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Original article

The Prevalence of the Different Components of the Metabolic Syndrome (MetS) in Obese Nondiabetic Children and Young Adolescents and their Anthropometric Data in Relation to Parents.

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Summary. *Introduction:* In Qatar, the prevalence of metabolic syndrome (MetS) in children and adolescents is increasing in parallel with the increasing trends in obesity rates. *Aim:* To assess the prevalence of the different components of MetS and plasma atherogenic indexes (AIP) in obese children and adolescents and to compare their anthropometric data with their parents (genetic background). *Methodology:* We analysed the anthropometric and biochemical profile of 91 randomly selected obese children and young adolescents (age: 10.5 ± 2.7 years) who attended to the Paediatric Clinic of Hamad Medical Center (HGH) in Doha (Qatar) form January 2017 to December 2019. Data recorded included: age, gender, weight and height, body mass index (BMI), systolic and diastolic blood pressures. Biochemical data including lipid profile, glycated hemoglobin (A1C), and alanine transferase level (ALT) were recorded and compared with normal lab data for the same age group. *Results:* Obese children had a high prevalence of dyslipidaemia, dysglycemia and non-alcoholic fatty liver disease (NAFLD). Using the modified adult MetS criteria, MetS was present in 30.2% of this obese cohort. AIP was high in 76.7% of the patients. Standing height standard deviation score (Ht-SDS) of obese children was significantly higher compared to Ht-SDS of their parents as well as to mid-parental height SDS (MPHt-SDS) (-0.37± 0.79). The BMI and BMI-SDS did not differ between obese children and their parents. *Conclusion:* The occurrence of MetS in 30% of our obese non-diabetic children and young adolescents pointed out to the necessity to impose early detection and preventive measures on a national scale. (www.actabiomedica.it)

Key words: Metabolic syndrome, obesity, children, adolescents, standing height, body mass index

Introduction

The prevalence of obesity among children and adolescents worldwide continued to increase since 1980 reaching 107.7 million in 2015.Almost one-quarter (23%) of both male and female children in developed countries are overweight or obese (1-3).

Obesity and diseases linked to obesity have reached particularly high levels in Qatar. According to the Qatari Biobank data 43% of the adult Qatari population is overweight or obese (4).

In 2001, the National Cholesterol Education Program (NCEP) Adult Treatment Panel III (ATP III) coined the term "metabolic syndrome" (MetS)

to describe the presence of any 3 of 5 particular risk factors, such as: hyperglycemia, hypertriglyceridemia, central adiposity, elevated blood pressure, and low high-density lipoprotein cholesterol (HDL-C) (5).

Adult modified criteria are used for the diagnosis of MetS in pediatric and adolescent population, including waist circumference, triglyceride level (> 1.7 mmol/L, HDL-C level < 1.03 mmol/L, systolic blood pressure > 130 and diastolic blood pressure > 85 mmHg, and fasting glucose > 5.6 mmol/L or type 2 diabetes mellitus (DM2) (6).

On the other hand, the International Diabetes Federation (IDF) consensus (www.idf.org/e-library/consensus-statements) for the definition of MetS in children and adolescents was based on waist circumference, triglyceride level (> 1.7 mmol/L, HDL-C level < 1.03 mmol/L, systolic blood pressure > 130 and diastolic blood pressure > 85 mmHg, and fasting glucose > 5.6 mmol/L or type 2 diabetes mellitus (T2 DM).

The MetS is a cluster of the most dangerous risk factors for developing T2DM and cardiovascular disease (CVD). Recent studies have shown that it develops during childhood and is highly prevalent among children and adolescents who suffer from obesity. The key elements of the MetS are central obesity, high blood pressure, dyslipidemia and hyperglycemia. Its early identification is very important to facilitate preventive action (7).

Qatar ranks amongst one of the countries with the highest prevalence of childhood obesity. Overweight and obesity prevalence is 44.8% and 40.4% among males and females and 45.6% and 40.9% among Qatari and non-Qatari students, respectively (8). The prevalence of MetS range from 48.5% to 60.3%. Its prevalence increases from 12.3% in young adults (18-29 years) to 24 % at the age of 40-49 years. Moreover, it has been estimated that the prevalence of impaired glucose tolerance is from 10 to 20%, and 23% of Qataris and 18.3% non-Qataris have T2DM. The estimated prevalence of hypertension and dyslipidaemia is also high and increasing (9,10).

Before 2008, in Qatar, there were not reported cases of children with T2DM. In the following years, the incidence of T2DM increased from 1.82 per 100,000 in 2012 to 2.7 per 100,000 in 2016, with an incidence of T2DM equal to 2.9/100,000 per year (11).

Considering the current high prevalence of obesity in children in Qatar, as well as the increasing incidence of T2DM, it becomes essential to plan measures for prevention of MetS in early in life. Each component of the syndrome can be identified as early as possible to prevent definitive lesions (12,13).

Atherogenic index of plasma (AIP) is a novel and better biomarker associated with obesity and composed of triglycerides and high-density lipoprotein cholesterol. It has been used to quantify blood lipid levels and commonly used as optimal indicator of dyslipidemia and associated diseases (e.g., cardiovascular diseases) (14). However, no published study has yet examined the association between AIP and obesity in children and adolescents.

Our study aimed to assess the prevalence of the different components of MetS and measure the AIP in a random sample of obese children and young adolescents in Qatar. In addition, the relation between their anthropometric data in relation to parents was assessed.

Patients and methods

In this retrospective study we measured the anthropometric and biochemical profile of 91 randomly selected obese children and adolescents who attended to the Paediatric Clinic of Hamad Medical Center (HGH) from January 2017 to December 2019. Data recorded included: age, gender, weight and height, body mass index (BMI), systolic and diastolic blood pressures, lipid profile, glycated hemoglobin (A1C), and alanine transferase level (ALT). The data were compared to normal lab data for the same age group of subjects. For the diagnosis of MetS, the IDF criteria were used as reference.

Ethical approval was obtained from the Institutional Review Board (IRB) of Hamad Medical Centre before the beginning of the study.

Statistical analysis

Data were presented as mean ± SD. Non-paired t test was used to compare anthropometric data of

children and their parents when data were normally distributed, and Wilcoxon test was used when the data were not normally distributed. The prevalence of each component of MetS was presented in percent. Linear regression equation was used to find correlations between variables. Significance was accepted when p value was <0.05.

Results

Anthropometric data for 91 children, young adolescents and their Qataris parent were analysed (Table 1). The mean age of obese children and young adolescents was 10.5 ± 2.7 years. BMI and BMI-SDS did not differ significantly between obese children and young adolescents and their parents. Their mean standing height standard deviation score (Ht-SDS) was significantly higher (0.9 ± 1.35) compared to their mid-parental height SD (MPHt-SDS) (-0.37 ± 0.79).

Forty-four per cent of mothers were overweight (BMI >25 < 30 kg/ m 2 and 52.7% were obese (BMI > 30 kg/ m2; range 24.5: 51.5 kg/ m 2). 18 % of fathers were overweight and 64 % were obese (range 21.5: 51.2). The Ht-SDS of the obese children and young adolescents was correlated significantly with their BMI-SDS (r: 0.37, p <0.01) and MPHT-SDS (r = 0.62, p < 0.001) (Table 2, Figure 1). The BMI of obese children and young adolescents was correlated significantly with maternal BMI (r: 0.34, p = 0.01) but was not with their paternal BMI (Figure 2).

The prevalence of different biochemical parameters of MetS are presented in Table 3. Obese children and young adolescents presented a high prevalence of dyslipidaemia, dysglycemia and non-alcoholic fatty liver disease (NAFLD). Using the modified MetS criteria, MetS was present in 30.2% of this obese cohort. They had also a high prevalence of elevated atherogenic indexes (AIP) (76.7%).

Discussion

The prevalence of MetS in children and adolescent varies from 0.2% to 38.9% although different criteria have been used for its definition (15).

Our data confirmed a considerably high prevalence of MetS (30.2%) in obese Qataris children and young adolescents. In support of our findings, data from the Third National Health and Nutritional Examination Survey (NHANES III) indicated that nearly one third (31.2%) of overweight/obese adolescents had a MetS (16).

A clustering of risk factors associated with MetS has been demonstrated in certain populations, including East Asians, Asian Indians, Native Americans, Japanese Americans and Hispanic (7,16,17).

The pathogenesis of MetS is not entirely understood, recent data suggest that interaction between obesity, insulin resistance (IR) and inflammation play a key-role in its development (17,18). Accumulation of free fatty acids in the liver, adipocytes, skeletal muscle, and the pancreas in the setting of obesity leads to impaired insulin signalling and subsequent (IR) in the liver leading to increased glucose production. Hyperinsulinemia causes an increase in the transcription of genes for lipogenic enzymes in the liver, which leads to increased production of triglycerides. The increase in free fatty acids delivery to the liver is thought to result in hepatic insensitivity to the inhibitory effects of insulin on very low-density lipoprotein (VLDL) secretion and overproduction of triglyceride rich VLDL particles (19).

Our obese children had high prevalence of dyslipidemia and considerably high prevalence of high atherogenic index. There is a strong relation between the simple clinical markers of atherogenic dyslipidemia, namely elevated triglycerides and reduced HDL-cholesterol and the concentration of small LDL-cholesterol particles that carry the greatest risk of atherogenesis. Investigators from Bogalusa Heart Study reported that overweight school children were 2.4 to 7.1 times more likely to have elevated total cholesterol (TC), low density lipoprotein (LDL) cholesterol, and TG than their lean counterparts. Similarly, hyperglycemia and elevated blood pressure, even within the prediabetic or pre-hypertension levels, are also pro-atherogenic (20-23). Abnormal fasting blood glucose (FBG; 21%) and A1C (32%) occurred in our obese children.

The blood pressure (BP) was elevated in 27.4% of our obese children and young adolescents. Elevated

BP in MetS syndrome is thought to be secondary to hyperinsulinemia via mechanisms such as sympathetic nervous system activity, renal sodium retention and smooth muscle growth (17). Endothelial dysfunction and disturbed vasodilatory response frequently occur secondary to IR (24). In addition, inflammatory cytokines release from dysfunctional adipocytes, such as, monocyte chemoattractant protein-1, and tumor necrosis factor-alpha, promotes macrophages migration to those adipose tissues and further increase cytokine production. A decrease in adiponectin level seen in obesity can result in more inflammatory process in the adipose tissues (25).

The significant high percentage of AIP (in 76.7%) observed in our obese children and young adolescents pointed out to the higher risk of developing cardiovascular diseases (CVDs) in their future life and necessitate early interference to normalize atherogenic lipemia as a preventive measure. The atherogenic dyslipidemia is characterized by hypertriglyceridemia, high LDL particles and low HDL cholesterol and is an important risk factor for myocardial infarction and cardiovascular disease. Several genes have now been linked to this pattern of lipoprotein changes (26,27).

In a review of multiple intervention studies, it has been shown that either lowering the dietary carbohydrate content and/or losing weight appears to attenuate this atherogenic dyslipidemia (28).

Overweight parents are considered as risk factors for overweight/obesity of their offspring. The association between overweight children and parental excess weight represents both gene and environment interactions. Studies indicate the higher impact of parental BMI on the severity of weight gain from childhood to adolescence. In our study 96% of obese children and young adolescents had an overweight or obese mother and 82% overweight or obese fathers. Their BMI was correlated significantly with their maternal BMI. Our observation is supported by a recent meta-analysis which identified significantly increased odds of child obesity with increasing maternal BMI. This association was strongest with maternal obesity, which

Table 1. Anthropometric data for obese children, young adolescents, and their parents

		Children and young adolescents	Mothers	Fathers
BMI	mean	30.02	33.9	32.41
	SD	6.59	7.1	6.36
BMI-SDS	mean	3.53	4.34	4.27
	SD	0.77	2.26	2.04
Ht-SDS	mean	0.91*	-0.65	-0.39
	SD	1.35	0.94	0.81

*p<0.05

Table 2. Correlations of anthropometric data of obese children and young adolescents with their parents

	Ht SDS	*BMI*	*BMI SDS*	*M-BMI*	*M-BMISDS*	*M-HtSDS*	*F-BMI*	*F-BMISDS*	*F-HtSDS*	*MPHtSDS*
Ht SDS	1.00									
BMI	-0.13	1.00								
BMI SDS	0.37	0.36	1.00							
M-BMI	-0.11	0.34	0.07	1.00						
M-BMISDS	-0.11	0.34	0.07	1.00	1.00					
M-HtSDS	0.52	-0.16	0.05	-0.45	-0.45	1.00				
F-BMI	0.13	-0.13	-0.06	-0.07	-0.07	-0.06	1.00			
F-BMISDS	0.13	-0.13	-0.06	-0.07	-0.07	-0.06	1.00	1.00		
F-HtSDS	0.13	0.00	0.19	0.19	0.19	0.16	-0.59	-0.59	1.00	
MPHtSDS	0.62	-0.18	0.14	-0.10	-0.10	0.72	0.04	0.04	0.41	1.00

Legend: M= mother, F- father.

Table 3. Prevalence of different metabolic components in obese children and young adolescents (%)

Obese children and young adolescents (n = 91)	Prevalence
AIC > 5.7%	21%
Fasting blood glucose >5.6mmol/l	32%
Low Hb < 11g/L	10%
LDL > 2.9 mmol/L	16.2%
HDL < 1.1 mmol/L	40%
Triglycerides > 1.7 mmol/l	18.6%
Cholesterol > 4.5 mmol/L	32.6%
Atherogenic index of plasma > 0.23	76.7%
Pre-hypertension BP >85th percentile	16.2%
Hypertension BP >95th percentile	11.2%
ALT > 35 IU/L	12%
Vitamin D < 50 nmol/L	78.50%

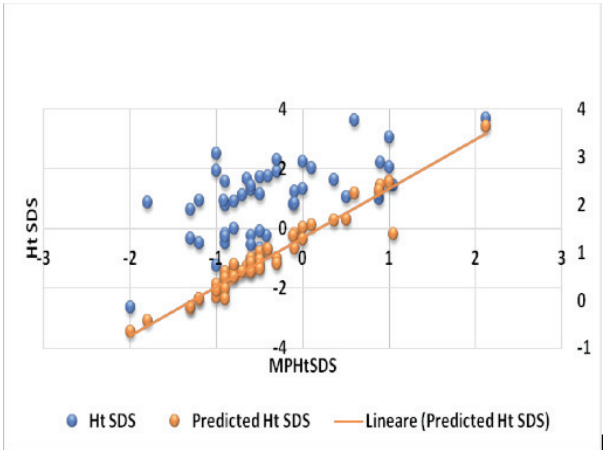

Figure 1. Correlation between height -SDS (Ht-SDS) in children and young adolescents with obesity versus mid-parental height - SDS (MPHt-SDS) (r:0.62, p:<0.001).

increased the odds of child obesity by 264%, followed by maternal overweight, which increased the odds by 89% (29).

Our data support also the relatively significant contributing role of genetic susceptibility in addition to environmental factors to development of obesity. Many studies have indicated that childhood and adolescent overweight and obesity are linked to obvious familial aggregation, because of complex interaction between genetic and environmental effects (30-32).

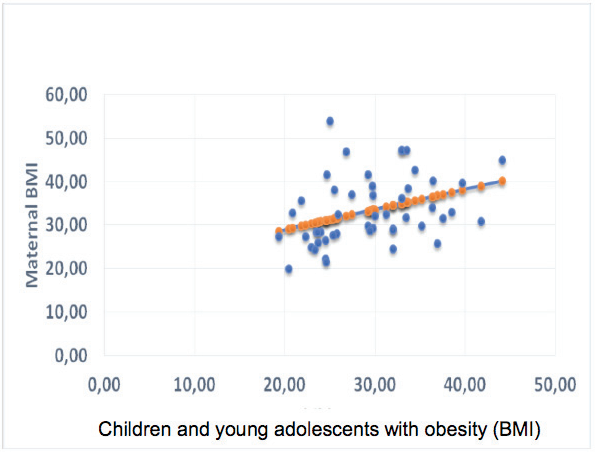

Figure 2. Correlation of body mass index (BMI) between children and young adolescents with obesity versus maternal BMI (r:0.34, p:0.01).

In conclusion, our study highlights the higher prevalence of MetS and its components as well as high atherogenic index in non-diabetic obese children and young adolescents. It stresses the importance for the screening of these components for an early detection of MetS abnormalities, prompt management and regular monitoring to achieve effective prevention of CVD and Type 2 DM. In addition, it is highly advisable to implement good family-centred preventive programs due to very high prevalence of obesity in their family members.

Conflicts of interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article.

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