Goal:
To learn how to identify obese and at risk children, identify medical problems associated with obesity, and then institute a program to help the child and family combat the weight issues.

Pre-Meeting Preparation:
- Read “Obesity in Children & Adolescents”
- Read “Obesity Among Low-Income Preschool Children”
  - Update from 2012 JAMA Study
- "Metabolic Syndrome in Children and Adolescence" (PIR, 2016)
- Read “Physical Activity Guidelines” (2008; most recent)
- Read “Impact of the Healthy Habits Clinic”
- CDC Website on Childhood Obesity: Includes links to “strategies and solutions” for parents & community advocacy. Residents should select ONE of these programs or recommendations and be prepared to report in detail to the group.

Conference Agenda:
- Complete Nutrition IV Quiz & Case Studies
- Round table discussion of resident researched “strategies & solutions” to pediatric obesity. Discussions should address both anticipatory guidance for parent tips, as well as avenues for community advocacy.

Post-Conference: Board Review Q&A

Extra Credit:
- AAP’s HealthyChildren webpage on Childhood Obesity
- 95210: A Wellness & Nutrition Initiative: used by Healthy Habits Clinic
- AAP 2003 Policy Statement on Child & Adolescent Obesity (9 pgs)
OBESITY IN CHILDREN AND ADOLESCENTS
(adapted from former obesity module by Kathy Camp)

DEFINITIONS AND MEASUREMENTS
The ideal classification of obesity should accurately reflect adiposity. Adiposity, however, is difficult to measure directly. Most usable criteria currently used to define obesity rely on weight-based measures that only indirectly measure adiposity, e.g. BMI, skin fold measurements, etc. **Though not perfect, BMI has been shown to correlate with densitometry measurements, but can be inaccurate in athletes.** There is no single level of fatness in children that reliably predicts morbidity or mortality. Therefore, all current measures of obesity are only statistical. The following chart is based on the CDC definitions:

<table>
<thead>
<tr>
<th></th>
<th><strong>OVERWEIGHT</strong> (or “at risk of overweight”)</th>
<th><strong>OBESE</strong> (or “overweight”)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight for height:</td>
<td>&gt;90%</td>
<td>&gt;95%</td>
</tr>
<tr>
<td>Triceps skin fold thickness</td>
<td>&gt;85%</td>
<td>&gt;95%</td>
</tr>
<tr>
<td>BMI [kg/height in m^2]</td>
<td>&gt;85%</td>
<td>&gt;95%</td>
</tr>
</tbody>
</table>

BMI-for-age is recommended to screen children aged 2 to 20 years, in order to identify children who may need further assessment and possible treatment. **For infants and children under the age of two years, plot the weight-for-length (overweight = W:L > 95th%ile).**

BMI increases during the first year of life decreases in years 1-4; and increases again after age 5. The relationship between obesity at age 3-5 years and adult obesity is stronger than during infancy. The relationship between obesity in adolescence and adult obesity is the strongest. **While 25% of obese infants remain obese, 80% of obese adolescents will become obese adults.**

ETIOLOGY
The etiology of obesity is likely to involve a complex interaction of diet, physical activity and, not yet identified, genetic components. Each of these is impacted upon, from a population perspective, by various social and environmental factors.

Nutrition
Too much fat is eaten by children and adolescents today: Only 15% of 6-9 year-olds have diets at or below the recommended amount of energy from fat (30%). Alternatively, 15% consumed more than 40% of energy from fat.
**Fatty foods have a number of negative consequences on a child’s diet.** First, high fat foods are typically very palatable, leading to over consumption. Dietary fat intake may then displace more micronutrient-dense fibrous, carbohydrate-containing foods. High-fat foods are also less filling (higher energy/less volume); thus, subsequent consumption may not adjust for the higher energy previously consumed. Finally, dietary fat is stored more efficiently. Oxidation of dietary fat does not increase as fat intake increases, as is the case with protein and carbohydrate.

**Genetics**

If both parents are obese, 2/3 of their children will become obese. If both parents are of normal size, only 9% of their children will become obese. Obesity genes were probably preselected in early humans in a variety of combinations because they offered a survival advantage. With food availability presently plentiful and exercise significantly

**Physical activity**

Physical activity has positive effects on children's growth and maturation. There are a number of factors that influence a child’s level of physical activity:

- The percentage of time spent outdoors.
- Television viewing. The AAP recommends < 2 hours/day of screen time for all children.
- Schools often use recess to substitute for, rather than supplement physical education.
- Parents: by modeling and by creating a supportive environment. In adolescence, peer influences probably replace parental influences.

**Social context**

TV advertises high fat and sugar snack-foods with low nutritional value. Children's requests for foods are related to the frequency with which the foods were advertised on television.

**DIFFERENTIAL DIAGNOSIS OF OBESITY**

<table>
<thead>
<tr>
<th>Family History</th>
<th>Endocrine/Genetic</th>
<th>Exogenous</th>
</tr>
</thead>
<tbody>
<tr>
<td>Obesity uncommon</td>
<td>Obesity common</td>
<td></td>
</tr>
<tr>
<td>Height</td>
<td>Inappropriately short for Parental heights OR Growth Rate subnormal</td>
<td>Height&gt; 50%ile</td>
</tr>
<tr>
<td>IQ</td>
<td>Often low</td>
<td>Normal</td>
</tr>
<tr>
<td>Bone Age</td>
<td>Delayed</td>
<td>Normal or advanced</td>
</tr>
<tr>
<td>Physical Exam</td>
<td>Associated abnormalities common</td>
<td>Normal</td>
</tr>
</tbody>
</table>

Medical or endocrine causes of obesity are found in <1% of children, examples as follows:

* Endocrine causes: Cushing's Syndrome, Hypothyroidism and Pseudoparathyroidism.
If the child has a normal physical exam, normal intelligence, and is of normal stature with a normal rate of growth, there is no underlying medical or hormonal cause for the obesity.

HEALTH CONSEQUENCES OF OBESITY

The most widespread health consequences of obesity are psychosocial. Obese children are subject to early and systemic discrimination. Many individuals associate obesity with a wide variety of negative characteristics such as laziness and sloppiness. Through increased peer pressure and criticism, obese adolescents often have a negative self-image that appears to persist into adulthood; these young patients are also at higher risk for depression. Of greater interest, recent studies have reported the presence of a significant negative body image in obese children as young as 5 years of age.

An increased prevalence of behavioral and learning difficulties has also been observed among children who are gaining weight rapidly. Studies, however, do not make clear whether this reflects subtle effects from the presence of psychosocial problems within these families or from undiagnosed sleep apnea.

Medical Consequences of Obesity

- **Hypertension** - In the general pediatric population, only 1% of children exhibit a persistently elevated blood pressure. Alternatively, as many as 60% of children with persistently elevated BP have weights of greater than 120% of the median for their sex, height, and age.

- **Sleep apnea** - Sleep apnea occurs in approximately 7% of obese children. However, when distinctly evaluated, up to 1/3 of asymptomatic children with a body weight greater than 150% of ideal will describe a history of breathing difficulties during sleep and will be shown to have sleep apnea. Further, neuro-cognitive deficits have also been shown to be common among obese children with sleep apnea.

- **Orthopedic complications** - Among young children, obesity can lead to bowing of the tibia and femur. The resultant overgrowth of the medial aspect of the proximal tibia is known as Blount's disease. Although the prevalence of Blount's disease is low in the general pediatric population, approximately 2/3 of these patients are obese. Slipped capital femoral epiphyses results from the effects of increased weight on the cartilaginous growth plate of the hip. Between 30-50% of pediatric patients with SCFE are overweight.

- **PCOS** - The majority of patients diagnosed with PCOS are either overweight or obese. The syndrome is characterized by irregular menstrual cycles, multiple ovarian cysts and excessive hair growth. In addition, PCOS causes significant insulin resistance, thereby increasing the woman’s risk of developing diabetes.

- **Diabetes** - The epidemic of obesity and the low level of physical activity among young people, as well as exposure to diabetes in utero, may be major contributors to the increase in type 2 diabetes during childhood and adolescence. These children are generally between 10-19 years-old, obese, have a strong family history of TIIDM, and have insulin resistance with poor glycemic control (A1C = 10-12%). Please note that just the presence of hyperinsulinism carries an increased risk of morbidity, without the presence of frank DM.

- **Other**: Obese children and adolescents are more likely to have high cholesterol, fatty liver disease, gallstones, GERD, asthma, and pseudotumor cerebri.
TREATMENT OF OBESITY:
In general, weight loss is recommended if complications such as hyperlipidemia or hypertension are identified, and for children 7 years or older with a BMI-for-age $\geq$ 95th percentile. Otherwise, weight maintenance is recommended. Prolonged maintenance will allow a gradual decline in BMI units (and BMI-for-age percentile) as children grow in height. See the CDC algorithm:

<table>
<thead>
<tr>
<th>Recommendations for weight management for children and adolescents 2-20 years old</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 to 7 years</td>
</tr>
<tr>
<td>BMI 85th-94th %ile</td>
</tr>
<tr>
<td>Complication No</td>
</tr>
<tr>
<td>Weight Maintenance</td>
</tr>
<tr>
<td>7 years or older</td>
</tr>
<tr>
<td>BMI $\geq$ 95th %ile</td>
</tr>
<tr>
<td>Complication No</td>
</tr>
<tr>
<td>Weight Maintenance</td>
</tr>
</tbody>
</table>

Dietary components
To lose weight it is necessary to decrease caloric intake. The use/substitution of foods with more fiber may be of some help. **No particular diet has been shown to be more efficacious compared to another of equal caloric content.** There is data that foods with lower glycemic indexes (that result in less insulin release) may produce longer lasting satiety.

Exercise and activity
Increasing exercise without dietary intervention does not work, however all interventions that are effective long term include a consistent increase in exercise/physical activity. Exercise works both thru the increased consumption of calories and thru increasing insulin sensitivity. Positively reinforcing reductions in sedentary activities (e.g. TV, video games) increases physical activity of obese children more than just reinforcing increased physical activity.

Behavioral issues in pediatric obesity treatment
**Including behavior therapy in obesity training programs significantly improves outcome.** Focusing on gradual change and including families/parents in the behavior management has resulted in better outcomes. It is important to set reasonable, reachable goals. For example, a goal of 4-8 pounds per month weight loss may be reasonable in an obese adolescent, whereas decreasing or stopping the rate of weight gain would be more reasonable for an obese child. Unreasonable, unreachable goals only serve to frustrate everyone.

Negative physiologic effects of treatment
**Potential exists for impaired linear growth with overzealous treatment.** Changes in growth velocity, however, must be interpreted cautiously as obese children experience an increased growth velocity during periods of excessive weight gain and may thus subsequently experience a physiologic growth deceleration with weight maintenance or actual weight loss.
PEDIATRIC OBESITY WORK-UP
(Developed by Dr. Karen Vogt based on 2007 AAP Clinical Report)

Definition:
Body Mass Index = Weight in kilograms ÷ Height in meters²
- BMI ≥ 85% for age & gender is overweight
- BMI ≥ 95% for age & gender OR ≥30 kg/m² is obese
- For age ≤ 2 years, weight-for-length ≥ 95% is overweight

History:
- Birth history: birth weight, h/o maternal gestational diabetes
- PMHx: early FTT
- Medications: steroids, psychotropics, Depo-Provera
- Development: onset of motor/speech milestones; puberty-early/late; menstrual hx
- Dietary history: caloric intake, size of servings, frequency/number of snacks, skipping meals
- Physical activity: types & frequency, barriers to activities, screen time
- Family History: obesity, DM, HTN, CV disease, hyperlipidemia

ROS:
- Evidence of OSA: snoring, tonsillar hypertrophy
- Abdominal pain (e.g. gallbladder disease, NAFLD)
- Polyuria, polydipsia (e.g. diabetes mellitus)
- Evidence of hypothyroidism: fatigue, constipation, cold-intolerance

Physical Exam:
- Vitals: BP, HR, Ht/Wt/BMI
- General: weight distribution; evidence of genetic syndrome (e.g. PWS, Albright hereditary osteodystrophy, Down Syndrome, Fragile X).
- HEENT: fundoscopic (evidence of papilledema?); enlarged tonsils; thyroid (goiter?)
- Chest: gynecomastia
- Cardiopulmonary: evidence of asthma/ pulmonary edema
- Abdomen: RUQ tenderness (nonalcoholic fatty liver disease = NAFLD)
- GU: Tanner stage, cryptorchidism
- Extremities: SCFE, Blount disease
- Skin: acanthosis nigricans, striae, hirsutism

Labs:

<table>
<thead>
<tr>
<th>BMI 85-94 %ile + no risk factors</th>
<th>Fasting lipids</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMI 85-94%ile + risk factors (e.g. fam h/o obesity-related disease, ↑BP, ↑lipids, tobacco)</td>
<td>Fasting lipids, AST/ALT, fasting glucose, Hgb A1c</td>
</tr>
<tr>
<td>BMI ≥ 95 %ile</td>
<td>Fasting lipids, AST/ALT, fasting glucose, Hgb A1c</td>
</tr>
</tbody>
</table>
Obesity Among Low-Income Preschool Children

1 of 3 Children Are Obese or Overweight Before Their 5th Birthday

According to the 2009 Pediatric Nutrition Surveillance System (PedNSS) data, nearly one-third of the 3.7 million low-income children aged two to four years surveyed were obese or overweight, and 541,000 were obese. Learn more at: www.cdc.gov/obesity/childhood/lowincome.html

Health Risk Now and Later for Obese Children

- Obese children are more likely to have high blood pressure, high cholesterol, and type 2 diabetes, which are risk factors for cardiovascular disease.
- Obese children are more likely to become obese adults.
- The tracking of body mass index (BMI) that occurs from early childhood to adulthood has been documented, and early adiposity rebound in young children is associated with increased risk of obesity in young adulthood.¹²

Some Children Burdened More Than Others

- American Indian and Alaska Native (20.7%) and Hispanic (17.9%) children aged 2 to 4 years have the highest rates of obesity.
- Since 2003, American Indian and Alaska Native children are the only ones that have shown a significant increase in obesity rates (1.7%) since 2003.

Importance of Reaching Low-Income Families

- According to the U.S. Census, in 2009, the number of U.S. people in poverty is the largest number in the 51 years poverty estimates have been published.
- Low-income families generally have less access to both healthy food choices and opportunities for physical activity. Many need nearby retail stores that provide healthy, affordable foods, as do many rural and predominantly minority communities. At the same time, many low-income communities lack or have restricted access to sidewalks, green space, parks, and recreation centers that may be perceived as unsafe; all are possible barriers to leisure time physical activity.
- More families are turning to public health programs, such as the Special Supplemental Nutritional Program for Women, Infants and Children Program (WIC), to meet the needs of their children younger than 5 years.

The PedNSS is a child-based public health surveillance system that describes the nutritional status of low-income U.S. children who attend federally-funded maternal and child health and nutrition program, primarily the WIC Program. Learn more at: http://www.cdc.gov/PedNSS.
Obesity Rates Among U.S. Low-Income Preschool Children

**Obesity Rates Exceed Health Goals**
Few states, U.S. territories, or Indian Tribal Organizations had an obesity rate among low-income preschoolers participating in the 2009 PedNSS at or less than the Healthy People 2020 target of 9.6%.

---

### 2007–2009 County Obesity Prevalence Among Low-Income Children Aged 2 to 4 Years

This map is accessible at [http://www.cdc.gov/obesity/childhood/lowincome.html](http://www.cdc.gov/obesity/childhood/lowincome.html)

### 2009 State Obesity Prevalence Among Low-Income Children Aged 2 to 4 Years

This map is accessible at [http://www.cdc.gov/obesity/childhood/lowincome.html](http://www.cdc.gov/obesity/childhood/lowincome.html)

---

**Key Statistics**

- 1 of 7 low-income, preschool-aged children is obese.
- 37.4% of counties with at least 100 records in the PedNSS have childhood obesity rates exceeding 15%.
- 5.5% of such counties have childhood obesity rates exceeding 20%.
- In 2009, American Indian or Alaska Native children had the highest prevalence of obesity (20.7%), followed by Hispanic (17.9%), non-Hispanic white (12.3%), non-Hispanic black (11.9%), and Asian/Pacific Islander (11.9%) children. The only increase in obesity rates since 2004 occurred among American Indian or Alaska Native children (1.7% increase).
- County obesity rates are variable within states. Even states with the lowest prevalence of obesity have counties where many income children are obese and at risk for chronic diseases.
Obesity Rates Among U.S. Low-Income Preschool Children

Action on Early Childhood Obesity: Priority Strategies

**Increasing Physical Activity**
- Priority strategies include increasing access with informational outreach, and conducting community-wide campaigns.

**Increasing Fruit and Vegetable Consumption**
- Priority strategies include starting or expanding *Farm to Where You Are* programs (e.g., farm to school, farm to health care, and farmers markets in communities), improving retail access, and promoting food policy councils.
- Use CDC’s *State Indicator Report on Fruits and Vegetables, 2009* to identify your state’s needs, develop solutions, and work together within your community to promote fruits and vegetables. Available at [http://www.fruitsandvegetsmarter.gov/health_professionals/statereport.html](http://www.fruitsandvegetsmarter.gov/health_professionals/statereport.html).
- Research-tested interventions, including a nutrition and physical activity self-assessment tool, resources related to *Eat Well Play Hard* in Child Care Settings, *KaBOOM*, and supporting communities to build play spaces, are accessible at [www.center-trt.org](http://www.center-trt.org).

**Reducing Energy Dense Food and Sugar Consumption**
- Priority strategies include ensuring that regulations and policies at all levels promote healthier foods and beverages in places where young children eat. Limiting access to sugar beverages and applying nutrition standards in child care settings are priority strategies.

**Breastfeeding Initiation and Duration**
- Priority strategies include developing state coalitions to support breastfeeding and implementing supports in maternity care and worksite settings.
- Use the CDC *Breastfeeding Report Card* to identify your state’s needs, develop solutions, and work together within your community to promote and support breastfeeding. Also access the CDC *Guide to Breastfeeding Interventions* at [http://www.cdc.gov/breastfeeding/resources/index.htm](http://www.cdc.gov/breastfeeding/resources/index.htm).
- The *WIC Program* is expanding breastfeeding peer counseling services. Learn more at [http://www.fns.usda.gov/wic/resources/](http://www.fns.usda.gov/wic/resources/).
- Read the latest national breastfeeding recommendations at [http://www.surgeongeneral.gov/topics/breastfeeding/index.html](http://www.surgeongeneral.gov/topics/breastfeeding/index.html).

December 26, 2012 / Volume 308 / No. 24

The data for this study is from the Pediatric Nutrition Surveillance System (PedNSS), which includes almost 50% of preschool children eligible for federally funded maternal and child health and nutrition programs, primarily the WIC Program. The study population included 27.5 million children aged 2 through 4 years from 30 states and the District of Columbia that consistently reported data to PedNSS from 1998 -2010.

**Extreme Obesity and Obesity decline among low-income preschool children**

- The prevalence of extreme obesity:
  - From 2003 through 2010, decreased slightly from 2.22% to 2.07%
  - From 1998 through 2003, increased from 1.75% to 2.22%

- The prevalence of obesity:
  - From 2003 through 2010, decreased slightly from 15.21% to 14.94%
  - From 1998 through 2003, increased from 13.05% to 15.21%

**Race**

- The prevalence of extreme obesity from 2003 through 2010 decreased in all groups except American Indians/Alaska Natives; and the greatest decreases were among Asian/Pacific Islander children.

- The prevalence of extreme obesity from 1998 through 2003 increased in all racial/ethnic groups except Asians/Pacific Islanders; and the greatest average annual increases were among non-Hispanic whites.

**Age**

- From 1998 through 2003, the prevalence of extreme obesity increased among low-income children aged 2 years, 3 years, and 4 years; the greatest average annual increase was among 4-year-olds.

- From 2003 through 2010, the prevalence of extreme obesity decreased among low-income children aged 2 years, 3 years, and 4 years; the greatest decrease was among 2-year-olds.
Gender

- From 1998 through 2003, the prevalence of extreme obesity increased among boys and girls aged 2-4 years living in low-income families.
- From 2003 through 2010, the prevalence of extreme obesity decreased from 2.17% to 2.01% among boys and from 2.27% to 2.14% among girls.

Risk Factors

- Childhood obesity has been associated with cardiovascular risk factors, increased health care costs, and premature death.
- The prevalence of cardiovascular risk factors increases with severity of childhood obesity.
- Children who are obese or extremely obese during early childhood are also likely to be obese during middle or late childhood and adulthood.
- Obese adults are at increased risk for stroke and many chronic diseases, including coronary heart disease, hypertension, type 2 diabetes, and certain types of cancer.

Obesity and Extreme Obesity defined

A child's weight status is determined using an age- and sex-specific percentile for BMI (Body Mass Index), rather than the BMI categories used for adults, because children's body composition varies as they age and varies between boys and girls. The weight status of children 2 years and older is defined based on the sex-specific smoothed percentile curves for BMI-for-age in the 2000 CDC growth charts.

- Obesity is a BMI at or above the 95th percentile for children of the same age and sex. For example, a 3-year-old boy of average height who weighs more than 37 pounds would be considered obese.

- Extreme obesity is defined as a BMI at or above 120% of the 95th percentile for children of the same age and sex. For example, a 3-year-old boy of average height who weighs more than 44 pounds would be classified as extremely obese.

Metabolic Syndrome in Children and Adolescents

Chrystal Wittcopp, MD,* Rushika Conroy, MD, MS*

*Department of Pediatrics, Baystate Children’s Hospital, Tufts University School of Medicine, Boston, MA.

Educational Gap

Metabolic syndrome in obese children is associated with increased risk for the development of type 2 diabetes and cardiovascular disease. Currently, no unifying definition exists and the impact of metabolic syndrome on other obesity-related comorbidities continues to be poorly understood.

Objectives

After completing this article, the reader should be able to:

1. Describe the relationship between obesity and metabolic syndrome (MetS).
2. Recognize the difficulty in defining MetS in the pediatric population.
3. Recognize the multiple risk factors associated with MetS in the pediatric population.
4. Describe the importance of various clinical features associated with MetS.
5. Initiate screening for MetS in appropriate patients and develop treatment strategies for those patients.

INTRODUCTION

As the prevalence of obesity in adults and youth continues at historically high rates, so does the occurrence of obesity-related comorbidities. Many chronic diseases that were once believed to be conditions of adults alone are now being seen commonly in the pediatric population. The combination of dyslipidemia, abnormal glucose regulation, central adiposity, and hypertension, known collectively as metabolic syndrome (MetS), has long been recognized in the obese adult population and is associated with an increased risk for the development of cardiovascular disease (CVD) and type 2 diabetes (T2D). The definitive criteria for MetS have not been firmly established; many criteria have small differences that can alter the risk stratification for progression to CVD and T2D. (1)(2) What is clear is that the risk of developing CVD or T2D increases substantially in the presence of MetS, with a twofold increase for the former and fivefold increase for the latter in adult populations. (3) In the pediatric population, only 1 set of criteria is available, and its use as an assessment for CVD and T2D risk continues to be a subject of debate. (1)(4)
DEFINITION

The description of MetS dates back to World War I, when Hitzenberger and Richter-Quittner in Austria discussed the relationship between blood pressure and diabetes mellitus. In 1981, Hanefeld and Leonhardt called a constellation of findings that are observed in MetS, giving the syndrome a number of names, including syndrome of affluence (Mehnert and Kuhlmann), plurimetabolic syndrome (Avogaro and Crepaldi), and insulin resistance syndrome (DeFronzo and Ferrannini, Haffner). In 1985, Haffner noted that the development of these conditions occurred in the setting of genetic predisposition, excessive food intake, and lack of physical activity. In the late 1980s, Reaven published his findings that the common denominator for these conditions was insulin resistance and coined the term syndrome X to describe them. Shortly thereafter, Kaplan defined the importance of central adiposity as a common factor in this constellation of findings and called the combination of central adiposity, hypertriglyceridemia, impaired glucose tolerance, and hypertension “the deadly quartet.” Since then, a multitude of researchers have contributed to our understanding of the development of MetS and the impact of its individual components. Although most of the terms used to describe the constellation of findings of central obesity, dyslipidemia, impaired glucose regulation, and increased risk of CVD and T2D are interchangeable, today this condition is most well known as metabolic syndrome.

Just as many terms have been ascribed to MetS, many definitions also have been used to describe it. Adult definitions have been published by the World Health Organization (WHO), International Diabetes Foundation (IDF), National Cholesterol Education Program III, National Heart, Lung and Blood Institute (NHLBI), and the American Association of Clinical Endocrinologists (Table 1). Differences include the presence or absence of microalbuminuria, the use of waist-to-hip ratios, and the use of hyperinsulinemic euglycemic clamp studies. The subtle differences in criteria led to the publication of a statement from the Joint Task Force of all groups stating that the criteria for MetS in adults should be 3 of the following 5 criteria (2):

- Elevated waist circumference (WC) based on population- and country-specific definitions
- Triglycerides of 150 mg/dL (1.7 mmol/L) or more or receiving treatment for elevated triglycerides
- High-density lipoprotein (HDL) cholesterol less than 40 mg/dL (1.0 mmol/L) in males and less than 50 mg/dL (1.3 mmol/L) in females or receiving treatment for reduced HDL cholesterol
- Systolic blood pressure of 130 mm Hg or more and/or diastolic blood pressure of 85 mm/Hg or more or receiving treatment for hypertension
- Fasting blood glucose of 100 mg/dL (5.6 mmol/L) or more or receiving treatment for hyperglycemia

There is currently no consensus guideline for the diagnostic criteria for pediatric MetS in the pediatric literature. In fact, more than 40 definitions have been reported in the pediatric population. In 2007, the IDF provided a definition for MetS in the pediatric population using pediatric-specific criteria (Table 2). A number of researchers have published their proposed definitions in addition to risk stratification for CVD and T2D using these definitions. Other published criteria for MetS in children and adolescents have used waist-to-hip ratio, fasting insulin levels, low-density lipoprotein (LDL) cholesterol, cholesterol-to-HDL cholesterol ratios as well as skinfold thickness. Defining MetS in the pediatric population is difficult for a number of reasons:

- The lack of a unifying definition in adults makes it less likely that a unifying definition can be developed in the pediatric population
- The increase in insulin resistance during puberty can potentially affect metabolism and weight gain
- The change in lipid profiles at different ages makes using one set of values for all age groups difficult
- The lack of consensus on cutoffs for WC to define central adiposity, which changes based on age

EPIDEMIOLOGY

Use of adult definitions for MetS in the pediatric population has led to substantial discrepancies in determining prevalence, which is not unlike the discrepancies noted in the adult population. Discrepancies have been up to 50% in some cases. For example, one study noted a prevalence of MetS in junior high and high school students of 4.8% using IDF criteria and 12.7% using NHLBI criteria. Studies to date have used the Adult Treatment Panel III (ATPIII) and WHO criteria to describe MetS in the pediatric population. Various publications have noted prevalence numbers using different definitions ranging from 0.2% to 38.9%.
that the prevalence of MetS among children and adolescents in the United States is 4.2% by ATPIII criteria and 8.4% by WHO criteria, (6) with a higher percent of obese and Hispanic patients compared to normal-weight, Caucasian, or African American patients. The prevalence of MetS in overweight individuals has been quoted as 7.1% to 11.9%, compared with 29.2% to 32.1% in obese individuals. (7)

**PATHOGENESIS**

The pathogenesis of MetS is not fully understood, but insulin resistance is believed to play a key role in the development of the syndrome as well as its individual components. The phenomenon of insulin resistance is most often seen in the setting of obesity and is believed to be due to free fatty acid accumulation in the liver, skeletal muscle, adipocytes, and pancreas, which interferes with normal insulin signaling. (8) Free fatty acid buildup in the liver leads to a decreased ability to regulate gluconeogenesis, which increases insulin levels further as well as triglyceride (TG) production. The insulin resistance at the level of the adipocyte leads to increased lipolysis and lipid deposition into the bloodstream. Muscle fatty acid buildup and insulin resistance

<table>
<thead>
<tr>
<th>WORLD HEALTH ORGANIZATION</th>
<th>INTERNATIONAL DIABETES FEDERATION</th>
<th>NATIONAL HEART, LUNG AND BLOOD INSTITUTE</th>
<th>NATIONAL CHOLESTEROL EDUCATION PROGRAM III</th>
</tr>
</thead>
<tbody>
<tr>
<td>■ Type 2 diabetes (fasting blood glucose ≥126 mg/dL [7.0 mmol/L] or OGTT 2 hour ≥200 mg/dL [11.1 mmol/L])</td>
<td>■ Central obesity: waist circumference &gt;94 cm (men) or 80 cm (women)</td>
<td>■ Fasting blood glucose ≥110 mg/dL (6.1 mmol/L) or treatment for hyperglycemia</td>
<td>■ Fasting blood glucose ≥100 mg/dL (5.6 mmol/L) or treatment for hyperglycemia</td>
</tr>
<tr>
<td>■ Insulin resistance (determined by hyperinsulinemic euglycemic clamp method)</td>
<td>■ Impaired fasting glucose (fasting blood glucose 110–125 mg/dL [6.1–6.9 mmol/L])</td>
<td>■ Fasting blood glucose ≥100 mg/dL (5.5 mmol/L) or previously diagnosed type 2 diabetes</td>
<td>■ Fasting blood glucose ≥100 mg/dL (5.6 mmol/L) or treatment for hyperglycemia</td>
</tr>
<tr>
<td>■ Impaired fasting glucose (fasting blood glucose 110–125 mg/dL [6.1–6.9 mmol/L])</td>
<td>■ SBP ≥130 mm Hg or DBP ≥85 mm Hg or antihypertensive medication</td>
<td>■ Fasting TG ≥150 mg/dL (1.7 mmol/L) or treatment for hyperlipidemia</td>
<td>■ SBP ≥130 mm Hg or DBP ≥85 mm Hg or treatment for hypertension</td>
</tr>
<tr>
<td>■ SBP ≥140 mm Hg or DBP ≥90 mm Hg and/or antihypertensive medication</td>
<td>■ SBP ≥130 mm Hg or DBP ≥85 mm Hg or antihypertensive medication</td>
<td>■ HDL &lt;40 mg/dL (1.0 mmol/L) (men) or &lt;50 mg/dL (1.3 mmol/L) (women) or treatment for hyperlipidemia</td>
<td>■ HDL &lt;40 mg/dL (1.0 mmol/L) (men) or &lt;50 mg/dL (1.3 mmol/L) (women) or treatment for hyperlipidemia</td>
</tr>
<tr>
<td>■ Fasting TG ≥150 mg/dL (1.7 mmol/L) and/or HDL &lt;35 mg/dL (0.9 mmol/L) (men) or &lt;39 mg/dL (1.0 mmol/L) (women)</td>
<td>■ Fasting TG ≥150 mg/dL (1.7 mmol/L) or treatment for hyperlipidemia</td>
<td>■ Waist circumference ≥102 cm (men) or 88 cm (women), with lower thresholds for ethnic groups or individuals prone to insulin resistance</td>
<td>■ Waist circumference ≥102 cm (men) or 88 cm (women)</td>
</tr>
<tr>
<td>■ BMI ≥30 and/or waist-to-hip ratio &gt;0.9 (men) or &gt;0.85 (women)</td>
<td>■ Urinary albumin excretion rate ≥20 μg/min or albumin-to-creatinine ratio &gt;30 mg/g</td>
<td>■ HDL &lt;40 mg/dL (1.0 mmol/L) (men) or &lt;50 mg/dL (1.3 mmol/L) (women) or treatment for hyperlipidemia</td>
<td>■ HDL &lt;40 mg/dL (1.0 mmol/L) (men) or &lt;50 mg/dL (1.3 mmol/L) (women) or treatment for hyperlipidemia</td>
</tr>
</tbody>
</table>

BMI=body mass index, DBP=diastolic blood pressure, HDL=high-density lipoprotein cholesterol, OGTT=oral glucose tolerance test, SBP=systolic blood pressure, TG=triglycerides

result in decreased glucose uptake as well as increased inflammation. (4)

Adipocyte dysfunction is an essential contributor to the pathogenesis of obesity and T2D. The pathogenesis is believed to be due, in part, to the release of inflammatory cytokines in response to excess fat stores in adipocytes, such as interleukin-6, monocyte chemotactic protein-1, and tumor necrosis factor-α, which subsequently promotes macrophage migration to the adipose tissue that further increases cytokine production. (7) The decrease in adiponectin has been shown to increase cytokine production. (7) The decrease in adiponectin has been shown to increase cytokine production. (7)

Possible mechanisms of action include insulin stimulation of inflammatory cytokines and growth factors in the vascular smooth muscle. Thus, data support a strong interplay among obesity, insulin resistance, and inflammation, and this interplay is important in the pathogenesis of MetS. The links connecting obesity, insulin resistance, and inflammation and their association with MetS continue to be elucidated.

### TABLE 2. Definition of Metabolic Syndrome in Children and Adolescents by the International Diabetes Federation

<table>
<thead>
<tr>
<th>6-&lt;10 YEARS</th>
<th>10-&lt;16 YEARS</th>
<th>&gt;16 YEARS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cannot diagnose in this age group</td>
<td>Obesity ≥90th percentile by waist circumference</td>
<td>Central obesity waist circumference &gt;94 cm (men) or &gt;80 cm (women)</td>
</tr>
<tr>
<td>2 or more of the following:</td>
<td>- Fasting glucose &gt;100 mg/dL (5.6 mmol/L) or known type 2 diabetes</td>
<td>2 of the following:</td>
</tr>
<tr>
<td>- SBP ≥130 mm Hg or DBP ≥85 mm Hg</td>
<td>- Fasting TG ≥150 mg/dL (1.7 mmol/L) or previously diagnosed type 2 diabetes</td>
<td>- Fasting glucose &gt;100 mg/dL (5.6 mmol/L) or previously diagnosed type 2 diabetes</td>
</tr>
<tr>
<td>- HDL &lt;40 mg/dL (1.0 mmol/L)</td>
<td>- SBP ≥130 mm Hg or DBP ≥85 mm Hg or treatment for hypertension</td>
<td>- Fasting TG ≥150 mg/dL (1.7 mmol/L) or treatment for hyperlipidemia</td>
</tr>
<tr>
<td></td>
<td>- Fasting TG ≥150 mg/dL (1.7 mmol/L) or treatment for hyperlipidemia</td>
<td>- HDL &lt;40 mg/dL (1.0 mmol/L) (men) or &lt;50 mg/dL (1.3 mmol/L) (women) or treatment for hyperlipidemia</td>
</tr>
</tbody>
</table>

DBP=diastolic blood pressure, HDL=high-density lipoprotein cholesterol, SBP=systolic blood pressure, TG=triglycerides

The participants’ omission of the MetS definition in children and adolescents is a significant concern. The prevalence of MetS is higher in Hispanics than in Caucasians and African Americans. (7) Some of the disparity in ethnic prevalence is related to the lower TG concentrations in African Americans due to lower apolipoprotein CIII levels. (12) Some have suggested redefining criteria for MetS in African American adults and children because of this difference, but no new definitions have been proposed to date. Data in adults show variations in ethnic predisposition, with the National Health and Nutrition Examination Survey data noting no ethnic difference in MetS prevalence between African Americans and Caucasians. (7)(13)

A number of studies in adults and some in children have assessed the impact of physical activity on the risk of developing MetS. Increased television viewing in adolescence has been associated with increased risk of developing MetS in adulthood. (14) Inactivity has been associated with a decrease in insulin sensitivity in the skeletal muscle that
can be regained with resumption of activity. Moderate and vigorous physical activity in both adults and adolescents has conferred a lower risk of developing MetS. (15) The presence or absence of gender and ethnic differences with respect to risk and activity are not clear. Nevertheless, sedentary behavior is a clear risk factor for the development of MetS.

Smoking has been linked to an increased risk of MetS. Cessation of the habit significantly reduces risk. (16)

Nonalcoholic fatty liver disease (NAFLD) has been implicated in the progression to MetS, possibly through liver cell inflammation increasing cytokine production as well as hepatic insulin resistance. (17) Insulin resistance in the liver leads to disinhibition of very low-density lipoprotein cholesterol production, which accumulates in the liver and leads to elevations in TGs. Thus, fat accumulation in the liver can be considered a risk factor for MetS. (17)

Both early and late menarche has been predictive of MetS in adulthood, (18) independent of weight. Further studies are needed to confirm these findings and understand the mechanisms by which time of menarche can affect development of metabolic abnormalities.

A small number of studies have suggested that high fructose consumption (amounts seen in soda and processed foods) leads to higher risk of MetS. (19) Fructose consumption has been associated with a decrease in insulin sensitivity in young adults compared to glucose consumption. (20) Fructose metabolism to fatty acids is more rapid than glucose metabolism, leading to a faster accumulation of fatty acids in the circulation. In addition, TGs can accumulate in the circulation following fructose-mediated decreases in lipoprotein lipase activity.

The use of antipsychotics to treat mood disorders such as bipolar disorder as well as anxiety and depression has been associated with an increased risk for the development of MetS. Bipolar disorder, irrespective of antipsychotic use, has also been linked to MetS, and both have been noticed irrespective of weight.

Any obesity syndrome confers an increased risk of obesity-related comorbidities, including MetS. However, Klinefelter syndrome has a notably increased risk for the development of MetS, with most studies suggesting a five-fold higher chance of developing the syndrome in affected boys compared to boys without Klinefelter syndrome. Klinefelter syndrome is heralded by a 47 XXY genotype with associated testicular failure, infertility, pubertal delay, tall stature, and social and behavioral dysfunction. The cause of this higher risk is not fully understood but is believed to be related to the increase in central obesity that these boys develop, leading to insulin resistance, even when body mass index (BMI) is in the normal or overweight range.

**CLINICAL FEATURES**

**Obesity**

Obesity is a crucial factor for the development of MetS, T2D, and adverse CVD outcomes. In addition, data from multi-racial cohorts of children have shown that the degree of obesity and the prevalence of MetS are strongly associated. (21) Calculating a BMI and plotting it on standard growth curves is the gold standard for diagnosing obesity in children, with a BMI above the 95th percentile for age and gender considered obese. Obtaining an accurate height and weight as well as calculating and plotting a BMI yearly are crucial for identifying children at risk for MetS.

In addition to the degree of obesity, fat distribution also appears to be important. Visceral fat accumulation, independent of BMI, has been shown to be strongly associated with both childhood MetS (22) and CVD later in life (23). This clustering of risk factors is most likely related to increased insulin resistance that is known to be associated with increased visceral adiposity. Different methods can be used to assess visceral fat accumulation, including magnetic resonance imaging, waist-to-hip ratios, and WC. Of these, WC is often recognized as the best clinical predictor of visceral fat accumulation in both children and adults. (24)(25) Increased WC in children and adolescents, independent of BMI, is a predictor of insulin resistance and is associated with elevated CVD risk factors. (25) However, due to lack of childhood-specific data, WC measurements are not currently recommended as part of routine assessment of the obese child.

An additional clinical tool for assessing adiposity in children is the waist-to-height ratio. A waist-to-height ratio greater than 0.6 has been shown to be a significant predictor of both MetS and CVD risk in obese children. (26)(27) The clinical application of this index needs to be explored further before making any recommendations for its routine use.

**Dyslipidemia**

Dyslipidemia, as defined by an increase in TGs and a decrease in HDL cholesterol, is found in children with obesity and insulin resistance and is an important criterion for the diagnosis of MetS. Insulin resistance and resultant hyperinsulinemia appear to increase the transcription of genes for lipogenic enzymes in the liver and stimulate the production of TGs. Elevated TGs in association with low HDL cholesterol has been shown to be a marker for small dense low-density lipoproteins (LDLs) in obese children. A TG/HDL cholesterol ratio of 3 or greater is associated with a markedly higher concentration of small LDLs than a ratio of less than 3. (28) The small dense LDL particles are very
atherogenic and may confer an added risk for CVD in obese children with MetS. (29)

Hypertension
Elevated blood pressure is an important component of the MetS and one of the most modifiable risk factors for CVD. Although understanding the effects of obesity and insulin on blood pressure has been difficult, there does appear to be a direct effect of hyperinsulinemia on blood pressure in children and adolescents. Studies not only have shown a direct correlation between fasting insulin and blood pressure in children and adolescents, but the level of insulin was predictive of blood pressure 6 years later. (30) This has been ascribed to various mechanisms, including sympathetic nervous system activity, sodium retention by the kidney, and insulin-stimulated smooth muscle growth. There also is a strong association between childhood hypertension and the development of MetS in adulthood. (31)

Glucose Intolerance and Type 2 Diabetes
Insulin resistance is well documented in obese children and is believed to be a normal reaction of tissues to maintain adequate insulin sensitivity against increased fat deposition. In some individuals with insulin resistance, B-cell function deteriorates and subsequently insulin decreases, which leads to progression from insulin resistance to glucose intolerance and T2D. Glucose intolerance is defined as either impaired fasting glucose or impaired glucose tolerance. Most individuals with glucose intolerance have either impaired fasting glucose or impaired glucose tolerance but not both. The Expert Committee on the Diagnosis and Classification of Diabetes Mellitus categorizes impaired fasting glucose as equal to or greater than 100 mg/dL (5.6 mmol/L) but less than 126 mg/dL (7.0 mmol/L) and impaired glucose tolerance as a 2-hour oral glucose tolerance test value equal to or greater than 140 mg/dL (7.8 mmol/L). Diabetes is defined by the American Diabetes Association as meeting any 1 of 4 criteria in the presence of symptoms of hyperglycemia or 1 of 4 criteria on two separate occasions in the absence of symptoms: hemoglobin A1c equal to or greater than 6.5%, fasting glucose equal to or greater than 126 mg/dL (7.0 mmol/L), 2-hour oral glucose tolerance test value equal to or greater than 200 mg/dL (11.1 mmol/L), or a random glucose value equal to or greater than 200 mg/dL (11.1 mmol/L). Not all individuals with insulin resistance develop glucose intolerance, and although children and adolescents with glucose intolerance are at higher risk for developing T2D, not all progress to diabetes. T2D is an additional CVD risk factor for individuals with MetS. Given the concern for adverse outcomes in individuals with T2D, it is imperative to monitor obese children with glucose intolerance regularly for signs and symptoms of overt diabetes such as polyuria, polydipsia, polyphagia, and weight loss.

Nonalcoholic Fatty Liver Disease
NAFLD is an important metabolic complication in the obese pediatric population. It includes a range of liver conditions from asymptomatic steatosis to nonalcoholic steatohepatitis to advanced fibrosis with cirrhosis. The intrahepatic fat accumulation that is apparent in this disease is believed to be associated directly with insulin resistance and, therefore, is also strongly associated with MetS. Children with a diagnosis of NAFLD often have many clinical features that overlap with MetS, increasing their risk for CVD. Definitive diagnosis can be difficult and requires a liver biopsy, but elevated aminotransferase values in an obese child should prompt the clinician to investigate further for NAFLD.

Polycystic Ovary Syndrome
Polycystic ovary syndrome (PCOS) is a common disorder affecting obese adolescent girls that is characterized by hyperandrogenism and associated with insulin resistance. Adolescent girls with PCOS have an increased risk of MetS independent of obesity or insulin resistance. (32) and the combination of PCOS and MetS may increase the risk for CVD and T2D more than just MetS alone. (33) Young women with PCOS should be screened routinely for the components of MetS and impaired glucose metabolism.

Inflammatory Markers
Obesity is associated with a proinflammatory state. Adipocytes, especially visceral adipocytes, respond to excess lipid stores by secreting increased amounts of inflammatory cytokines, thus triggering an inflammatory cascade. Levels of several circulating inflammatory markers, including interleukin-6, tumor necrosis factor-α, and C-reactive protein (CRP), have been shown to be elevated in obese children. (34) The marker most commonly used to assess systemic inflammation is CRP. High-sensitivity CRP, in particular, is associated with increased cardiovascular risk and is used for CVD risk stratification in adults. CRP has been shown in children and adolescents to be associated with insulin resistance and the components of MetS and, therefore, may be an additional risk factor in obese children. (35)(36) However, the exact relationship between CRP and MetS is not well delineated, and longitudinal data on its predictive importance in children are lacking.
SCREENING

Children who have MetS that continues into adulthood have a severalfold higher risk of CVD and T2D. (30)(37) Given the ongoing obesity epidemic, it is critical for clinicians to identify overweight and obese children who are at high risk for CVD and T2D. Once identified, children with MetS should be tracked and treated using a systematic, patient-centered medical home model that focuses on chronic disease management.

Although no specific screening guidelines exist for MetS in children, the evidence-based 2007 American Academy of Pediatrics (AAP) Expert Committee recommendations propose screening for several of the CVD risk factors that encompass the components of MetS in overweight and obese children. (38) Physical examination should include pulse, blood pressure, and a search for signs commonly associated with obesity, such as hepatomegaly (NAFLD) and acanthosis nigricans (associated with insulin resistance). Laboratory testing is recommended based on the patient’s BMI percentile and any known risk factors for CVD, such as hypertension, dyslipidemia, a strong family history of diabetes, or other obesity-related disease. A fasting lipid profile should be obtained in children who have no risk factors with a BMI between the 85th and 94th percentiles. A fasting lipid profile, serum alanine transaminase and aspartate transaminase assessment, and fasting blood glucose should be obtained for children with a BMI between the 85th and 94th percentiles and risk factors. Children with a BMI above the 95th percentile should have the same tests plus measurement of blood urea nitrogen and creatinine. In addition, the summary report from 2011 NHLBI Expert Panel states “The presence of obesity should prompt specific evaluation for all other cardiovascular risk factors, including family history of premature CVD, hypertension, dyslipidemia, DM, and tobacco exposure.” (39)

TREATMENT

The optimal strategies for treating MetS in children and adolescents are yet to be determined. Currently, treatment of childhood MetS focuses on several areas that include weight reduction through dietary modification and increased physical activity and disease-specific management of its various components.

Weight reduction or, in younger children, a decrease in BMI percentile, is a critical component of MetS treatment. Even a small reduction in BMI percentile can have beneficial effects. However, before engaging a patient and family in a weight reduction program, clinicians should assess them for readiness to change. This information can guide the degree of intervention and may help the clinician avoid investing excess time and energy in patients who are not ready for change. For patients and families who are ready, lifestyle changes have been shown to reduce weight and improve many of the components of MetS. Dietary recommendations continue to focus on a moderately reduced calorie intake while maintaining a well-balanced diet. Obese children with the components of MetS should be engaged in comprehensive behavioral modification programs that focus on nutrition and physical activity. Interventions that offer more contact hours (>26 hours) have more success with weight loss over both the short and long term. (40) The recent US Preventive Services Task Force Recommendations found “adequate evidence that multi-component, moderate- to high-intensity behavioral interventions for obese children and adolescents aged 6 years and older can effectively yield short-term (up to 12 months) improvements in weight status.” (41). Because of the high prevalence of depression and mood disorders in obese children, such treatment programs also should actively screen for mental health disorders and offer appropriate behavioral health resources.

An increase in physical activity, independent of a change in weight status, may be an important treatment strategy for children with MetS. A 2011 systematic review found evidence supporting a conclusion that increased physical activity improved insulin sensitivity in obese children. (42) However, relatively few of the reviewed studies specifically examined the impact of physical activity on MetS as a whole. Adult studies have shown up to a 30% reduction in MetS after supervised aerobic training. (3)

Appropriate management of the diseases that are part of MetS, such as hypertension, dyslipidemia, and impaired glucose homeostasis, is essential to decrease the risk of CVD in affected children. Management should be evidence-based and follow the guidelines outlined by the 2011 NHLBI Expert Panel on Integrated Guidelines for Cardiovascular Health and Risk Reduction in Children and Adolescents. (39)

For adolescents with MetS in whom lifestyle management of obesity has not resulted in improvements, less traditional methods have been employed. Medications have been suggested as adjunctive therapy. Several small-scale studies have reported beneficial effects on body weight and insulin resistance from the use of metformin in obese children and adolescents with hyperinsulinemia. (43)(44)(45) These studies have not examined overall resolution of MetS and have documented only short-term efficacy. Further large-scale trials are needed before making recommendations involving the routine use of metformin in children with MetS.
Bariatric surgery has become a successful method of reducing weight and eliminating a number of comorbid conditions in both the morbidly obese adult and pediatric populations. Pediatric data are still limited, but results to date have been consistent with those observed in the adult population. A recent study that specifically assessed the status of MetS in morbidly obese adolescents pre- and postlaparoscopic gastric banding noted a 59% decrease in the presence of MetS after 6 months and a 69% decrease after 12 months. (46) Further studies with long-term data on pediatric patients undergoing bariatric surgery are still necessary to determine if the initial decrease seen in CVD risks translates to decreased morbidity in adulthood.

CONCLUSION

MetS in children and adolescents continues to be a challenge for clinicians, patients, and families. Although further research is needed to gain a better understanding of this syndrome, clearly childhood obesity can dramatically impair cardiovascular health, and the potential long-term impacts on health are very concerning. Given the large percentage of children and adolescents who are at high risk for the development of T2D and CVD, clinicians must screen all overweight and obese patients for the components of MetS and provide guidance during health supervision visits about the importance of exercise and healthy eating habits to prevent the condition from developing. Clinicians should identify individuals who have components of MetS and not focus on whether they meet a certain definition. For patients who have components of MetS, the primary care clinician should address these components using a chronic disease model that includes close, regular follow-up visits. In addition, it is imperative that clinicians use the primary care setting to begin counseling patients and their caregivers on healthy eating and exercise habits before overweight and obesity occur, employing guidelines set forth by the AAP for the treatment and prevention of obesity. These include limiting screen time to 2 hours daily; increasing fruit and vegetable consumption; limiting fast food; monitoring portions; and avoiding grazing, eating in front of the TV, and skipping meals. By establishing healthful habits early, clinicians can help prevent the development of obesity, MetS, and other related comorbidities in the pediatric population.

Summary

- On the basis of strong research evidence, metabolic syndrome (MetS) has increased in prevalence along with the increase in the prevalence of obesity.
- On the basis of expert opinion and consensus, the definitions of MetS in both adults and children have been challenged, leading to a unifying definition of MetS in adults but still leaving the definition of the condition unclear in children. The only group that has established a definition of MetS in children is the International Diabetes Federation. (2)(4)
- On the basis of strong research evidence, risk factors for MetS can be both genetic and environmental, including gender, ethnicity, obesity, inactivity, smoking, menarchal age, nonalcoholic fatty liver disease (NAFLD), and fructose consumption. (10)(11)(13)(14)(15)(18)(19)(20)
- On the basis of consensus, the components of MetS, as defined in the pediatric population, include obesity (determined by waist circumference and body mass index), hypertension, dyslipidemia, and either impaired fasting glucose, impaired glucose tolerance, or frank type 2 diabetes. (12)
- Based on research evidence, inflammation and NAFLD have been linked to MetS, and the presence of NAFLD portends greater risk for the development of MetS. (17)(34)
- On the basis of consensus and expert opinion, no specific screening guidelines for MetS exist, but all obese children and adolescents should be screened yearly for MetS as well as other cardiovascular risk factors. (40)(41)
- On the basis of research evidence, expert opinion, and consensus, treatment of MetS involves weight loss as well as treatment of its individual components. (39)(40)

CME quiz and References for this article are at http://pedsinreview.aappublications.org/content/37/5/193.
## Metabolic Syndrome in Children and Adolescents

Chrystal Wittcopp and Rushika Conroy

*Pediatrics in Review* 2016;37;193

DOI: 10.1542/pir.2014-0095

<table>
<thead>
<tr>
<th>Updated Information &amp; Services</th>
<th>including high resolution figures, can be found at:</th>
</tr>
</thead>
<tbody>
<tr>
<td>References</td>
<td>This article cites 46 articles, 9 of which you can access for free at:</td>
</tr>
<tr>
<td>Subspecialty Collections</td>
<td>This article, along with others on similar topics, appears in the following collection(s):</td>
</tr>
<tr>
<td></td>
<td><strong>Medical Education</strong></td>
</tr>
<tr>
<td></td>
<td><a href="http://classic.pedsinreview.aappublications.org/cgi/collection/medical_education_sub">http://classic.pedsinreview.aappublications.org/cgi/collection/medical_education_sub</a></td>
</tr>
<tr>
<td></td>
<td><strong>Journal CME</strong></td>
</tr>
<tr>
<td></td>
<td><a href="http://classic.pedsinreview.aappublications.org/cgi/collection/journal_cme">http://classic.pedsinreview.aappublications.org/cgi/collection/journal_cme</a></td>
</tr>
<tr>
<td></td>
<td><strong>Current Policy</strong></td>
</tr>
<tr>
<td></td>
<td><a href="http://classic.pedsinreview.aappublications.org/cgi/collection/current_policy">http://classic.pedsinreview.aappublications.org/cgi/collection/current_policy</a></td>
</tr>
<tr>
<td></td>
<td><strong>Endocrinology</strong></td>
</tr>
<tr>
<td></td>
<td><a href="http://classic.pedsinreview.aappublications.org/cgi/collection/endocrinology_sub">http://classic.pedsinreview.aappublications.org/cgi/collection/endocrinology_sub</a></td>
</tr>
<tr>
<td></td>
<td><strong>Metabolic Disorders</strong></td>
</tr>
<tr>
<td></td>
<td><a href="http://classic.pedsinreview.aappublications.org/cgi/collection/metabolic_disorders_sub">http://classic.pedsinreview.aappublications.org/cgi/collection/metabolic_disorders_sub</a></td>
</tr>
<tr>
<td>Permissions &amp; Licensing</td>
<td>Information about reproducing this article in parts (figures, tables) or in its entirety can be found online at:</td>
</tr>
<tr>
<td></td>
<td><a href="http://classic.pedsinreview.aappublications.org/site/misc/Permissions.xhtml">http://classic.pedsinreview.aappublications.org/site/misc/Permissions.xhtml</a></td>
</tr>
<tr>
<td>Reprints</td>
<td>Information about ordering reprints can be found online:</td>
</tr>
<tr>
<td></td>
<td><a href="http://classic.pedsinreview.aappublications.org/site/misc/reprints.xhtml">http://classic.pedsinreview.aappublications.org/site/misc/reprints.xhtml</a></td>
</tr>
</tbody>
</table>
How much physical activity do youth need?

The physical activity guidelines for children and adolescents aged 6 to 17 focuses on three types of activity: aerobic, muscle-strengthening, and bone-strengthening. Each type has important health benefits.

Aerobic, Muscle-strengthening, and Bone-strengthening Activities

**Every day** children and adolescents should do **1 hour or more** of physical activity.

**Aerobic activities.** Most of the 1 hour a day should be either moderate or vigorous-intensity* aerobic physical activity, and include and include **vigorous-intensity** physical activity **at least 3 days a week**.

As a part of the 1 hour a day of physical activity, the following should be included:

- **Muscle-strengthening on at least 3 days a week.** These activities make muscles do more work than usual during daily life. They should involve a moderate to high level of effort and work the major muscle groups of the body: legs, hips, back, abdomen, chest, shoulders, and arms.

- **Bone-strengthening on at least 3 days of the week.** These activities produce a force on the bones that promotes bone growth and strength through impact with the ground.

Youth should be encouraged to engage in physical activities that are **appropriate** for their age, **enjoyable**, and offer **variety**.

No period of activity is too short to count toward the Guidelines.

*Intensity is the level of effort required to do an activity.
A person doing **moderate-intensity** aerobic activity can talk, but not sing, during the activity.
A person doing **vigorous-intensity** activity cannot say more than a few words without pausing for a breath.
How much physical activity do youth need for health benefits?

 Participating in regular physical activity provides several health benefits for youth as summarized below. Reducing risk of some of these conditions may require longer periods of participation in regular physical activity. Other benefits, such as increased heart and lung—or cardiorespiratory—fitness, may require only a few weeks or months of participation.

### Aerobic Activities

- Improved:
  - Cardiorespiratory (aerobic) fitness and muscular strength
  - Bone health
  - Cardiovascular and metabolic health biomarkers
- Favorable body composition (percentages of muscle, bone, and fat)

### Moderate Evidence for Health Benefits

- Reduced symptoms of depression

### Aerobic Activities by Level of Intensity

Youth should not do only moderate-intensity activity. Including vigorous-intensity activities is important because they cause more improvement in cardiorespiratory fitness.

The intensity of aerobic physical activity can be defined on either an absolute or a relative scale. Either scale can be used to monitor the intensity of aerobic physical activity.

- **Absolute intensity** is based on the rate of energy expended during the activity, without considering cardiorespiratory fitness.
- **Relative intensity** uses cardiorespiratory fitness to assess level of effort.

Those doing moderate-intensity activity will notice their heart beating faster than normal and they will be breathing harder than normal. Those doing vigorous-intensity activity will feel their heart beating much faster and their breathing being much harder than normal.

Young people can meet the guidelines in many ways. Examples of different types of activities are included below.

### Examples of Moderate- and Vigorous-Intensity Aerobic, Muscle-Strengthening, and Bone-Strengthening Activities for Youth

<table>
<thead>
<tr>
<th>Type of Physical Activity</th>
<th>Children</th>
<th>Adolescents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aerobic Moderate–Intensity</td>
<td>• Active recreation such as hiking, skateboarding, rollerblading</td>
<td>• Active recreation, such as canoeing, hiking, cross-country skiing,</td>
</tr>
<tr>
<td></td>
<td>• Bicycle riding*</td>
<td>skateboarding, rollerblading</td>
</tr>
<tr>
<td></td>
<td>• Brisk walking</td>
<td>• Brisk walking</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Bicycle riding* (stationary or road bike)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Housework and yard work such as sweeping or pushing a lawn mower</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Playing games that require catching and throwing, such as baseball,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>softball</td>
</tr>
</tbody>
</table>
### Ways to Promote Physical Activity in Youth

Many youth are naturally physically active and need opportunities to be active. They benefit from encouragement from parents and other adults to be active. Adults can promote youth physical activity by:

- **Providing time for both structured and unstructured physical activity during school and outside of school.**
  Children need time for active play through recess, physical activity breaks, physical education classes, after-school programs, and active time with friends and family.

- **Providing youth with positive feedback and good role models.**
  Adults should model and encourage an active lifestyle. Praise, rewards, and encouragement help youth to be active.

- **Promoting activities that set the basis for a lifetime of activity.**
  Children and adolescents should be exposed to a variety of activities: active recreation, team sports, and individual sports. In this way, they can find what they can do well in both competitive and non-competitive activities and in activities that do not require exceptional athletic skills.

---

**Vigorous-Intensity**
- Active games involving running and chasing, such as tag
- Bicycle riding*
- Jumping rope
- Martial arts, such as karate
- Running
- Sports such as ice or field hockey, basketball, swimming, tennis or gymnastics
- Cross-country skiing

**Muscle-Strengthening**
- Games such as tug of war
- Modified push-ups (with knees on the floor)
- Resistance exercises using body weight or resistance bands
- Rope or tree climbing
- Sit-ups (curl-ups or crunches)
- Swinging on playground equipment/bars

**Bone-Strengthening**
- Games such as hop-scotch
- Hopping, skipping, jumping
- Jumping rope
- Running
- Sports such as gymnastics, basketball, volleyball, tennis

- Cross-country skiing
- Games such as tug of war
- Push-ups
- Resistance exercises with exercise bands, weight machines, hand-held weights
- Climbing wall
- Sit-ups (curl-ups or crunches)

*Some activities, such as bicycling, can be moderate or vigorous intensity, depending upon level of effort.*
Pediatric Obesity: Impact of the Healthy Habits Clinic
Prepared by Drs. Emerick & Percival, based on 2012 Fellows PI Project

1. **Our population** (from the US Army Surgeon General)
   a. Army children ages 2-18 in 2010-11: 13% obese, 15% overweight

2. **AAP Recommendations** for obese or overweight with risk factors
   a. Make the (correct) diagnosis!
   b. Screening labs: Fasting Lipids; Fasting glucose q2 yrs; ALT, AST q2 yrs

**Pre-Healthy Habits Clinic:**
Of children diagnosed with obesity (BMI ≥ 95%) over 6 months:
1. Only 69% were correctly diagnosed w/ obesity; 31% incorrectly diagnosed as overweight
2. Screening labs were ordered only 55% of the time (and performed only 47% of the time)
3. Follow-up within 4 months recommended 50% of the time; actual f/u rate was only 18%

**Healthy Habits Clinic:**
Children ages 6-18 yrs with BMI ≥ 85th%ile are eligible:
1. **Intake visit:** 0800-1100 (2nd Wed of the month)
   * Comprehensive medical visit, SMART goal-setting and education, surveys
2. **Follow-up visits:** 1400-1600 (2nd Wed of the month; 9 sessions at the fitness center)
   * Group exercise, education, and behavioral health modification techniques

**Post-Healthy Habits Clinic:**
Of children diagnosed with obesity (BMI ≥ 95%) (the first 6 months of HH)
1. 81% were correctly diagnosed w/ obesity; only 19% incorrectly diagnosed w/ overweight
2. Screening labs were ordered 65% of the time (and performed only 63% of the time)
3. Follow-up within 4 months was recommended 75% of the time; actual f/u was only 40%

**Inspiring Case:**

**HH Resources:** [http://www.nccpeds.com/HealthyHabits.html](http://www.nccpeds.com/HealthyHabits.html) and on the PedsShare Drive
Nutrition Module IV Quiz:

1. Obesity in children is defined as a BMI:
   a. ≥ 20
   b. > 95th% for age
   c. 25
   d. 85-95th%

2. If both parents are obese, what percentage of their children will be obese? >60%

3. Of the following causes, which contributes most commonly toward adolescent obesity?
   a. Lack of nutritional knowledge
   b. Psychosocial and emotional issues
   c. Changing genetic factors
   d. Lack of affordable low calorie/low fat foods
   e. A hectic, active lifestyle

4. Common medical consequences of adolescent obesity include:
   a. Insulin deficiency and diabetes
   b. Rebound anorexia nervosa and bulimia
   c. Osteoporosis and increased frequency of fractures
   d. Depressed self-image and depression
   e. Short stature and delayed bone age

5. Which of the following statement(s) is/are true?
   a. The probability of an overweight teenager becoming an overweight adult is very high
   b. Obese infants are likely to become obese teenagers
   c. Severely obese individuals most likely have a single gene defect that accounts for their obesity
   d. It is important to set low cutoff values for identification of obesity in children in order to identify and treat all children who are overweight.

Overweight teens are 7X more likely to be overweight adults than normal weight teens. Obesity in infancy does not track into older childhood. Single gene defects have been identified in obese individuals but this is extremely rare. Cutoff points for labeling children as overweight or obese were designed to minimize false-positives (i.e. there will be children who are overweight who will be missed).

6. What percentage of low-income preschool children are overweight and/or obese? What are some contributing social factors?
   One in 3 are obese and overweight, and 1 in 7 are obese (see map). Two factors are (1) less access to healthy food choices and (2) restricted access to areas for physical activity.

7. What three-types of physical activities are recommended for children and adolescents? Give an example of each: (see enclosure for more examples)
   • Aerobic: bicycle-riding
   • Muscle-strengthening: swinging on playground equipment
   • Bone-strengthening: jumping rope
**Nutrition Module IV Cases:**

**Case 1:**
3-year-old Jeffrey is overweight. Although his parents have recently started offering him healthier foods, he will not eat them. His parents have trouble tolerating Jeffrey’s crying when his favorite foods are withheld. As a result, Jeffrey ends up being offered the very foods his parents were trying to avoid.

Now that Jeffrey is 3 years old and overweight, his parents are really worried. They really want to do the "right thing," but aren't getting anywhere. **Discuss some specific recommendations to counsel Jeffrey's parents and include your rationale for each one.**

**Recommendations:**

1) **Healthy options:** Always bring healthy foods to the table, and keep a list of the healthy foods your child likes. Offer a variety of foods, but do not offer foods you don’t want the child to eat (i.e. “out of sight, out of mind”). Remove the dessert once everyone has been served.

2) **New foods:** Provide small portions of new foods alongside old favorite ones. Use low-key persistence to introduce new foods, but not at every meal (e.g. 10-14 days to offer again). Leave refused foods within reach so the child can try them later after he has forgotten he said no. Exploit similarities (e.g. if he likes green beans, try snow peas).

3) **Hunger cues:** Learn to read real food needs from a child’s behavior (e.g. a whiny and pale child may be hungry—offer a healthy snack). Work with the child’s eating patterns: Do not force food just because it is mealtime; alternatively, do not refuse food because it is in-between meals. Recognize that 2-3 year-olds instinctively eat high, calorie-dense foods first when they are hungry, that's OK.

4) **Portion control:** 3 year-olds are very cautious eaters, so do not put too much food on the plate, as this has unpredictable effects. Some children eat too much and others will get overwhelmed and eat too little. Let child eat as much as she wants (no “just 2 more spoonfuls”). Parents need to control the types of foods; the child controls the amounts.

5) **Food battles:** Do not push too hard or praise too much. Infants and toddlers instinctively want to control what goes in their mouth; forcing food may lead to food aversions. No rewards, encouragement, bribery, or punishment around food. Also remember, 3-year-olds may be demonstrating typical-for-age fussiness, rather than specifically rejecting healthy foods. Some food refusals may simply be from boredom.

6) **Mealtime Culture:** Let the child be messy: take a back seat and let the child self-feed. Also, discourage “drive-by” eating: the child MUST sit at the table, but does not have to eat. Temper tantrums around food should never be allowed to work.

7) **Role-modeling:** Provide good role-modeling. Make it clear that he doesn’t have to eat it, but that you enjoy it. Do not discuss food/eating problems at the dinner table.

8) **Fluid intake:** Offer solids before the bottle/cup. Juices should be limited to 4-6oz/day. Encourage water. (Remember—in infancy, solids in the bottle DO NOT help the infant sleep through the night, do not teach mechanics of eating and risk caloric overload).

9) **Treats & Sweets:** Avoid more than 1 sweet per day.
Case 2:
An 8 year-old female is accompanied by her mother for a health maintenance visit. The child’s weight for height is just above the 90%. The mother says to you, “My daughter and I agree that she needs to lose weight. I’ve just started a low calorie diet, can she just do the same?”

What additional history do you want to obtain before providing recommendations? What would be some nutritional “red flags” or areas to address?
Obtain a detailed diet history for 3 DAYS. Typical problem areas are the following:
- eating fewer vegetables and fruits per day than recommended,
- eating daily desserts,
- consuming more than 6 ounces per day of juice, soda or punch
- drinking whole milk,
- consuming more than 2 small cookies or 1 small bag chips per day,
- eating fast food or in restaurants more than every 3 days,
- eating deep-fried foods more than every 3 days,
- eating white bread,
- eating candy greater than once a week,
- eating more than 3 meals or 2 snacks a day.

Provide some specific suggestions for counseling this mother and her daughter on age-appropriate nutritional recommendations and include your rationale for each.

Weight loss for growing children, unless morbidly overweight, is not indicated. Approach should entail “growing down the percentiles” or “growing into their weight” (see next page for growth chart example). Also remember, be very careful about what you say regarding the child’s size and run interference when others say something that is harmful.

RECOMMENDATIONS:
Set realistic goals.

Encourage good food choices lower in caloric density with delayed rate of absorption.
- watch caloric content of drinks
- offer a wide-variety of foods. (Let the child decide how much he eats but from a carefully controlled list). Avoid food restriction.
- do not bring foods you do not want eaten into the house
- no snacks in front of the television or computer
- limit eating out
- do not feed boredom or emotional hunger with food
- child must eat with a parent for at least 2 meals a day and no “eating on the run”.

Encourage a variety of physical activities.
- aim for 1-2 hours per day of vigorous activity,
- decrease television viewing time to 10 hrs/week or less,
- participate in physical activities as a family.
Here is an example of weight maintenance, or “growing down the percentiles”:

This chart shows the BMI-for-age pattern of a 7-year-old male who became at risk for overweight at age 3. An intervention was not recommended until age 6, when his BMI-for-age indicated overweight. At this time, a medical assessment revealed no complications, and weight maintenance was encouraged. Over the course of the next 12 months his weight remained 69.3 pounds and his height increased to 52.6 inches. Over the year, BMI decreased as height continued to increase relative to weight and by age 7 years, his BMI-for-age was slightly above the 85th percentile.

<table>
<thead>
<tr>
<th>Age</th>
<th>Weight</th>
<th>Stature</th>
<th>BMI</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>28.4 lb</td>
<td>34.8&quot;</td>
<td>16.6</td>
</tr>
<tr>
<td>3</td>
<td>38.1 lb</td>
<td>38.9&quot;</td>
<td>17.8</td>
</tr>
<tr>
<td>4</td>
<td>43.6 lb</td>
<td>41.6&quot;</td>
<td>17.7</td>
</tr>
<tr>
<td>6</td>
<td>69.3 lb</td>
<td>50.5&quot;</td>
<td>19.1</td>
</tr>
<tr>
<td>7</td>
<td>69.3 lb</td>
<td>52.6&quot;</td>
<td>17.7</td>
</tr>
</tbody>
</table>
Case 3:
A 15-year-old female patient is accompanied by her mother for a health maintenance visit. The girl is 75 pounds overweight. The mother says to you, “She needs help, what should I do?”

After eliciting a dietary history (see Case #2 answer key for suggestions), you perform a detailed physical exam. What are specific areas on your physical exam you want to target?

- Vitals: BP, HR, Ht/Wt/BMI
- General: weight distribution
- HEENT: fundoscopic exam; enlarged tonsils; thyroid (goiter?)
- Chest: gynecomastia
- Cardiopulmonary: evidence of asthma/pulmonary edema
- Abdomen: RUQ tenderness
- GU: Tanner stage
- Extremities: SCFE, Blount disease
- Skin: acanthosis nigricans, striae, hirsutism

Provide some specific suggestions for counseling this mother and her daughter on obesity and include your rationale for each.

**RECOMMENDATIONS:**

- **Nutrition recommendations similar to Case #2:** Eat 5 fruits and vegetables per day. Limit consumption of sugar-sweetened beverages. Eat breakfast daily. Switch to low-fat dairy products. Limit fast food, take out, and eating out. Prepare foods at home as a family and regularly eat family meals together. Eat a diet rich in calcium and fiber.

- **Physical activity recommendations similar to Case #2:** Get 1hr of physical activity/day (does not need to be consecutive). Limit screen time to < 2hrs/day.

- **Determine child’s and family’s perspective:** Encourage parents to provide support, to help with the food environment and to facilitate access to, and participate in the treatment program jointly decided on.

- **Consider referral to “Pediatrics Healthy Habits Clinic”—a monthly multidisciplinary obesity clinic, including general pediatrics, pediatric endocrinology, nutrition, behavioral health, diabetic education, and exercise physiology.**
  - Place consult to the PEDS Healthy Habits Clinic BE in CHCS or AHLTA
  - There is an initial 2hr intake visit, to include fasting screening labs, a health-screening questionnaire, and a medical evaluation with focus on obesity and its co-morbidities.
  - After the intake visit, the goal is for the patient to complete **9 monthly f/u visits**, consisting of **group-exercise and problem-solving sessions.** All clinics 2nd Wed/mo
  - E-mail jill.e.emerick.mil@mail.mil with questions.

What additional work-up, if any, would you like to perform?

| BMI ≥ 95 %ile | Fasting lipids, AST/ALT, fasting glucose, Hgb A1c |
Here is an example of **weight loss**, as indicated for *Case 3*:

This chart shows the growth pattern of an 8 year-old who became overweight very early in her life. At age 2, her *BMI-for-age was at the 95th percentile* and continued to accelerate until age 7. At that point, her parents expressed concern about her eating habits and large body size. A medical assessment revealed a *family history* of diabetes and obesity in both parents.

Based on these findings and the parents’ readiness to participate in the child’s weight management, she was placed on a weight loss program. By age 8, she had averaged 1 pound weight loss per month and her stature-for-age remained at about the 75th percentile. **The dramatic change in the BMI-for-age percentile reflects continued increase in stature, combined with slow steady weight loss** that lowered BMI-for-age to the 90th percentile.

* Growth Chart examples in Case #2 & #3 from [CDC Obesity Growth Chart Module](https://www.cdc.gov/obesity/publications/heightwt/obesity_growthchart_module.pdf)
Nutrition Module IV Board Review:

1. An 8-year-old girl presents for follow-up assessment for obesity management with a body mass index (BMI) of 24 kg/m², only slightly improved from 25 kg/m² at her visit 6 months ago. At that visit, a consultation with a nutritionist was arranged, and the girl's parents report successful reduction in her consumption of sweets, juice, and fast food. Because of bullying at school and neighborhood crime, she is not allowed to play outside alone. She spends 8 hours each day watching television.

Of the following, the next BEST step in anticipatory guidance is to recommend

A. removal of the television from the child's bedroom
B. restriction of television and video games to no more than 4 hours/day
C. substitution of video games for passive television viewing
D. watching television only when eating with the family
E. watching videos rather than commercial television

The girl and her family described in the vignette have made modest progress with dietary changes in addressing her obesity, but she remains significantly overweight. Therefore, further steps must be taken to reduce her weight. Risk factors for obesity include limited outdoor play and social isolation. Most importantly, excessive television viewing and a television in her bedroom place her at risk not only for continued obesity but also for the psychosocial risks of potentially unsupervised television watching and exposure to substance use and sexuality in television.

Although technology affords opportunities for young children to develop early computer skills, the independent use of this technology may be harmful in excess. In particular, there are concerns that independent television and computer use may replace valuable time spent in outdoor play and socialization that the traditional playground has offered. The impact of television viewing on children has been of concern for the last 2 decades, along with other "screen time" elements of computer and video games and substituting other forms of "screen time" (eg, videos, computer) for television time will not address the need for exercise or reduce the social isolation associated with excessive screen time. Results of numerous studies, including those that are prospective and randomized in a variety of settings in industrialized countries, suggest that television has significant effects on child behavior. However, confounders in the studies include ethnicity, poverty, parental education, and parental health habits. In general, more television viewing occurs in households that have many of those factors.

Parents should be made aware of the recommendations to limit television viewing to **2 hours per day or less for all children**; should be discouraged from placing a television in a child's bedroom; and should be made aware of links between television viewing, obesity, and diminished academic performance. There is no evidence that television viewing in young children provides any benefit over reading and playing with parents and other children. Further, television viewing may contribute to obesity through both the time spent in the sedentary activity and exposure to advertising for food and largely sedentary toys. Watching television while eating decreases family communication during meals.

The recommendation for ensuring less than 2 hours of total screen time per day still allows for sharing of family-oriented programming, limited amounts of computer experience and skill development, and very limited access to "educational" programming. Older children may find limiting such activity to be a challenge because of homework requirements using the computer, use of social networking sites, casual television watching, and playing video games, some of which may have benefits for social interaction.

Placing a television in the child's bedroom is especially problematic in terms of adult supervision for both the time and quality of programming. Research has demonstrated that children who have televisions in their rooms have increased risks of obesity, sleep disturbance (especially sleep latency prolongation), and lower academic performance.
2. A nurse practitioner in your clinic has asked you to review the chart of an 11-year-old boy referred from school for evaluation of acanthosis nigricans.

**Of the following, the physical examination parameter that is MOST likely to be useful in predicting comorbidities in this patient is**

A. blood pressure at the 75th percentile for height  
B. body mass index at the 95th percentile for age  
C. sum of triceps and subscapular skinfold thickness greater than 90% for age  
D. weight at the 50% and height at the 25% for age  
E. weight at the 95% and height at the 75% for age

Because acanthosis nigricans is associated with obesity, the young man in the vignette is likely to be overweight and at risk for numerous comorbidities, including hypertension, hyperlipidemia, and the metabolic syndrome.

Although several methods have been used to assess obesity, body mass index (BMI), defined as weight in kilograms divided by height in meters squared (kg/m²), has become the standard measure for children, adolescents, and adults. The correlation of BMI with measures of adiposity is excellent in adults, but slightly less reliable for children, whose BMIs change with age during childhood and adolescence. Of note, boys have less body fat than do girls at the same BMI. Total body fat correlates with sexual maturational level more than age because as sexual maturity progresses, body fat increases. Those who have a higher waist-to-hip ratio at the same BMI have more body fat.

In 2000, the Centers for Disease Control and Prevention (CDC) released new growth curves, including BMI curves for boys and girls from ages 2 to 20 years (www.cdc.gov/growthcharts). Obesity has been defined as a BMI greater than the 95th percentile for age on the 2000 CDC growth curves. Children whose BMIs fall between the 85th and 95th percentiles for age are considered overweight. Children whose BMIs are greater than the 99th percentile are defined as severely obese.

Weight-for-height is a less accurate measure and is subject to misinterpretation of overweight versus obesity. In the estimation of risk for comorbid conditions, including diabetes or insulin insensitivity, hypertension, hyperlipidemia, or metabolic syndrome, the BMI now represents a standardized measurement. However, high weight-for-height must be used to assess obesity in children younger than 2 years of age for whom BMI norms are not available. It is unclear whether childhood obesity is an independent risk factor for hyperlipidemia and atherosclerotic heart disease. It is known that the higher the BMI, the greater the risk of left ventricular wall thickness in children who have hypertension and that BMI correlates with arterial wall thickness. Skin-fold thickness measurements are accurate in estimating total body fat but are not currently the standard for determining risk for co-morbidities of obesity. In addition, they may be difficult to obtain in the primary care office setting due to issues with interobserver reliability, training of staff in the technique, and the expense of the calipers ($200). However, skin-fold thickness measurements may be useful in very athletic, muscular adolescent males whose BMIs are artificially elevated by high muscle mass.

All children older than 3 years of age should have blood pressures measured at each health supervision visit; children who are overweight should have blood pressures monitored more frequently. A blood pressure that is at the 75th percentile is within the normal range and less likely to be associated with co-morbidities than BMI at the 95th percentile.

3. During your examination of a 7-year-old boy at his health supervision visit, conducted with a pediatric resident, you determine that his weight is greater than the 97th percentile for age. His mother is obese, his father has type 2 diabetes mellitus, and one grandfather died of a myocardial infarction at 51 years of age. You counsel the family about improvements they can make in the boy’s diet and level of exercise.
Of the following, you are MOST likely to advise that this child's risk of developing metabolic syndrome
A. can be predicted by a determination of hgb A1c values
B. is close to that of the general population because there is no family history of hyperlipidemia or systemic hypertension
C. is reduced if he begins to develop a healthy lifestyle as a child
D. is the same as the general population if cholesterol-lowering agents are started, even without lifestyle changes
E. is the same as the general population if his fasting lipid profile is currently normal

The findings on physical examination combined with the family history for the boy described in the vignette suggest that he is at risk of metabolic syndrome, a combination of medical disorders that increase the risk of developing cardiovascular disease and diabetes. Metabolic syndrome affects one in five people, the prevalence increases with age, and some studies estimate the prevalence in the United States to be up to 25% of the population. Metabolic syndrome also is known as metabolic syndrome X, syndrome X, and insulin resistance syndrome. The term "metabolic syndrome" describes the associations of obesity, diabetes mellitus, hyperlipoproteinemia, and hyperuricemia describes the additive effects of risk factors on atherosclerosis.

Very little is known about the development of metabolic syndrome in children, and the term is not used in pediatrics. However, clinicians are becoming increasingly cognizant of the risk factors in the pediatric population, which include obesity, family predisposition to early cardiovascular disease, systemic hypertension, type 2 diabetes, and an unhealthy dietary and exercise-related lifestyle. Criteria have been determined for treating childhood hyperlipidemia, with the first line of therapy being diet modification and exercise programs. Adoption of such lifestyle changes in childhood can reduce the risk of developing metabolic syndrome. Cholesterol-lowering agents never are used in the absence of concomitant recommendations for institution of lifestyle changes. Although an elevated hemoglobin A1c value does predict diabetes, data are insufficient in the pediatric population to make predictions regarding the use of this value alone to predict risk for the eventual development of the metabolic syndrome. The same holds for fasting lipid profiles: an abnormal panel predicts the development of hyperlipidemia during adulthood but does not predict the development of the metabolic syndrome. A normal fasting lipid profile does not reduce this risk. The risk for the development of metabolic syndrome does not require the presence of all components of the definition. The absence of several risk factors (ie, family history of hyperlipidemia/hypertension) does not reduce this child's risk to that of the normal population because of the presence of other risk factors.

The exact mechanisms of the complex pathways of metabolic syndrome are not yet completely known. Most patients are older, obese, sedentary, and have a degree of insulin resistance. Stress also can be a contributing factor. There is debate regarding whether obesity or insulin resistance is the cause of the metabolic syndrome or if they are consequences of a more far-reaching metabolic derangement. A number of markers of systemic inflammation, including C-reactive protein, often are increased, as are fibrinogen, interleukin-6, tumor necrosis factor-alpha, and others. Central adiposity is a key feature of the syndrome. However, despite the importance of obesity, patients who are of normal weight also may be insulin-resistant and have the syndrome.

The International Diabetes Federation consensus worldwide definition of the metabolic syndrome (2006) includes central obesity (defined by waist circumference), AND any two of the following:

- Elevated triglycerides
- Low high-density lipoprotein (HDL) cholesterol
- Hypertension
- Elevated fasting plasma glucose

Various strategies have been proposed to prevent the development of metabolic syndrome, including increased physical activity (such as walking 30 minutes every day) and a healthy, reduced-calorie diet. However, these measures are effective in only a minority of people, primarily due to a lack of compliance. Drug treatment frequently is required. Diuretics and angiotensin-converting enzyme inhibitors may be used to treat hypertension. Cholesterol drugs may be used to lower low-density lipoprotein cholesterol and triglyceride
concentrations, if they are elevated, and to raise HDL concentrations, if they are low. Use of drugs that decrease insulin resistance such as metformin is controversial; this treatment is not approved by the FDA. Cardiovascular exercise has been shown to be therapeutic in approximately 30% of cases. The most probable benefit is reduction in triglyceride concentrations, but fasting plasma glucose and insulin resistance in most patients did not improve.

4. A 10 y/o boy who recently emigrated from Central America is referred by the school nurse for evaluation of obesity. Physical examination reveals an obese but generally healthy boy who has acanthosis nigricans. He has had limited access to medical care in the past.

Of the following, the finding MOST likely to suggest an underlying cause for the child’s obesity is:
A. a normal blood pressure
B. abdominal striae
C. penile length at 1 standard deviation below the mean
D. small hands and feet
E. stature greater than the 95th percentile

The incidence of obesity continues to increase among children in industrialized nations. In general, the causes in most children relate to increased caloric intake and decreased physical activity. However, the pediatrician must exclude genetic, metabolic, or other underlying causes of obesity in children for two reasons: 1) some underlying causes may require treatment and 2) the focus on changing the child’s lifestyle must involve parents who are reassured that hormonal or other abnormalities are not the cause. A child who exhibits normal linear growth, has normal developmental milestones, and has normal findings on physical exam is unlikely to have an underlying cause for his or her obesity.

The most common metabolic cause of obesity is hypothyroidism, but routine testing for thyroid function in the overweight child who has normal linear growth velocity for age and no clinical signs of hypothyroidism is unwarranted. A stature greater than the 95th % should be interpreted with caution because one measurement is not sufficient to determine growth velocity. However, this finding is reassuring because normal to above-average height is unlikely in a child who has hypothyroidism and common in children who have exogenous obesity.

Children who have small hands and feet, hypogonadism, learning disabilities, or mental retardation should be evaluated for Prader-Willi and Bardet-Biedl syndromes. These syndromes often present in infancy or early childhood with hypotonia and developmental delay. Small hands and feet are common and strongly suggest an underlying anomaly for the child described in the vignette. Genetic testing for these conditions is available.

The normal blood pressure reported for the boy is reassuring because HTN often complicates obesity. Penile length is normal at 1 SD below the mean, but it is important to remember that measurement of penile length can be a challenge in obese children due to interference from the pubic fat pad.

Striae may be seen in many overweight children simply due to rapid weight gain. Although this finding also occurs with cortisol excess, conditions associated with hypercortisolism usually are associated with other signs and symptoms. Thus, the finding of striae in an obese child is not an indication that additional testing is necessary.

Treatment of childhood obesity is difficult, although there is some evidence for a variety of interventions that may prove successful in some populations. Numerous diets, including low-carbohydrate diets, appear to have some impact on obesity in children. For morbidly obese adolescents who have comorbidities unresponsive to diet and exercise, some centers are moving toward bariatric surgery. Barriers to health lifestyles (lack of availability in some communities of safe outdoor play areas, specific exercise programs geared to very obese children, and school lunch programs) remain topics of scientific and political investigation.
5. A 15-year-old girl is concerned about irregular menses and acne. Menarche was at age 11 years and 9 months, and she remembers developing pubic hair around age 7 years. On physical examination, her vital signs are normal and her body mass index is 32.3 kg/m². She has facial comedonal and papular acne as well as mild darkening of the skin of her neck and axilla. You also note hypopigmented, narrow stretch marks on her abdomen and hair in a linear distribution from her umbilicus to the pubic symphysis and on the upper inner surface of her thighs. She is at Sexual Maturity Rating 5, and her clitoral diameter is 2mm.

Of the following, the MOST likely diagnosis is
A. Cushing syndrome
B. hypothyroidism
C. Metabolic syndrome
D. physiologic anovulation
E. polycystic ovarian syndrome

The presence of acanthosis nigricans combined with obesity (body mass index >30 kg/m²), acne, and some increase in body hair described for the girl in the vignette as well as irregular menses 3 years after menarche suggests the need for further evaluation for polycystic ovarian syndrome (PCOS). The diagnosis of PCOS, using the 2003 Rotterdam criteria, requires, in addition to exclusion of related conditions, the presence of two of the following three criteria: 1) oligo- or anovulation, 2) clinical or biochemical signs of hyperandrogenism, and 3) polycystic ovaries. Oligo- or anovulation presents as irregular menses, and hyperandrogenism may present as acne, increased body hair, and rarely, clitorimegaly (a transverse clitoral diameter greater than 3 mm). The severity of hirsutism may be assessed using the Ferriman-Gallwey Scoring system. A score ranging from 0 (no hair) to 4 (frankly virile [extensive hair growth]) is assessed for each of nine body areas most sensitive to androgens. These sites include the upper lip, chin, chest, abdomen, suprapubic region, arms, thighs, upper back, and lower back. A score of 8 or more is considered significant and suggestive of increased androgen concentrations. The severity of acne and hirsutism, however, may not correlate well with the concentrations of androgens because the response of the androgen-dependent follicle to androgen excess varies considerably between and within persons. Therefore, total and free testosterone measurement may be supportive of this diagnosis.

A number of risk factors for PCOS have been outlined at various stages of development. One of these factors is premature adrenarche, which is the appearance of pubic hair before age 8 years without other evidence of puberty. Whether peripubertal obesity predisposes to PCOS remains to be determined. Those who have risk factors for insulin resistance such as acanthosis nigricans or a family history of type 2 diabetes and cardiovascular disease may be at increased risk for PCOS. Acanthosis nigricans is a velvety hyperpigmentation and thickening of the skin on the nape of the neck, axilla, and other body folds. It is a nonspecific sign of insulin resistance.

A number of disorders may be considered in the differential diagnosis of PCOS but are not associated with signs of androgen excess. Patients who have hypothyroidism may be overweight and have menstrual disturbances, but they typically have other symptoms, including hair loss, constipation, and dry skin. A common symptom of Cushing syndrome is sudden weight gain. In addition, affected patients have signs or symptoms of cortisol excess such as muscle weakness; facial rounding and plethora; easy bruising; and multiple wide, purplish striae on the abdomen, not the narrow hypopigmented type exhibited by the patient in the vignette. In addition to central obesity and high blood pressure, patients who have metabolic syndrome have elevated fasting glucose and triglyceride values and decreased high-density lipoprotein cholesterol values. Metabolic syndrome is common in those who have PCOS, and such patients should be screened regularly for metabolic syndrome. Physiological anovulation becomes less likely as an explanation for irregular menses 3 years after menarche.
6. A 10-year-old boy presents to your office as a new patient for follow-up care after being seen in the emergency department for acute pharyngitis. On physical examination, the boy, who is obese (>95% body mass index for age), has enlarged tonsils that are not inflamed and acanthosis nigricans. Findings on his cardiac, pulmonary, and genital examinations are normal, and his genitalia are prepubertal. According to his mother, his school performance is declining, he has prolonged sleep latency, and he has been increasingly irritable, with aggressive behavior at home and at school.

Of the following, in addition to aggressive weight management efforts, the study MOST likely to guide therapy for several of this child's concerns is
A. Chest radiography
B. Electrocardiography
C. Electroencephalography
D. Pulmonary function testing
E. Sleep study

The clinician for the child described in the vignette is challenged by determining which features of the child's medical and behavioral symptoms are due to his obesity. Behavioral concerns, especially problems with attention and aggressiveness, seem to correlate with sleep dysfunction or sleep hygiene, which suggests the need to investigate whether this child is having problems with sleep. In addition to taking a complete history of the child's sleep pattern since birth and ascertaining other psychosocial stressors, the clinician should request input from the parents and the school via questionnaires such as the Pediatric Symptom Checklist, the Vanderbilt questionnaires, and other instruments. At that point, the clinician can decide on the risks and benefits of ancillary testing.

Questionnaires that address sleep behaviors may help with gathering more information, but they are not evidence-based in terms of reliability and validity. Parents of children of this age may have little knowledge of their children's awakenings and other episodes during the night. A formal sleep study or polysomnography that includes electrocardiography (ECG), pulse oximetry, measures of airway resistance, and video capturing of paroxysmal events may provide the most information that could lead to a diagnosis of sleep apnea.

It should be noted that sleep studies for children may not be widely available in all communities. Further, interventions for sleep apnea, such as adenotonsillectomy and continuous positive airway pressure machines, may have unintended consequences such as increased weight gain, and there is little evidence at this time to support these interventions. Weight management is the most recommended intervention.

The lack of documented seizure activity for this child obviates the need for electroencephalography. ECG may be useful in children who are overweight and have hypertension to provide information about cardiac ventricular function, but it does not predict cor pulmonale or other sequelae of sleep apnea or other disturbance. Pulmonary function testing and chest radiography are not helpful in the evaluation of sleep disorders.