Evaluation and Management of Childhood and Adolescent Obesity

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The prevalence of obesity in children and adolescents has increased dramatically in the past 3 decades. Childhood and adolescent obesity are associated with serious comorbidities including type 2 diabetes mellitus, hyperlipidemia, and hypertension. Most obese children and adolescents have no defined underlying endocrine or genetic syndrome. Evaluation of an obese child or adolescent involves a detailed personal and family history, physical examination, and selected laboratory evaluation. Lifestyle interventions and behavioral modification aimed at decreasing caloric intake and increasing caloric expenditure are essential to management of childhood and adolescent obesity. Surgical approaches have a role in management of morbid obesity and serious obesity-related comorbidities in adolescents. Further research is needed to evaluate the role of various dietary approaches and pharmacotherapy in the treatment of obesity in childhood and adolescence.

***Mayo Clin Proc.* 2007;82(10):1258-1264**

AGB = adjustable gastric banding; BMI = body mass index

The rapidly increasing prevalence of obesity among children and adolescents is one of the most challenging dilemmas facing pediatric care professionals today. Childhood and adolescent obesity are important risk factors for adult obesity, with its consequent morbidity and mortality.[1,2] Therefore, prevention and/or treatment of childhood and adolescent obesity offers the best hope of preventing adult obesity and its related morbidities. A variety of adverse consequences are associated with being overweight in childhood or adolescence, including but not limited to type 2 diabetes mellitus, dyslipidemia, hypertension, and poor self-esteem. Type 2 diabetes mellitus currently accounts for up to 45% of all newly diagnosed diabetes in pediatric patients and is more common in ethnic and racial groups with higher rates of obesity.[3] In a study conducted in Louisiana, more than half of the overweight children had at least 1 risk factor for cardiovascular disease, such as elevated blood pressure, hyperinsulinemia, or dyslipidemia, and a quarter had 2 or more risk factors.[4] From 1997 to 1999, 3 times as many children and adolescents had conditions associated with being overweight, such as sleep apnea and gallbladder disease, than from 1979 to 1981.

EPIDEMIOLOGY

Body mass index (BMI, [calculated as weight in kilograms divided by the square of height in meters]) is the most widely accepted method used to screen for obesity in children and adolescents because the measurements needed to calculate BMI are noninvasive. Body mass index is a reliable indicator of body fat content for most children and adolescents. Although the BMI does not measure body fat directly, it correlates well to direct measures of body fat, such as underwater weighing and dual-energy x-ray absorptiometry.[5] Additionally, BMI has been found to correlate well with obesity-related complications.

The Centers for Disease Control and Prevention uses the term *overweight* to designate children (aged 2-19 years) with BMI at or above the 95th percentile for age and sex and does not use the term *obese* in describing childhood weight categories. The term *at risk for overweight* is used for children with BMI between the 85th percentile and the 95th percentile for age and sex. For the sake of simplicity, the terms *overweight* and *obese* will be used interchangeably in this article.

Childhood obesity has reached epidemic proportions in developed nations throughout the world. According to the National Health and Nutrition Examination Surveys, the prevalence of obesity in preschool children (aged 2-5 years) and children (aged 6-11 years) from 1999 to 2002 was double that between 1976 and 1980; for adolescents (aged 12-19 years), triple.[6,7] Among children aged 6 to 19 years in 1999 to 2002, 31.0% were overweight or at risk of being so and 16.0% were overweight.[7] Furthermore, the prevalence of children being overweight is even higher among certain ethnic groups such as African Americans, Mexican Americans, and Native Americans.[7] The risk for being overweight is increased among persons with high birth weight (≥4000 g) or with obese parents.[1,8]

PATHOPHYSIOLOGY

Almost all obesity in children is exogenous, caused by a caloric intake that is greater than needed. An excess intake

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A question-and-answer section appears at the end of this article.

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of only 50 to 100 kcal per day can lead to a 2.0 kg to 5.0 kg weight gain over a 1-year period. Energy output is derived from resting energy expenditure, the thermal effect of food and activity. The epidemic of obesity in the past 2 decades is likely a result of a gradually increasing caloric intake and a decreasing level of physical activity. Endocrine and genetic diseases are rare causes of obesity in childhood, accounting for less than 1% of childhood obesity in tertiary care centers. Certain antidepressants such as monoamine oxidase inhibitors and tricyclic antidepressants tend to be more associated with weight gain than are selective serotonin reuptake inhibitors. However, this association does not imply causation.

EVALUATION OF OBESE CHILDREN

Obesity can be seen in association with a wide variety of genetic and endocrine disorders (Table 1), the signs and symptoms of which include hypogonadism, short stature, dysmorphic features, and mental retardation. Growth failure characterizes endogenous obesity secondary to endocrine disorders such as hypothyroidism and hypercortisolism. Children with obesity secondary to genetic syndromes typically have characteristic physical examination findings. Prader Willi syndrome, the most common syndromic form of obesity, is characterized by failure to thrive early in life, short hands and feet, short stature, hypotonia, and genital hypoplasia. Children with endogenous obesity are short and often have a delayed or normal bone age. Conversely, children with idiopathic or exogenous obesity are taller and often have growth acceleration along with advancement in bone age. A careful history and physical examination are usually adequate to rule out or suspect an endogenous cause for obesity in most children (Figure 1).

Evaluation of overweight children should also focus on morbidities associated with obesity including type 2 diabetes mellitus, hypertension, hyperlipidemia, sleep apnea, orthopedic complications, and psychiatric sequelae. Conditions that indicate consultation with a pediatric obesity specialist include pseudotumor cerebri, sleep disorders, orthopedic problems, massive obesity, and obesity in children aged younger than 2 years.

LABORATORY EVALUATION

Only a small percentage of overweight children require laboratory evaluation to rule out a secondary cause for obesity. If hypothyroidism is suspected, a thyroid-stimulating hormone level should be obtained. A 24-hour urine collection for free cortisol or a dexamethasone suppression test is generally recommended as a screening test in a child with suspected hypercortisolism, although overweight children frequently have a mild elevation in urinary free cortisol levels.

TABLE 1. **Secondary Causes of Obesity**

Genetic
Monogenic disorders
Melanocortin-4 receptor mutation
Leptin deficiency
Proopiomelanocortin deficiency
Syndromes
Prader-Willi
Bardet-Biedl
Cohen
Alstrom
Fröhlich
Neurologic
Brain injury
Brain tumor
Consequences of cranial irradiation
Hypothalamic obesity
Endocrine
Hypothyroidism
Cushing syndrome
Growth hormone deficiency
Pseudohypoparathyroidism
Psychological
Depression
Eating disorders (binge eating, eating at night)
Drug-induced
Tricyclic antidepressants
Oral contraceptives
Antipsychotics
Anticonvulsants (sodium valproate, carbamazepine)
Sulfonylureas
Glucocorticoids

Some experts suggest that a basic panel of tests (ie, fasting plasma glucose, insulin, and lipid panel) be performed in children with BMI greater than the 85th percentile or the 95th percentile to determine whether common comorbidities are present.[9] Fasting glucose greater than 100 mg/dL (to convert to mmol/L, multiply by 0.0555) is considered prediabetic, and a level greater than or equal to 126 mg/dL is consistent with the diagnosis of diabetes. The American Diabetes Association recommends a fasting plasma glucose measurement for children aged 10 years or older who have a BMI at or above the 85th percentile and 2 of the following risk factors: a family history of type 2 diabetes mellitus in first- or second-degree relatives, nonwhite race, and conditions associated with insulin resistance (eg, acanthosis nigricans, hypertension, dyslipidemia, or polycystic ovary syndrome).

Fasting serum triglyceride levels are often elevated in obesity and are considered an early sign of metabolic syndrome. Children with total triglyceride levels greater than 200 mg/dL (to convert to mmol/L, multiply by 0.0113) should be followed up closely. Liver function tests should be obtained because nonalcoholic fatty liver disease is

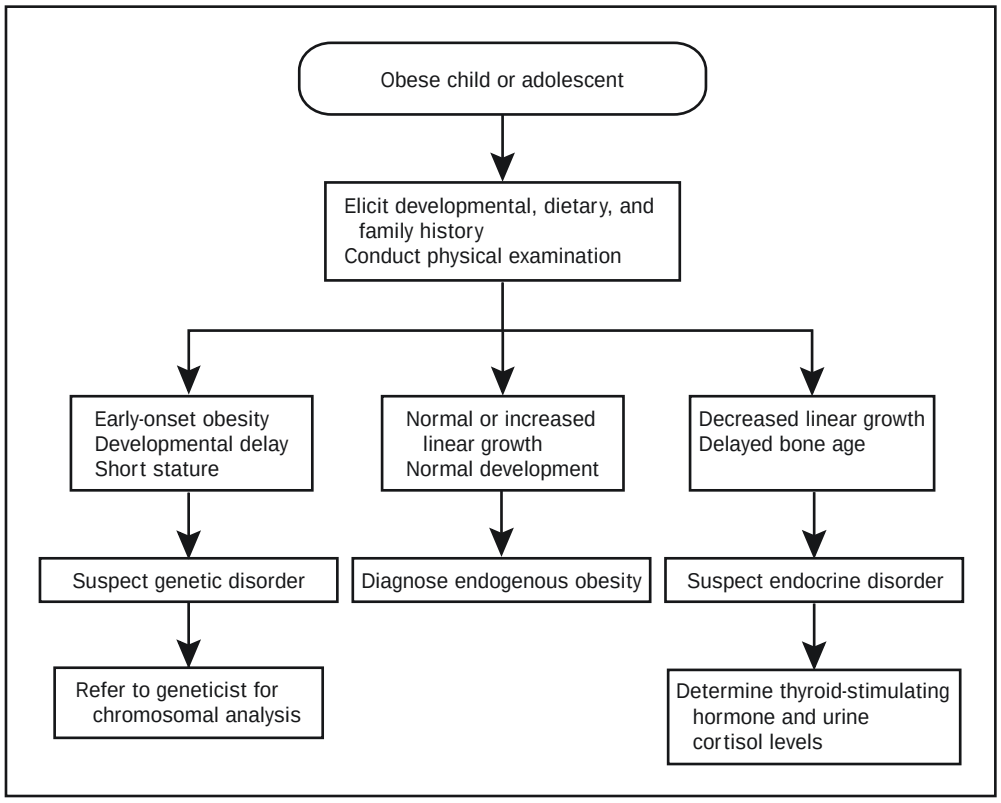

FIGURE 1. Practical algorithm for diagnosing childhood and adolescent obesity.

typically asymptomatic. Obese children should be referred to a gastroenterologist to be evaluated for nonalcoholic fatty liver disease and other chronic liver diseases (eg, viral hepatitis, autoimmune hepatitis, Wilson disease, and α_1-antitrypsin deficiency) if alanine transaminase levels are greater than twice the normal value and persist for more than 3 months.

COMMUNICATION WITH CHILDREN AND THEIR FAMILIES

Health care professionals are often reluctant to discuss the issue of obesity with overweight children and their families. Clinicians who care for these families must show sensitivity, compassion, and a conviction that obesity is an important chronic medical problem that can be treated. Questions about caloric intake and activity should be framed in objective and nonaccusatory language. By assessing the parents' conceptions regarding their child's weight, clinicians can better understand the characteristics of the family without seeming to blame or put pressure on the parents. Because obesity is often a pejorative term, the term overweight is preferable when discussing weight with parents.

TREATMENT

Weight-Loss Goals

For overweight children aged 7 years or younger who have no secondary complications, the accepted standard of practice is prolonged weight maintenance. However, children in this age group with secondary complications of obesity may benefit from weight loss if their BMI is at the 95th percentile or higher.

For children older than 7 years, prolonged weight maintenance is an appropriate goal if the BMI is between the 85th percentile and 95th percentile and no secondary complications of obesity are observed. However, weight loss is recommended for those older than 7 years with a BMI between the 85th percentile and 95th percentile who have a secondary complication of obesity and for those with a BMI at or above the 95th percentile. The initial goal in all children is weight maintenance followed by a slow rate of weight loss of approximately 0.45 kg per month.[9] Children and adolescents with comorbidities such as pseudotumor cerebri, sleep apnea, orthopedic abnormalities, type 2 diabetes mellitus, and hypertension require a more rapid weight loss.

Dietary Management

A successful weight-management program offers strategies for decreasing caloric intake and increasing physical activity (Table 2).[10] Data on the long-term outcomes of pediatric obesity treatment programs in an outpatient clinical setting are scant. Programs that use comprehensive behavioral interventions for treating overweight children have been shown to be beneficial.[11,12]

Most studies have used the Stoplight Diet, in which (a) green-light foods are low-calorie, high-fiber foods, with no restrictions placed on intake; (b) yellow-light foods are higher in nutrient density and are essential to a healthful, well-balanced diet but should be eaten in moderation; and (c) red-light foods are high in fat or simple sugars and should be restricted to no more than 4 servings per week and eaten only away from the home.

Currently, most health care professionals recommend a moderate restriction in energy and a nutritionally balanced age-appropriate diet using the US Department of Agriculture's Food Guide Pyramid and the dietary guidelines of the American Heart Association.[11,13] Dietary interventions are aimed at reducing the intake of high-fat foods, simple sugars, and sweetened beverages and at increasing the intake of lower-calorie, high-fiber foods such as fruits, vegetables, and whole grains.

The long-term safety and effectiveness of the low-carbohydrate, high-protein diets such as the Atkins diet have not been adequately studied in children. Only 1 controlled trial with adolescents (aged 12-18 years), lasting 12 weeks, showed that the low-carbohydrate group (n=16) lost significantly more weight than did the control group (n=14), who followed a portion-controlled, nutritionally balanced, low-fat diet (<30% of energy from fat) (weight lost ± SD, 9.9 kg±9.3 kg for the low-carbohydrate group vs 4.1 kg± 4.9 kg for the control group).[14]

Large long-term studies are needed to evaluate the role of a reduced–glycemic load diet in the treatment of overweight children. Overweight children and adolescents who followed a reduced–glycemic load diet have been found to have a significantly greater decrease in BMI and reduction in body fat mass vs those who followed an energy-restricted, reduced-fat diet.[15,16]

Physical Activity

Another essential component of a successful behavioral weight-management intervention is increasing the level of physical activity and decreasing the time spent in sedentary activities. Programmed aerobic exercise appears to be less effective than lifestyle exercise, which increases movement through daily routines and encourages regular time for active play or more interactive, fun, structured exercise such as community soccer, karate, or dance.[10] The most recent guidelines for physical activity recommend that elementary-school–aged children and adolescents accumulate at least 30 to 60 minutes of age-appropriate activity on most days of the week.[13] In lifestyle modification, sedentary behaviors such as watching television, playing video games, or using a computer are reduced and more physically active ones encouraged.[17]

TABLE 2. **Treatment Strategies for Childhood and Adolescent Obesity**

Dietary approaches
Restrict total caloric intake to achieve mild negative energy balance
Decrease intake of calorie-dense foods such as saturated fats, salty snacks, and high glycemic foods such as candy
Eliminate use of juice and regular soda and replace with skim milk, water, or nonalcoholic beverages
Eat balanced diet containing fiber, fruits, vegetables, low-fat dairy products, and fish
Physical activity
Decrease sedentary behavior (watching television, "surfing" the Internet, and playing video games)
Engage in fun and age-specific exercise that is appropriate to individual abilities
Incorporate exercise into family time
Gradually increase intensity, frequency, and duration of exercise, as tolerated

Pharmacological Therapy

In the United States, 2 prescription drugs, orlistat and sibutramine, are currently approved by the Food and Drug Administration for long-term treatment of obesity in adolescents.

Approved for children older than 12 years by the Food and Drug Administration in 2003, orlistat blocks absorption of fat in the intestine by inhibiting lipase activity, thereby potentially establishing a negative energy balance. Because it may also interfere with the absorption of fat-soluble vitamins (A, D, E, and K), a daily multivitamin supplement is recommended either 2 hours before or after orlistat is taken. Gastrointestinal adverse effects, such as fatty or oily stools, are common with treatment.[18] In a large, multicenter, randomized, placebo-controlled trial, orlistat resulted in a decreased BMI compared to placebo.[19] Concerns regarding possible malabsorption of fat-soluble vitamins and gastrointestinal adverse effects are likely to limit the use of orlistat for the treatment of pediatric obesity.[20]

Sibutramine is the only anorectic agent currently approved for use in obese adolescents older than 16 years. This drug promotes satiety and enhances energy expenditure by inhibiting the reuptake of the neurotransmitters noradrenaline and serotonin. A 1-year randomized controlled trial in obese adolescents showed reduction in BMI and body weight and improved metabolic profile in the

sibutramine-treated group.[21] Tachycardia and headache were seen in the sibutramine-treated patients but did not warrant discontinuation of treatment.[21] Blood pressure and heart rate should be closely monitored in patients taking sibutramine.

A recent study showed significantly more improvement in body composition (weight, BMI, waist circumference) and fasting insulin levels in a small number of obese insulin-resistant pediatric patients with metformin therapy vs placebo.[23]

For optimal effect, these drugs should be used in conjunction with behavioral interventions that promote a healthful diet and a physically active lifestyle.

Bariatric Surgery

One important tool in the management of adult severe obesity (BMI >40) is bariatric surgery, ie, surgical procedures that help promote weight loss by either decreasing the absorption of nutrients from the gut or by restricting food intake. Bariatric surgery has been shown to be effective in maintaining significant weight loss (mean of 61% loss of excess body weight) long-term and in resolving or improving many of the obesity-related comorbidities such as diabetes, sleep apnea, hypertension, and hyperlipidemia.[23]

In contrast, only limited data exist on the long-term outcome of bariatric surgery in children and adolescents. One long-term (5-10–year) follow-up study of patients who had undergone bariatric surgery suggested that it can be performed safely in adolescents and showed that it resulted in significant weight loss (mean of 63% loss of excess body weight), correction of obesity-related comorbidity, and improvement in self-image and socialization.[24] However, concerns remain regarding the ability of adolescents to adhere to long-term vitamin and mineral supplements and to sustain healthy eating habits.[25] Therefore, institutions that offer bariatric surgery for severely obese adolescents must devise developmentally appropriate behavioral intervention strategies to optimize adherence to the postoperative medical and dietary regimens.

There is a growing consensus that obese adolescents with a BMI of 40 or more who have a serious obesity-associated medical complication (including type 2 diabetes mellitus, obstructive sleep apnea, or pseudotumor cerebri) or a BMI of 50 or more with less serious obesity comorbidities are good candidates for bariatric surgery. Of these obese adolescents, only those who have achieved at least 95% of their adult height and who have failed after 6 months or more to lose substantial weight using more conventional, medically supervised, weight-management strategies should be considered for bariatric surgery.[26] These selection criteria should be used in combination with a comprehensive assessment by a multidisciplinary team to ensure that the adolescent is in good physical and psychological health and has strong family support. Contraindications to bariatric surgery include substance abuse or psychiatric disorders (including severe eating disorders) that are likely to interfere with long-term adherence to medical surveillance and nutritional recommendations.[27]

Comparison of the efficacy and safety of various bariatric procedures among adolescents has been hampered by limited data. However, both Roux-en-Y gastric bypass and adjustable gastric banding (AGB) have been effective in treating the medical consequences of severe obesity in adolescents.

The advantages of gastric bypass among adults include substantial loss of weight (typically, 33% reduction in body weight or BMI 1 year after surgery) that is largely sustainable for up to 14 years, inherent deterrence to carbohydrate ingestion, and enhanced satiety after surgery. In adults, a greater risk of perioperative (within 30 days after surgery) death exists with gastric bypass (0.5%) than with AGB (0.05%). Early complications observed among adolescents who undergo bariatric surgery have included pulmonary embolism, wound infections, stomal stenoses (requiring endoscopic dilation), dehydration, and marginal ulcers (medically treated). Late complications have included small-bowel obstruction, incisional hernias, micronutrient deficiencies, and late weight regain in up to 15% of cases.

Adjustable gastric banding consists of laparoscopic placement of a silicone band that encircles the proximal stomach, just beyond the gastroesophageal junction. The band can be adjusted with injection of saline into a peripherally placed reservoir. The band is removable if necessary and, in most cases, has no serious adverse effect on esophagogastric anatomic features. The major advantages of AGB include the ease and safety of minimally invasive placement, adjustability, and reduced potential for adverse nutritional consequences. Adjustable gastric banding has not been approved by the Food and Drug Administration for use among patients younger than 18 years. Many, but not all, US studies have reported fewer surgical complications and less weight loss with AGB than with gastric bypass.[28-30] Very good outcomes have been seen in the health care centers in Europe and Australia that have the most experience using this procedure, but patients at those centers have been monitored less than a decade, and therefore the long-term results of the procedure are not known.[31,32] Possible device-related complications include port malposition or malfunction, tubing leaks, band slippage that leads to gastric prolapse, foreign-body infection, and band erosion into the stomach or esophagus. Moreover, because these mechanical devices have a finite lifetime, adolescent patients may need to undergo replacement of the device.

CONCLUSION

The dramatic increases seen in the prevalence and severity of childhood obesity have important implications for morbidity and mortality during adult life. Immediate action must be taken to prevent excess weight gain during childhood and adolescence and to treat those children and adolescents who are already overweight. The health care system, government agencies, the school system, the food and entertainment industries, and public health professionals all have their part to play in preventing obesity. Further research is needed to develop interventions for the prevention and treatment of childhood and adolescent obesity.

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Questions About the Evaluation and Treatment of Childhood Obesity

1. An 8-year-old girl presents for a general medical examination. She has gradually gained 13.6 kg during the past 2 years. Her linear growth has been normal. Physical examination reveals an obese child with weight greater than the 97th percentile and height at the 95th percentile. Which *one* of the following is the *most likely* cause of weight gain?

   a. Hypothyroidism
   b. Hypercortisolism
   c. Pituitary tumor
   d. Leptin gene mutation
   e. Overeating and lack of physical activity

2. A 3-year-old boy presents for an evaluation of excessive weight. His medical history is remarkable for hypotonia and developmental delay. Findings on physical examination are remarkable for an obese child with height below the 3rd percentile and weight above the 97th percentile. He has short hands and feet and microphallus. Which *one* of the following is the *most likely* diagnosis?

   a. Prader-Willi syndrome
   b. Brain tumor
   c. Exogenous obesity
   d. Cushing syndrome
   e. Hyperthyroidism

3. A 12-year-old African American girl presents to her primary care physician with concerns regarding a rash. The patient has been overweight since the age of 5. Findings on physical examination are remarkable for obesity and for acanthosis nigricans affecting the neck and axillary region. Which *one* of the following tests is *most appropriate* in her case?

   a. Determination of thyroid-stimulating hormone level
   b. Bone age
   c. Fasting plasma glucose
   d. Determination of leptin level
   e. Complete blood cell count

4. A 15-year-old girl is being seen for exogenous obesity. She has been overweight since the age of 8. She has tried several unsupervised diets with no success. On physical examination, the patient is found to have a BMI of 38; her weight is greater than the 97th percentile and her height is at the 95th percentile. Fasting glucose level, transaminase levels, and the lipid profile are all normal. The patient and her family request referral to a bariatric surgeon. Which *one* of the following is the *most appropriate* response?

   a. Refer the patient to a bariatric surgeon
   b. Start the patient on orlistat
   c. Start metformin
   d. Refer the patient to a nutritionist for dietary modification and to a psychologist with expertise in behavior modification
   e. Start sibutramine

5. A 10-year-old boy presents for evaluation of excessive weight gain. Findings on physical examination are unremarkable except for obesity. The clinical impression is consistent with exogenous obesity. Which *one* of the following is a *key element* in the treatment of obesity in this child?

   a. Restriction of caloric intake to 4000 kcal
   b. Family involvement
   c. Prescription of appetite-suppressant drugs such as sibutramine
   d. Prescription of antidepressant drugs
   e. Restriction to low-sugar, low-fat foods

Correct answers:
1. *e*, 2. *a*, 3. *c*, 4. *d*, 5. *b*