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Metabolic syndrome in Turkish children and adolescents

Mehmet Agirbasli[a,*], Servet Cakir[b], Sencan Ozme[b], Gonenc Ciliv[c]

[a]Department of Cardiology, Marmara University Medical School, Tophanelioglu Cad 13/15, 34660 Altunizade Istanbul, Turkey
[b]Department of Pediatrics, Hacettepe University Medical School, Ankara 06100, Turkey
[c]Department of Biochemistry, Hacettepe University Medical School, Ankara 06100, Turkey

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Abstract

The aim of this study was to determine the prevalence and phenotype of metabolic syndrome in Turkish children and adolescents. We adapted the National Cholesterol Education Program Adult Treatment Panel III criteria of metabolic syndrome to children and adolescents. Using the international cutoff points and percentiles, we determined 10- to 17-year-old Turkish children and adolescents with high blood pressure, high triglyceride (TG), low high-density lipoprotein cholesterol (HDL-C), fasting glucose of 100 mg/dL or greater, and elevated body mass index corresponding to overweight or obesity. We examined 1385 apparently healthy students between the ages of 10 to 17 years from Ankara, Turkey: 4.9% of the subjects were overweight or obese; 29.2% had either low HDL-C and/or high TG levels; and 15.7% had either systolic or diastolic blood pressure above the 95th age-, sex-, and height-specific percentile. Thirty students (2.2%) had metabolic syndrome by having 3 or more risk variables. Metabolic syndrome was nearly 10 times more common among overweight and obese students (21%), compared with lean students. Components of metabolic syndrome such as high blood pressure and high TG, and low HDL-C levels were common among Turkish children and adolescents. Strategies should focus on early detection and treatment of these risk variables in Turkish children.

1. Introduction

Metabolic syndrome represents a constellation of lipid and nonlipid cardiovascular risk factors of metabolic origin [1,2]. Individuals with metabolic syndrome are at risk for type 2 diabetes mellitus [3] and cardiovascular disease [4]. The World Health Organization [1] and National Cholesterol Education Program (NCEP) Adult Treatment Panel III [2] define metabolic syndrome in adults. These definitions carry certain differences; NCEP definition is based on the number of risk factors, among which are abdominal obesity, elevated triglycerides (TGs) (>150 mg/dL), low high-density lipoprotein cholesterol (HDL-C) (<40 mg/dL in men and <50 mg/dL in women), blood pressure (≥130/85 mm Hg), and elevated fasting glucose (≥110 mg/dL). Having 3 or more risk determinants is defined as metabolic syndrome [2]. On the other hand, insulin resistance, hyperglycemia, or known diabetes are central components of the World Health Organization definition [1]. Recently, the International Diabetes Federation released a consensus clinical definition for metabolic syndrome [5]. The International Diabetes Federation definition considers central obesity as the prerequisite, and it has broader criteria for waist circumference, HDL-C, and fasting plasma glucose [5].

Several studies suggest that metabolic syndrome starts early in life [6-9], yet definition of metabolic syndrome in children and adolescents remains controversial [10]. Ethnic differences exist in the criteria, definition, and prevalence of metabolic syndrome in adolescents between populations [11,12]. Understanding ethnic differences is crucial for the development of screening and treatment strategies. We examined a representative sample of apparently healthy students from Ankara, Turkey.

An increase in waist circumference is used to define central obesity in adults. Body proportions normally change during pubertal development and may vary among persons of different races and ethnic groups. Studies suggest that body mass index (BMI) may correlate better with blood

* Corresponding author. Hacı Mehmet Efendi Sokak No 33/6 Cemil Topuzlu Cad., Fenerbahce, 34726 Istanbul, Turkey. Tel.: +90 216 3851070; fax: +90 216 3276035.
E-mail address: agirbasli@gmail.com (M. Agirbasli).

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pressure and dyslipidemia than does the waist circumference [13]. We therefore defined obesity based on age- and sex-specific cutoff points of BMI, which were developed and published from the centile curves of an international reference population [14]. Using the international cutoff points and percentiles, we determined children with high blood pressure, high TG, low HDL-C, fasting glucose of 100 mg/dL or greater, and elevated BMI corresponding to overweight or obesity. Because of the lack of standardization and unavailability of assays for insulin, we used the NCEP definition of metabolic syndrome.

The aims of this study were (*a*) to determine the prevalence of metabolic syndrome in Turkish students living in an urbanized and low to middle socioeconomic class environment in Ankara and (*b*) to determine the prevalence and importance of different risk factors of metabolic syndrome in Turkish students.

2. Materials and methods

2.1. Study population

A cross-sectional study of 10- to 17-year-old students for cardiovascular risk factors has been conducted between 1992 and 1994. We collected data from every student attending an elementary and secondary school during this period. A total of 1385 children and adolescents were examined. Fasting blood sample was collected from all subjects. Every participant underwent complete medical history and physical examination. Children with acute or chronic medical problems and/or those who did not want to participate in the survey were excluded (<1%). Participants were asked to complete a brief questionnaire. Few sample questions were asked to learn their dietary habits.

They were asked about parental cigarette smoking and presence of heart disease in the family. Family history of coronary artery disease (CAD) was defined as having a first-degree relative with established CAD before 50 years of age or before menopause. To complete the questionnaire accurately, the subjects confirmed the information with their parents. The study was approved and conducted according to the institutional guidelines. It was conducted according to the principles expressed in the Declaration of Helsinki. Subjects were given case numbers, identities were kept confidential, and the parents were informed.

2.2. Overweight and obese subjects

Body proportions normally change during pubertal development and may vary among persons of different races and ethnic groups. The differences in waist-to-hip ratios are difficult to interpret in children. We therefore defined obesity based on age- and sex-specific cutoff points of BMI (the weight in kilograms divided by the square of the height in meters), which were developed and published from the centile curves of an international reference population [14,15].

2.3. Blood lipid and glucose analyses

Serum cholesterol, TG, and HDL-C levels were measured in duplicate. Blood samples were obtained after an overnight fast of 12 to 14 hours. Samples were allowed to clot at room temperature, and serum was separated by centrifugation at 4°C. Triglycerides were determined colorimetrically by the Hantzsch reaction [16]. High-density lipoprotein cholesterol was determined by phosphotungstate magnesium chloride precipitation method [17]. Glucose was determined by the glucose oxidase method [18].

Large-scale studies provide age- and sex-specific percentiles for TG and HDL-C levels in different populations [19]. Because age- and sex-specific lipid percentiles are not available in Turkish children, we used the National Heart Lung and Blood Institute Growth and Health Study (NGHS) as the reference population [19]. Triglycerides at or above the 90th percentile level and HDL-C at or below the 10th percentile level of the NGHS were considered as risk determinants of metabolic syndrome. We also determined subjects with high TG (≥110 mg/dL) and low HDL-C (≤40 mg/dL) levels based on the adapted definition of the metabolic syndrome for adolescents [20].

2.4. Blood pressure in children

Blood pressure was measured by mercury sphygmomanometer 3 times while the subjects were seated, and the last 2 measurements were averaged for analysis. To find the age-specific height percentile level for each case, we used the growth curves drawn for healthy Turkish Children [21]. Using the tables provided by the Task Force Report on High Blood Pressure in Children and Adolescents, we determined children and adolescents with elevated blood pressure (≥95th percentile) [22,23].

2.5. Definition of metabolic syndrome in children and adolescents

The metabolic syndrome criteria in children and adolescents were modified from those of the NCEP Adult Treatment Panel [2]. The 5 risk determinants of metabolic syndrome in children are described below:

1. body mass index corresponding to overweight or obese state;

Table 1
Anthropometric and metabolic data from 1385 children and adolescents

	Boys (n = 690)	Girls (n = 695)	*P*
Age	14.0 ± 2	13.9 ± 2	.53
Systolic blood pressure	113 ± 14	112 ± 13	.15
Diastolic blood pressure	72 ± 10	71 ± 90	.32
Weight (kg)	48 ± 12	45 ± 10	<.01
Height (cm)	158 ± 14	155 ± 11	<.01
BMI (kg/m^2)	18.9 ± 2.4	18.8 ± 2.8	.51
HDL-C (mg/dL)	49 ± 10	50 ± 10	.19
TGs (mg/dL)	87 ± 45	90 ± 49	.31
Fasting glucose (mg/dL)	76 ± 8	76 ± 9	.17

Table 2
Frequency of the risk variables of metabolic syndrome

Risk determinant	n	%
Obesity	8	0.6
Overweight	60	4.3
Overweight or obesity	68	4.9
Diastolic blood pressure >95th percentile	130	9.4
Systolic blood pressure >95th percentile	131	9.5
Systolic and/or diastolic blood pressure >95th percentile	218	15.7
HDL-C ≤10th percentile	224	16.2
HDL-C ≤40 mg/dL	186	13.4
TGs ≥90th percentile	259	18.7
TGs ≥110 mg/dL	370	26.7
HDL-C ≤10th percentile and/or TGs ≥90th percentile	404	29.2
Fasting glucose >100 mg/dL	7	0.5

2. elevated systolic and/or diastolic blood pressure (≥95th percentile);
3. triglycerides (≥90th percentile level) [19];
4. high-density lipoprotein cholesterol (≤10th percentile level) [19];
5. impaired fasting glucose (>100 mg/dL) [24].

As with the NCEP definition [2], the children and adolescents with 3 or more of the above criteria were considered to have metabolic syndrome.

2.6. Statistical analyses

Continuous variables are presented as mean ± SD and were compared by unpaired 2-tailed Student *t* test between the 2 groups. Categorical variables are presented as percent frequencies. Comparison between categorical groups was performed using χ^2 test. All tests were 2-tailed, and $P < .05$ was accepted as significant. Univariate analysis was performed to determine differences among subjects with and without metabolic syndrome.

3. Results

We examined 1385 children and adolescents (690 boys [49.8%] and 695 [50.2%] girls]. Anthropometric and metabolic data are shown in Table 1. Family history of CAD was present in 198 (14.3%) subjects. Parental smoking was present in 998 subjects (72.1%). Only 1 parent was a smoker in 641 cases (46.3%); more than 1 person in the family was a smoker in 357 (25.8%) subjects. Frequencies of metabolic syndrome risk variables are shown in Table 2. Dyslipidemia and elevated blood pressure were common risk variables, yet obesity and elevated fasting glucose were rarely detected among the subjects (Table 2). Nearly one third of the cases (29.2%) had either elevated TG (≥90th percentile of the NGHS population [19]) or low HDL-C (≤10th percentile of the NGHS population) levels. Low HDL-C and high TG levels (defined as ≤40 mg/dL for HDL-C and ≥110 mg/dL for TG, according to the adopted criteria [20]) were present in 13.4% and 26.7% of the subjects, respectively.

Finally, 15.7% of the subjects had systolic and/or diastolic blood pressure above the 95th age-, sex-, and height-specific percentile.

Table 3
Phenotype of metabolic syndrome in 30 children

Phenotype of metabolic syndrome	n	%
High blood pressure + low HDL-C + high TG	16	53
Overweight or obese + high blood pressure + high TG	5	17
Overweight or obese + low HDL-C + high TG	4	13
Overweight or obese + high blood pressure + low HDL-C	3	10
Overweight or obese + high blood pressure + low HDL-C + high TG	1	3
Overweight or obese + high blood pressure + high FG + high TG	1	3

FG indicates fasting glucose.

Table 4
Univariate comparison of subjects with metabolic syndrome and healthy subjects

	Metabolic syndrome (n = 30)	Healthy subjects (n = 1355)	*P*
Sex			
Girl	7 (23%)	667 (49%)	<.01
Boy	23 (77%)	688 (51%)	
Age	13.5 ± 2	13.9 ± 2	.32
No. of eggs per 1 week	4.4 ± 2.8	5.0 ± 4.8	.25
Smoking in the family			
Yes	19 (63%)	979 (72%)	.30
No	11 (37%)	376 (28%)	
CAD in the family			
Yes	7 (23%)	191 (14%)	.18
No	23 (77%)	1164 (86%)	

3.1. Frequency and phenotype of metabolic syndrome

Thirty subjects (2.2%) had metabolic syndrome by having 3 or more risk variables (Table 3). Students with metabolic syndrome frequently had elevated blood pressure (88%), elevated TG (90%), and low HDL-C (80%) levels. Nearly half of them (47%) were overweight or obese. On the other hand, elevated fasting glucose was rare. Only 1 subject with metabolic syndrome had a fasting glucose of more than 100 mg/dL. Metabolic syndrome was common among obese or overweight children (21%). More than half of the children with metabolic syndrome (53%) were not overweight or obese. They had elevated blood pressure, elevated TG, and low HDL-C levels despite their normal body mass index. On univariate analysis, male sex was more common among subjects with metabolic syndrome (76.7%) (Table 4).

4. Discussion

Constellation of metabolic syndrome components in children can help us to predict cardiovascular risk in adulthood [25]. Our findings suggest that components of the metabolic syndrome are highly prevalent even among apparently healthy and lean school children. A continuum may exist between our findings and the Turkish Adult Risk Factor Study, which reports that cardiovascular risk factors are highly prevalent in Turkish adults [26]. As previously

reported [8,9], metabolic syndrome was common among those who were overweight or obese (21%). Male sex was an important predictor of metabolic syndrome.

Fifteen percent of the school children had either systolic or diastolic blood pressure above the 95th age-, sex-, and height-specific percentile. Our findings support that elevated blood pressure in children and adolescents is more common than previously recognized [22,23]. Hypertension is estimated to affect nearly 30% of persons at 18 to 74 years of age, and blood pressure levels in childhood are useful in the prediction of subsequent hypertension in adults [27].

Our previous observations indicate that Turkish children have lower HDL-C and higher TG levels despite their lower BMI, compared with American children and adolescents [28]. Low HDL-C and/or high TG levels are highly prevalent among Turkish school children; 13.4% of Turkish adolescents had low HDL-C (compared with 26.1% for white American, 11.7% for African American, and 20.2% for Mexican American adolescents), and 26.7% of Turkish adolescents had high TG (compared with 25.5% for white American, 10.5% for African American, and 24.7% for Mexican American adolescents) levels despite a lower prevalence of obesity in Turkish children compared with these populations [20].

Similarly, Turkish adults are known to have these characteristics in their lipid profile [29]. Low HDL-C problem is more prevalent in Turkey than in any other country [29,30]. The underlying reason(s) for low HDL-C and high TG levels in Turks remain unclear. Mahley et al [29] reported that HDL-C levels in Turks were reduced, independent of the regional variation in diet and behavioral factors such as smoking. Supporting their findings, we observed a drop in HDL-C levels in Turkish boys after puberty, which may reflect alteration in androgen balance with puberty and modulation of hepatic lipase activity affecting HDL-C levels [31]. Therefore, efforts to increase HDL-C levels in Turks should start in childhood.

Strategies should focus on early detection and treatment of these risk variables. Measurement of blood pressure and lipid levels in children and young adults is important in the early detection and, possibly, prevention of metabolic syndrome. Parental smoking was very common in our study group, and elimination of environmental factors that can decrease HDL-C further (eg, cigarette smoking and physical inactivity) should be reinforced.

5. Limitations

Our study has several limitations. Data were collected between 1992 and 1994, and current guidelines are based on NCEP recommendations set more than a decade ago [32]. We need future studies reflecting the current status of Turkish children.

It is hard to prove that these children are representative of all school children and adolescents in Turkey. Recent studies report a higher prevalence of obesity among Turkish adolescents [33]. Socioeconomic status (SES) can affect diet and, hence, BMI and serum lipid levels of adolescents. Our study participants attended a public school in Ankara; therefore, most students were from middle to lower socioeconomic level. In a previous study, Mahley et al [30] selected 2 groups of 225 Turkish children from either end of the socioeconomic spectrum. Upper-SES children had higher BMI and higher incidence of overweight or obesity (22%). On the other hand, only 8% of lower-SES Turkish children were overweight or obese in their study. Our group was similar to the lower SES group in their study.

In our study, we performed a limited dietary questionnaire to understand participant's dietary habits; similarly, we did not have any data in the physical activity status of the Turkish children. Both can affect metabolic syndrome risk variables.

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