Prevalence of the Metabolic Syndrome in American Adolescents
Findings From the Third National Health and Nutrition Examination Survey

Sarah D. de Ferranti, MD, MPH; Kimberlee Gauvreau, ScD; David S. Ludwig, MD; Ellis J. Neufeld, MD, PhD; Jane W. Newburger, MD, MPH; Nader Rifai, PhD

Background—Metabolic syndrome (MetS) is defined by the Third Report of the Adult Treatment Panel (ATP III) using criteria easily applied by clinicians and researchers. There is no standard pediatric definition.

Methods and Results—We defined pediatric MetS using criteria analogous to ATP III as ≥3 of the following: (1) fasting triglycerides ≥1.1 mmol/L (100 mg/dL); (2) HDL <1.3 mmol/L (50 mg/dL), except in boys aged 15 to 19 years, in whom the cutoffpoint was <1.2 mmol/L (45 mg/dL); (3) fasting glucose ≥6.1 mmol/L (110 mg/dL); (4) waistcircumference >75th percentile for age and gender; and (5) systolic blood pressure >90th percentile for gender, age, and height. MetS prevalence in US adolescents was estimated with the Third National Health and Nutritional Survey 1988 to 1994. Among 1960 children aged ≥12 years who fasted ≥8 hours, two thirds had at least 1 metabolic abnormality, and nearly 1 in 10 had MetS. The racial/ethnic distribution was similar to adults: Mexican-Americans, followed by non-Hispanic whites, had a greater prevalence of MetS compared with non-Hispanic blacks (12.9%, [95% CI 10.4% to 15.4%]; 10.9%, [95% CI 8.4% to 13.4%]; and 2.5%, [95% CI 1.3% to 3.7%], respectively). Nearly one third (31.2% [95% CI 28.3% to 34.1%]) of overweight/obese adolescents had MetS.

Conclusions—Our definition of pediatric MetS, designed to be closely analogous to ATP III, found MetS is common in adolescents and has a similar racial/ethnic distribution to adults in this representative national sample. Because childhood MetS likely tracks into adulthood, early identification may help target interventions to improve future cardiovascular health. (Circulation. 2004;110:2494-2497.)

Key Words: metabolic syndrome pediatrics risk factors

The metabolic syndrome (MetS), also called insulin resistance syndrome, has been described in many ways, in part owing to the lack of a “gold standard” diagnostic test. The Adult Treatment Panel III (ATP III) defines adult MetS as ≥3 of the following abnormalities: hypertriglyceridemia, low HDL, high fasting glucose, excessive waist circumference, and hypertension, on the basis of associations with adverse cardiovascular outcomes derived from large research trials.1 Adults with MetS are at greater risk for cardiovascular disease2 and diabetes mellitus.3 Ford et al,4 using the Third National Health and Nutritional Survey (NHANES III), estimated the syndrome affected 25% of US adults.

The MetS has not been well characterized in children and adolescents in terms of criteria, prevalence, or clinical implications, although studies have examined MetS abnormalities.5,6 We propose a definition of MetS in adolescents based closely on the ATP III1 and, using NHANES III data, describe its prevalence in US children aged 12 to 19 years.

Methods
ATP III defines adult MetS as ≥3 or more of the criteria described in the Table. To generate a definition appropriate for children aged 12 to 19 years, we extrapolated from adult criteria. Triglyceride (TG) and HDL cutoffpoints were taken from equivalent pediatric percentiles.7 We defined hyperglycemia using the ATP III cutoffpoint. ATP III uses waist circumference as a measure of central obesity, and percentiles for age and gender have been most associated with central obesity in children across genders and races; therefore, we used percentiles comparable to the adult male cutoffpoint of the 70th percentile.9 Because normal pediatric blood pressure varies significantly, we used the National Heart, Lung, and Blood Institute’s recommended cutoffpoint of >90th percentile for age, gender, and height.10

NHANES III is a national data set collected between 1988 and 1994, weighted to represent the population of noninstitutionalized US civilians not living on Indian reservations and aged 2 years and
older. It uses a multistage, stratified sampling design and has been well described. The present sample was drawn from children aged 12 to 19 years who underwent physical examinations and fasted before blood testing.

**Statistical Methods**

For the 1960 children aged 12 to 19 years who participated in the examination of the NHANES III survey and fasted for at least 8 hours, the prevalence of MetS was calculated overall and by gender, age group, and race or ethnicity. Because of the survey’s complex sampling design, estimates and standard errors were calculated in Stata with the sampling weights provided, to be representative of the civilian, noninstitutionalized US population. Sample weights are adjusted for nonresponse. For estimates of prevalence, subjects with missing information on MetS criteria were assumed not to have met that criterion. A second set of estimates was calculated solely for subjects with nonmissing data for all 5 criteria. MetS prevalence was also estimated in the subgroup of adolescents with body mass index ≥85th percentile for age and gender.

**Results**

Low HDL, hypertriglyceridemia, and central obesity were common among the present sample, whereas hyperglycemia and hypertension were infrequent (Figure 1). As in adults, hypertriglyceridemia and low HDL were most common among non-Hispanic whites and least common among non-Hispanic blacks, whereas Mexican-Americans had the greatest prevalence of high waist circumference (data not shown). For the 1707 adolescents with complete data were analyzed, the prevalence of 3 or more elements of MetS was slightly higher (10.1% [95% CI 8.5% to 11.7%] versus 9.2%) and the CI was slightly wider. Among children with BMI ≥85th percentile for age and gender, the prevalence of MetS was 31.2% [95% CI 28.3% to 34.1%].

**Discussion**

Using a pediatric definition based closely on ATP III, we found the prevalence of MetS in US children aged 12 to 19 years was approximately 1 in 10. In overweight/obese children, a notable 1 in 3 had MetS. Moreover, two thirds of all adolescents had at least 1 metabolic abnormality. Our findings are consistent with research in young adults, in whom the 10-year incidence of MetS was 8% to 12% in the nonobese and 34% to 41% in the obese, although this definition used more extreme lipid cutoffs and body mass index instead of waist circumference. Our results are not surprising in view of the high and rising rates of obesity and type 2 diabetes mellitus in US children.

Pediatric researchers have investigated individual metabolic abnormalities that increase cardiovascular risk and found they track from childhood to adulthood, leading one to suspect MetS might also track into adulthood. Typically, four or more abnormalities were found in 35 children (1.6%); no child had all 5 criteria. Mexican-Americans, followed by non-Hispanic whites, had a greater prevalence of MetS compared with non-Hispanic blacks (12.9% [95% CI 10.4% to 15.4%], 10.9% [95% CI 8.4% to 13.4%], and 2.5% [95% CI 1.3% to 3.7%, respectively). Figure 2 shows the prevalence of MetS by gender and race/ethnicity. Information was not available on every criterion for all participants. When the 1707 adolescents with complete data were analyzed, the prevalence of 3 or more elements of MetS was slightly higher (10.1% [95% CI 8.5% to 11.7%] versus 9.2%) and the CI was slightly wider. Among children with BMI ≥85th percentile for age and gender, the prevalence of MetS was 31.2% [95% CI 28.3% to 34.1%].

**Pediatric Definitions of MetS**

<table>
<thead>
<tr>
<th>Adult Definition*</th>
<th>Percentiles</th>
<th>Proposed Pediatric Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypertriglyceridemia</td>
<td>≥1.65 mmol/L</td>
<td>75th (male); 85th (female)</td>
</tr>
<tr>
<td>Low HDL</td>
<td>&lt;1.04 mmol/L (men); &lt;1.33 mmol/L (women)</td>
<td>40th</td>
</tr>
<tr>
<td>High fasting glucose</td>
<td>≥6.1 mmol/L</td>
<td>NA</td>
</tr>
<tr>
<td>Central obesity (waist circumference)</td>
<td>&gt;102 cm (men); &gt;88 cm (women)</td>
<td>72nd (male); 53rd (female)</td>
</tr>
<tr>
<td>Hypertension</td>
<td>SBP ≥130 mm Hg; DBP ≥80 mm Hg</td>
<td>NA</td>
</tr>
</tbody>
</table>

*ATP III. To convert SI to conventional units, divide mmol/L by 0.0113 for triglycerides, 0.0259 for HDL, and 0.0555 for glucose.
童年期的肥胖预测了代谢综合症（MetS）在成年期的发展。代谢综合症是一个重要的影响因素，青少年期的代谢综合症体脂百分数高于正常体重控制的人。肥胖独自增加了高血压、胆囊炎和滑脱性髋关节发育不良的危险，并与心理社会症状有关。17

不同的定义和研究手段已经使用了各种定义。魁北克家庭队列研究14使用皮下脂肪测量和血液血压，标准更为具体，以适应儿童的特殊需要，并且基于ATP III中的脂质水平。19

高危美国人口中的肥胖儿童，39%的MetS被定义为以BMI而不是腰围为基础。在高风险的美国白人人群中，BMI是ATP III中腰围和脂质水平的变化率的指征。在现有定义中，使用ATP III中更极端的脂质水平和腹部脂肪水平的指征，导致较高的年龄和性别百分比。儿科定义的代谢综合症，检测到腹部脂肪水平，体重测量和24小时血压监测。在高危非裔美国人的研究中，39%的MetS被定义为以BMI为基础的腰围和腹部脂肪水平的变化率。20

在多民族人群中，质子密度受质子密度影响。质子密度受质子密度影响，可以更好地反映其病理生理学和与心血管疾病的关系。18

我们的研究应该在注意其局限性的背景下进行。主要的限制是，研究结果可能基于MetS的定义的不同，导致到儿科定义。我们使用了标准的胆固醇切点，以形成ATP III和国家胆固醇教育项目（NCEP）指南。胆固醇水平，特别是在儿童中，受剖面图影响。21

我们使用了标准的胆固醇切点，以形成ATP III和国家胆固醇教育项目（NCEP）指南。胆固醇水平，特别是在儿童中，受剖面图影响。21

控制这一值的年龄-性别-腰围百分位数。这一定义是ATP III中的标准，广泛认可的代谢综合症，使用更严格的胆固醇教育项目和儿童和影响儿童的干预措施的需要。理解代谢综合症的代谢综合症可能促进干预和研究；进一步的研究将更好地反映其病理生理学和与心血管疾病的关系。22

参考文献


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