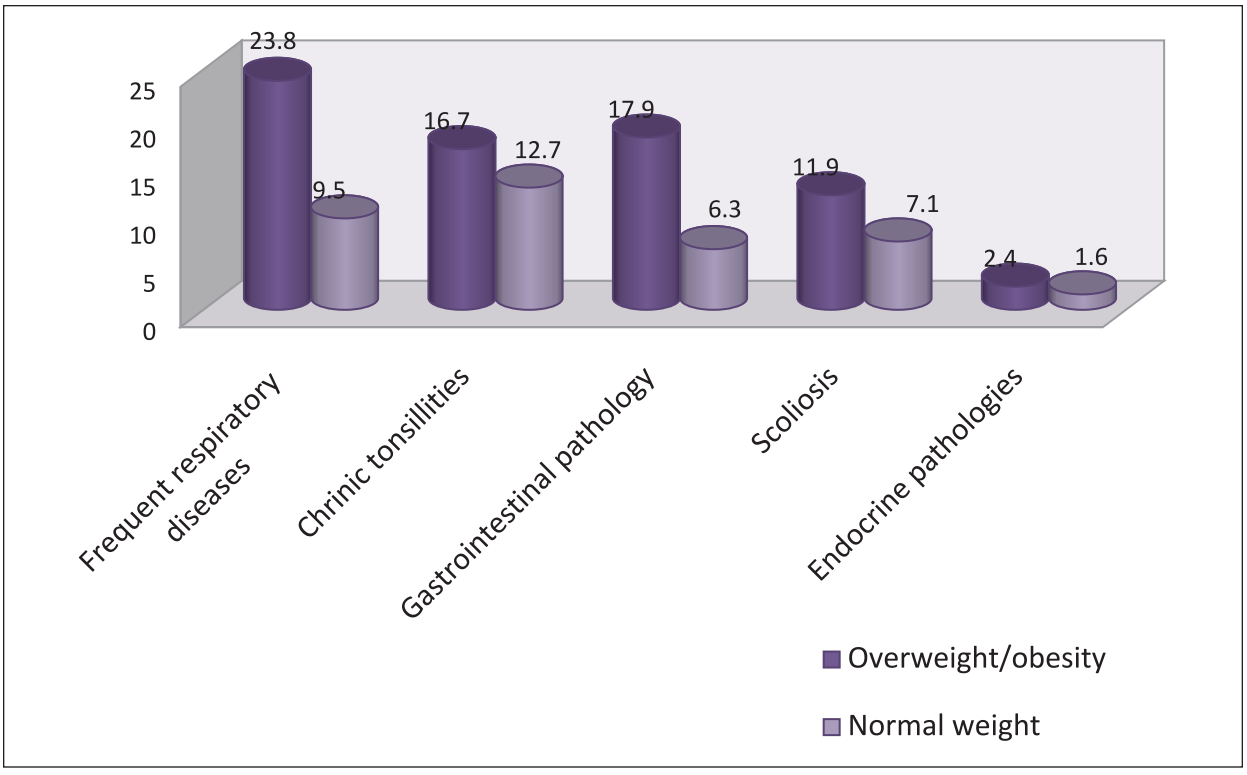

Figure 1. Comparison of chronic morbidity between overweight/obese and normal weight children.

overweight and obese children: abdominal obesity was detected in 14.3% to 16.7% of studied cohort, the elevation of systolic arterial pressure in—27.4%, the increase in diastolic pressure in—10.7% and hypercholesterolemia was manifested in 9.5% of cases.

Obviously, obese children are at high risk of developing metabolic syndrome, but even in case of overweight 70% of children are identified at least a single metabolic syndrome. Despite the fact, that metabolic syndrome is not diagnosed under 10 years of age, we think, that the existence of abdominal obesity and arterial hypertension in overweight/obese children indicates the onset of metabolic syndrome, especially in cases of loaded family history (obesity, diabetes mellitus, cardiovascular pathology arterial hypertension).

Irrespective of the age, the primary clinical complication of obesity represents arterial hypertension, whose stage and nature determines the further prognosis of the disease and conditions the likelihood for formation of cardiovascular system pathology at earlier age. Despite the fact, that 50% of adolescents with normal MBI rates are developed the arterial hypertension in adulthood, the unified risk factors have not been established in pediatric practice. According to our materials, 27.4% of overweight/obese children were detected the elevated systolic pressure, and in 10.7% the increase was manifested in both systolic and diastolic pressure ($P < .025$).

It is deemed, that at children age the abdominal obesity activates various pathogenic mechanisms, increases the metabolic risk and eventually conditions the complete manifestation of the syndrome.[17,18] Waist circumference represents the highly specific marker of abdominal obesity. In children the waist circumference represents the independent predictive marker of insulin resistance and clearly correlates with the level of lipids and insulin.[19] The problem is posed by the absence of precise recommendations on the diagnostics of metabolic syndrome at children and adolescent age. Despite the fact, that nowadays the role of abdominal obesity in developing the metabolic syndrome in adolescents is confirmed, its significance as a diagnostic criterion is varying and necessitates additional evidences.[6,20]

The unified criteria for assessing waist circumference does not exist up today. A number of countries (the USA, Australia, Canada, England, Bulgaria, Turkey) have developed the national percentile tables, which clearly demonstrate the discrepancy in normal indicators. The mentioned above is supposedly conditioned by the changes in body proportions with a child's growth and does not allow to use the waist circumference as an

authentic sign of assessing abdominal obesity.[21] Waist circumference mainly reflects the subcutaneous and visceral fat volume, but it does not frequently correlate with other phenomena of metabolic syndrome (arterial hypertension, the increase in level of glucoses and triglycerides). At the same time, the degree of its correlation with abdominal obesity considerably outnumbers BMI rate and the indicator is considered as a marker for the existence of various types of obesity.[22]

In addition, the role of waist/hip and waist/ height indices, as the markers for abdominal obesity in children, has not ultimately established. The indices are more frequently utilized above 15 of age, but they have less correlation with fat content even in adolescents in contrast to waist circumference and BMI

So, despite the numerous discussions, the early manifestation of metabolic phenomena in overweight and obese children focuses the agenda again on the expediency of separating the metabolic syndrome at children age that will allow us to cluster the abnormal conditions having the unified pathogenic mechanisms.

Conclusion

Considering the sustained expansion of prevalence of obesity at children age, the findings of research highlight the urgency of separating the leading components of metabolic syndrome in overweight and obese children, the necessity of stratification of atherogenic and diabetogenic risks, the aggressive therapy of clinical manifestation as well as taking the corrective and preventive actions.

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Author Contributions

Lia Otiashvili contributed to the design and implementation of the research, to the analysis of the results, and to the writing of the manuscript.

Declaration of Conflicting Interests

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