Human & Veterinary Medicine
International Journal of the Bioflux Society HVM

OPEN ACCESS
Research Article

Metabolic syndrome in children

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Abstract. Objective: To determine the prevalence of the metabolic syndrome (MS) in children. Material and methods: We performed a cross sectional, retrospective study. A total of 395 children aged between 2-19 years old were examined.. The children have undergone physical examination; weight, height, waist circumference, blood pressure (BP) were measured. The nutritional status of the children was assessed by body mass index (BMI) and laboratory tests needed to diagnose MS were performed. IDF criteria for MS were used in children 10 years and older and age and gender specific cut-off points in children younger than 10 years. The statistical analysis of the data was descriptive and inferential analysis. In the bivariate analysis of association between qualitative variables, we used the Chi-Square test and the exact Fisher test. The statistical analysis was performed with SPSS v 13.0. Results: Eighty-two (20.8%) children were normal weight, 150 (37.9%) were overweight and 163 (41.2%) were obese. One (1.2%) of the normal weight children, 21 (14%) of the overweight and 30 (18.4%) of the obese ones had MS. Twenty-four (12.5%) of the girl and 28 (13.79%) of the boys had MS. According to the age groups 21 (11.53%) subject under 10 years, 26 (13.83%) between 10-16 years and 5 (20%) older than 16 years had MS.Conclusions: Prevalence of the metabolic syndrome was higher in obese children than in overweight and normal weight children. There were no significant differences of the MS prevalence between sexes and age groups.

Key Words: obesity, overweight, metabolic syndrome, children.

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Introduction

Although the interest in the metabolic syndrome (MS) in children has increased as a result of the increase of the prevalence of obesity in children and of the large number of adults with the MS and related diseases, there is still no standardized definition of the MS in children.

The importance of early identification of obese children, of those with increased risk of developing MS, type 2 diabetes and cardiovascular diseases in adulthood, cannot be neglected, as it has been demonstrated that obesity and cardiovascular risk factors associated with obesity persist until adulthood (Ford & Giles et al 2002).

Most clinical manifestations of cardiovascular diseases occur in adulthood, but research conducted over the past 40 years indicates that the atherosclerotic process begins in childhood and evolves throughout life (Newman & Freedman et al 1986). Reduction of carotid elasticity was highlighted in children with the MS and in adults who had elements of the MS as children (Juonala & Jarvisalo et al 2005;Iannuzzi & Licenziati et al 2006). Detecting children with MS elements would mean timely identification of those who will develop comorbidities (cardiovascular diseases or type 2 diabetes), allowing early intervention. There are many controversies related to the definition of this syndrome in children, to the reference values that would be relevant to the future progress and to the importance of diagnosing this syndrome in children, as some authors suggest that it would be useful to highlight the syndrome components separately. The problem of defining the syndrome as such is complicated by the fact that the syndrome elements appear gradually, in evolution and the full picture is not present at a young age. Moreover, the pathophysiological changes and syndrome components are also influenced by growth, puberty, not just by gender and ethnicity as in the case of adults (Chen & Bao et al 2000). Because of these features, criteria used for adults should be applied with great caution (Goodman 2006; Jones 2006).

However, in the studies conducted in children the criteria were largely the same as those used in the studies on adults, with some changes. After examining the definitions used by different researchers, Ford et al found 27 published articles which used 46 diagnostic criteria, most of which were based on the NCEP ATP III definition. The number of MS components considered necessary for diagnosis also ranged, though generally speaking, the individuals chosen had at least three components of the syndrome (Earl & Chaoyang 2008).

The results of the studies vary because of the great diversity of the criteria used, of the reference values, of the study design, of the criteria for inclusion in the group, which is why the results are difficult to compare (Golley et al 2006). The prevalence of the MS established in children ranges between 20-58% in our geographic area, depending on the definition used, while the number of the studies is very small. (Pop 2011; Puha Preda & Matasaru 2011)

The objective of the study was to determine the prevalence of the MS in children.

Materials and methods

We performed a cross sectional retrospective study, on a group of 395 subjects, children aged between 2-19 years old, who presented at the Pediatric Clinic no. 2 in Cluj-Napoca and children from 2 schools in the same city. The study was performed

Table I. Metabolic syndrome in children-definition criteria

Metabolic syndrome in children-definition criteria					
Age	**WC**	**TG**	**HDL**	**BP**	**glucose**
<10 years	>p90	>p90 and/or ≥150mg/dl	<p10 and/or <40 mg/dl	>p90	gl ≥100mg/dl* and/or OGTT≥200mg/dl* and/or HOMA-IR>2,5**
10-16 years	>p90	≥150mg/dl	<40mg/dl	BPs≥130mmHg BPd≥85mmHg	gl≥100mg/dl and/or OGTT≥200mg/dl and/or HOMA-IR>2.5
>16 years	Girls≥80cm Boys≥94 cm	≥150mg/dl	Girls<50mg/dl Boys<40mg/dl	BPs≥130mmHg BPd≥85mmHg	gl ≥100mg/dl
WC: waist circumference; HDL: high-density lipoprotein cholesterol; BP: blood pressure BPs systolic BPd diastolic; gl: fasting glucose; OGTT: oral glucose tolerance test *(American Diabetes Association 2010) **(Sharma & Lustig et al 2011)					

Table II. Characterization of the group in terms of average age

Normal weight (N)		**Overweight (OW)**		**Obese(OB)**	
11.38±3.01 (7-18)		11.53±3.30 (4-19)		10.20±3.67 (2-19)	
N vs OW p=0.71 N vs OB p=0.20 OW vs OB p=0.15					
Girls	Boys	Girls	Boys	Girls	Boys
11.57±3.01 (7.5-18)	10.90±2.61 (7-15)	11.37±3.40 (5-19)	11.67±3.22 (4-18)	10.90±4.12 (2-19)	10.32±3.22 (4-18)
p=0.12		p=0.55		p=0.26	
with SM		without SM			
11.09±3.62 (5-19)		10.53±3.54(2-19)		p<0.05	

Table III. Characterization of the group in terms of nutritional status

	Normal weight (N)	**Overweight (OW)**	**Obese(OB)**	
BMI	18.23±2.5 (13.9-24.1)	23.43±2.8 (17.8-29.7)	26.29±4.5 (19-39.1)	N vs SP p<0.001 SP vs OB p<0.001
BMI/BMIp50	1.02±0.09 (0.9-1.2)	1.29±0.08 (1.1-1.5)	1.54±0.02 (1.2-2.1)	Nvs SP p<0.001 SP vs OB p<0.001
	<10 years	10-16 years	>16 years	
BMI	21,18 3,44 (13.9-32.6)	25.12±4.37 (16.45-39.09)	28.99±4.59 (21.52-39.14)	

during the period 2005-2010. The parents of the children gave their informed consent to use the data in this study. We obtained the approval of the medical ethics committee of the Pediatric Emergency County Hospital.

The children were measured: weight, height, waist circumference (WC) and blood pressure (BP). We calculated the body mass index (BMI). BMI was compared against the BMI corresponding to the 50th percentile.

The laboratory test performed were: fasting glucose level, oral glucose tolerance test, fasting insulin level, total cholesterol, HDL cholesterol, triglycerides. Insulin resistance was evaluated by the homeostasis model assessment method (HOMA-IR).

We defined the metabolic syndrome according to IDF criteria for children and adolescents (Zimmet et al 2007) Considering there is no clear definition of this syndrome in children younger than 10 years old, we have used age and gender specific cut-off points, as mentioned in the table, according to each variable (McCarthy et al 2001; National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents 2004; Report of a WHO/IDF consultation 2006; Daniels et al 2008; Madeira et al 2008). The definition used in this study is presented in the table I. We considered a MS diagnosis if at least 3 of 5 criteria were present, based on the latest IDF recommendations in adults. (Alberti et al 2009).

Subjects were distribuited in 3 age groups (younger than 10 years old, between 10-16 years old and older than 16 years old) according to the MS definition in children, in two groups per gender and in 3 groups depending on the nutritional status.

The nutritional status of the children was assessed with the use of BMI and defined the groups of normal weight, overweight and obese children according to the IOTF references. (Cole et al 2000). Only those with idiopathic obesity were included in this study, we excluded the children with obesity due to other causes and children with diseases which may influence the laboratory tests.

The statistical analysis of the data was descriptive and inferential analysis. In the bivariate analysis of association between qualitative variables, we used the Chi-Square test and the exact Fisher test. The significance level for all tests was $\alpha=0.05$. Thus, the type 1 error rate we are willing to assume is 5%. Test significance is given by the bilaterally observed significance level, $p<0.05$. The exact Fisher test was used if at least 20% of the theoretical frequencies were less than 5. The statistical analysis was performed with SPSS v 13.0.

Results

In the group of 395 subjects 192 (48.6%) were girls, 203 (51.4%) were boys, aged 2-19 (mean: 10.5 ± 3.45 years), 182 (46%) were under 10 years, 188 (47.6%) were 10-16 year-old, and 25 (6.4%) were over 16. There were 82 normal weight (20.8%) subjects, 150 (37.9%) overweight subjects and 163 (41.2%) obese subjects, 313 (79.2%) were overweight + obese.

There were no significant differences in terms of average age between normal weight, overweight and obese patients, nor in terms of gender. There were no differences in terms of nutritional status by gender and age groups.

A percentage of 1.2% of the normal weight subjects were diagnosed with MS, with the highest percentage - of 18.4% - recorded in obese subjects. 16.3% of those with excess weight were identified with MS.

Table IV. Presence of MS depending on the nutritional status

	MS		
	present	**absent**	**total**
Normal weight	1 (1.2%)	81 (98.8%)	82(100.0%)
Overweight	21(14%)	129(86%)	150(100.0%)
Obese	30(18.4%)	133(81.6%)	163(100.0%)
OW+OB	51(16.3%)	262(83.7%)	313(100%)
total	52(13.2%)	343	395
N vs OW p=0.001	N vs OB p<0.001	OW vs OB p=0.35	

Table V. The presence of the metabolic syndrome by age groups

Age group	with MS	without MS	% with MS
<10 years	21	161	11.53%
10-16	26	162	13.83%
>16	5	20	20.00%
total	52	343	
p=0.46			

When analyzing the presence of MS by age groups we can notice an increase in the percentage of those with metabolic syndrome with age, but this is not statistically significant.

Table VI. The presence of the metabolic syndrome by age and BMI

	N		OW+OB	
age group	**with MS**	**without MS**	**with MS**	**without MS**
<10 years(%)	0(0%)	36(100%)	21(14.4%)	125(85.6%)
10-16(%)	1(2.3%)	42(97.7%)	25(17.2%)	120(82.8%)
>16(%)	0(0%)	3(100%)	5(22.7%)	17(77.3%)
	N p=0.9		OW+OB p=0.56	

In those with excess weight, the percentages of those with MS increase with age in all the three age groups (14.4%, 17.2 % and 22.7%), but this is not statistically significant.

MS prevalence in girls was similar to that in boys, namely: 12.50 % and 13.79 % respectively. The percentages of normal weight girls and boys were small, namely: 1.92% and 0 % respectively. The percentage of those with MS is higher in obese subjects, in girls, 20%, compared to boys, 17.2% . The prevalence of MS in overweight girls and boys (overweight + obese) is almost identical .

The presence of the metabolic syndrome by age in boys and girls is shown in Table VIII; with no statistically significant differences between girls and boys in different age groups ($p = 0.64$, $p = 0.29$, and $p = 0.9$ respectively) or between age groups in the two gender groups ($p = 0.58$ and 0.34 respectively).

Table VII. The presence of MS by sex and BMI groups

	Girls (G)			Boys (B)		
	with MS	**without MS**	**% with MS**	**with MS**	**without MS**	**% with MS**
N	1	51	1.92%	0	30	0.00%
OW	9	61	12.85%	12	68	15.00%
OB	14	56	20.00%	16	77	17.20%
OW+OB	23	117	16.42%	28	145	16.18%
total	24	168	12.50%	28	175	13.79%
OW G vs B p=0.81 OB G vs B p=0.68						

Table VIII. The presence of the metabolic syndrome by age and BMI

	Girls			Boys		
age group	**with MS**	**without MS**	**% with MS**	**with MS**	**without MS**	**% with MS**
<10 years	11	73	13.09%	10	88	10.20%
10-16	10	83	10.75%	16	79	16.84%
>16	3	12	20.00%	2	8	20%
total	24	168	12.50%	28	175	13.79%
G with MS vs without MS p=0.58				B with MS vs without MS p=0.34		
<10 years G vs B p=0.64 10-16 years F vs B p=0.29 >16 years G vs B p=0.9						

Discussions

The percentage of patients with MS was small (1.12%) in the case of normal weight patients, similar to that reported in the literature (Reinehr et al 2007; Lee et al 2008). The percentage is higher in obese compared to overweight patients, but without this being statistically significant, again consistently with the results reported by other studies (generally based on the ATP III definition); prevalence increases with the degree of overweight. The prevalence of MS among overweight and obese patients is statistically significantly higher (Weiss et al 2004; Braga-Tavares & Fonseca 2010). When using IDF criteria, the prevalence of MS in obese patients as compared against that in overweight patients is not much different, as in our study group (Braga-Tavares & Fonseca 2010). On the other hand, there is a significant difference in overweight patients compared with normal weight patients, as reported in other studies (Reinehr et al 2007).

MS prevalence in the population studies, but also in those conducted on groups of overweight and / or obese subjects varies, especially depending on the definitions used and depending on the population studied (Cook et al 2003; Golley et al 2006; Reinehr et al 2007; Bokor et al 2008; Lee et al 2008; Braga-Tavares & Fonseca 2010; Pedrosa et al 2010). A higher prevalence of MS and a reduction of the false negative is obtained when using HOMA-IR as a defining element of SM (Sharma et al 2011).

In the groups of overweight and / or obese patients higher percentages were reported by the studies conducted in the U.S. 38.7 - 49.7% (Weiss et al 2004) 30.2% (Cruz 2004) as compared with those reported by the studies conducted in Europe 21.4% 27.2% (Atabek et al 2005), 15.8% -19.1% (Pedrosa et al 2010), most of which were based on the NCEP ATP III definition; but variations in prevalence appear also depending on the definition itself (15.6%, 35% and 8.9% Braga-Tavares & Fonseca 2010).

The study conducted in five European countries in which four definitions of the MS were comparatively used, reported an average prevalence of MS in overweight subjects of 12.2%; depending on the definition, the prevalence was: 35.7%, 31.4%, 20.3% and 16.4% in the case of the IDF definition. (compared to our study, where the prevalence was 16.3% in overweight subjects (overweight + obese), 18.4% in obese subjects and 14% in overweight subjects) (Bokor et al 2008).

Population studies, most of which are based on the NCEP definition, report small percentages in the general population, 4.2% (Cook et al 2003), 4.2% -8.4% (Goodman 2006). The studies conducted in Europe which were based on the IDF definition, report an average prevalence of the MS of 2.2% (ranging between 0.3% -5%) (Fried et al 2013) Our study was not a population study, therefore the percentage of overweight and obese patients is higher than in the general population (although we do not have national statistics); probably the percentage of the individuals with MS in the general population is actually lower than that obtained by us in the study group. The percentages will vary according to age, race of the children enrolled in the study (Cook et al 2003)

Studies on overweight and / or obese European children show percentages by age group similar to those shown in our study. (Braga-Tavares & Fonseca 2010; Druet et al 2010). The average prevalence of MS among overweight and obese European children according to the studies based on the IDF definition is 21%, but actually ranging between 8.9% -50% (Fried et al 2013) In our country the percentages range from 20% -58% (Pop 2011; Puha Preda & Matasaru 2011).

There is an increase in the percentage of those with MS, with age, but without this being statistically significant, as Braga-Tavares et al found increasing prevalence in the age group 10-15 years compared to the age group 15-20 years (Atabek et al 2006; Braga-Tavares & Fonseca 2010).

We did not notice significant differences between MS prevalence in girls and boys by age or by nutritional status, consistently with some studies. (Atabek et al 2006; Braga-Tavares & Fonseca 2010; Pedrosa et al 2010); however, there are others which report higher percentages in boys (Cook et al 2003).

Conclusion

The prevalence of MS was 18.4% in obese children, 14% in overweight children and 1.2% in normal weight children. There were no significant differences in MS prevalence between the two genders and by age groups.

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Citation	Morea, M., Miu, N., 2013. Metabolic syndrome in children. HVM Bioflux 5(3):103-108.
Editor	Ştefan C. Vesa
Received	1 September 2013
Accepted	20 October 2013
Published Online	22 October 2013
Funding	None reported
Conflicts/ Competing Interests	None reported