THE EVALUATION OF OBESITY-RELATED CARDIOMETABOLIC DISEASES: A SIMPLE ANTHROPOMETRIC TOOL FOR A COMPLICATED MATTER

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ABSTRACT

Introduction. Anthropometric measurements are simple clinical tools that can be used for the evaluation of obesity-related cardiometabolic complications.
Objective. To identify obesity-related cardiometabolic outcomes and to compare the relevance of BMI or WHtR for early diagnosis in a group of obese children and adolescents.
Material and methods. The study included 174 children diagnosed with simple obesity during a three year period. Anthropometric measurements (including BMI and WHtR) and biochemical variables were analyzed.
Results. 4.28% of children were overweight, 31.43% were obese and 64.29% had extreme obesity. The main cardiometabolic complication was insulin resistance (47.76%) followed by hyperinsulinism, alteration of the lipid metabolism and hypertension. All children had a WHtR ≥ 0.5. One Way ANOVA with post-hoc t-test analysis was used for the comparative evaluation of the BMI and WHtR; there were no statistic significant differences between groups.
Conclusion. Obesity defined by BMI and a WHtR ≥ 0.5 is in the majority of cases associated with adverse cardiometabolic outcomes. Both anthropometric indexes should be used as evaluation tools in medical practice, but WHtR has some important advantages.

Keywords: child obesity, body mass index, waist to height ratio, obesity related cardiometabolic disease

INTRODUCTION

In the past decade, the child obesity was widely studied. One of the most important aspects highlighted, especially because of its long-term consequences, is the development of obesity-related cardiometabolic disorders. Alteration of the glucose metabolism, type 2 diabetes mellitus, arterial hypertension, dyslipidemia, and later, coronary heart disease, ischemic stroke and neoplasia are known to be more frequent in overweight and obese individuals compared to the general population. It is worldwide recognized that atherosclerosis begins in early childhood (1), so early diagnosis and treatment of these cardiometabolic complications is essential.

Anthropometric measurements, like body mass index (BMI) or waist circumference (WC), are commonly used for diagnosis and classification of child obesity, but these indexes can also be used in the evaluation of obesity-related complications. There are numerous evidences suggesting that central adiposity in children is more relevant to long-term outcomes. Waist circumference (WC) and waist to height ratio (WHtR) (2) have been proposed to be better indicators than BMI in the clinical practice (3,4,5).

AIMS

The purposes of this study are to identify obesity-related cardiometabolic complications and to determine which is the most relevant anthropometric tool (BMI or WHtR), that can be used for early diagnosis of these complications in a group of obese children and adolescents.

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MATERIAL AND METHODS

Data from 174 observational charts of children and adolescents followed-up in the IInd Pediatric Clinic Timişoara for excessive weight, during the three-year period (January 1st, 2010 to December 31st, 2012) were analyzed. Exclusion criteria were: children with chronic medical problems and/or chronic treatment known to be associated with weight gain, presence of clinical signs suggesting a syndromic obesity and incomplete clinical or biochemical data. Seventy children with simple obesity were included in the study group.

Weight and height were measured using calibrated scales, rounded up to the nearest 0.5 kilograms and respectively 0.5 centimeter. BMI was calculated using the following formula: weight (kilograms) divided by the square of height (meters).

Overweight and obesity was defined according to The Centers for Disease Control and Prevention 2000 standards (CDC).

Waist circumference was measured using a non-elastic tape, at the end of a normal expiration, at the midpoint between the lower border of the rib cage and the iliac crest. WHtR was calculated using the formula: WC (cm) divided by height (cm).

The systolic (SBP) and diastolic (DBP) blood pressures were measured with age specific cuffs, in the morning. Two different measurements were made, and the average value was recorded. Blood pressure z-scores and percentiles for age, sex and height, were calculated according to National Heart Lung and Blood Institute guidelines (NHLBI) (6). Pre-hypertension was defined as blood pressure (BP) $\geq 90^{th}$ percentile but lower than the 95^{th} percentile. Hypertension was considered when BP $\geq 95^{th}$ percentile for age, sex and height.

The biochemical blood samples were obtained after a twelve-hour fasting period. Fasting glucose blood (FBG) levels and at 120 minutes during the standard Oral Glucose Tolerance Test (OGTT) were evaluated according to American Diabetes Association (ADA) recommendations (7). Reference level for fasting insulin was 3 to 17 mcU/ml. The homeostatic model assessment of insulin resistance (HOMA – IR) was estimated using the formula: [baseline insulin (mcU/ml) X fasting blood glucose (mg/dl)] / 405. For the definition of insulin resistance (HOMA IR +) we used the cut-off values corresponding to the 90^{th} and 95^{th} percentile, according to gender and pubertal status found in a Romanian study (8,9). The 90^{th} percentile for prepubertal children was 2.12 for girls and 2.11 for boys and during puberty increased at 3.64 for girls and 2.47 for boys, respectively.

Altered lipid profile was defined according to National Cholesterol Education Program (NCEP) Expert Panel of Cholesterol levels in children recommendations (6).

The data are expressed as: mean ± standard deviation (SD), minimum and maximum. One Way ANOVA (confidence interval 95%) with post-hoc t-test analysis was used for the comparative evaluation of the BMI and WHtR. Statistical data analysis was performed using Excel 2007.

TABLE 1. *Clinical and biochemical characteristics of the study group*

Variables	Girls (n = 42)		Boys (n = 28)		Total (n = 70)	
	mean ± SD	Minim – Maxim	mean ± SD	Minim – Maxim	mean ± SD	Minim – Maxim
Age (years)	12.06 ±3.56	3.5 – 18.5	11.56 ± 2.77	7.2 – 17.7	11.86 ± 3.25	3.5 – 18.5
BMI (kg/m^2)	30.98 ± 5.92	22.34 – 48.25	31.13 ± 4.78	21.70 – 41.45	31.04 ± 5.46	21.70 – 48.25
BMI z score	2.21 ± 0.51	0.99 – 3.54	2.34 ± 0.30	1.66 – 2.99	2.26 ± 0.44	0.99 – 3.54
WC (cm)	97.00 ± 14.26	66 -120	101.82 ± 10.91	80 – 126	98.92 ± 13.16	66 – 126
WHtR	0.66 ± 0.06	0.55 – 0.80	0.63 ± 0.06	0.50 – 0.79	0.64 ± 0.06	0.50 – 0.80
SBP (mmHg)	114.52 ± 15.84	90 – 160	119.82 ± 13.70	100 – 150	116.64±15.14	90 – 160
DBP (mmHg)	70.83 ± 11.68	55 – 90	73.03 ± 10.21	50 – 90	71.71 ± 11.09	50 – 90
FBG (mg/dl)	82.23 ± 14.37	52 -108	89.64 ± 14.35	59 – 119	85.20 ± 14.72	52 -119
*2h glucose (mg/dl)	130.33 ± 24.89	85 – 196	135.25 ± 34.58	83 – 239	132.30 ± 29.02	83 – 239
Insulin (mcU/ml)	15.43 ± 9.73	3.3 – 56.6	17.55 ± 17.74	1.2 – 95.7	16.27 ± 13.44	1.2 – 95.7
HOMA-IR	3.04 ± 1.80	0.79 – 10.20	3.74 ± 3.04	0.17 – 14.17	3.32 ± 2.38	0.17 – 14.17
TC (mg/dl)	170.45 ± 36.30	111 – 280	179.39 ± 37.96	117 – 275	174.02 ± 36.96	111 – 280
TG (mg/dl)	102.14 ± 44.34	21 – 238	111.92 ± 73.87	44 – 398	106.05 ± 57.68	21 – 398
HDLc (mg/dl)	46.38 ± 8.11	21 – 64	47.39 ± 7.31	32 – 59	46.78 ± 7.76	21 – 64
LDLc (mg/dl)	97.04 ± 34.39	43 – 196	101.71 ± 37.14	30 – 186	98.91 ± 35.33	30 – 196

BMI – body mass index; WC – waist circumference; WHtR – waist to height ratio; SBP – systolic blood pressure; DBP – diastolic blood pressure; FBG – fasting blood glucose; HOMA-IR – the homeostatic model assessment of insulin resistance; TC – total cholesterol; TG – triglyceride , HDLc – high density lipoprotein cholesterol; LDLc – low density lipoprotein cholesterol.
*The two hours glucose level was assessed during The Oral Glucose Tolerance Test.

RESULTS

The study group was formed of 70 children, 42 girls and 28 boys, with simple obesity. Descriptive data analysis of the study group is shown in Table 1.

According to obesity definition (CDC) and using the specific growth charts, only 4.28% of children were overweight, 31.43% were obese, while 64.29% had extreme obesity, as shown in Table 2.

TABLE 2. *Overweight and obesity using BMI age and sex specific percentile*

	Girls (n = 42)	Boys (n = 28)	Total (n = 70)
Overweight*	3 (7.14%)	0 (0.00%)	3 (4.28%)
Obesity**	16 (38.10%)	6 (21.43%)	22 (31.43%)
Extreme obesity***	23 (54.76%)	22 (78.57%)	45 (64.29%)

* ≥ 85th percentile and < 95th percentile for age and sex;
** ≥ 95th percentile and < 99th percentile for age and sex;
*** ≥ 99th percentile for age and sex;

Due to their small number (n = 3), the overweight children, were excluded from the following part of the statistical analysis. The two remaining groups were divided according to their age in: prepubertal children (under ten years old) and at puberty (≥ ten years old). The cardiometabolic obesity-related complications were evaluated in each group. The results are shown in Table 3.

All the obese children in this study had WHtR values ≥ 0.5. Each of the two initial groups, one with obesity and the other with extreme obesity, were divided into two smaller groups using the WHtR cut-off value of 0.6. The statistical characteristics of the four groups and the results of the One Way ANOVA test performed for each obesity-related complication are shown in Table 4.

DISCUSSIONS

Obesity is an important public health problem. The relationship between high BMI during childhood and development of cardiometabolic adverse effects in adulthood is still debated. There are studies suggesting an important correlation between high BMI in preschool children and adult obesity, central obesity and early onset of metabolic syndrome (10). In a systematic review, Lloyd et al. (11) found little scientific evidence supporting the idea that childhood obesity is an independent risk factor for the development of lipid and carbohydrate metabolism alterations during adult life. It seems that those who had a BMI at the lower end during childhood, but gain weight during adulthood are at particular risk, and not those with high BMI, as expected.

Looking at the means of the main clinical and biochemical variables in the study group it can be seen that boys had a slightly higher BMI and WC and a worse cardiometabolic profile, except for the HDLc mean value. On the contrary, they had a lower WHtR mean value than girls, but the differences are not statistically significant.

The majority of children (83.58%) evaluated had at least one obesity-related cardiometabolic outcome. Only seven children from the obese group and four children with extreme obesity were appar-

TABLE 3. *Obesity-related cardiometabolic complications by age and sex in the obese and extreme obese children and adolescents*

*Variable	Pre-puberty (n = 19)				Puberty (n= 48)				Total (n = 67)
	Girls (n = 12)		Boys (n = 7)		Girls (n = 27)		Boys (n = 21)		
	Obesity (n = 3)	Extreme obesity (n = 9)	Obesity (n = 1)	Extreme obesity (n = 6)	Obesity (n = 13)	Extreme obesity (n = 14)	Obesity (n = 5)	Extreme obesity (n = 16)	
↑ BP	1	2	0	2	2	3	1	6	17 (25.37)
IFG	0	0	1	0	0	0	0	0	1 (1.49%)
IGT	1	1	0	0	2	5	1	5	15 (22.38)
DM 2	0	0	0	1	0	0	0	1	2 (2.98%)
↑ insulin	0	2	0	1	5	8	1	7	24 (35.82)
HOMA -IR +	1	5	1	2	3	7	3	10	32 (47.76)
↑ TC	1	2	0	1	2	3	1	5	13 (19.40)
↑ TG	1	6	0	1	3	3	0	7	21 (31.34)
↓ HDLc	0	0	0	1	2	2	0	3	8 (11.94)
↑ LDLc	0	2	0	1	1	1	1	3	9 (13.43)

* Complete definitions are presented at "Material and methods".
BP – Blood Pressure; IFG – impaired fasting glucose; IGT – impaired glucose tolerance; DM 2 – Diabetes mellitus type 2; HOMA-IR – the homeostatic model assessment of insulin resistance; TC – total cholesterol; TG – triglycerides; HDLc – high density lipoprotein cholesterol; LDLc – low density lipoprotein cholesterol.

TABLE 4. *Cardiometabolic factors by adiposity category*

	BMI ≥ 95th and < 99th WtHR < 0.6	BMI ≥ 95th and < 99th WtHR ≥ 0.6	BMI ≥ 99th WtHR < 0.6	BMI ≥ 99th WtHR ≥ 0.6	p-value
SBP (mmHg)	107.5 (8.80)	117.18 (11.68)	107.5 (12.94)	118.71 (15.54)	0.127
DBP (mmHg)	64.16 (11.14)	71.56 (11.50)	67.5 (9.87)	73.84 (10.28)	0.148
FBG (mg/dl)	86.5 (9.93)	83.43 (14.78)	86.0 (17.92)	86.05 (15.27)	0.942
At 2h glucose* (mg/dl)	128.16 (21.04)	135.31 (27.05)	139.5 (22.60)	131.02 (32.83)	0.876
Insulin level (mcU/ml)	10.86 (4.61)	14.76 (7.11)	26.43 (34.34)	16.78 (10.95)	0.212
HOMA - IR	2.33 (1.07)	3.00 (1.52)	4.76 (4.81)	3.52 (2.30)	0.304
Total cholesterol (mg/dl)	197.16 (56.78)	173.31 (36.71)	146.83 (21.13)	178.58 (36.05)	0.286
Triglycerides (mg/dl)	86.83 (49.53)	95.5 (43.35)	115 (32.67)	113.12 (67.6)	0.609
HDLc (mg/dl)	45.66 (4.76)	46.75 (6.29)	40.5 (7.42)	47.94 (8.61)	0.188
LDLc (mg/dl)	107.83 (52.88)	100.0 (32.36)	75.83 (23.82)	101.38 (35.04)	0.381

* Values are expressed as mean (SD); p value according to One Way ANOVA test.
BMI – body mass index; WtHR – waist to height ratio; SBP – systolic blood pressure; DBP – diastolic blood pressure; FBG – fasting blood glucose; The two hours glucose level was assessed during The Oral Glucose Tolerance Test; HOMA-IR – the homeostatic model assessment of insulin resistance; HDLc – high density lipoprotein cholesterol; LDLc – low density lipoprotein cholesterol.

ently metabolically healthy. On a close evaluation, four of the seven obese children had alterations of the lipid metabolism (n = 3) or carbohydrate metabolism close to the highest borderline limit (n = 1). Three of four extremely obese children considered "metabolically healthy" had a borderline low HDLc level and the other had prehypertension. Literature data show that 14% of boys and 12% of girls diagnosed with prehypertension at baseline had hypertension two years later (12).

Insulin resistance was the main metabolic adverse effect found in the two groups. Almost half of the children (47.76%) had a high HOMA-IR and a large number of children, (35.82%) had a high baseline insulin level. These negative outcomes were followed by alteration of the lipid metabolism and hypertension (25.37%). Most of the children were having multiple of the studied variable modified. Hyperinsulinemia and alteration of the blood glucose level accelerates the atherosclerosis (5). It also influences the lipid metabolism. Similar results showing a combined dyslipidemia pattern, with mild elevations in TC and LDLc, moderate to severe elevation in TG and low HDLc in overweight and obese children were presented in the literature (6). In the Young Finns study, elevated levels in LDLc and TG during childhood predicted an increased carotid intima-media thickness independently by other risk factors (13,14).

One Way ANOVA (confidence interval 95%) with post-hoc t-test analysis was used for the comparative evaluation of the BMI and WHtR. The p-value ≤ 0.05 was considered significant. No differences were found in the four analyzed groups (Table 4). A post-hoc t-test analysis was performed for each of the cardiometabolic variable, separately and, taking the different groups two by two. No statistical significant differences were found before and after using the Bonfferoni correction ($p \leq 0.0125$).

Khoury et al. (15) demonstrated in a group of children classified according to BMI that an increased WHtR was associated with worsened cardiometabolic risk and increased frequency of abnormal cardiometabolic risk factor levels. The results were similar with ones found in another study that showed trends of increasing mean lipid values and higher odds of a high blood pressure along with the increasing WC across overweight and obese subjects. The greatest associations were seen in the obese population (16). The different results obtained by us are probably due to the study limitation: small sample evaluated; the absence of the underweight, normal weight and overweight children.

CONCLUSIONS

Obesity defined by BMI and/or a WHtR ≥ 0.5 is in the most of cases associated with adverse cardiometabolic outcomes. Both anthropometric indexes should be used as screening and evaluation tools in medical practice.

WHtR is a reliable alternative to BMI because there is no need to use the specific table for the interpretation; as no population-specific growth references are available in our country, a correct interpretation of BMI according to age and sex is rather complicated.

Cardiometabolic adverse outcomes are usually present in children with variable stages of obesity. Children with a WHtR ≥ 0.5 should be the target of medical intervention without considering the number of diagnosed adverse outcomes.

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