Overweight Adolescents: A Group at Risk for Metabolic Syndrome (Tehran Adolescent Obesity Study)

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Background: Metabolic syndrome not only is a serious problem for adults, but is also afflicting an increasing number of children and adolescents. This syndrome is a risk factor for type 2 diabetes mellitus and cardiovascular diseases. The aim of this study was to estimate the prevalence of metabolic syndrome in a sample of Iranian adolescents.

Methods: A total of 554 overweight adolescents (aged 11 – 17 years) participated in a community-based cross sectional survey. Anthropometric examinations including height, weight, body mass index, and blood pressure were assessed. A fasting blood sample was taken for measurement of glucose and lipid profile. Metabolic syndrome was determined by the definition released by the National Cholesterol Education Program Adult Treatment Panel III, which was modified for age.

Results: The overall prevalence of metabolic syndrome was 26.6%. There was no gender difference in the distribution of metabolic syndrome. When stratified by body mass index, 22.5% were overweight (BMI ≥ 95th percentile) besides having the criteria for metabolic syndrome, while the remaining 4.1% of the adolescents were at risk for overweight (BMI between 85th and 95th percentile) together with metabolic syndrome. Hypertriglyceridemia was the most common and high-density lipoprotein was the least common constituent of metabolic syndrome.

Conclusion: This study suggests a high prevalence of metabolic syndrome among overweight Iranian adolescents. This poses a serious threat to the current and future health of Iranian youth.

Keywords: Adolescents • metabolic syndrome • overweight

Introduction

Metabolic syndrome (MS), a condition that results from obesity and other several disorders of body metabolism has generated a great deal of interest.\(^1\) A report prepared for World Health Organization (WHO) by International Obesity Task Force (IOTF) warns: “cardiovascular risk factors are now becoming routinely reported among children in many populations”.\(^2\)

Components of metabolic syndrome are present in children and adolescents as well as in adults but there is no agreement on definition of MS as whole in this population.\(^3,5\)

Some researchers use definitions that follow the Third National Cholesterol Education ATP III guidelines.\(^6–8\)

However, research about MS among children and adolescents and the implications of having MS is limited.\(^6–13\)

In a sample of adolescents in the United States who were included in the National Health and Nutrition Examination Survey III (NHANES III), conducted between 1988 and 1994, the prevalence of MS was 6.8% among at risk for overweight adolescents and 28.7% among overweight adolescents.\(^6\)

The prevalence of MS phenotype among the U.S. adolescents increased from 28.7% in overweight adolescents in NHANES of 1988 –
1994 to 32.1% in NHANES 1999 – 2000.9

In a study, from the Yale School of Medicine and Cincinnati Children’s Hospital, the prevalence of MS increased with the severity of obesity and reached 50% in severely obese youngsters.7 Because MS significantly increases the future risk for type 2 diabetes mellitus and premature coronary heart disease in adults, lifestyle modifications and aggressive therapeutic interventions (if required) must be targeted toward adolescents. This is likely to reduce the incidence of associated morbidities and mortalities that accumulate with their passage into adulthood.

However, studies designed to explore the prevalence of MS in Iranian youth are few.14,15 The present study focused on a representative sample of an apparently healthy young population to find the prevalence of MS in adolescents attending school, between 11 and 17 years of age.

Materials and Methods

This study was conducted within the framework of Tehran Adolescent Obesity Study (TAOS), a cross-sectional study performed on a representative sample of students (11 – 17 years) with the aim of determining the prevalence of obesity. A total of 2900 students living in Tehran were selected by a multistage stratified cluster sampling. For this, a “cluster” was defined as a school. A list of the names of the schools in different zones of the city was prepared. An appropriate number of clusters were randomly selected from the list. The number of schools was determined based on proportional allocation to ensure that the sample was the representative of the clusters.

Written informed consent was obtained from the parents. This study was approved by the Human Research Board of Tehran University of Medical Sciences. Details of TAOS have been published elsewhere.16

Totally, 707 overweight and at risk for overweight adolescents aged 11 – 17 years were identified.

We defined overweight as BMI ≥ 95th percentile, and risk for overweight as BMI between 85th and 95th percentiles according to age- and sex-specific NCHS/CDC 2000 BMI values.17 The participants were eligible if they were healthy, between 11 to 17 years old, and had a BMI ≥ 85th percentile for age and sex.

Subjects with normal weight (BMI < 85th percentile), and those who fasted for less than 12 hr, had known systemic diseases, or took medications that altered blood pressure, glucose, or lipid metabolism were excluded from the study.

Of 707 eligible subjects, 143 students did not refer to the clinic, therefore a total of 554 overweight and at risk for overweight adolescents (282 girls, 272 boys) were screened for MS.

An anthropometric and general physical examination was carried out. Height was measured in the upright position with stadiometer. Weight was measured with a self zeroing scale. It was rounded to nearest 0.1 kg and the height to 0.5 cm. BMI was calculated as weight in kilograms divided by squared height in meter. All measurements were taken by two trained physicians.

Blood pressure was measured three times after a 10-min rest in a supine position from the right arm reading with an appropriate cuff and the last two measurements were averaged for analysis. Hypertension was defined in accordance with the Second National Task Force on High Blood Pressure in Children and Adolescents as systolic or diastolic blood pressure > 95th percentile for age, height, and gender.18

Early morning blood samples for serum lipids and glucose were collected in all subjects after 12 – 14 hr of overnight fasting. An oral glucose tolerance test was then performed for the subjects with impaired fasting glucose by administration of 1.75 g of oral glucose per kilogram of body weight (to a maximum of 75 g).

Fasting blood glucose was measured by glucose oxidase method and lipids were assessed using the enzymatic kit method by standard automated analyzer (vital Scientific Span Keren Netherlands). Low-density lipoprotein-cholesterol (LDL-C) concentrations were calculated using the Friedewald formula (LDL-C=total cholesterol-HDL-C+Triglycerides/5) except when triglyceride (TG) concentration was > 400 mg/dL.19

Abnormalities in fasting levels of TG and HDL-C were adjusted for age, sex, and race (95th percentile for TG, < 5th percentile for HDL-C). The standards for TG (≥ 110 mg/dL=1.24 mM) and HDL-C (≤ 40 mg/dL=1.03 mM) in the present study was based on the National Cholesterol Education Program (NCEP) report on blood cholesterol levels in children and adolescents.20

Fasting hyperglycemia was defined as a fasting glucose level ≥ 110 mg/dL (≥ 6.1 mM) according to American Diabetes Association definition.21
In our study, MS was determined using the ATP III definition modified by Cook et al for age. Adolescents were classified as having MS if they met three or more of the following criteria for age and sex: a BMI ≥ 95%, elevated blood pressure, fasting hyperglycemia, hypertriglyceridemia, and low HDL.

The data were analyzed by SPSS software version 10.0. Data were expressed as means±SD. Student’s t-test and Chi-square test were used to compare groups. Statistical significance was taken at P<0.05.

**Results**

Demographic characteristics and results of the metabolic parameters are shown in Table 1. The overall prevalence of MS was 26.6%. There was no gender difference between boys (28.1%) and girls (25.2%, P=0.05).

When we stratified our subjects according to BMI, 22.5% were overweight (BMI ≥ 95th percentile) besides having metabolic syndrome and 4.1% were at risk for overweight (BMI between 85th and 95th percentiles) together with the criteria for MS.

The distribution of the individual components of MS is shown in Figure 1. Hypertriglyceridemia was most common (54.8%) while low HDL was the least common (6.6%) metabolic abnormality in this study. The distribution of the number of risk factors of MS in the studied adolescent subjects are shown in Figure 2.

Approximately 90% of participants had at least one component of MS. The presence of one, two, and three or more components, associated with MS was 23.2, 36.5, and 32.2%, respectively.

The spectrum of all five risk factors was not seen in any of our subjects. Fifty-five of the participants had fasting plasma glucose ≥ 110 mg/dL. Of these only 28 subjects underwent an oral glucose tolerance test. None fulfilled the criteria for the diagnosis of diabetes mellitus.

**Discussion**

The crude prevalence of MS in the present study according to the modified ATP III criteria was 26.6%. A few studies from Iran have assessed the prevalence of MS in children and adolescents. In Ebrahimpour et al’s study, the crude prevalence rate of MS in overweight 7 – 11-year-old students was 20.6%. In a population-based cross-sectional study of 3036 Iranian adolescents (10 – 19-year-old) by Esmailzadeh et al the prevalence of MS in overweight adolescents, compared with those at risk for overweight and those with normal weight was 42% versus 13.3% and 4%, respectively. The high prevalence of MS in Iranian studies are in accordance with various studies from other parts of the world, mainly from developed countries.

Several large population studies have established the prevalence of MS during childhood. Although direct comparison across studies is hampered because of differences in the definition of the syndrome, the overall prevalence in children and adolescents is relatively low (3 – 4%) compared with adult population. For instance, the age-adjusted prevalence of MS based on the ATP III definition in the US adults was 23.7% whereas in adults aged 20 to 29 years, it was 6.7%.22

In Bogalusa Heart Study (a population-based...
longitudinal study) of cardiovascular diseases risk factors in black and white children, the prevalence of metabolic syndrome was 4% and 3% in white and black children, respectively. The prevalence of MS varies by the definitions used for the components and by the weight status of the subjects.

The incidence of MS is on the rise worldwide. This trend coincides with the rising prevalence of overweight and physical inactivity. The reported prevalence of MS in overweight adolescents varies from 26 to 33%. Cook et al also observed that 28.7% of overweight adolescents and 6.8% of those at risk for overweight had MS. Duncan et al observed a comparable prevalence of 32.1% in overweight adolescents, while 7.1% of those at risk for overweight had MS.

Indians are a race characteristically more insulin resistant than white Caucasians and have more components of MS. A prevalence of 36.6% versus 11.5% was reported by investigators from India in overweight and at risk for overweight adolescents of 12 – 17 years of age, respectively.

The wide range of discrepancies in the prevalence of MS in various studies may be due to

**Figure 1.** Prevalence of the individual risk factors of metabolic syndrome in the studied adolescent subjects. TG=triglyceride; BP=blood pressure; HDL=high density lipoprotein.

**Figure 2.** Prevalence of the number of risk factors of metabolic syndrome in the studied adolescent subjects.
difference in ethnic background, geographic area, and population size in each report. Furthermore the 7.1% prevalence of overweight in TAOS,16 is much lower than the prevalence of 15% reported among adolescents in the U.S. population.23 In addition, obese children in the U.S. were plumper than in our study population with a mean BMI of 26.7±4.4 kg/m² (Table 1). It should be noted that the degree of obesity is also a factor determining the risk of development of MS.

Therefore, we believe that the less severe obesity as well as the lower prevalence of overweight contributes to the lower prevalence of MS in our study compared with other studies. However, the difference in MS prevalence among overweight subjects compared with at risk for overweight subjects was striking and it further highlights the importance of a small degree of weight loss for avoidance of MS-associated morbidities.

In this study, the constituent factors for MS were as follows. One factor in 23.2%, two in 36.5%, three in 28.1%, and four factors in 4.1%. The spectrum of all five risk factors was not seen in any of our subjects. Our findings are in agreement with those of Cruz et al’s study,8 where 22.1% had one risk factor, 38.1% had two, and 30.2% had three or more risk factors.

The prevalence of MS in youth may vary by sex, as it does in adults but data on this issue is conflicting.6,8 In the present study, there was no gender difference in the distribution of MS, that is in accordance with those of Cruz et al studies.8 However, more large multicentric studies with boys and girls are needed to find whether the sex differences seen in MS in adults is also present during childhood and adolescents.

In the present study, and also in report by Ebrahimpour et al14 high fasting TG was the most common satisfied criteria for MS whereas low HDL-C was the least common metabolic risk factor. This is marked contrast to the situation in developed countries where low HDL was the most prevalent constituent of MS in most of the studies.7–9 The mechanism for this discrepancy is not clearly understood, while it might be a unique finding in Iranian adolescents.

In conclusion, although the prevalence of obesity and MS in our study group is much lower than the prevalence reported among adolescents in the U.S., it is still considered as a public health problem. Given the increasing number of overweight children and adolescents and the known morbidity of MS, its association with overweight may have important public health and clinical implications.

If these data are confirmed, a uniform definition of MS for pediatric population should be instituted. Currently, prevention may be the best approach to decrease the incidence of MS in children.24–26 Therefore, there is a necessity to apply a preventive strategy that addresses all children to promote healthy lifestyle from birth onward. This strategy should be supported by changes in public policy to promote increased physical activity such as decreasing time spent for watching television, walking to school, increase in physical education times in schools, and decreasing sedentary activities. Furthermore, consuming healthy diets should be reinforced.

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References

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