

OBESITY AND METABOLIC SYNDROME AMONG A REPRESENTATIVE SAMPLE OF IRANIAN ADOLESCENTS

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Abstract. Metabolic syndrome (MetS) increases the risk of developing many chronic diseases and originates early in life; its prevalence varies by population. The present study investigated the prevalence of MetS and the association between MetS and obesity in a population of adolescents in northern Iran. A total of 450 Iranian high school students (50% boys), aged 15-18 years, were enrolled in the study. Physical examination and biochemical analyses were conducted according to standard protocols; MetS was defined according to the modified NHANES III criteria. The prevalence of MetS among subjects was 3.3%. Eight percent of subjects had a body mass index (BMI) >75th percentile, and 10.5% had a BMI >85th percentile. Overall, 42.1% of students did not have any components of MetS. Waist circumferences (WC), Body Mass Index (BMI), serum level of triglycerides (TG) and high density lipoprotein-cholesterol (HDL-C) were significantly higher among girls than boys. Systolic blood pressure (SBP) and fasting blood sugar (FBS) were significantly higher among boys than girls. The associations between a BMI \geq 85th percentile and MetS (OR 6.97; 95%CI 2.41-20.16) and between a BMI \geq 75th percentile and MetS (OR 6.74; 95%CI 2.10-21.57) were statistically significant. The association between an increased WC and MetS was also statistically significant (OR 21.64; 95%CI 6.7-69.81). This study confirms the high prevalence of components of MetS among apparently Iranian adolescents, even among those not overweight. The high prevalence of MetS among adolescents with generalized and abdominal obesity underscores the need for primary prevention of MetS in early life.

Keywords: metabolic syndrome, obesity, overweight, Iranian adolescents

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INTRODUCTION

Metabolic syndrome (MetS) is a cluster of risk factors that increases the risk of developing many chronic diseases, especially type 2 diabetes and cardiovas-

cular disease. Various definitions exist for MetS; the third report of the National Cholesterol Education Program Adult Treatment Panel III (ATP III) defined MetS as a cluster of three or more of five factors, including elevated waist circumference, blood pressure, triglycerides, glucose and low high-density lipoprotein cholesterol (HDL-C) (Expert Panel on Detection, Evaluation and Treatment of High Cholesterol in Adults, 2001).

MetS is not limited to adults; there is a growing body of evidence about its presence from early childhood (Jiang *et al*, 1995; Arslanian *et al*, 1996; Caprio *et al*, 1996; Mo-Suwan *et al*, 1996). Changes in childhood lifestyle, characterized by lack of physical activity and high caloric diet, represent a significant concern in public health and pediatric medicine (Weiss *et al*, 2004). Childhood obesity has been shown to be associated with major and new cardiovascular risk factors as the components of MetS (Steinberger *et al*, 1995; Sinaiko *et al*, 2001; Sorof *et al*, 2004), insulin resistance, (Steinberger *et al*, 1995; Arslanian *et al*, 1996; Caprio *et al*, 1996), inflammation, (Cook *et al*, 2000; Ford *et al*, 2001; Visser *et al*, 2001; Ford and National Health and Nutrition Examination Survey, 2003), abnormal glucose metabolism, (Sinha *et al*, 2002) and compromised vascular function (Tounian *et al*, 2001). There is a growing body of evidence similar to adults, abdominal or upper body fat is associated with an increased risk for metabolic complications among children and adolescents; waist circumference (WC) is known as a useful anthropometric measure for abdominal obesity in the pediatric age group (Zannolli and Morgese, 1996; Asayama *et al*, 2000; Savva *et al*, 2000; Kahn *et al*, 2005). Because of ethnic variations in body size and fat patterning, WC percentiles are generated for children and

adolescents in various countries (Martinez *et al*, 1994; Moreno *et al*, 1999; McCarthy *et al*, 2001; Savva *et al*, 2001; Fernandez *et al*, 2004; Katzmarzyk *et al*, 2004; Eisenmann, 2005; Schwandt *et al*, 2008) including Iran (Kelishadi *et al* 2007b).

The prevalence of MetS increases as the percent overweight increases (Cook *et al*, 2003): For instance it is reported to be present in 38.7% of moderately obese [mean body mass index (BMI) 33.4 kg/m²] and 49.7% of severely obese (mean BMI 40.6 kg/m²) children and adolescents (Weiss *et al*, 2004).

The prevalence of MetS among children and adolescents varies by the definitions used for the components. In a nationwide study in Iran, the prevalence of metabolic syndrome was reported to be 10-14.1%, among Iranian children and adolescents (Esmailzadeh *et al*, 2006; Kelishadi *et al*, 2006). Because of the high prevalence of childhood obesity in northern Iran (Kelishadi *et al*, 2007a), with the present study we aimed to investigate the relation between BMI and the prevalence of MetS among a group of adolescents in northern, Iran.

MATERIALS AND METHODS

Participants and study design

This cross sectional study was conducted among 450 high school students, aged 15-18 years, living in Gorgan City (northern Iran). The sample size was set for a maximum 10% relative error and a 95% confidence interval (95% CI). Students with chronic disease or chronic medication use were not included in the study. Written and verbal informed consent were obtained from parents and students, respectively. Ethical approval was obtained from the Research Ethics

Committee of Golestan University of Medical Sciences.

Procedures

All students were invited to complete a questionnaire about personal information. Anthropometric measurements were taken according to standard protocols. Height and weight were measured without shoes, with light clothing. Body mass index (BMI) [weight (kg)/height (m²)] was calculated. Waist circumference (WC) was measured midway between the lower rib margin and iliac crest. Blood pressure was measured with a mercury sphygmomanometer twice from the right arm after sitting for 5 minutes. Fasting venous blood specimens were obtained and sent to the laboratory.

Definitions

To define overweight, we used the BMI percentile of the Centers for Disease Control and Prevention (CDC) (Kuczmarski *et al*, 2000); our national survey (Keli-shadi *et al*, 2008) showed a high agreement between the national BMI percentiles of Iranian children and adolescents and the CDC than the cutoff values suggested by the International Obesity Task Force (Cole *et al*, 2000).

The criteria we used to diagnose MetS were those of the Third National Health and Nutrition Examination Survey (NHANES III). According to the NHANES III (Expert Panel on Detection, Evaluation and Treatment of High Cholesterol in Adults, 2001), we classified participants with a WC above the 90th percentile for age and sex as abnormal. An elevated systolic or diastolic blood pressure was defined as a value at or above the 90th percentile for age, sex and height. The midpoint value for HDL-C (40 mg/dl) was used as a 10th percentile value, and the midpoint value for triglycerides (110 mg/dl) was taken

as the 90th percentile for age. The cut-off value for elevated fasting blood glucose of 100 mg/dl was used.

Statistical analysis

Analyses were performed using SPSS version 16 (SPSS, College Station, TX). Continuous variables are expressed as mean \pm standard deviation (SD) and categorical data are expressed as percentages. The prevalence of MetS is expressed as a percentage with 95% confidence intervals. The chi-square test was used to estimate the odds ratio (OR) of the different components of MetS by sex, WC and BMI. The Student's two-tailed *t*-test was used to compare mean differences of components by sex. A *p*-value < 0.05 was considered as statistically significant.

RESULTS

The mean values of the variables studied are presented in Table 1. The mean WC, BMI, TG and HDL-C were significantly higher among girls than boys, whereas the SBP and FBS were significantly higher among boys than girls. The frequency of most components of MetS was higher among girls than boys (Table 2).

As presented in Table 3, 3.3% of students (4 girls and 11 boys) had MetS, 13.3% (25 girls and 35 boys) had 2 components of MetS and 41.3% (105 girls and 81 boys) had at least 1 risk component. Of students with MetS, 60% (9 cases) had a BMI \geq 85th percentile and 73% (11 cases) had a BMI \geq 75th percentile. The associations between a BMI \geq 85th percentile and MetS (OR 6.97; 95%CI 2.41-20.16) and a BMI \geq 75th percentile and MetS (OR 6.74; 95%CI 2.10-21.57) were statistically significant. The association between an increased WC and MetS was statistically significant (OR 21.64; CI

Table 1
Presence of components of metabolic syndrome.

Variables	Girls (N=225) Mean±SD	Boys (N=225) Mean±SD	p-value
Age (years)	16.34 ± 0.77	15.66 ± 0.68	NS
Weight (kg)	56.90 ± 12	61.22 ± 11.08	< 0.01
Height (cm)	159.18 ± 5.71	169.67 ± 8.02	< 0.01
Body mass index(kg/m ²)	22.41 ± 4.32	21.24 ± 3.45	< 0.01
Waist circumference (cm)	79.85 ± 10.35	75.24 ± 8.76	< 0.01
Systolic blood pressure (mmHg)	108 ± 11.30	119.06 ± 12.37	< 0.01
Diastolic blood pressure (mmHg)	70.02 ± 7.29	69.42 ± 9.16	NS
Fasting blood sugar (mg/dl)	86.96 ± 7.35	96.34 ± 9.04	< 0.01
Triglycerides (mg/dl)	121.41 ± 38.20	105.35 ± 70.11	< 0.01
HDL-cholesterol (mg/dl)	51.09 ± 10.53	43.35 ± 9.15	< 0.01

Table 2
Gender differences in the prevalence of components of metabolic syndrome.

Variables	Boys n (%)	Girls n (%)	p-value
Increased waist	2 (0.9)	17 (7.6)	< 0.01
High systolic blood pressure	29 (12.9)	7 (3.1)	< 0.01
High diastolic blood pressure	15 (6.7)	7 (3.1)	NS
High blood sugar	48 (21.3)	8 (3.6)	< 0.01
High triglycerides	62 (27.6)	118 (52.4)	< 0.01
Low HDL-cholesterol	39 (17.3)	13 (5.6)	< 0.01

6.7-69.81); 31.6% of students with a high WC had MetS (Table 4).

DISCUSSION

This study investigated the prevalence of MetS and its relationship with an elevated BMI and WC among a representative sample of adolescents in northern Iran. Although the prevalence of MetS was 3.3% in general, it was considerably higher among those with generalized or abdominal obesity. Only 42.1% of the

students studied had none component of MetS. This finding underscores the importance of early prevention and control of cardio-metabolic risk factors.

The frequency of the MetS increases with the degree of obesity among children and adolescents (Calcaterra *et al*, 2007; Ryu *et al*, 2007). Different frequencies of MetS are reported from different populations. Two previous studies in Iran, by using the same definition of MetS as the current study, found MetS prevalences of 14.1% and 10% (Esmailzadeh *et al*, 2006;

Table 3
Number of components of metabolic syndrome.

Number of components of metabolic syndrome	Number (%) of students	95% Confidence interval
None	189 (42.1)	37-46
1	186 (41.3)	36-46
2	60 (13.3)	10-17
≥3	15 (3.3)	1.8-5.4

Table 4
Relationship between body mass index and waist circumference with metabolic syndrome.

Variable	Category	MetS		OR (95%CI)	p-value
		Yes n (%)	No n (%)		
BMI 85 th percentile	Normal	6 (40)	358 (82.3)	6.97 (2.41-20.16)	< 0.01
	Abnormal	9 (60)	77 (17.7)		
BMI 75 th percentile	Normal	4 (26.7)	309 (71)	6.74 (2.10-21.57)	< 0.01
	Abnormal	11 (73.3)	126 (29)		
Waist circumference	Normal	9 (60)	422 (97)	21.64 (6.7-69.81)	< 0.01
	Abnormal	6 (40)	13 (3)		
Gender	Girls	4 (26.7)	221 (50.8)	2.84 (0.89-9.05)	NS
	Boys	11 (73.7)	214 (49.2)		

Kelishadi *et al*, 2006). MetS has been found in 14.8% of Kuwaiti adolescents (Al-Isa *et al*, 2010), 2.5 % of Chinese adolescents (Xu and Ji, 2008) and 5.1 % in 1998 to 4.9 % in 2001 of Korean adolescents (Lim *et al*, 2008). In a population-based birth cohort study from Finland the overall prevalence estimate of MetS of subjects with a mean age of 16 years using the IDF pediatric definition was 2.4% (Pirkola *et al*, 2008). These differences may be due to different ethnicities and ages of subjects.

The present study showed some risk factors were more frequent among girls than boys. This finding is consistent with

a national report of Iranian adults (Delavari *et al*, 2009) which found a higher prevalence of MetS and its components among women than men. This may be because of the higher prevalence of obesity, notably abdominal obesity, among women than men. This finding highlights the importance of improving the lifestyle habits of females, especially increasing their physical activity using feasible and culturally-acceptable interventions (Kelishadi *et al*, 2010).

The current study provides confirmatory evidence of the importance of increased WC as a marker of central

fat deposition in adolescents. Since increased WC is a predictor of insulin resistance among children and adolescents (Hirschler *et al*, 2005), its measurement could be included in clinical practice as a simple tool to identify children and adolescents at higher risk for chronic diseases.

A main limitation of this study was its cross sectional design; its findings should be confirmed with future longitudinal studies.

In conclusion, this study provides evidence of a high prevalence of the components of MetS among healthy Iranian adolescents, even in those not overweight. The high prevalence of MetS among adolescents with generalized and abdominal obesity underscores the necessity primary prevention among this age group.

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