Short Communication

# Prevalence of the metabolic syndrome and its influencing factors among adolescent girls in Mashhad, Iran

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Introduction: This study sought to determine the prevalence of the metabolic syndrome, one of the major public-health challenges worldwide, and its influencing factors among 15 to 17 years old adolescent girls in Mashhad, Iran. Methods: A total of 622 high school adolescents participated in a cross-sectional study. A self-administered questionnaire was used to assess socio-demographic characteristics and dietary habits. Anthropometric assessments, blood pressure measurement and biochemical assessment were done. Results: Applying BMI Z-score for age and gender (WHO 2007), 14.6 % and 3.4 % of subjects were classified as overweight and obese, respectively. Enlarged WC (> 80 cm) was seen in 9.5% of subjects. The prevalence of combined hypertension was 6.1% which was increased by the severity of obesity. A total of 24.5% of subjects had hypertriglyceridemia and 57% of them had low level of HDL-cholesterol. Hyperglycemia was present in 16.7% of subjects. Based on the NCEP ATP III (2001) criteria, the prevalence of the metabolic syndrome was 6.5% and increased to 45.1% in obese subjects. Increasing BMI or WC, led to significant increment in the number of metabolic syndrome features ($p < 0.001$). High socioeconomic status of family, medical history of parents and dietary habits especially high consumption of carbohydrates were influencing factors in the prevalence of the metabolic syndrome. Conclusion: Approximately 6.5% of all and 45% of obese subjects met the criteria for the metabolic syndrome. Dietary habits especially carbohydrate consumption, socioeconomic status of family and medical history of parents can be influential factors in the prevalence of the metabolic syndrome.

**Key Words: metabolic syndrome, adolescent girl, obesity, prevalence, diet**

## INTRODUCTION

Childhood obesity is significantly associated with hyperinsulinemia, dyslipidemia and hypertension in adulthood which is collectively know as the metabolic syndrome.[1] The metabolic syndrome (MS) has become one of the major public-health challenges worldwide. Recent data suggest that the incidence of this syndrome has an increasing trend in developing countries because of the westernization of diet and lifestyle.[2] The ultimate importance of diagnosis of the metabolic syndrome is that it helps to identify individuals at high risk of both type 2 diabetes and cardiovascular disease (CVD).[3] Individuals with the metabolic syndrome had an approximately two to four times higher risk of dying of atherosclerotic disease than those without the metabolic syndrome.[4] Although the metabolic syndrome is particularly important in adults, the pathological processes and risk factors have been shown to begin during childhood.[5,6]

The incidence of the childhood metabolic syndrome in Asian populations has been reported to range from 10 to 40% in most countries such as China, Hong Kong, Taiwan, Vietnam, Korea, India, Japan, the Philippines and Singapore.[7] Iran like many other developing countries is now experiencing the global epidemic of obesity and its consequences. Recent epidemiological studies have revealed that the prevalence of obesity and overweight in Iran is equal to or even higher than that found in Europe and the US. It is estimated that, 1 in 10 young adults in Iran is suffering from the metabolic syndrome.[8]

The prevalence of the metabolic syndrome among Iranian adults was around 30%.[8,9] The Tehran Lipid and Glucose Study showed that 13.3% of girls and 12.6% of boys aged 10 to 19 years were overweight, whilst the prevalence of obesity was 4.1% and 6.7% respectively.[9-11]

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Increased consumption of calorie-dense regular and fast foods, cordials and junk foods which are enriched sources of carbohydrates and fats, together with an increasingly sedentary life-style were shown as major factors contributing to the obesity epidemic.[11] However, due to scarce data among Iranian children and adolescents, this study was conducted to determine the prevalence of the metabolic syndrome in adolescent girls in Mashhad, Iran.

## MATERIALS AND METHODS

This cross-sectional study was conducted among 622 adolescent girls aged 15 to 17 years old from Mashhad, the second biggest city in Iran. The sample size was calculated using Jones Formula (2004) with 95% power and increased up 50% in number due to attrition. Subjects were selected by using a multi-stage sampling technique. The first stage was stratified sampling in 5 zones of educational division of Mashhad, the second stage was cluster sampling to select one high school in each zone and the third stage was convenient sampling to select students in each high school. In each high school, students who fulfilled the inclusion criteria and signed the consent form were invited to participate in the study. Due to fear of taking blood, the response rate was 86.5%. Data collection was carried out from May to August 2007, namely: data from a questionnaire (that had been pre-tested), anthropometric assessment, 24-hour recall and 2-days food record in selected high schools and biochemical assessment in Ghaem Hospital. Subjects were excluded if they suffered from congestive heart disease, renal disease, endocrine abnormalities (poly cystic ovary syndrome), and using any medication that altered blood pressure, glucose or lipid metabolism. For excluded subjects, their medical history was obtained using a self-administered questionnaire. Demographic data, food habits, food intake record and physical activity habits were asked to determine factors influencing metabolic syndrome in this population. Written informed consent from adolescents and their parents were obtained. The protocol was approved by the Medical Ethics Committee of Mashhad Medical University.

Overweight was defined as BMI Z-score 1 SD more than the median and obesity as BMI Z-score 2 SD more than the median for age and sex group (WHO 2007).[12] Subjects were classified in the metabolic syndrome group if they met three or more of the following criteria based on NCEP ATP III (2001):[13,14] central obesity with waist circumference above 90$^{th}$ percentile (WC $\geq$ 87 cm) of WC Iranian charts,[14,15] a systolic or diastolic blood pressure above the 90$^{th}$ percentile (SBP $\geq$ 126 mmHg, DBP $\geq$ 80 mmHg) for age and sex according to the National Heart, Lung, and Blood Institute, and the 1987 update on the Second Task Force Report on Hypertension in Children charts, triglyceride level above the 90$^{th}$ pediatric percentile (TG $\geq$114 mg/dL) from NHANES III (1988-1994), low HDL-cholesterol level below the 5$^{th}$ percentile (HDL-C $\leq$ 37 mg/dL),[16,17] or impaired glucose tolerance ( FBS $\geq$ 100 mg/dL).[1,4]

With regard to anthropometric assessments, height was measured using a height-meter (Seca 214 portable stadiometer), and weight using a digital weighing balance (Seca 881 digital floor scale) with the subjects in light clothing.[18,19] Waist circumference (at the level of the mid-point between the lower costal, 10$^{th}$ rib border and the iliac crest) and hip circumference (at the level of the greatest posterior protuberance of the buttocks corresponds anteriorly to the level of the symphysis pubis) were determined using non-elastic fiberglass measuring tape.[19,20] Body mass index (BMI = weight (kg)/ height (m)$^2$), waist to hip ratio (WHR) and waist to stature ratio (WSR) were calculated. Blood pressures (BP) were taken using a mercury sphygmomanometers (Hader Aneroid Guage-W/Balanced inflation system adult size).[21] Food intake was assessed using a 24-hour dietary recall (weekday) and 2-days food record (1 weekday and 1 weekend). Nutritionist IV software (The Hearst Corporation 1994) was used to analyze the nutrient intake of the subjects.

Fasting venous blood (10 ml) was collected for measurement of biochemical parameters. Fasting blood sugar (FBS), total cholesterol (TC) and triglyceride (TG) were determined using enzymatic colorimetric determination.[22-24] The coefficients of variations for the three measurements were 2.8-3.1%, 0.29-0.43% and < 4%, respectively. Low density lipoprotein cholesterol (LDL-C) and high density lipoprotein cholesterol (HDL-C) were also determined by homogenous enzymatic assay (CV = 2.4-8.4%).[25] All assays were carried out using Selectra 2 auto-analyzer (Vital Scientific, Spankeren, Netherlands).

Data were analyzed using the SPSS software (version 15.5.0.). Prior to analyses, data that were not normal according to the Gaussian distribution, including serum triglyceride and family salary, were log transformed. Mean and standard deviation were used to summarize the variables. Differences in anthropometric and biochemical characteristics between the two groups (the metabolic syndrome and the normal groups) were tested using the independent sample t-test and the chi-square test. Prevalence rate was expressed with 95% confidence intervals and significance level at $p$-value < 0.05.

## RESULTS

A total of 622 adolescent girls from different educational zones in Mashhad participated in this study. Among those, 84 subjects did not have blood taken. Demographic and anthropometric characteristics of subjects were summarized in Table 1. According to BMI Z-score for age and gender (WHO 2007) 14.6 % of subjects were overweight and 3.4 % obese. A total of 3.7% of subjects had a waist circumference more than the 90$^{th}$ percentile according to WC percentile charts for adolescent girls,[14,15] and 9.5% of them had waist circumference more than 80 cm. High risk WHR (0.8 – 1) that predisposes adolescents to coronary heart diseases was seen in 9.5% of subjects.[26,27]

Approximately 24.1% (n = 622) of subjects suffered from isolated diastolic hypertension (IDHTN). Isolated systolic hypertension (ISHTN) and combined hypertension were seen in 7.2% and 6.1% of subjects respectively. Based on the Mansoub category for cholesterol,[26] 6.5% had a high risk level for cholesterol (> 200 mg/dL) and in 21% of subjects cholesterol level was borderline (170-199 mg/dL). Hypertriglyceridemia was seen in 24.5% of the adolescents. High density lipoprotein cholesterol which was known as the good cholesterol was less than normal

**Table 1.** Distribution of demographic and anthropometric characteristics of subjects

| Characteristic | Mean | SD | Range |
|---|---|---|---|
| Age (year) | 16.4 | 0.9 | 15-18 |
| Birth Weight (kg) | 2.97 | 0.64 | 0.7-5.2 |
| Family salary/month (USD/mo) | 297 | 215 | 30-2500 |
| Weight (kg) | 51.7 | 9.8 | 30-99 |
| Height (cm) | 157 | 5.4 | 133-174 |
| BMI (kg/m2) | 20.7 | 3.6 | 13.5-36.9 |
| WC (cm) | 69 | 7.8 | 54-106 |
| HipC (cm) | 93 | 7 | 74-121 |
| WHR | 0.7 | 0.04 | 0.62-0.93 |
| WC/Stature | 0.4 | 0.05 | 0.34-0.65 |
| Systolic BP (mmHg) | 95 | 12.9 | 60-140 |
| Diastolic BP (mmHg) | 59 | 9.3 | 40-90 |

BMI, body mass index; WC, waist circumference; HipC, hip circumference; WHR, waist to hip ratio; WC/Stature, waist circumference to height ratio; BP, blood pressure; SD, standard deviation

in almost 60% of subjects. In addition, hyperglycemia was present in 16.7% of them.

The prevalence of the metabolic syndrome was 6.5%. This prevalence increased to 45.1% in obese subjects. Of the study subjects, 17.2 % s did not show any criteria of the metabolic syndrome. One criterion was seen in almost 45.2 % of the subjects. So nearly half of the adolescents in this study had at least one metabolic abnormality and were at risk for having the metabolic syndrome in the future if no prevention effort is taken. Also in this population 30.3 % and 6.5 % of subjects had 2 and 3 criteria of the metabolic syndrome respectively.

Determining influencing factors for the metabolic syndrome, family medical history was obtained via questionnaire. Positive family history for cardiovascular diseases (20% MS subjects vs. 4.5% normal), hypertension (10% MS subjects vs. 2.3% normal), diabetes (10% MS subjects vs. 3% normal) and obesity (20% MS subjects vs. 7.4% normal) was seen with higher percentage in subjects who suffers from the metabolic syndrome ($p < 0.001$). The family income was served as an indicator for socioeconomic status. The percentage of subjects with the metabolic syndrome was higher in families with a better economic status (1000 US$/month) compared to the poorer (222 US$ /month) ($p < 0.001$). Regarding physical activity, the percentage of subject engaging in sedentary free time activities such as watching television (26% of MS subjects vs. 19% normal), study and working in front of the computer (28% of MS subjects vs. 18% normal) were higher in the metabolic syndrome group. Also, daily physical activities such as cycling (2.9% MS subjects vs. 17.9% normal), swimming (5% MS subjects vs. 15.1%

**Table 2.** Comparison of macronutrient consumption between subjects with and without the metabolic syndrome

| Macronutrients | Non-metabolic Syndrome Mean ± SD ( N= 284) | Metabolic Syndrome Mean ± SD (N= 17) | *p*-Value |
|---|---|---|---|
| Energy (Kcal/d) | 1888 ± 486 | 1986 ± 497 | 0.427 |
| Carbohydrate (g/d) | 252 ± 63 | 293 ± 76 | 0.013* |
| Protein (g/d) | 70 ± 19.6 | 70 ± 19.5 | 0.933 |
| Fat (g/d) | 69 ± 30.6 | 60 ± 18.7 | 0.273 |
| Saturated Fat (g/d) | 22.5 ± 10.3 | 19.9 ± 6.5 | 0.325 |
| Polyunsaturated Fat (omega 3, g/d) | 15.8 ± 10.8 | 13.8 ± 6.5 | 0.449 |
| Linoleic Fat (omega 6, g/d) | 13.7 ± 10.5 | 11.4 ± 6 | 0.380 |
| Monounsaturated Fat (g/d) | 23.7 ± 12.2 | 20.8 ± 6.6 | 0.327 |
| Sugar (g/d) | 67 ± 30.1 | 74 ± 26.5 | 0.400 |
| Cholesterol (mg/d) | 218 ± 111 | 189 ± 84 | 0.306 |
| Dietary Fiber (g/d) | 6.8 ± 3.8 | 5.7 ± 2.5 | 0.248 |

*$p < 0.05$, independent sample T-test

**Table 3.** Comparisons of anthropometric and clinical characteristics between subjects with and without the metabolic syndrome

| Characteristics | Non-metabolic Syndrome Mean ± SD (n = 503) | Metabolic Syndrome Mean ± SD (n = 35) | *p*- value |
|---|---|---|---|
| Height (cm) | 157 ± 5.3 | 159 ± 5.1 | 0.089 |
| Weight (kg) | 50.9 ± 8.8 | 62 ± 17.2 | 0.001* |
| BMI (kg/m2) | 20.4 ± 3.2 | 24.4 ± 6.6 | 0.001* |
| WC (cm) | 68 ± 6.8 | 78 ± 13.4 | <0.001* |
| HipC (cm) | 92 ± 6.4 | 99 ± 11.5 | 0.001* |
| WC/HipC | 0.7 ± 0.04 | 0.8 ± 0.05 | <0.001* |
| WC/Statue | 0.4 ± 0.04 | 0.5 ± 0.08 | <0.001* |
| Systolic BP (mmHg) | 95 ± 12.5 | 108 ± 13.8 | <0.001* |
| Diastolic BP(mmHg) | 59 ± 8.9 | 71 ± 7.2 | <0.001* |
| FBS (mg/dL) | 74 ± 11.1 | 85 ± 10.6 | <0.001* |
| TG (mg/dL) | 93 ± 41.1 | 122 ± 42 | <0.001* |
| Cholesterol (mg/dL) | 153 ± 30.1 | 160 ± 27.5 | 0.184 |
| HDL-C (mg/dL) | 36.7 ± 5.2 | 35.4 ± 4.8 | 0.167 |
| LDL-C (mg/dL) | 98 ± 26.3 | 100 ± 23 | 0.601 |

* $p < 0.05$, Independent Sample T-test, BMI=Body Mass Index, WC=waist circumference, HipC=hip circumference, BP=blood pressure, TG=triglyceride, HDL-c=HDL-cholesterol, FBS=fasting blood sugar, WC/Stature= Waist Circumference to Height Ratio

normal), football (2.9% MS subjects vs. 5.3% normal) and aerobics (5.7% MS subjects vs. 12.1% normal) showed a significant increase ($p < 0.001$) in the normal group compared to the metabolic syndrome group.

The mean of the three days food intake, including one 24-hour recall and a two-day food record, was employed to specify the macro- and micronutrient intake in the study subjects. In order to control the reliability of food records, under-reporting and over-reporting was calculated using energy intake/ basal metabolic rate ratio (Bingham 1994). Food analyses in this study showed 31.9% under-reporting and 15.6% over-reporting. Sweets, candies and chocolates were preferred by a higher percentage of subjects in the metabolic syndrome group compared to subjects in the normal group ($p = 0.002$). Macronutrient analyses which was summarized in Table 2 shows that carbohydrate and sugar consumption was significantly higher in subjects with the metabolic syndrome compared to subjects without ($p = 0.013$). With regard to micronutrient intake, mean consumption of sodium was higher in the metabolic syndrome subjects (3775 mg vs. 3405 mg) than subjects in the normal group. Dietary fiber, vitamins D, C, A, B12 and Copper were consumed less in the metabolic syndrome group although this difference was not significant. This difference was only significant for Manganese intake ($p = 0.002$). Comparing anthropometric and biochemical parameters between two group, table 3 shows that weight, BMI, WC and its indexes, blood pressure, FBS and TG were seen with significantly higher level in the metabolic syndrome subjects ($p < 0.001$).

## DISCUSSION

Our findings suggested that obesity associated metabolic abnormalities are no longer solely a characteristic of the adult. Obesity in adolescents is not just obesity, but is accompanied by co-morbidities that cluster to form the metabolic syndrome. Although there are no internationally acceptable uniform criteria so far for diagnosing metabolic syndrome in adolescents, the prevalence of metabolic syndrome in this study, 6.5%, was consistent with other findings among adolescents, aged 15-18 years in which the incidence of the metabolic syndrome was 4.2% to 9.9% and increased 28.7% to 41.1% in the obese subjects.[14-16,28,29,43]

In this study it was found that around 18% of adolescent girls suffered from some degree of obesity (14.6 % overweight, 3.4 % obese). These figures were similar with that found in the Tehran Lipid and Glucose Study that showed that 13.3% of girls aged 10-19 years were overweight and 4.1% obese.[10] In another study in Iran, the prevalence of overweight and obesity was 13.6% and 2.2% respectively.[30] A prevalence of 10% for enlarged waist circumference among adolescent girls is remarkably high. Abdominal adiposity measured by waist circumference is associated with increased risk of cardiovascular disease, dislipidemia and type 2 diabetes mellitus which all can be resulted from obesity. High WHR (> 0.8) was present in 9.5% of the subjects which is a good predictor for coronary heart diseases. This was consistent with similar research that showed the prevalence of WHR more than 0.9 to be 11%.in the same age group.[26,31-33] Increasing BMI and WC played an important role in high prevalence of the metabolic syndrome.[14,34,35] It can be related to a strong correlation between anthropometric parameters such as weight, BMI or WC and other determining factors such as high blood pressure and high triglyceride levels ($r = 0.358$, $p < 0.001$; $r = 0.148$, $p = 0.001$).

The prevalence of hypertension was 6.1% in this study and was consistent with recent studies that showed that the prevalence of hypertension in children in Kuwait and Israel to ranged from 0.5% - 11% depending on the age and the criteria used to define hypertension.[36-38] Most of the adolescents with essential hypertension are asymptomatic whereas they are at risk for stroke, ischemic coronary disease and renal damage. Therefore frequent screening for hypertension is needed especially in adolescents in the vulnerable groups. The high prevalence of low HDL-cholesterol in this study was consistent with other studies in Asian countries.[9,39,40,43] Overweight children were reported to have low HDL cholesterol and high triglycerides and insulin, but normal glucose levels, suggesting that glucose intolerance might develop later than other syndrome abnormalities.[41]

Socioeconomic status of the family was an influencing factor in the prevalence of the metabolic syndrome as it had been proved in previous studies.[39,43] Family medical history including cardiovascular diseases, obesity, diabetes and hypertension was also a predisposing factor for the prevalence of the metabolic syndrome.[2,42] In the Iranian community, rapid changes in lifestyle especially the mass consumption of food with undesirable composition of excessive carbohydrates and sugars and the lack of sufficient physical activities have contributed to the increased prevalence of the metabolic syndrome. These results were consistent with other research that mentioned to sedentary lifestyle and dietary habits as important predictors for the metabolic syndrome.[11,43]

In conclusion, approximately 6.5% of all- and 45% of obese subjects met the criteria for metabolic syndrome. The prevalence of the metabolic syndrome increased directly with the degree of obesity. The socioeconomic status of family, parents' medical history and dietary habits of the adolescents can affect on the prevalence of the metabolic syndrome. The optimum evaluation of an overweight or obese subject should include waist circumference, lipoprotein panel, fasting blood glucose and measurement of blood pressure.

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## AUTHOR DISCLOSURES

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# 伊朗馬什哈德青少女代謝症候群盛行率及其影響因子

前言：本研究企圖找出全球性的公共健康挑戰之一的代謝症候群在，其主要為伊朗馬什哈德 15 至 17 歲青少女的盛行率，及其影響因子。方法：一個 622 位高中青少年參與的橫斷性研究。以自填式問卷用來評估社會人口學特徵和飲食習慣，並完成體位、血壓和生化測量。結果：採用年齡和性別身體質量指數 Z-分數 (WHO 2007），有 14.6%個案為過重，3.4%為肥胖。9.5%的個案為大腰圍(>80 cm)。合併高血壓盛行率為 6.1%，會隨著肥胖的嚴重度而增加。24.5%的個案有高三酸甘油酯血症和 57%有低的高密度脂蛋白。16.7%的個案有高血糖症。根據 NCEP ATP III(2001)的標準，代謝症候群的盛行率為 6.5%，在肥胖的個案則增為 45.1%。增加身體質量指數或腰圍，導致顯著增加代謝症候群特徵的數目($p < 0.001$)。高社經地位的家庭，家族史和飲食習慣，尤其攝取較多的碳水化合物，是代謝症候群盛行率的影響因子。結論：約有 6.5%的所有研究對象和 45%的肥胖者符合代謝症候群的標準。碳水化合物的攝取習慣、社經地位的家族史，可能影響代謝症候群的盛行率。

**關鍵字：代謝症候群、青少女、肥胖、盛行率、飲食**