Differences in the prevalence of metabolic syndrome in boys and girls based on various definitions

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Original Article

Abstract

BACKGROUND: The prevalence of metabolic syndrome (MetS) is increasing among children and adolescents. However, the prevalence of this disorder varies based on its different definitions. This study aimed to determine the prevalence of MetS in Iranian adolescents in junior high and high schools according to the definitions provided by the International Diabetes Federation (IDF) and De Ferranti.

METHODS: Overall, 1039 junior high school and 953 high school students were selected using multistage random sampling. Demographic data was collected using validated questionnaires. Fasting blood sugar, total cholesterol, triglyceride, high-density lipoprotein cholesterol (HDL-C) and low-density lipoprotein cholesterol (LDL-C) levels were determined. Waist circumference and blood pressure were measured by trained individuals. Subjects with MetS were selected according to two definitions provided by the IDF and De Ferranti. Chi-square and Fisher's exact tests were used to compare the prevalence of MetS and its components based on sex, school level, and the two definitions.

RESULTS: The mean age of junior high and high school students was 13.11 ± 1.21ad 15.93 ± 1.07 years old, respectively. The prevalence of MetS among all participants was 4.8% and 12.7% according to the definitions by the IDF and De Ferranti, respectively. It was significantly higher among boys compared to girls. According to the IDF definition, low HDL-C and hypertension were the most frequent components. Based on the De Ferranti, abdominal obesity and hypertriglyceridemia were the most frequent components.

CONCLUSION: The prevalence of MetS was higher in both groups of students based on De Ferranti definition compared to the IDF definition. The prevalence was not significantly different in boys and girls. Further studies to investigate the most suitable definition of MetS for Iranian adolescents are necessary.

Keywords: Metabolic Syndrome, Adolescence, International Diabetes Federation and De Ferranti

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Introduction

The prevalence of metabolic syndrome (MetS) is on the rise as a result of the global epidemic of obesity among children and adolescents.[1] There are different definitions of MetS including those provided by the Third National Health and Nutritional Survey (NHANES III), the International Diabetes Federation (IDF), and the World Health Organization (WHO).[2,3] The prevalence of MetS differs within the same population based on each definition.[4,5] Different studies have shown that MetS increases with age, but the frequency depends on the studied population and the applied definition. The

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NHANES IIIreported the prevalence of MetS as 4.2% in teenagers.[6] A study on 9-10 year-old children in Tehran (Iran) suggested the prevalence of MetS based on IDF, NHANES III, the American Heart Association (AHA), and Adult Treatment Panel III (ATP III) as 1.5%, 5.9%, 17.8%, and 5.8%, respectively. It found the values to be significantly higher in boys than in girls. It also showed the prevalence of MetS based on the ATP III definition to be 2.2% among normal weight children and 62.2% among obese children.[7] Weiss et al. showed that increased prevalence of MetS was directly related to obesity in children and adolescents.[8] The difference in the frequency of this syndrome in children and adolescents is related to different definitions used.[5,9-11] The cut-off point specified for MetS definition differs probably due to the lack of a gold standard for the diagnosis of MetS in adolescents. The place of residence is also important in determining the prevalence of MetS. A previous study calculated the prevalence of MetS in urban and rural adults of Isfahan (Iran) as 24.2% and 19.5%, respectively.[12]

The definitions developed by IDF and De Ferranti and Osganian[5] (which we call the De Ferranti's definition throughout this paper) appear to be more efficient for determining the prevalence of MetS in adolescents.[3-5] Increasing prevalence of MetS has an important role in the increased prevalence of other diseases and mortality at older ages. To the best of our knowledge, no Iranian study has evaluated MetS in school children based on the two mentioned definitions. Due to the absence of estimates of the prevalence of the MetS using the mentioned definitions, we analyzed data from an American sample of children and adolescents to estimate the prevalence of the syndrome and to examine demographic variation in its prevalence. Our results provide the first data of the prevalence of the MetS using the definitions provided by the pediatric IDF and De Ferranti among a representative sample of Iranian adolescents.

Materials and Methods

This study was a part of the Healthy Heart from Childhood (HHC) project which was in turn one of the 10 projects forming the Isfahan Healthy Heart Program (IHHP) conducted from 2000 to 2007 in Isfahan, Najafabad, and Arak (all in Iran).[13,14] The IHHP was a community-based interventional program that was performed to prevent and control cardiovascular diseases and to promote healthy lifestyle. While the intervention community comprised urban and rural regions in Isfahan and Najafabad, Arak was studied as the control area. Details relating to the methodology, sampling, and study populations of HCC are noted elsewhere.[15]

In summary, 1039 junior high school and 953 high school students in Isfahan and Najafabad were selected by multistage random sampling. Validated questionnaires were used to collect sociodemographic data. Parents of all participating students signed informed consent forms. This study was approved by the Ethics Committee of the Isfahan Cardiovascular Research Center (a WHO collaborating center).

Fasting blood samples were taken from all participants to measure blood sugar, total cholesterol, and triglyceride levels using the enzymatic methods. The amount of high-density lipoprotein cholesterol (HDL-C) was determined by heparin-manganese precipitation. LDL was estimated using the Friedewald equation.[15] All tests were performed at the laboratory of the Isfahan Cardiovascular Research Center which had been validated by national and international authorities. In order to measure weight, height, and waist circumference (WC), the participants were asked to wear light clothes and to take off their shoes. They stood upright on a scale after it had been reset and their weight was measured to a standard error of 1%. The participants' right hand blood pressure was measured twice after a five-minute rest and the mean value was recorded as their blood pressure. All measurements were performed by trained individuals.

MetS was defined according to the definitions suggested by the IDF and De Ferranti.[3-5] The IDF defines MetS as the presence of at least three of the following criteria: 1) WC $\geq 90^{th}$ percentile, 2) serum triglyceride $\geq$ 150 mg/dl, 3) HDL-C < 40 mg/dl, 4) systolic and diastolic blood pressure $\geq 90^{th}$ percentile, and 5) fasting blood sugar (FBS) > 100 mg/dl. De Ferranti De Ferranti consider all the above-mentioned criteria except for WC $\geq 75^{th}$ percentile and serum triglyceride > 100 mg/dl.[5]

Statistical analysis

Data was entered in Epi Info 2000 and analyzed with SPSS for Windows 15.0 (SPSS Inc., Chicago, IL, USA). Comparisons of the prevalence of MetS based on sex in the two school levels were performed using chi-square test and Fisher's exact tests (if required). P values less than 0.05 were considered significant.

Results

Of the 978 female adolescents (500 junior high school and 478 high school students) and 1014 male adolescents (539 junior high school and 475 high school students), 1532 students were from urban areas and 460 from rural regions. The mean age of the junior high school and high school students was 13.11 ± 1.21 and 15.93 ± 1.07 years old, respectively.

In general, the prevalence of MetS was 4.8% based on the IDF's definition and 12.7% based on the De Ferranti's definition (Table 1). Based on the IDF's definition, the prevalence of MetS in boys of all grades was significantly higher than in girls. However, there was no significant relation between the prevalence of MetS and school grade either boys or girls. Similarly, the definition provided by De Ferranti revealed the prevalence of MetS to be significantly higher in male junior high school students than in girls of the same level (15.8% vs. 10.2%; P = 0.012). However, no significant difference was observed between boys and girls in high school (11.5% vs. 13.0%; P = 0.510). Furthermore, the overall prevalence of MetS was higher in all grades and both sexes according to the De Ferranti's definition compared to the IDF's definition (13.2 and 12.3 vs. 5.3 and 4.2).

Table 2 shows the components of MetS stratified based on sex, school, and the two definitions. Using both definitions, the prevalence of hypertriglyceridemia, low HDL-C, and hypertension was higher than other components. Based on the IDF's definition, low HDL-C and hypertension and based on the De Ferranti's definition, abdominal obesity and hypertriglyceridemia were the most prevalent components. In junior high school students, hypertension and high FBS level were significantly higher in boys than in girls. Moreover, boys in junior high schools had significantly higher blood pressure than boys in high schools. Although the prevalence of MetS in male and female high school students was not significantly different, a significantly higher prevalence was observed in boys in junior high schools than in the girls of the same age.

Base on the IDF's definition, the frequency of hypertriglyceridemia in girls was higher in junior high schools than in high schools (15.1% vs. 6.4%; P < 0.001). In addition, the frequency of hypertriglyceridemia in boys was significantly higher than that in girls (P = 0.003). Based on the De Ferranti's definition, the frequency of hypertriglyceridemia in girls in junior high schools was higher than that in boys of the same age and higher than that in high school girls. Using both definitions resulted in significantly higher frequency of abdominal obesity among junior high school boys than in girls (P < 0.001). However, this difference was not significant in high school students.

Discussion

This was the first study to compare the prevalence of MetS in female and male junior high school and high school students from two districts in Iran based on definitions provided by the IDF and De Ferranti. The prevalence of MetS was three-fold higher when our measurements were based on the De Ferranti's definition compared to the IDF's definition irrespective of sex and school grade. Previous studies on MetS in adolescents and adults have reported different results in different parts of the world. The prevalence of MetS has been calculated as 3.0-11.0% in Europe,[16] 2.5-12.9% in the U.S.,[17] 3.6% in Brazil,[18] and 4.8% in Greece.[19]

Table 1. Prevalence of metabolic syndrome based on sex and school level according to the definitions by the International Diabetes Federation (IDF) and De Ferranti and Osganian[5]

Metabolic syndrome			Girls	Boys	Total	P
Based on the IDF's definition	Junior high school	Number	14	37	51	0.005
		Percent (SE)	3.1 (0.8)	7.2 (1.1)	5.3 (0.7)	
	High school	Number	11	28	39	0.008
		Percent (SE)	2.4 (0.7)	5.9 (1.1)	4.2 (0.7)	
	Total	Number	25	65	90	< 0.001
		Percent (SE)	2.8 (0.5)	6.6 (0.8)	4.8 (0.5)	
	P		0.530	0.430	0.280	---------
Based on the De Ferranti's definition	Junior high school	Number	46	81	127	0.012
		Percent (SE)	10.2 (1.4)	15.8 (1.6)	13.2 (1.1)	
	High school	Number	52	61	113	0.510
		Percent (SE)	11.5 (1.5)	13.0 (1.5)	12.3 (1.1)	
	Total	Number	98	142	240	0.022
		Percent (SE)	10.9 (1.0)	14.4 (1.1)	12.7 (0.8)	
	P		0.540	0.210	0.540	---------

SE: Standard error P values were obtained from chi-square test.

Table 2. Frequency of metabolic syndrome components based on sex and school level according to the definitions by the International Diabetes Federation (IDF) and De Ferranti and Osganian[5]

Component of metabolic syndrome			Girls	Boys	Total	P
High blood pressure	Junior high school	Number	117	167	284	0.007
		Percent (SE)	23.7 (1.9)	31.2 (2.0)	27.6 (1.4)	
	High school	Number	83	87	170	0.780
		Percent (SE)	17.7 (1.8)	18.4 (1.8)	18.0 (1.3)	
	Total	Number	200	254	454	0.020
		Percent (SE)	20.8 (1.3)	25.2 (1.4)	23.0 (0.9)	
		P	0.021	< 0.001	< 0.001	--------
Low high-density lipoprotein cholesterol	Junior high school	Number	114	133	247	0.87
		Percent (SE)	25.3 (2.1)	25.8 (1.9)	25.6 (1.4)	
	High school	Number	102	147	249	0.004
		Percent (SE)	22.7 (1.9)	31.3 (2.1)	27.1 (1.5)	
	Total	Number	216	280	496	0.031
		Percent (SE)	24.0 (1.4)	28.4 (1.4)	26.3 (1.0)	
		P	0.36	0.056	0.45	--------
High fasting blood sugar	Junior high school	Number	11	38	49	0.001
		Percent (SE)	2.4 (0.7)	7.4 (1.1)	5.1 (0.7)	
	High school	Number	15	28	43	0.058
		Percent (SE)	3.3 (0.8)	5.9 (1.1)	4.6 (0.7)	
	Total	Number	26	66	92	< 0.001
		Percent (SE)	2.9 (0.5)	6.7 (0.8)	4.9 (0.5)	
		P	0.440	0.370	0.670	--------
High triglyceride base on the IDF's definition	Junior high school	Number	68	63	131	0.190
		Percent (SE)	15.1 (1.7)	12.2 (1.4)	13.6 (1.1)	
	High school	Number	29	57	86	0.003
		Percent (SE)	6.4 (1.1)	12.1 (1.5)	9.3 (0.9)	
	Total	Number	97	120	217	0.340
		Percent (SE)	10.8(1.0)	12.2(1.0)	11.5(0.7)	
		P	< 0.001	0.940	0.004	--------
High TG Base on De Ferranti's definition	Junior high school	Number	244	232	476	0.004
		Percent (SE)	54.2 (2.3)	45.0 (2.2)	49.3 (1.6)	
	High school	Number	179	199	378	0.450
		Percent (SE)	39.7 (2.3)	42.2 (2.3)	41.0 (1.6)	
	Total	Number	423	431	854	0.15
		Percent (SE)	46.9 (1.7)	43.7 (1.6)	45.2 (1.1)	
		P	< 0.001	0.360	< 0.001	--------
High waist circumference base on the IDF's definition	Junior high school	Number	30	65	95	0.001
		Percent (SE)	6.1 (1.1)	12.1 (1.4)	9.2 (0.9)	
	High school	Number	35	49	84	0.100
		Percent (SE)	7.4 (1.2)	10.4 (1.4)	8.9 (0.9)	
	Total	Number	65	114	179	<0.001
		Percent (SE)	6.7 (0.8)	11.3 (1.0)	9.1 (0.6)	
		P	0.410	0.390	0.810	--------
High waist circumference base on the De Ferranti's definition	Junior high school	Number	79	141	220	< 0.001
		Percent (SE)	16.0 (1.6)	26.3 (1.9)	21.3 (1.3)	
	High school	Number	92	108	200	0.190
		Percent (SE)	19.5 (1.8)	23.0 (1.9)	21.2 (1.3)	
	Total	Number	171	249	420	< 0.001
		Percent (SE)	17.7 (1.2)	24.8 (1.4)	21.3 (0.9)	
		P	0.150	0.220	0.940	--------

P values were obtained from chi-square test.

The prevalence of MetS in Germany was 4.0%,9.5%, 7.6%, and 9.6% based on a definition suggested by Cook et al.,[9] the De Ferranti's definition, the Jolliffe and Janssen's definition,[11] and the IDF's definition, respectively.[5]

In the present study, based on both the De Ferranti's and the IDF's definitions, the prevalence of MetS was higher among boys than among girls in all grades. While based on the IDF's definition, the prevalence of MetS was higher in junior high school girls than in high school girls, evaluations based on the De Ferranti's definition did not show a similar significant difference. In contrast, applying the De Ferranti's definition revealed higher prevalence of MetS in junior high school boys than in high school boys. These differences are related to differences in the cut-off points for WC and serum triglycerides in the two definitions. The prevalence of hyper-triglyceridemia was higher among girls than among boys in junior high schools using both definitions. This difference can be attributed to the age of puberty in girls which can affect triglyceride levels.

Various definitions of pediatric MetS have been used in different populations. Cook et al. reported lower prevalence in adolescents since they used more limited lipid and abdominal obesity cut-off points. They in fact translated the adult definition of MetS to pediatric percentiles. For instance, a higher triglyceride cut-off point of 110 mg/dl represents the 85th to 95th pediatric percentiles which is higher than the adult range (75th to 85th percentiles). The HDL-C level of 40 mg/dl represents the 10th to 25th percentiles in boys and the 10th to 15th percentiles in girls (lower than the 40th percentile in adults).[9] Moreover, their waist circumference cut-off point of the 90th percentile[9] is higher than the 75th percentile used in the present study. In contrast to other criteria, De Ferranti De Ferranti considered the effects of gender, age, and puberty and provided a pediatric definition based on the more inclusive ATP III adult criteria.[5]

The definitions suggested by De Ferranti and Osganian[5] and the IDF have been used more commonly than other definitions of MetS in recent years. Although their prevalence and cut-off points differ, it seems that both definitions are effective in determining MetS in adolescents.[20] The advantage of the De Ferranti's definition is that it is completely based on the ATP III which is recommended as a standard definition for determining the prevalence of MetS in adults.[2] A study in Mashhad (Iran) reported the prevalence of MetS based on ATP III to be 6.5% in high school girls.[21]

Although the etiology of MetS is not yet known, factors such as genetics, metabolism, and several environmental factors affect its occurrence.[22] The high prevalence of MetS in junior high schools compared to high schools can be attributed to the lifestyles of adolescents at this age, e.g. immobility,[23] interest in processed food, and entertainment devices such as computers and television. On the other hand, high school students pay more attention to their appearance, shape, and weight.

The importance of MetS in childhood is its impact on the health of adults. What is worrying about our studied population is the higher prevalence of other risk factors in junior high school students. In addition, we found higher prevalence of high blood pressure and FBS in junior high school boys than girls of the same age. Their prevalence was also higher among junior high school students than in high school students. Burns et al. showed that those who suffer from MetS in childhood will have systolic and diastolic hypertension, hypertriglyceridemia, and a higher body mass index in adulthood.[24] A cohort study in Japan with seven years of follow-up indicated that as the number of MetS components increased at the beginning of the study, the probability of cardiovascular diseases increased in the following years.[25]

The prevalence of obesity, which is the starting point of acquiring MetS in children and adolescents, is increasing in most parts of the world, especially in developing countries.[26] Acquiring the Western lifestyle and reduced physical activity can be responsible in this regard. It seems that obesity in one family member impacts MetS in adolescents. According to previous research, having an overweight or obese family member increases the prevalence of MetS to 7.0% in the boys and 8.1% in the girls of the family.[27,28] As obesity is turning into an epidemic among Iranian families,[22] it is necessary to pay more attention to children's lifestyle.

Conclusion

Compared to the IDF's definition, employing the De Ferranti's definition resulted in higher prevalence of MetS among junior high and high school students. Furthermore, the prevalence of MetS was higher in boys than in girls. Hence, more attention has to be paid to the definition used in determining the prevalence of MetS in adolescents. Further studies may introduce a standard definition specific for different societies and age groups.

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Conflict of Interests

Authors have no conflict of interests.

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