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

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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 ± 1.21 and 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

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

Date of submission: 02 Dec 2012, Date of acceptance: 02 Feb 2013

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

Based 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 junior high school students 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

| Metabolic syndrome | Girls | Boys | Total | P |
|--------------------|-------|------|-------|---|
| **Based on the IDF’s definition** | | | | |
| Junior high school | Number | 14 | 37 | 51 |
| | Percent (SE) | 3.1 (0.8) | 7.2 (1.1) | 5.3 (0.7) |
| High school | Number | 11 | 28 | 39 |
| | Percent (SE) | 2.4 (0.7) | 5.9 (1.1) | 4.2 (0.7) |
| Total | Number | 25 | 65 | 90 |
| | 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 |
| | Percent (SE) | 10.2 (1.4) | 15.8 (1.6) | 13.2 (1.1) |
| High school | Number | 52 | 61 | 113 |
| | Percent (SE) | 11.5 (1.5) | 13.0 (1.5) | 12.3 (1.1) |
| Total | Number | 98 | 142 | 240 |
| | 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 Osganian5

| 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) | 0.780 |
| High school                     | Number      | 83         | 87     | 170   | 0.020 |
|                                 | Percent (SE)| 17.7 (1.8) | 18.4 (1.8) | 18.0 (1.3) | 0.004 |
| Total                           | Number      | 200        | 254    | 454   | 0.021 |
|                                 | Percent (SE)| 20.8 (1.3) | 25.2 (1.4) | 23.0 (0.9) | 0.031 |
| 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) | 0.004 |
| High school                     | Number      | 102        | 147    | 249   | 0.058 |
|                                 | Percent (SE)| 22.7 (1.9) | 31.3 (2.1) | 27.1 (1.5) | 0.031 |
| Total                           | Number      | 216        | 280    | 496   | 0.021 |
|                                 | Percent (SE)| 24.0 (1.4) | 28.4 (1.4) | 26.3 (1.0) | 0.056 |
| 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) | 0.058 |
| High school                     | Number      | 15         | 28     | 43    | 0.004 |
|                                 | Percent (SE)| 3.3 (0.8)  | 5.9 (1.1) | 4.6 (0.7) | 0.190 |
| Total                           | Number      | 26         | 66     | 92    | 0.010 |
|                                 | Percent (SE)| 2.9 (0.5)  | 6.7 (0.8) | 4.9 (0.5) | 0.150 |
| 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) | 0.003 |
| High school                     | Number      | 29         | 57     | 86    | 0.340 |
|                                 | Percent (SE)| 6.4 (1.1)  | 12.1 (1.5) | 9.3 (0.9) | 0.100 |
| Total                           | Number      | 97         | 120    | 217   | 0.001 |
|                                 | Percent (SE)| 10.8 (1.0) | 12.2 (1.0) | 11.5 (0.7) | 0.004 |
| P                               | < 0.001     | 0.360      | < 0.001 | -------- |       |
| **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) | 0.450 |
| High school                     | Number      | 179        | 199    | 378   | 0.150 |
|                                 | Percent (SE)| 39.7 (2.3) | 42.2 (2.3) | 41.0 (1.6) | 0.190 |
| Total                           | Number      | 423        | 431    | 854   | 0.001 |
|                                 | Percent (SE)| 46.9 (1.7) | 43.7 (1.6) | 45.2 (1.1) | 0.100 |
| 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) | 0.001 |
| High school                     | Number      | 35         | 49     | 84    | 0.100 |
|                                 | Percent (SE)| 7.4 (1.2)  | 10.4 (1.4) | 8.9 (0.9) | 0.100 |
| Total                           | Number      | 65         | 114    | 179   | < 0.001 |
|                                 | Percent (SE)| 6.7 (0.8)  | 11.3 (1.0) | 9.1 (0.6) | 0.100 |
| 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) | 0.190 |
| High school                     | Number      | 92         | 108    | 200   | 0.001 |
|                                 | Percent (SE)| 19.5 (1.8) | 23.0 (1.9) | 21.2 (1.3) | 0.100 |
| Total                           | Number      | 171        | 249    | 420   | < 0.001 |
|                                 | Percent (SE)| 17.7 (1.2) | 24.8 (1.4) | 21.3 (0.9) | 0.100 |
| 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 hypertriglyceridemia 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 percentile9 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 Osganian5 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.
Acknowledgments

The IHHP was conducted by the Isfahan Cardiovascular Research Center with the collaboration of Isfahan Provincial Health Office. It was supported by a grant (No. 31309304) from the Iranian Budget and Planning Organization, as well as the Deputy for Health of the Iranian Ministry of Health and Medical Education and the Iranian Heart Foundation. We are thankful to the mentioned organizations and collaborators from Najafabad Health Office and Arak University of Medical Sciences.

Conflict of Interests

Authors have no conflict of interests.

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How to cite this article: Sarrafzadegan N, Gharipour M, Sadeghi M, Nouri F, Asgary S, Zarfeshani S. Differences in the prevalence of metabolic syndrome in boys and girls based on various definitions. ARYA Atheroscler 2013; 9(1): 70-6.