Instability in the Diagnosis of Metabolic Syndrome in Adolescents

Elizabeth Goodman, MD; Stephen R. Daniels, MD, PhD; James B. Meigs, MD, MPH; Lawrence M. Dolan, MD

Background—Factor analyses suggest that the structure underlying metabolic syndrome is similar in adolescents and adults. However, adolescence is a period of intense physiological change, and therefore stability of the underlying metabolic structure and clinical categorization based on metabolic risk is uncertain.

Methods and Results—We analyzed data from 1098 participants in the Princeton School District Study, a school-based study begun in 2001–2002, who were followed up for 3 years. We performed factor analyses of 8 metabolic risks at baseline and follow-up to assess stability of factor patterns and clinical categorization of metabolic syndrome. Metabolic syndrome was defined using the current American Heart Association/National Heart, Lung, and Blood Institute definition for adults (AHA), a modified AHA definition used in prior pediatric metabolic syndrome studies (pediatric AHA), and the International Diabetes Federation (IDF) guidelines. We found that factor structures were essentially identical at both time points. However, clinical categorization was not stable. Approximately half of adolescents with baseline metabolic syndrome lost the diagnosis at follow-up regardless of the definitions used: pediatric AHA=56% (95% confidence interval [CI], 42% to 69%), AHA=49% (95% CI, 32% to 66%), IDF=53% (95% CI, 38% to 68%). In addition to loss of the diagnosis, new cases were identified. Cumulative incidence rates were as follows: pediatric AHA=3.8% (95% CI, 2.8% to 5.2%); AHA=4.4% (95% CI, 3.3% to 5.9%); IDF=5.2% (95% CI, 4.0% to 6.8%).

Conclusions—During adolescence, metabolic risk factor clustering is consistent. However, marked instability exists in the categorical diagnosis of metabolic syndrome. This instability, which includes both gain and loss of the diagnosis, suggests that the syndrome has reduced clinical utility in adolescence and that metabolic syndrome–specific pharmacotherapy for youth may be premature. (Circulation. 2007;115:2316-2322.)

Key Words: adolescents ■ insulin ■ obesity ■ syndrome X

Clustering of metabolic and clinical risk factors that predict subsequent development of disease is well established in adolescents and adults. Previous work in adults suggests that metabolic syndrome (MetS)—the clustering of hyperglycemia, hypertriglyceridemia, hypertension, low high-density lipoprotein cholesterol (HDL-C), and abdominal obesity—is independently associated with future risk of developing both type 2 diabetes mellitus and cardiovascular disease. This diagnosis is believed to be particularly valuable for identifying overweight or obese individuals at higher likelihood for developing disease and helping to motivate these individuals to address their risks. Current estimates suggest that >2 million adolescents, most of whom are overweight, have a MetS phenotype. This number is expected to rise along with the prevalence of overweight and obesity in this age group, leading to fears of increasing prevalence and earlier onset of morbidity and mortality. Despite these growing concerns, application of the MetS concept to children is more controversial than to adults. At present, no consensus exists on the definition of pediatric MetS. Lack of consensus is due in part to our evolving understanding of normal developmental changes associated with childhood and puberty. These changes in metabolic and clinical characteristics impede agreement on criteria to define pediatric MetS.

The difficulties in creating a pediatric MetS definition highlight the differences between MetS as a concept and MetS as a diagnostic category. The concept is based on...
clustering along an entire physiological spectrum, whereas the diagnostic category is based on dichotomies. Clustering of metabolic risk appears constant across development, but less is known about the stability of clinical diagnosis of MetS, especially in pediatric populations.6,20,21 The potential instability in the diagnosis of MetS is perhaps highest in adolescence, when pubertal growth and development, which influence a number of the metabolic traits used to define MetS, may cause the levels of these risks to cross the thresholds used in defining MetS. Such threshold crossings can be independent of the clustering phenomenon, but no studies to date in either adult or adolescent populations have assessed the stability of both metabolic risk factor clustering and the clinical diagnosis.

The purpose of the present study was to address this gap in the literature. First, we determine whether the metabolic risk factor relationships assessed through factor analysis are consistent during adolescence. Second, we explore changes in the metabolic risks associated with MetS over 3 years and evaluate the stability of the clinical classification of MetS within individual young people. We address these goals in a community-based sample of adolescents using MetS definitions from the current American Heart Association (AHA) guidelines and the International Diabetes Federation (IDF) guidelines.8,22

Methods

Study Sample

Data were drawn from 1098 participants in the Princeton School District Study, a longitudinal cohort study, which began in the 2001–2002 school year, situated in a public school district near Cincinnati, Ohio.21 The sample (51.6% non-Hispanic white, 46.9% non-Hispanic black, 1.5% Hispanic; 50.5% female; mean baseline age, 15.0 years [SD = 1.6 years]; range, 12.2 to 19.3 years) included those who had a baseline physical examination and usable fasting morning blood sample and who returned for reassessment 3 years later (73% retention rate; mean length of follow-up, 2.74 years).

The authors had full access to and take full responsibility for the integrity of the data. All authors have read and agree to the manuscript as written.

Study Protocol and Measures

Data collection took place in the morning after a verified minimum 10-hour fast. The study protocol was approved by the institutional review boards of the local children’s hospital and participating university. Eight metabolic risks were assessed: waist circumference, body mass index (BMI), systolic (SBP) and diastolic (DBP) blood pressure, glucose, HDL-C, triglycerides, and insulin. Both student assent and parental consent were obtained. BMI was calculated as BMI = weight (kg)/height (m)². BMI percentiles and Z scores were based on the Centers for Disease Control growth chart data.22,23 Obesity was defined as BMI ≥ 95% or BMI ≥ 30, overweight as BMI between 85% and < 95%, and normal weight as BMI < 85%. Although these categories are often referred to as at risk for overweight for those with BMI 85% to 95% and overweight for those with BMI ≥ 95% when referring to children, we use the terms overweight and obesity, respectively, because many of these young people are ≥ 18 years and because we believe that these terms are better suited to developmental studies assessing the transition to adulthood. At baseline, SBP and DBP were assessed per protocol20 on a convenience subsample of 165 of 433 subjects with BMI ≥ 85% because of time restrictions in the school setting. Because MetS is rare in normal-weight adolescents, BMI represented a logical screening factor to obtain this initial blood pressure sample. At follow-up, blood pressure was obtained on all subjects through use of a DynaPulse Pathway instrument (Pulse Metric, Inc, San Diego, Calif).27 After a 5-minute rest, 3 blood pressure recordings were obtained and averaged for analyses. Laboratory assays assessed glucose, insulin, HDL-C, and triglycerides.23,28

Definition of MetS and Group Categorization

We term the presence of a particular metabolic risk above the cut point used in defining MetS a constituent risk. For the AHA definition, a participant was categorized as having MetS if he or she had any 3 of the following 5 constituent risks: glucose ≥ 100 mg/dL, triglycerides ≥ 150 mg/dL, HDL-C ≤ 40 mg/dL for boys and 50 mg/dL for girls, waist circumference ≥ 102 cm for boys and 88 cm for girls, or DBP ≥ 85 mm Hg, SBP ≥ 130 mm Hg.5 The waist circumference cut points recommended for Europids and sub-Saharan African populations were used in the IDF definition (94 cm for boys and 80 cm for girls) because the cohort was 98.5% non-Hispanic black and white. Other cut points were the same as those used in the AHA definition. Elevated waist circumference plus 2 of the other 4 constituent risks were required to be classified as MetS-positive per the IDF definition.22 In addition, we created a pediatric MetS definition similar to that used in prior pediatric MetS studies.15,17 The pediatric definition (pediatric AHA) was based on the adult AHA definition but used updated pediatric reference standards for blood pressure, waist circumference, triglycerides, and HDL-C. The glucose cut point was identical to that in the adult definitions (100 mg/dL). The pediatric AHA cut points for the other constituent risks were as follows: 90% for blood pressure adjusted for age, sex, and height20; 90% for waist circumference adjusted for age, sex, and race/ethnicity20; 10% for HDL-C adjusted for race and sex31; midpoint for the borderline high triglycerides range (110 mg/dL).13 Thresholds for the oldest age group were applied to subjects older than the highest age category for the blood pressure (>17 years) and waist circumference (>18 years) criteria.

Subjects were classified further on the basis of the number of times AHA-defined MetS was present into 1 of 3 groups: (1) baseline only; (2) incident (MetS at follow-up but not at baseline); and (3) persistent (MetS at both time points). We identified a fourth group of all non-Hispanic black and white subjects who were baseline overweight and MetS-free at both time points as a comparison group to assess whether the metabolic changes in the MetS groups differed from a group of those who remained MetS-free. The comparison group was composed of 291 individuals (74 white boys, 81 black boys, 49 white girls, and 87 black girls). Eighty-three individuals who, at baseline, were missing information on blood pressure and had 2 AHA-defined constituent risks and therefore may have been baseline AHA-defined MetS-positive were excluded from the MetS group comparisons.

Statistical Analyses

Analyses were performed with SPSS for Windows (SPSS, Inc, Chicago, Ill). To identify the factor structure at baseline and follow-up, we performed principal components analysis, which is a type of exploratory factor analysis, using an eigenvalue of 1 as the extraction method and Varimax rotation. Variables with factor loading ≥ 0.4 were used in interpreting factors. Instability was defined as the percentage of baseline MetS-positive youth who were MetS-negative at follow-up. Cumulative incidence was defined as the proportion of new cases from those who had been MetS-negative at baseline. Instability and cumulative incidence were calculated for each definition. Because most MetS-positive youth are obese, MetS prevalence at baseline and follow-up, instability, and cumulative incidence, along with their 95% confidence intervals (CIs), are reported for the total and the subgroup of those who were obese at baseline.

For statistical testing, α was set at 0.05. Because the distribution of most of the metabolic risks was skewed, Kruskal-Wallis tests were used to determine whether within-person changes in the 8 metabolic risks differed by MetS group assignment. These tests for group differences were also performed on height and weight. In addition, we assessed whether the proportion of subjects with threshold
crossings differed among the 4 groups. We ran $\chi^2$ analyses for each of the 6 possible pairwise combinations among the 4 groups. Because multiple comparisons were involved in the tests for group differences of both continuous and categorical variables, probability values were adjusted with the use of Hochberg’s method.32

Results

Metabolic Risks and Weight Status

Table 1 describes the distribution of metabolic risks in these 1098 adolescents. Baseline prevalence of overweight was 19.8% and of obesity was 19.7%. At follow-up, 20.1% were overweight and 20.4% obese. At follow-up, 14.3% of normal-weight youth, 21.4% of youth with a BMI $\geq 85\%$, and 77.9% of baseline obese youth were obese.

Factor Structure Stability

Three factors (Table 2) were extracted at both baseline and follow-up. These included an adiposity factor (insulin, BMI, waist circumference), a metabolic factor (triglycerides, HDL-C), and a blood pressure factor (SBP, DBP). Factor loadings and the amount of variance explained were very similar at both time points. The major difference was that glucose loaded on the metabolic factor at baseline and on the adiposity factor at follow-up. Also of note was that insulin loaded on the metabolic factor and the adiposity factor at baseline but only on the adiposity factor at follow-up. Overall, these differences were minor and suggest that the factor structure is stable.

Stability of the MetS Diagnosis

Table 3 provides information on the baseline and follow-up prevalences, as well as proportion of subjects who lost or gained the diagnosis. At baseline, 37 adolescents fulfilled the AHA definition for MetS, 57 the pediatric AHA definition, and 49 the IDF definition. At follow-up, these numbers had increased to 66 for the AHA definition, 65 for the pediatric AHA definition, and 78 for the IDF definition. The number of new cases was greater than would have been expected from the prevalence data because the diagnosis was unstable in approximately half of those who were MetS-positive at baseline (Table 3, Figure). The pediatric-specific definition had a higher degree of instability than the either of the 2 adult definitions, although CIs overlapped considerably. This pattern was also found among baseline obese MetS-positive youth, >90% of whom remained obese (93% AHA, 92% IDF, 90% pediatric AHA; $P=NS$).

### Table 1. Description of Metabolic Risks in 1098 Princeton School District Study Participants

<table>
<thead>
<tr>
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<th>Baseline</th>
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<th>Follow-Up</th>
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<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Median</td>
<td>IQ Range</td>
<td>Mean</td>
<td>SD</td>
<td>Median</td>
<td>IQ Range</td>
</tr>
<tr>
<td>Age, y</td>
<td>15.0</td>
<td>1.6</td>
<td>14.8</td>
<td>2.4</td>
<td>17.7</td>
<td>1.5</td>
<td>17.6</td>
<td>2.2</td>
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<td>Insulin, pmol/L</td>
<td>131.5</td>
<td>114.6</td>
<td>100.0</td>
<td>84.8</td>
<td>120.9</td>
<td>125.4</td>
<td>85.0</td>
<td>76.4</td>
</tr>
<tr>
<td>BMI</td>
<td>23.8</td>
<td>5.9</td>
<td>22.4</td>
<td>6</td>
<td>25.5</td>
<td>6.5</td>
<td>23.8</td>
<td>6.9</td>
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<td>0.71</td>
<td>1.05</td>
<td>0.70</td>
<td>1.51</td>
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<tr>
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<td>85.9</td>
<td>9.2</td>
<td>85.7</td>
<td>11.8</td>
<td>76.3</td>
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<td>76.1</td>
<td>11.5</td>
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<td>Waist circumference,* cm</td>
<td>79.6</td>
<td>13.9</td>
<td>76.1</td>
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<tr>
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<td>69.6</td>
<td>7.6</td>
<td>69.0</td>
<td>10.3</td>
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<tr>
<td>HDL-C,* mg/dL</td>
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<td>11.0</td>
<td>45</td>
<td>14</td>
<td>48.0</td>
<td>11.7</td>
<td>46</td>
<td>14</td>
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<tr>
<td>Triglycerides, mg/dL</td>
<td>77.2</td>
<td>42.6</td>
<td>67.5</td>
<td>35</td>
<td>82.6</td>
<td>51.7</td>
<td>69</td>
<td>42</td>
</tr>
</tbody>
</table>

*IQ indicates interquartile.
*A risk factor used in defining MetS.

<table>
<thead>
<tr>
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<td>IQ Range</td>
<td>Mean</td>
<td>SD</td>
<td>Median</td>
<td>IQ Range</td>
</tr>
<tr>
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<td>$\quad$</td>
<td>$\quad$</td>
<td>$\quad$</td>
<td>$\quad$</td>
<td>$\quad$</td>
<td>$\quad$</td>
<td>$\quad$</td>
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</tr>
<tr>
<td>Insulin</td>
<td>0.52‡</td>
<td>0.43‡</td>
<td>$-0.06$</td>
<td>$\quad$</td>
<td>0.66‡</td>
<td>0.29</td>
<td>$-0.02$</td>
<td>$\quad$</td>
</tr>
<tr>
<td>BMI</td>
<td>0.92‡</td>
<td>0.06</td>
<td>0.05</td>
<td>$\quad$</td>
<td>0.86‡</td>
<td>0.007</td>
<td>0.18</td>
<td>$\quad$</td>
</tr>
<tr>
<td>Waist</td>
<td>0.93‡</td>
<td>0.13</td>
<td>0.12</td>
<td>$\quad$</td>
<td>0.85‡</td>
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</tr>
<tr>
<td>Triglycerides</td>
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<td>0.66‡</td>
<td>0.09</td>
<td>$\quad$</td>
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<tr>
<td>Glucose</td>
<td>$-0.06$</td>
<td>0.73‡</td>
<td>0.004</td>
<td>$\quad$</td>
<td>0.44‡</td>
<td>0.11</td>
<td>0.07</td>
<td>$\quad$</td>
</tr>
<tr>
<td>DBP</td>
<td>0.06</td>
<td>$-0.08$</td>
<td>0.83‡</td>
<td>$\quad$</td>
<td>0.06</td>
<td>0.06</td>
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</tr>
<tr>
<td>SBP</td>
<td>0.03</td>
<td>0.16</td>
<td>0.82‡</td>
<td>$\quad$</td>
<td>0.26</td>
<td>0.09</td>
<td>0.87‡</td>
<td>$\quad$</td>
</tr>
</tbody>
</table>

Variance explained, %

Table 2 provides information on the baseline and follow-up prevalences, as well as proportion of subjects who lost or gained the diagnosis. At baseline, 37 adolescents fulfilled the AHA definition for MetS, 57 the pediatric AHA definition, and 49 the IDF definition. At follow-up, these numbers had increased to 66 for the AHA definition, 65 for the pediatric AHA definition, and 78 for the IDF definition. The number of new cases was greater than would have been expected from the prevalence data because the diagnosis was unstable in approximately half of those who were MetS-positive at baseline (Table 3, Figure). The pediatric-specific definition had a higher degree of instability than the either of the 2 adult definitions, although CIs overlapped considerably. This pattern was also found among baseline obese MetS-positive youth, >90% of whom remained obese (93% AHA, 92% IDF, 90% pediatric AHA; $P=NS$).

### Table 2. Rotated Factor Loadings From Exploratory Factor Analysis

<table>
<thead>
<tr>
<th></th>
<th>Baseline*</th>
<th></th>
<th></th>
<th></th>
<th>Follow-Up†</th>
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<td>Blood Pressure</td>
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<tr>
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<td>0.13</td>
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<tr>
<td>Triglycerides</td>
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<td>0.09</td>
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<tr>
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<td>$\quad$</td>
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</table>

*Total variance explained = 62.1%  
†Total variance explained = 65.4%  
‡Factor loading was used in interpretation of the factor structure (loading >0.4).
Group Comparisons

Obesity was highly prevalent in all MetS groups, ranging from 63.3% at baseline in the incident group to 94.7% at follow-up in the persistent group. Table 4 describes group comparisons in the distribution of metabolic risks. Significant group differences were demonstrated for HDL, triglycerides, SBP, waist circumference, BMI, height, and weight. Insulin levels, glucose, and DBP were not significantly different between groups.

The diagnosis of MetS is based on categorization of metabolic risks into constituent risks. Prevalence of each constituent risk is noted in Table 5. All those with MetS at baseline (persistent and baseline only groups) had low HDL-C. High waist circumference was the next most common risk, and hyperglycemia was the rarest. This pattern of risks was also seen in the incident MetS group. In the MetS-free group, low HDL-C was also highly prevalent. High waist circumference was less prevalent in this group, perhaps because of the lower proportion of obese youth. Among the 109 obese youth in the MetS-free group, low HDL-C was the most prevalent baseline risk (45.9%), followed by high waist circumference (32.1%) and then high blood pressure (7.3%), hyperglycemia (4.6%), and hypertriglyceridemia (2.8%). At follow-up, high waist circumference (55.0%) had succeeded low HDL-C (38.5%) as the most common risk in the obese MetS-free subjects.

When the variability in a metabolic risk between baseline and follow-up caused its level to cross the threshold used in defining MetS, a change in that particular constituent risk occurred. The total number of such threshold crossings, which were demonstrated in all groups, is found in the bottom row of Table 5. In the baseline only MetS group, 61.1% lost 1 constituent risk, 22.2% lost 2 constituent risks, and 10.0% lost 3 constituent risks. Conversely, in the incident MetS group, 53.3% gained 2 constituent risks, 36.7% gained 1 constituent risk, 10.0% gained 3 constituent risks, and none lost a constituent risk. In the persistent MetS, the proportion who gained or lost constituent risks was more equal (31.6% gained 1 constituent risk, and 47.4% lost a constituent risk). In the MetS-free group, changes also occurred in both directions, but gain in risks was more common than loss of risks; 25.5% gained at least 1 constituent risk, and 8.2% lost 1 constituent risk. Differences in threshold crossings between the persistent group and both the incident MetS and MetS-free groups were not statistically significant. All other pairwise between-group differences in threshold crossings were statistically significant.

Discussion

This study demonstrates 2 important points about MetS in youth. First, the replicability of the factor structure suggests that the overall clustering of metabolic risks, which provides the conceptual underpinnings for MetS, does not change during adolescence. Second, the frequent instability of the clinical diagnosis of MetS within individual young people suggests that the clinical utility of the syndrome is reduced among adolescents. Furthermore, because the insulin changes in this observational study did not distinguish between MetS groups, our findings suggest that changes in fasting insulin during adolescence do not cause short-term changes in metabolic risk. Whether such developmental changes cause alterations in metabolic risks over a longer time frame requires further investigation.

These findings have important implications for both investigators and clinicians. For researchers working to understand the developmental trajectory of cardiovascular risk clustering, the replication of the factor analysis results within this cohort demonstrates the robust nature of the linear relationships between these physiological factors. Additionally, our findings support the use of factor analysis, specifically principal components analysis, as a valuable analytical tool for investigators who want to assess dysregulation across multiple metabolic pathways. A MetS approach reduces such multiple pathway effects to a single, dichotomous outcome. In con-
trast, factor analysis allows investigators to expand their assessment of such multisystem dysregulation and can provide more detailed information on the natural history of the metabolic derangements. Factor scores from a principal components analysis may be more useful than MetS for developmental studies of heart disease risk.28

For clinicians, these data provide a note of caution. MetS was developed as a means to identify overweight adults at greatest risk for diabetes mellitus and cardiovascular disease.33 The application of this construct has not been evaluated thoroughly in children and adolescents. In addition, regardless of age, measurement variability is a critical issue when specific cut points are used to create the definition of a pathological state such as MetS. These data demonstrate that, in adolescents, significant within-person variability exists across the diagnostic thresholds during growth and development. This variability led to loss of the diagnosis in approximately half of those with baseline MetS and gain of the diagnosis in others. The high degree of diagnostic instability, whether due to measurement variability or normal physiological variation, suggests that MetS classification may not be an effective method for risk stratification in pediatrics.

In our study, the instability was greatest when a pediatric-specific, percentile-based definition of MetS was used. The definition of pediatric MetS is currently being debated. At present, pediatric studies use a multitude of strategies to define MetS for children and youth. The application of an adult-based definition is rare.23 These findings suggest that,
even if consensus is reached on definitional criteria for pediatric MetS, the problem of instability of the clinical syndrome will remain. Thus, these data call into question the utility of the concept of pediatric MetS.

The major limitation of this study is lack of baseline blood pressure data for most of the cohort. However, we had baseline blood pressure for 38.1% of youth with BMI ≥85%, who are at greatest risk for MetS, and for the entire cohort at follow-up. We were able to identify only 14 individuals (1.5%) who were missing baseline blood pressure data and had high blood pressure at follow-up, 10 of whom met criteria for MetS at follow-up. Thus, we may have slightly underestimated baseline MetS prevalence and overestimated cumulative incidence. In addition, this cohort does not provide adequate representation from racial/ethnic groups other than non-Hispanic blacks and whites, and the number of MetS-positive youth at baseline was relatively small, which limited our ability to determine predictors of instability by multivariable analyses. Balancing these limitations are the longitudinal design of our study, careful measurement of physiological risks, and use of a community-based sample, which provides greater generalizability than clinic-based samples of overweight youth.16,17

Since publication of the first article on MetS in adolescents in 2003,15 there has been growing interest in and movement toward therapeutic intervention for this syndrome in children and adolescents.17,34,35 This drive toward treatment has been fueled, in part, by reports that rising rates of obesity and concomitant MetS would lead to “epidemics” of type 2 diabetes mellitus and early cardiovascular disease in the young.16,36 Although these epidemics have not materialized,37 the focus on intervention, which would include potential use of pharmacological agents, remains.9,34,35,38–40 Our findings do not support the use of pharmacological agents, such as insulin sensitizers,17 specifically for treatment of MetS in youth. The issues we raise about MetS treatment for adolescents echo the concerns of a number of MetS experts who have suggested that the definition of the syndrome is not sensitive or specific enough to be used in treatment decisions in adults.41–44 Our data suggest that treatment of cardiovascular risk in adolescence should focus on treatment of established risks rather than MetS. Such a focus might include emphasis on exercise promotion, prevention and treatment of teen smoking, and obesity prevention and treatment. Indeed, for growing young people, encouraging and supporting weight stability during the years of long bone growth, which can be a more readily attainable goal for many than weight loss, may provide the clinician with the most effective means to reduce cardiovascular risk factor clustering and long-term risk of cardiovascular disease.

Acknowledgment

The authors thank Ralph B. D’Agostino, PhD, for statistical advice.

Sources of Funding

This study was supported by National Institutes of Health grants HD41527, DK59183, and M01RR 08084.

disclosures

Dr Meigs has received research grants from GlaxoSmithKline and Wyeth and has served on Merck’s advisory board. Dr Daniels has been a consultant to Abbott Laboratories. Drs Goodman and Dolan report no conflicts.

References

Metabolic syndrome in both adults and children is a topic of considerable debate and controversy. In the treatment of children and adolescents, interest in metabolic syndrome has been driven by soaring rates of overweight and obesity, particularly among youth. However, application of the metabolic syndrome concept to pediatric patients is more controversial than to adults. At present, no consensus exists on the definition of metabolic syndrome for children and adolescents. Although the factor structure underlying metabolic risk clustering was replicated over time, marked instability existed in the clinical diagnosis of metabolic syndrome over the 3 years. The instability was greatest when a pediatric-specific definition was used. Thus, even if consensus is reached on definitional criteria for pediatric metabolic syndrome, the problem of instability of the diagnosis remains. The marked instability calls into question the appropriateness of pediatric metabolic syndrome–specific interventions and suggests that treatment decisions for adolescents should focus on established risks, such as obesity, sedentary lifestyle, and smoking, rather than metabolic syndrome–specific pharmacotherapy.
Instability in the Diagnosis of Metabolic Syndrome in Adolescents
Elizabeth Goodman, Stephen R. Daniels, James B. Meigs and Lawrence M. Dolan

Circulation. 2007;115:2316-2322; originally published online April 9, 2007;
doi: 10.1161/CIRCULATIONAHA.106.669994

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