

# Review of Childhood Obesity: From Epidemiology, Etiology, and Comorbidities to Clinical Assessment and Treatment

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## Abstract

Childhood obesity has emerged as an important public health problem in the United States and other countries in the world. Currently 1 in 3 children in the United States is afflicted with overweight or obesity. The increasing prevalence of childhood obesity is associated with emergence of comorbidities previously considered to be “adult” diseases including type 2 diabetes mellitus, hypertension, nonalcoholic fatty liver disease, obstructive sleep apnea, and dyslipidemia. The most common cause of obesity in children is a positive energy balance due to caloric intake in excess of caloric expenditure combined with a genetic predisposition for weight gain. Most obese children do not have an underlying endocrine or single genetic cause for their weight gain. Evaluation of children with obesity is aimed at determining the cause of weight gain and assessing for comorbidities resulting from excess weight. Family-based lifestyle interventions, including dietary modifications and increased physical activity, are the cornerstone of weight management in children. A staged approach to pediatric weight management is recommended with consideration of the age of the child, severity of obesity, and presence of obesity-related comorbidities in determining the initial stage of treatment. Lifestyle interventions have shown only modest effect on weight loss, particularly in children with severe obesity. There is limited information on the efficacy and safety of medications for weight loss in children. Bariatric surgery has been found to be effective in decreasing excess weight and improving comorbidities in adolescents with severe obesity. However, there are limited data on the long-term efficacy and safety of bariatric surgery in adolescents. For this comprehensive review, the literature was scanned from 1994 to 2016 using PubMed using the following search terms: *childhood obesity*, *pediatric obesity*, *childhood overweight*, *bariatric surgery*, and *adolescents*.

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Childhood obesity has emerged as one of the most important public health problems in the United States and other countries in the world.<sup>1,2</sup> The increasing prevalence of childhood obesity has led to the emergence of multiple serious obesity-related comorbidities<sup>3</sup> that not only threaten the health of those affected but also promise to place a large strain on the health care system. In addition, obesity in childhood tracks strongly into adulthood, particularly in those with severe obesity and/or a strong family history of obesity.<sup>4,5</sup> For this comprehensive review, the literature was scanned from 1994 to 2016 using PubMed using the following search terms: *childhood obesity*, *pediatric obesity*, *childhood overweight*, *bariatric surgery*, and *adolescents*.

## DEFINITION OF CHILDHOOD OBESITY

The term *obesity* refers to an excess of fat. Because of the unavailability and high cost of techniques that directly measure body fat, body mass index (BMI), derived from the body weight and height, has emerged as the accepted clinical standard measure of overweight and obesity for children 2 years and older. Body mass index is calculated by dividing the body weight in kilograms by the height in meters squared. In general, BMI provides a reasonable estimate of adiposity in the healthy pediatric population.<sup>6</sup> However, BMI may slightly overestimate fatness in children who are short or who have relatively high muscle mass and may underestimate adiposity in a substantial proportion of children, such as those with reduced muscle mass due to low



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## ARTICLE HIGHLIGHTS

- Childhood obesity has increased in epidemic proportions both in the United States and worldwide. We discuss the epidemiology of childhood obesity including the trend toward increasing prevalence of severe obesity in children.
- Children with obesity are at high risk for multiple comorbidities previously considered to be “adult” diseases. We discuss the association of childhood obesity with type 2 diabetes mellitus, hypertension, dyslipidemia, obstructive sleep apnea, nonalcoholic fatty liver disease, and other diseases.
- Lifestyle modifications including dietary changes aimed at decreasing total caloric intake, increasing physical activity and decreasing sedentary time are crucial for weight management.
- Pharmacotherapy may have a role in the treatment of pediatric obesity, but evidence is scant.
- Bariatric surgery is effective in achieving weight loss and improving comorbidities in adolescents with severe obesity. We discuss the indications for bariatric surgery in adolescents and the data on the efficacy and safety of these procedures.
- We discuss the components of family-based lifestyle interventions for weight loss.

levels of physical activity.<sup>7</sup> Therefore, BMI should be viewed as a surrogate measure of adiposity and its strengths and limitations should be considered when used in clinical and research settings. For children younger than 2 years, weight for length is the accepted measure of overweight and obesity.

Waist circumference and waist-to-hip ratio can be used to assess abdominal obesity, whereas skinfold thickness is helpful as an indicator of adiposity.<sup>8-11</sup>

Because children experience constant fluidity in height and weight as a result of normal growth and development, the norms for the absolute level of BMI in children vary with age and sex. In 2000, the National Center for Health Statistics and the Centers for Disease Control and Prevention (CDC) published BMI reference standards for children between 2 and 20 years of age.<sup>12</sup> Similarly, the World Health Organization (WHO)<sup>13</sup> developed growth standards through the WHO Multicentre Growth Reference Study to describe normal child growth from birth to 5 years

under optimal environmental conditions. Although probably not ideal for all segments of the pediatric population, these standards have been applied to all children everywhere, regardless of ethnicity, socioeconomic status, and type of feeding. The CDC recommends using curves based on the WHO child growth standards for infants and toddlers younger than 2 years and the CDC/National Center for Health Statistics growth references for children 2 years and older.<sup>12</sup>

The following BMI-based definitions are used for *overweight* and *obesity* for children and adolescents between 2 and 20 years of age:

- *Overweight*: BMI at or greater than 85th to less than 95th percentile for age and sex
- *Obesity*: BMI at or greater than 95th percentile for age and sex
- *Severe obesity*: BMI at or greater than 120% of the 95th percentile, or BMI at or above 35 kg/m<sup>2</sup> (whichever is lower).<sup>14,15</sup> This corresponds to approximately the 99th percentile, or BMI *z* score at or above 2.3 above the mean.<sup>16,17</sup> Some experts recommend classifying obesity in 3 classes: class I obesity (BMI at or above 95th percentile to less than 120% of the 95th percentile), class II (BMI at or above 120% to less than 140% of the 95th percentile, or BMI at or above 35 kg/m<sup>2</sup>), and class III (BMI at or above 140% of the 95th percentile, or BMI at or above 40 kg/m<sup>2</sup>).<sup>15</sup>

## EPIDEMIOLOGY

## Prevalence

Currently, about one-third of children and adolescents in the United States are classified as either overweight or obese.<sup>1</sup> The prevalence of overweight or obesity increases with advancing age: 22.8% of preschool children (age, 2-5 years), 34.2% of school-aged children (age, 6-11 years), and 34.5% of adolescents (age, 12-19 years) are afflicted with overweight or obesity<sup>1</sup> and 8.4% of preschool children (age, 2-5 years), 17.7% of school-aged children (age, 6-11 years), and 20.5% of adolescents (age, 12-19 years) have obesity.<sup>1</sup>

The prevalence of obesity varies by racial, ethnic, and socioeconomic factors. Childhood obesity is more common in African Americans,

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