Original Research

Prevalence of Metabolic Syndrome in Middle School Children and Evaluation of Components of Metabolic Syndrome

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Abstract

Objectives: This study was designed to determine the prevalence of metabolic syndrome (MS) in Turkish children and to examine the relationship between MS components in this age group.

Methods: A total of 395 students in Istanbul aged 10 to 14 years in the 2004-2005 school year were enrolled in the study. Body weight, height, waist circumference, hip circumference, and systolic-diastolic blood pressure were measured. Of the total, 353 provided blood samples for analysis of fasting glucose level, basal insulin, total cholesterol, triglyceride, high-density lipoprotein (HDL), low-density lipoprotein (LDL), and very-low-density lipoprotein (VLDL) levels. Modified World Health Organization criteria were used for the diagnosis of MS.

Results: In this study, 44.5% of the children were female and 55.5% were male. The mean body mass index (BMI) was 20.57±3.48 kg/m², 10.4% (n=41) were overweight, and 12.7% (n=50) were obese. MS was diagnosed in 0.85% of the entire study group and in 6% of the obese children. There was a positive correlation between BMI and waist circumference (p<0.001), waist/hip ratio (p<0.001), systolic blood pressure (p<0.001), diastolic blood pressure (p<0.001), basal insulin level (p<0.001), homeostasis model assessment of insulin resistance (p<0.001), triglyceride value (p<0.001), total cholesterol level (p<0.05), LDL (p<0.001), and VLDL level (p<0.001), and a negative correlation with HDL level (p<0.001).

Conclusion: The study results confirmed that MS is present in children and not limited to adults, and this is an important health problem. The prevalence of MS is more common in obese children. Therefore, early diagnosis of obese children and examination of cardiovascular risk factors and metabolic syndrome criteria is very important.

Keywords: Adolescent; child; metabolic syndrome; obesity.

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It has been reported in adult studies that there is a relationship between type 2 diabetes mellitus and metabolic syndrome (MS) and that MS is an important risk factor for cardiovascular mortality and morbidity.[1–4] In a study from USA, MS was observed in 24% of adults (>20 years), and the rate was determined to be 50% in some ethnic groups.[5] In other research, the rate of heart attack and stroke was found to be 2 to 3 times higher in adults with MS than in those without MS.[6]

It has been reported that MS starts early in life.[7–9] It has also

been observed that insulin resistance is the main factor in the pathogenesis of MS and that there is a relationship between the degree of insulin resistance and the frequency of MS.[3, 10]

Discussion of the precise diagnostic criteria for MS in childhood, the components to be used, and the threshold values is ongoing.[11–13] What should the ideal criterion be for determining impaired glucose metabolism? What is the best indicator of insulin resistance in children? Should MS screening be performed in non-obese children? What are the ideal diagnostic criteria for predicting future risks in MS? These questions remain unanswered.[11, 14–17] Thus far, the diagnostic criteria of the National Cholesterol Education Program (NCEP-ATP III), the World Health Organization (WHO), and the International Diabetes Federation (IDF) have been used in the research in children.[11–13] Although there are some differences in the criteria and threshold values, obesity, glucose intolerance, hypertension, and dyslipidemia constitute the basic components of MS diagnostic criteria.

The primary aim of this study was to determine the incidence of MS in healthy Turkish children aged 10 to 14 years, and to investigate the relationship between the components of MS in this age group.

Methods

Study Group

The study was conducted with morning session students at Istanbul Çapa Middle School aged 10 to 14 years in the 2004-2005 academic year. At the first interview, consent forms were given to the students and their families describing the purpose and characteristics of the study. Written consent to participate in the study was obtained from 395 students and their families.

Study Design

Bodyweight, height, waist circumference, hip circumference, and systolic and diastolic blood pressure of participants were measured. Anthropometric measurements were performed while the children were standing in sock feet and underwear by a single team using the same equipment. Height measurements were made with a non-elastic, 1-mm-spaced measuring tape while the students' heels, hips, and head touched the wall, and weight measurements were made with a 0.5-kg-sensitive scale. Body mass index (BMI) was calculated using the BMI formula of weight (kg)/height^2 (m). Those with a BMI in the 85th to the 94th percentile were considered to be overweight and those with a value in the 95th percentile or greater were assessed as obese.[18] The waist circumference was measured at the

level of the navel and the hip circumference was measured around the large trochanter in the upright position with the abdomen released. Waist/hip ratio was calculated.

Blood pressure was measured at the heart level in the right arm while resting. A non-mercury sphygmomanometer covering 3/4 of the arm. Blood pressure measurements were all performed by the same person. Hypertension was defined as systolic and/or diastolic blood pressure values in the 95th percentile or above according to age and sex.[19]

Blood samples were subsequently taken from 353 children between 8:30 and 9:30 in the morning after 12 hours of fasting. Venous whole blood samples were taken to the Haseki Training and Research Hospital biochemistry laboratory within 30 minutes. Serum samples were obtained using centrifugation at 3000 rpm for 10 minutes. These serum samples were divided into 2 parts (samples 1 and 2) for each patient. From sample 1, fasting glucose level, total cholesterol, high-density lipoprotein (HDL), low-density lipoprotein (LDL), very-low-density lipoprotein (VLDL), and triglyceride levels were studied in the biochemistry laboratory within 1 hour of sample arrival. Sample 2 was transferred to the central biochemistry laboratory at Istanbul University under the appropriate conditions and basal insulin levels were examined. Homeostasis model assessment insulin resistance (HOMA-IR) was calculated with the formula of fasting insulin (mIU/mL) x fasting glucose (mmol/L)/22.5.

An Olympus AU 2700 analyzer (Olympus Corp., Tokyo, Japan) was used for the laboratory evaluation. Glucose was determined using the hexokinase enzymatic method. Total cholesterol, triglycerides, HDL and LDL were estimated by the enzymatic colorimetric method, VLDL was measured using the Friedewald calculation. A Roche Modular E170 system (F. Hoffmann-La Roche Ltd., Basel, Switzerland) and the electrochemiluminescence method were used to evaluate the basal insulin level.

Modified WHO criteria were used for the diagnosis of MS.[20] The presence of 3 or more of the components of obesity (BMI ≥95th percentile), impaired fasting glucose level (≥110 mg/dL), hypertension (systolic and/or diastolic blood pressure ≥95th percentile), dyslipidemia (HDL <35 mg/dL), and triglyceride level >108 mg/dL in boys and >114 mg/dL in girls 11 years and under and >138 mg/dL in both sexes 12 years and older was considered MS.[21]

Statistical Analysis

SPSS for Windows, Version 11.0 (SPSS Inc., Chicago, IL, USA) was used for the statistical analysis. The results were provided as mean (±) SD with a 95% confidence interval. The upper and lower limits of the data in the study group were

calculated using Student's t-test for the single group mean. Descriptive methods were used in the calculation of demographic data and Pearson correlation analysis was used to examine the relationship between variables. P<0.05 was considered statistically significant.

Results

Anthropometric measurements were taken of 395 students. The mean age of the children was 12.51±0.90 years, and 44.5% (n=176) were girls while 55.5% (n=219) were boys. The mean BMI was 20.57±3.48 kg/m², 10.4% (n=41) were overweight, and 12.7% (n=50) were obese. The mean systolic blood pressure was 103.41±12.77 mmHg (min-max: 70-150 mmHg) and the mean diastolic blood pressure was 60.77±11.12 mmHg (min-max: 40-100 mmHg). Anthropometric measurement values are shown in Table 1.

There were 353 students who provided a blood sample. Laboratory data are shown in Table 2. Anthropometric and laboratory data of the participants were evaluated in terms of MS. Obesity was detected in 14.1% (n=50) of the children, impaired fasting glucose in 1.4% (n=5), high systolic blood pressure in 3.1% (n=11), high diastolic blood pressure in 2% (n=7), low HDL in 2.5% (n=9), and a high triglyceride count in 7.4% (n=26). MS diagnostic criteria were positive in 3 patients. MS was found in 0.85% of the total group of participants and in 6% of the obese patients.

When the study data were examined, a positive correlation was detected between BMI and waist circumference (p<0.001), waist/hip ratio (p<0.001), systolic blood pressure (p<0.001), diastolic blood pressure (p<0.001), basal insulin level (p<0.001), HOMA-IR (p<0.001), triglyceride level (p<0.001), total cholesterol (p<0.05), LDL (p<0.001), and

VLDL (p<0.001). There was a negative correlation between HDL (p<0.001) and BMI. The relationship between anthropometric values and MS components is illustrated in Table 3.

A positive correlation was found between systolic blood pressure and diastolic blood pressure (p<0.001), basal insulin level (p<0.001), HOMA-IR (p<0.001), VLDL (p<0.05), and triglyceride level (p<0.05). There was a negative correlation with HDL (p<0.05). A positive correlation was also

Table 1. Anthropometric characteristics of the study group (n=395)

	Minimum	Maximum	Mean (SD)
Age (years)	10.75	14.42	12.51 (±0.90)
BMI (kg/m²)	13.20	31.00	20.57 (±3.48)
Waist circumference (cm)	55	99	69.55 (9.42)
Waist/hip ratio	0.68	1.00	0.05

BMI: Body mass index. SD: Standard deviation.

Table 2. Laboratory values of the study group (n=353)

	Mean	SD
Fasting glucose level (mg/dL)	90.69	7.94
Basal insulin (µ/mL)	8.70	4.81
HOMA-IR	1.95	1.11
HDL (mg/dL)	53.37	11.67
LDL (mg/dL)	93.08	23.55
VLDL (mg/dL)	15.50	8.05
Total cholesterol (mg/dL)	162.17	29.33
Triglyceride (mg/dL)	77.69	40.28

HDL: High-density lipoprotein; HOMA-IR: Homeostasis model assessment insulin resistance; LDL: Low-density lipoprotein; VLDL: Very-low-density lipoprotein; SD: Standard deviation.

Table 3. Relationship between anthropometric values and metabolic syndrome components

	Body mass index		Waist circumference (cm)		Waist/hip ratio	
	r	p	r	p	r	p
Waist circumference (cm)	0.819	0.000***	-	-	-	-
Waist/hip ratio	0.297	0.000***	0.568	0.000***	-	-
Systolic blood pressure (mmHg)	0.459	0.000***	0.470	0.000***	0.129	0.013*
Diastolic blood pressure (mmHg)	0.459	0.000***	0.432	0.000***	0.106	0.042*
Fasting glucose level (mg/dL)	-0.099	0.062	0.015	0.780	0.125	0.019*
Basal insulin (µ/mL)	0.437	0.000***	0.388	0.000***	0.097	0.076
HOMA-IR	0.393	0.000***	0.364	0.000***	0.108	0.048*
Total cholesterol (mg/dL)	0.137	0.010**	0.147	0.006**	0.187	0.000***
LDL (mg/dL)	0.170	0.001***	0.165	0.002**	0.165	0.002**
VLDL (mg/dL)	0.360	0.000***	0.335	0.000***	0.212	0.000***
Triglyceride (mg/dL)	0.363	0.000***	0.334	0.000***	0.209	0.000***
HDL (mg/dL)	-0.263	0.000***	-0.196	0.000***	0.001	0.980

HDL: High-density lipoprotein; HOMA-IR: Homeostasis model assessment insulin resistance; LDL: Low-density lipoprotein; VLDL: Very-low-density lipoprotein. *p<0.05; **p<0.01; ***p<0.001.

observed between diastolic blood pressure and basal insulin level (p<0.001), HOMA-IR (p<0.001), LDL (p<0.05), VLDL (p<0.05), and triglyceride count (p<0.05). There was a negative correlation with HDL (p<0.05). The relationship between blood pressure values and other parameters is shown in Table 4.

An investigation of the relationship between insulin resistance and lipid parameters was performed. There was no significant correlation between fasting glucose level and basal insulin level (p=0.726), triglyceride (p=0.299), total cholesterol (p=0.256), LDL (p=0.761), or VLDL (p=0.252). There was a positive correlation between basal insulin level and triglyceride (p<0.001; r=0.252), and with VLDL (p<0.001; r=0.253), and a negative correlation with HDL (p<0.001; r=-0.238). There was no significant relationship between basal insulin level and total cholesterol (p=0.968) or LDL (p=0.527). There was a positive correlation between HOMA-IR and triglyceride (p<0.001; r=0.248) and with VLDL (p<0.001; r=0.249), and a negative correlation with HDL (p<0.001; r=-0.212). There was no significant correlation between HOMA-IR and total cholesterol (p=0.78) or LDL (p= 0.445).

Discussion

The incidence of MS in children is low in comparison with adults.[12] However, studies have reported a significant prevalence of MS in obese children and adolescents, and there is a strong relationship between obesity and MS.[11, 12, 14] In the National Health Nutrition Research (NHANES) III study conducted by Cook et al.[22] in the USA, 2430 adolescents in the 12 to 19 age group were evaluated according to the Adult Treatment Panel III criteria and the prevalence of MS was determined to be 4.2%. In the same study, 28.7% of obese adolescents were found to have MS.[22] Duncan et al.[23] found an overall prevalence of MS of 6.4% (12-19 years, 991 adolescents). In that study, the prevalence of MS

was 32.1% in obese participants, 7.1% in those classified as overweight, and <1% in those of normal weight.

In our country, Atabek et al.[24] examined 169 (7-18 years) cases classified as obese according to the WHO criteria and found 27.2% with MS. Sen et al.,[25] in their study with 352 participants between the ages of 2 and 19 considered obese according to the NCEP-ATP III criteria, reported MS in 41.8%. In a study conducted with 1385 healthy children aged 10 to 17 in Ankara, the prevalence of MS in all children was reported to be 2.2%.[26] It was noted that the 21% prevalence of MS in the obese and overweight groups was 10 times higher than the other children.[26] The NCEP-ATP III criteria were used in that study. Research conducted in a population of 10- to 19-year-olds in the Kocaeli region according to the IDF criteria, the prevalence of MS in the overall group was 2.3%, while it was 5.5% in those who were overweight, and 28.1% in obese participants.[13] In our study, we found that the prevalence of MS was 7 times higher in obese children compared with the total population. The prevalence of MS was 0.85% in all of the children studied and 6% in the obese children. These values were lower than the other 2 groups in Turkey. This may be due to differences in the diagnostic criteria for MS and threshold values used in the studies.

In our study, we determined that 10.4% of the children were overweight and 12.7% were obese. The rates we found were similar to those of the Kocaeli study (11.5% overweight, 6.8% obese), which was conducted during the same time period.[13] The increase in the frequency of obesity and overweight children is striking when the results of the school screening conducted in Ankara 10 years earlier (4.3% overweight, 0.6% obese) are examined.[26]

Studies have reported that children with high BMI values had high systolic and diastolic blood pressure values.[27] In the NHANES 1999-2000 and the NHANES III study con-

Table 4. Relationship between blood pressure values and other parameters

	Systolic blood pressure (mmHg)		Diastolic blood pressure (mmHg)	
	r	p	r	p
Diastolic blood pressure (mmHg)	0.725	0.000***	-	-
Fasting glucose level (mg/dL)	0.064	0.231	-0.023	0.660
Basal insulin (μ/mL)	0.242	0.000***	0.217	0.000***
HOMA-IR	0.264	0.000***	0.218	0.000***
Total cholesterol (mg/dL)	0.043	0.419	0.080	0.135
LDL (mg/dL)	0.063	0.240	0.124	0.020*
VLDL (mg/dL)	0.136	0.011*	0.130	0.015*
Triglyceride (mg/dL)	0.136	0.011*	0.122	0.022*
HDL (mg/dL)	-0.121	0.023*	-0.123	0.021*

HDL: High-density lipoprotein; HOMA-IR: Homeostasis model assessment insulin resistance; LDL: Low-density lipoprotein; VLDL: Very-low-density lipoprotein; *p<0.05; **p<0.01; ***p<0.001.

ducted in the USA, the strongest correlation between BMI and cardiovascular risk factors was found to be between BMI - systolic blood pressure and BMI - triglyceride level. The correlation between BMI and total cholesterol and with glucose has been reported to be poor.[28] Sur et al.,[29] found a positive correlation between BMI and the LDL/HDL ratio and the triglyceride level in both sexes. The results of the study conducted by Blackett et al.[30] demonstrated that the HDL-cholesterol value decreased as the BMI z-score increased in both genders. In our study, we identified a positive correlation between BMI and systolic-diastolic blood pressure, basal insulin level, triglyceride level, total cholesterol, LDL, and VLDL, and a negative correlation with HDL. We did not find a significant relationship with fasting glucose level.

In studies, it has been determined that increased waist circumference is important as an indicator of abdominal obesity in young MS patients.[31, 32] Regardless of BMI, waist circumference measurement has been associated with visceral adipose tissue and insulin resistance, and increased waist circumference has been associated with systolic blood pressure and hyperinsulinemia.[14, 33] In our study, we found a positive correlation between the waist circumference value and systolic-diastolic blood pressure, basal insulin level, HOMA-IR, triglyceride level, total cholesterol, LDL, and VLDL, and a negative correlation with HDL. Our results support the other studies.

It has been shown that insulin resistance is the basis of the metabolic syndrome and that there is a correlation between the degree of insulin resistance and the frequency of MS.[3, 10, 34] Insulin resistance represents a decrease in the body's glucose uptake in physiological insulin levels, with a normal concentration of insulin producing a lower response than the normal biological response. Chronic hyperinsulinism occurs in response to insulin resistance and leads to the development of negative effects.[11] Garces et al.[35] found an important relationship between the fasting insulin value and HOMA-IR and BMI. In another study examining the relationship between insulin resistance and dyslipidemia, insulin resistance was found to be positively correlated with the triglyceride level while the HDL level was negatively correlated.[34] In our study, we found a positive correlation between basal insulin level and HOMA-IR and BMI, waist circumference, systolic blood pressure, diastolic blood pressure, triglyceride level, and VLDL, and a negative correlation with HDL, consistent with previous studies.

Conclusion

According to the results of our study, MS is an important health problem not only in adulthood but also in childhood. The prevalence was much greater in obese children than in non-obese children. A greater BMI and waist circumference were also associated with systolic-diastolic blood pressure, insulin resistance and dyslipidemia in childhood. Therefore, early diagnosis of obese children and evaluating them in terms of cardiovascular risk factors and MS criteria is very significant. Another notable result of our study is the increase in the frequency of overweight and obese children. It is possible to prevent many diseases with high mortality and morbidity in the long term by preventing obesity at an early age.

Disclosures

The study was carried out in accordance with the Good Clinical Practice and Helsinki Declaration. Verbal and written consent was obtained from the families for participation in the study.

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